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Test mining in the Area: Legal, regulatory, environmental governance and scientific perspectives

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Test mining in the Area: Legal, regulatory, environmental governance and scientific perspectives

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Kurzbeschreibung

Die Internationale Meeresbodenbehörde, ISA, handelt im Namen der gesamten Menschheit und kontrolliert das Gebiet und seine mineralischen Vorkommen, das gemeinsame Erbe der Menschheit. Dazu gehört die Verpflichtung, die Meeresumwelt wirksam vor den möglicherweise schädlichen Auswirkungen von Rohstoffexplorations- und -abbauaktivitäten zu schützen. Das bedeutet, dass die durch die ISA ergriffenen Maßnahmen und Regeln verhindern müssen, dass die betroffenen Biota und Ökosysteme durch die Aktivitäten der Vertragnehmer irreversibel geschädigt werden. Dies kann am besten durch *in situ* Tests der für den Abbau verwendeten Technologie demonstriert werden. In den gegenwärtig vorhandenen bzw. verhandelten Regularien gibt es keine Pflicht zur Durchführung von Komponenten-, System- und Betriebstests vor Abschluss eines Abbauvertrages, so dass Vertragnehmer theoretisch von der Exploration zur kommerziellen Produktion übergehen könnten, ohne der ISA praktisch nachweisen zu müssen, dass kein unzulässiger Umweltschaden entstehen wird. Auch Vorhersagemodelle können ohne *in situ* Tests nicht validiert und verifiziert werden. Außerdem würden Tests:

a) den Vertragnehmern die notwendigen Daten und Kenntnisse für aussagekräftige Umweltprüfungen (und anschließend alle notwendigen Dokumente für den kommerziellen Bergbauantrag zu erstellen);

b) die ISA als Regulierungsbehörde mit den notwendigen Daten und Kenntnissen ausstatten, um ihre Umweltziele, -standards und Schadensgrenzwerte so festzulegen, dass die Meeresumwelt effektiv geschützt wird; und

c) es der ISA als Aufsichtsbehörde ermöglichen, die technische Kapazität des Vertragnehmers/Antragstellers angemessen einzuschätzen, die schädlichen Auswirkungen seiner Bergbauaktivitäten zu steuern und zu minimieren.

Dieser Bericht untersucht das Thema Testbergbau im Gebiet aus rechtlicher, regulatorischer, umweltpolitischer und wissenschaftlicher Sicht.

Abstract

The International Seabed Authority, ISA, acts on behalf of all humanity and controls the area and its mineral deposits, the common heritage of humankind. This includes the obligation to effectively protect the marine environment from the potentially harmful effects of mineral exploration and extraction activities. This means that the measures and rules adopted by the ISA must prevent the affected biota and ecosystems from being irreversibly damaged by the activities of the contractors. This can best be demonstrated by *in situ* testing of the technology used for extraction. In the regulations currently in place or negotiated, there is no requirement to carry out equipment, system and operational testing prior to entering into a mining contract. Thus, while it is recognised that contractors can carry out tests of all kinds, there is no mandatory requirement for tests to be carried out. This allows contractors to theoretically move from exploration to commercial production without having to practically demonstrate to the ISA that no unacceptable environmental harm will occur. Prediction models also cannot be validated and verified without *in situ* testing. Furthermore, tests would:

(a) provide contractors with the necessary data and knowledge for meaningful environmental assessments (and to subsequently prepare all the documents necessary to accompany the commercial mining application);
(b) b) provide the ISA, as regulator, with the data and knowledge necessary to set its environmental objectives, standards and damage limits in a manner that effectively protects the marine environment; and
(c) enable the ISA, as regulator, to adequately assess the technical capacity of the contractor/applicant to manage and minimise the adverse impacts of its mining activities.

This report examines the issue of test mining in the area from legal, regulatory, environmental and scientific perspectives.

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Abkürzungsverzeichnis

ABNJ	Areas beyond national jurisdiction
BGR	Federal Institute for Geosciences and Natural Resources, BGR
BIE	Benthic Impact Experiments
CCZ	Clarion-Clipperton Zone
COMRA	China Ocean Mineral Resources Research and Development Association
CRC	Cobalt rich crusts
DEME	Dredging, Environmental and Marine Engineering NV
DISCOL	Disturbance and Recolonisation Experiment
DOMES	Deep Ocean Mining Environmental Study
DORD	Deep Ocean Resources Development Company
DSSRS	Deep Sediment Suspension
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMMP	Environmental Management and Monitoring Plan
GSR	Global Sea Mineral Resources
IFREMER	Institut français de recherche pour l'exploitation de la mer (French Research Institute for Exploitation of the Sea)
IOM	Interoceanmetal Joint Organisation
ISA	International Seabed Authority
ITLOS	International Tribunal for the Law of the Sea
LTC	Legal and Technical Commission
NOAA	National Oceanic and Atmospheric Administration
OMCO	Ocean Minerals Company
OMI	Ocean Mining Inc.
OMA	Ocean Mining Associates
PEIS	Programmatic Environmental Impact Statement
PMN	Polymetallic nodules
REMP	Regional Environmental Management Plans
RRP	Rules, regulations and procedures (of the ISA)
SDC	Seabed Disputes Chamber (of the ITLOS)
SEGO	Strategic environmental goals and objectives
SMS	Seafloor massive sulphides
UNCLOS	United Nations Convention on the Law of the Sea, 1982
1994 IA	Agreement Relating to the Implementation of Part XI of UNCLOS, 1994

Zusammenfassung

Einführung

Tiefseebergbau ist ein in Entwicklung befindlicher Industriezweig, der im weitgehend unbekannten Lebensraum Tiefsee weit vor der Küste und mit noch nicht erprobten Technologien arbeiten wird. Dieser Bericht untersucht die Notwendigkeit, Erfahrung und Kenntnisse über das Ausmaß der zu erwartenden Umweltschäden durch in situ Tests in der Entwicklung befindlichen Abbaugeräte, -systeme und -praktiken zu sammeln, bevor die Ausbeutung von Bodenschätzen in diesem Gebiet genehmigt wird.

Die Internationale Meeresbodenbehörde, ISA, ist damit beauftragt, die Erkundung und den Abbau der im Gebiet befindlichen mineralischen Ressourcen, die sogenannten "Tätigkeiten im Gebiet", zu organisieren und zu kontrollieren. Während die wissenschaftliche Meeresforschung und die der Erkundung vorausgehende Prospektion ohne vorherige Genehmigung der ISA durchgeführt werden können, können die Erkundung und den anschließenden Abbau von mineralischen Rohstoffen im Gebiet nur dann legal durchgeführt werden, wenn ein entsprechender Antrag durch die ISA genehmigt und ein Vertrag über entsprechende Tätigkeiten mit ihr abgeschlossen wurde. Das Mandat der ISA umfasst die Verabschiedung von Regeln, Vorschriften und Verfahren zur Erschließung der Ressourcen des Gebiets, einschließlich finanzieller Regelungen für von den Vertragspartnern zu leistende Zahlungen für abgebaute Ressourcen. Ein Verteilungsmechanismus, der die sich daraus ergebenden finanziellen und sonstigen wirtschaftlichen Vorteile gemäß Artikel 140 Absatz 2 des SRÜ gerecht und zum Nutzen der gesamten Menschheit aufteilt muss vereinbart werden. Insbesondere ist die ISA gemäß Artikel 145 des SRÜ verpflichtet alle notwendigen Maßnahmen zu ergreifen, um die Meeresumwelt vor schädlichen Auswirkungen, die sich aus den Tätigkeiten im Gebiet ergeben können, wirksam zu schützen.

Während der Erkundungsphase (Exploration) wird von den Vertragnehmern erwartet, dass sie neben der Erkundung der Aussichten für eine kommerzielle Nutzung der mineralischen Ressourcen auch Umweltgrundlagendaten sammeln und den Ist-Zustand von Flora und Fauna zu überwachen. Die Vertragnehmer haben demnach die Möglichkeit, alle für einen Antrag auf Abbau erforderlichen Daten, insbesondere Umweltdaten, zu sammeln, ihre Technologie zu entwickeln, zu testen, und deren Umweltauswirkungen zu messen, sowie mit der Vorbereitung eines Arbeitsplans für den künftigen Abbau zu beginnen. Dies ist aus Umweltsicht von entscheidender Bedeutung, da diese Daten die bei Beantragung einzureichende Umweltverträglichkeitserklärung, den Arbeitsplan sowie den Umweltmanagement- und Monitoringplan unterstützen. Nach der Genehmigung des Abbauantrags und dem Abschluss eines Vertrages würde der Vertragnehmer in die Nutzungsphase eintreten, die im Allgemeinen zwei Phasen umfasst. Die erste Phase ist die vorkommerzielle Produktionsphase, in der der Vertragnehmer mehrere Jahre verbringt, um sich auf die anschließende Phase der kommerziellen Gewinnung von mineralischen Rohstoffen vorzubereiten.

In den derzeit bestehenden ISA-Empfehlungen, den Explorationsvorschriften und der aktuell verhandelten Version des Entwurfs der Betriebsvorschriften wird zwar anerkannt, dass Vertragnehmer Testaktivitäten durchführen können, aber es gibt keine zwingende Vorschrift, dass oder wie Tests durchgeführt werden müssen. Dies ermöglicht es Vertragnehmern theoretisch, von der Exploration zur kommerziellen Produktion überzugehen, ohne der ISA praktisch nachweisen zu müssen, dass kein unzulässiger Umweltschaden entstehen wird. Diese Erprobung von Technologien *in situ* (ab jetzt Test Mining*)* bei gleichzeitiger Überwachung der Umweltauswirkungen ist unabdingbar in einer neu entstehenden Industrie, um schädliche Auswirkungen von Tiefseebergbautätigkeiten auf die hochgradig wissensarmen und sensiblen Lebensraum Tiefsee feststellen, verhindern oder minimieren zu können. Ohne *in situ* Ausrüstungs-, System- und Betriebstests Tests können auch Vorhersagemodelle nicht validiert und verifiziert werden. Anders ausgedrückt: Aus regulatorischer Sicht ist es für einen Vertragnehmer theoretisch möglich, von der Exploration zur kommerziellen Produktion überzugehen, ohne vorher irgendeine Form von in situ-Test durchzuführen. Dies ist, gelinde gesagt, aus ökologischer Sicht ziemlich alarmierend. Es wird zwar erwartet, dass die Vertragnehmer für ihre eigenen Zwecke, d.h. zur Bestimmung der technischen oder wirtschaftlichen Machbarkeit, in situ, ex situ oder in Labors irgendeine Form von Tests durchführen, aber es gibt keinen Zwang für die Durchführung von Testaktivitäten aus Umweltsicht.

Die ISA handelt im Namen und zum Nutzen der gesamten Menschheit und kontrolliert dazu das Gebiet und seine mineralischen Vorkommen, das gemeinsame Erbe der Menschheit. Sie ist ausdrücklich verpflichtet, den wirksamen Schutz der Meeresumwelt vor den schädlichen Auswirkungen von Tätigkeiten zur Erkundung und Ausbeutung von mineralischen Rohstoffen zu gewährleisten. Das bedeutet, dass die durch die ISA ergriffenen Maßnahmen und Regeln verhindern müssen, dass die betroffenen Biota und Ökosysteme (langfristig? irreversibel?) durch die Tätigkeiten der Vertragnehmer geschädigt werden. Geräte-, System- und Betriebstests wären unerlässlich, um wichtige Erkenntnisse zu diesem Zweck zu gewinnen. Test Mining würde:

a) den Vertragnehmern die notwendigen Daten und Kenntnisse zur Verfügung stellen, um aussagekräftige Umweltprüfungen sowie Umweltmanagement- und Monitoringpläne zu erstellen;

b) die ISA als Regulierungsbehörde mit den notwendigen Daten und Kenntnissen auszustatten, um ihre Umweltziele, -standards und Schadensgrenzwerte so festzulegen, dass die Meeresumwelt effektiv geschützt wird; und

c) es der ISA als Aufsichtsbehörde ermöglichen, die technische Kapazität des Vertragnehmers/Antragstellers auf der Grundlage seiner während des Probeabbaus nachgewiesenen Fähigkeiten angemessen zu bewerten, um die schädlichen Auswirkungen seiner Bergbauaktivitäten zu steuern und zu minimieren.

Dieser Bericht untersucht das Thema Test Mining im Gebiet aus rechtlicher, regulatorischer, umweltpolitischer und wissenschaftlicher Sicht.

Regulatorischer Rahmen und gesetzlicher Auftrag für Test Mining

In Kapitel 2 werden der bestehende Rechtsrahmen und das gesetzliche Mandat für das Test-Mining erläutert. Insbesondere wird gezeigt, dass Test Mining unter dem derzeitigen Rahmenwerk zwar erlaubt und möglicherweise sogar gefördert wird, aber nicht zwingend vorgeschrieben ist. Daher sollte die ISA das gegenwärtige Zeitfenster nutzen, nämlich die Verhandlungen über den Entwurf der Abbauregularien und die damit zusammenhängenden Themen, um Test Mining zu einer verpflichtenden Anforderung zu machen. Dies hat viele Vorteile, und es gibt mehrere Optionen, um dies zu verwirklichen.

Vorteile der Anforderung von Test-Mining-Aktivitäten

- Einheitliche Bedingungen (level playing field) für alle Vertragnehmer.
- Hilft sicherzustellen, dass nur Vertragspartner, die es mit dem effektiven Schutz der Meeresumwelt vor den schädlichen Auswirkungen des Abbaus ernst meinen, in die Abbauphase und schließlich in die kommerzielle Produktionsphase eintreten dürfen.
- Legt die Grundlage für ein effektives Umweltmanagement, das im Kerninteresse der ISA, des Sponsorstaates und des Vertragnehmers liegt.
- Entscheidend für die ISA, um anwendbare Umweltindikatoren und Schadensschwellen zu entwickeln, und für den Vertragnehmer, um aussagekräftige EIS und EMMPs zu entwerfen.
- Generiert zuverlässiges Wissen, validiert Modelle und betrachtet die Umweltbewertung als einen kontinuierlichen und fortlaufenden Prozess.
- Hilft bei der Entwicklung der "besten Umweltpraktiken" und der "besten verfügbaren Techniken".
- Stellt das Element der Kontinuität zwischen Erkundungs- und Betriebsphase sicher.

- Ermöglicht eine fundierte Entscheidungsfindung und ein anpassungsfähiges Management und steht im Einklang mit dem Vorsorgeansatz.

Das Kapitel beginnt mit einer Betrachtung der Ziele, des notwendigen Umfangs und einer möglichen Definition für Test Mining. In Bezug auf den aktuellen rechtlichen Rahmen für Test Mining analysiert das Kapitel die relevanten Bestimmungen des SRÜ und die geltenden Regeln, Vorschriften und Verfahren sowie die Empfehlungen des ISA für die Erkundungsphase, um zu veranschaulichen, wie Test Mining derzeit behandelt wird. Anschließend wird der gesetzliche Auftrag des ISA zur weiteren Regulierung des Test Minings betrachtet. Dabei werden die Verpflichtungen zur Durchführung von Umweltverträglichkeitsprüfungen, zur Einhaltung des Vorsorgeprinzips, zur Anwendung der besten Umweltpraxis sowie die Verantwortlichkeiten der befürwortenden Staaten (Sponsoring States) in Bezug auf Test Mining betrachtet. Insbesondere wird argumentiert, dass, obwohl Test Mining in den Regeln, Vorschriften und Verfahren der ISA nicht zwingend vorgeschrieben ist, die Verpflichtung zur Durchführung von Test Mining implizit Teil der Verpflichtung der ISA, der befürwortenden Staaten und der Vertragnehmer ist, den wirksamen Schutz der Meeresumwelt vor den schädlichen Auswirkungen der Bergbauaktivitäten zu gewährleisten und ernsthafte Schäden an der Meeresumwelt zu verhindern. Auch wenn die Erwartung und Verpflichtung zur Durchführung von Test Miningaktivitäten implizit ist, wäre es wünschenswert, dies explizit zu machen. Daher werden Optionen in Betracht gezogen, Test Mining innerhalb des ISA-Regimes verpflichtend zu machen. Schließlich soll auch erörtert werden, ob eine Verpflichtung zum Test Mining auch Anreize für die Vertragnehmer schaffen und gleiche Wettbewerbsbedingungen im Zusammenhang mit den Aktivitäten im Gebiet schaffen würde. Die folgenden Empfehlungen werden vorgeschlagen, um die derzeitige umweltpolitische Steuerung von Bergbauaktivitäten im Hinblick auf den Testabbau zu verbessern:

Empfehlungen

- Der Rat sollte sich umgehend damit befassen, vor dem Probeabbau in der Explorationsphase geeignete Formen von Garantien zu verlangen.
- Die ISA sollte im Einklang mit dem Vorsorgeansatz in Erwägung ziehen, die Beweislast auf die Abbauinteressenten umzukehren, um durch Test Mining nachzuweisen, dass die geplanten kommerziellen Abbauaktivitäten die Umweltgrenzwerte und -standards nicht überschreiten.
- Die ISA sollte die Verpflichtung der Vertragnehmer zur Durchführung von Test Mining klarstellen und spezifizieren, insbesondere den Umfang der Tests und des begleitenden Umweltmonitorings, die während der Explorationsphase durchgeführt werden müssen, um der ISA ausreichende Daten und Informationen zur Verfügung zu stellen. Dies wird eine fundierte Entscheidungsfindung in Bezug auf einen Antrag auf Genehmigung eines Arbeitsplans für die Ausbeutung ermöglichen (und anschließend, falls erforderlich, bevor mit der kommerziellen Produktion begonnen wird).
- Die ISA sollte die Durchführung von vorherigem Test Mining als zwingende vertragliche Verpflichtung aufnehmen, indem eine entsprechende Klausel in den Vertrag eingefügt wird, oder die notwendigen Standards (rechtsverbindlich) für den Test Mining erlassen.
- Die ISA sollte das Bewusstsein der befürwortenden Staaten in Bezug auf die Vorteile einer Verpflichtung der Vertragnehmer zur vorherigen Durchführung von Test Mining schärfen.
- Die ISA sollte eine Studie in Auftrag geben, um die Durchführbarkeit der Annahme eines "vorläufigen Abbauvertrags" und der Annahme eines obligatorischen zweistufigen Ansatzes für den Testabbau als Teil des Entwurfs der Ausbeutungsverordnungen zu untersuchen.

Aktueller Stand der Erkundung in diesem Gebiet

Kapitel 3 zeigt, dass die technologische Entwicklung der Komponenten und Systeme für den Meeresbodenbergbau je nach Ressource sehr unterschiedlich weit fortgeschritten ist. Es ist bis heute nicht ersichtlich, welche Art von Bergbau zuerst beginnen wird - wenn überhaupt. Der Grund dafür ist, dass die Lebensräume, in denen sich die verschiedenen mineralischen Rohstoffe befinden, unterschiedliche technische Herausforderungen stellt.

Insgesamt scheint vieles an dem Gerede über "*baldigen Beginn des Abbaus*" und "*der Abbau steht vor der Tür*" übertrieben und sehr unwahrscheinlich zu sein. Wenn wir uns die verschiedenen Vertragnehmer der ISA und ihre befürwortenden Staaten ansehen, sind zwei Dinge offensichtlich: Staaten und ihre Behörden, insbesondere diejenigen mit einer Pionier-Investoren-Vergangenheit, haben einen anderen Ansatz zum Tiefseebergbau als die kommerziellen Unternehmen, die in letzter Zeit ins Spiel kommen. Während erstere meist die Strategie verfolgen, sich alle Optionen offen zu halten und die Technologie langsam, aber stetig weiterzuentwickeln, kommen letztere mit einem Geschäftsmodell ins Spiel, das eine kurzfristige Hochgeschwindigkeitsexploration und Ambitionen für den Beginn des Abbaus in naher Zukunft erfordert.

Stand Dezember 2020 ist Japan wahrscheinlich (mit allen Unsicherheiten aufgrund von Wissenslücken) das Land und der Vertragnehmer, der am ehesten für eine Ausbeutung in der nahen Zukunft bereit ist. Allerdings wird diese Ausbeutung wahrscheinlich zuerst in Japans nationalen Gewässern stattfinden, und die Mineralien aus dem Massivsulphid- (SMS-) und schließlich dem Krustenbergbau werden eher an den nationalen als an den globalen Markt geliefert werden.

Alle staatlichen Vertragnehmer können die Monitoringergebnisse eines *in situ*-Systemtests (Pilotabbauversuch) als Teil ihrer Umweltverträglichkeitsprüfung bei der Beantragung der Nutzung vorlegen (siehe weiterführendes Kapitel 2). Tatsächlich testen Japan, Korea und China bereits Systemkomponenten und Vor-Prototypen oder sogar Prototypen von Systemen in nationalen Gewässern. In dieser Hinsicht scheint es, dass diese Regierungen oder ihre gesponserten Vertragnehmer ziemlich leicht einen vollständigen Systemtest innerhalb ihrer Explorationsvertragslaufzeit in ihrem ISA Vertragsgebiet durchführen könnten, einschließlich der Sammlung von *in situ*-Monitoringdaten für mindestens einige Jahre (abhängig von einer weiteren Verlängerung ihrer Verträge).

Die kommerziellen Vertragnehmer hingegen sind möglicherweise in der Lage, einige Ausrüstungstests im Vor-Prototyp- oder Prototyp-Maßstab durchzuführen, es ist jedoch nicht zu erwarten, dass sie in ein vollständiges Bergbausystem investieren können, bevor sie einen Betriebsvertrag mit der ISA erhalten haben. Es wird davon ausgegangen, dass die kommerziellen Vertragnehmer erst dann in der Lage sind, umfangreiche Finanzmittel zu beschaffen und bereit sind, stark in die Technologie zu investieren, wenn sie im Besitz des Betriebsvertrags sind. Insgesamt scheint ihre Technologieentwicklung noch in den Kinderschuhen zu stecken, wie die DEME/GSR-Entwicklung eines völlig neuen Modells eines Knollenkollektors zeigt. Ein weiteres Unternehmen, DeepGreen, das geäußert hat, dass es in den Jahren 2024-2026 mit der Produktion von Knollen in vollem Umfang beginnen möchte, hat in keinem der drei Vertragsgebiete mit der ISA, an denen es beteiligt ist, physische Tests durchgeführt, obwohl es Pressemitteilungen und öffentliche Dokumente herausgegeben hat, in denen es seine Absicht erklärt, in naher Zukunft Tests von Ausrüstungen durchzuführen (die sogar ein Steigrohrsystem umfassen können).

Um die schädlichen Auswirkungen von bergbaubedingten Tätigkeiten auf die Lebensräume und die Fauna der Tiefsee zu verhindern oder zu minimieren, ist die Optimierung der Technologie an der Quelle besonders wichtig, u.a. um die Freisetzung von Schadstofffahnen, die Eindringtiefe in das Sediment, die Freisetzung von Schadstoffen usw. zu minimieren. In dieser Hinsicht wird von den Vertragnehmern erwartet, dass sie die Anwendung der besten Umweltpraktiken (BEP), der besten verfügbaren Techniken (oder der besten verfügbaren Technologien, BAT) und die Konformität mit den guten Industriepraktiken nachweisen, wenn sie sich um einen Ausbeutungsvertrag mit der ISA bewerben.

Anders als in der Zeit vor dem Seerechtsübereinkommen, SRÜ, (UNCLOS) und insbesondere vor dem Umsetzungsabkommen von 1994 entwickeln die Vertragnehmer ihre Technologien unabhängig und als nationale oder betriebliche Bemühungen. Dies macht es nahezu unmöglich, einen Überblick über die Umweltauswirkungen verschiedener bergbautechnischer Lösungen zu erhalten. Darüber hinaus behindert der Mangel an Standardisierung und an gemeinsam vereinbarten Modellen für die Prüfung von Auswirkungen und allen anderen Elementen der wissenschaftlichen Forschung die Schlussfolgerungen zu den Engpässen der Technologieentwicklung und den damit verbundenen Umweltauswirkungen.

Nicht nur die Technologie selbst, sondern auch ihr Betrieb in der Umweltpraxis ist entscheidend für Art und Umfang der verursachten Umweltauswirkungen. Unter "bester Umweltpraxis" versteht man im Allgemeinen die Anwendung der am besten geeigneten Kombination von Umweltkontrollmaßnahmen und -strategien unter Berücksichtigung der von einer bestimmten Aufsichtsbehörde festgelegten Kriterien, alles in allem ein sehr anspruchsvolles Unterfangen für eine sich neu entwickelnde Industrie.

Gute Technologie in Kombination mit einer guten Umweltpraxis kann viel dazu beitragen, das Gesamtausmaß der Schäden an der Meeresumwelt zu reduzieren. Bislang gibt es jedoch keinerlei Erkenntnisse darüber, wie der Betrieb abläuft, und die Betreiber haben quasi ein Monopol auf ihre Technologie. Tatsächlich hat es den Anschein, dass die ISA bereit ist, die Rolle eines schwachen Regulierers zu übernehmen (Ginzky et al., 2020) und zuzulassen, dass das derzeitige Betriebsmodell die meisten vertragsbezogenen Lasten dem Vertragnehmer aufbürdet, die dieser nach eigenem Gutdünken angehen kann. In Ermangelung eines starken Regulierers können diese somit ein eigenes Selbstmonitoring und -bewertung nach eigenen, selbst entworfenen Standards entwickeln (Gerber und Grogan, 2018).

Solange es keine klaren, verbindlichen und ehrgeizigen Standards für die einzuhaltende Umweltqualität gibt, wird kein Vertragnehmer in der Lage sein, seine Technologie zu optimieren und sicher zu sein, dass die ISA-Standards eingehalten werden. Der ISA wiederum fehlt es an eigenen Daten, Informationen und Erfahrungen, und sie hat nicht einmal Zugang zu einem größeren Pool von Experten. Daher wird es unmöglich sein, BAT und BEP zu bestimmen, was es für die ISA schwierig machen wird, das Mandat einer "*einheitlichen Anwendung der höchsten Standards zum Schutz der Meeresumwelt, der sicheren Entwicklung von Aktivitäten in dem Gebiet und des Schutzes des gemeinsamen Erbes der Menschheit*" zu erfüllen (ITLOS, 2011, Abs. 159).

Die einzige Lösung könnte darin bestehen, dass die Vertragnehmer ihre Abbaukomponenten und -systeme schrittweise in angemessenem Umfang und mit angemessener Dauer vor Ort testen, bis die Auswirkungen eines Abbaubetriebs im kommerziellen Maßstab auf die Umwelt zuverlässig vorhergesagt werden können. Nur dann kann die ISA ihre für alle Unternehmungen gültigen Vorschriften und Beurteilungskriterien entwickeln. Diese Rahmenbedingungen müssen vorhanden sein, bevor ein Antrag auf Abbau beurteilt und genehmigt werden kann. Andernfalls müssten die Vertragnehmer nachweisen, dass kein signifikanter Umweltschaden entsteht.

Umweltverträglichkeitsprüfungen für Test Mining

Kapitel 4 befasst sich mit den Anforderungen an die Durchführung von Umweltverträglichkeitsprüfungen (EIA) im Zusammenhang mit Test Mining während der Erkundungsphase. Dies ist nicht zu verwechseln mit Umweltverträglichkeitsprüfungen für Abbautätigkeiten, welche Antragsteller zusammen mit einem Antrag auf Genehmigung eines Arbeitsplans für Abbauaktivitäten einreichen müssen. Einige Erfahrungen aus den Diskussionen um jenen Umweltverträglichkeitsprüfungsprozess helfen allerdings auch im Zusammenhang mit der Bewertung der Umweltauswirkungen des Test Minings, da es sich im Wesentlichen um Bergbau handelt, wenn auch für einen kürzeren Zeitraum und in einem kleineren Maßstab. Dennoch wird die Umweltbelastung für die Meeresumwelt im Vergleich zu anderen Erkundungstätigkeiten als potenziell signifikant angesehen. Da solche Erkundungsunternehmen, welche einen Antrag auf einen Abbauvertrag stellen wollen, der ISA die für eine fundierte Entscheidungsfindung notwendigen Informationen und Daten vorlegen müssen, sollten bereits in der Explorationsphase in ausreichendem Umfang Tests durchgeführt werden. Diese erfordern eine eigene Bewertung der erwarteten Umweltschäden, da bei der Beantragung der Exploration nur eine vorläufige Bewertung möglicher Umweltauswirkungen - und keine vollständige Bewertung der Umweltauswirkungen - erforderlich ist. Daher ist die Durchführung einer hochwertigen Umweltverträglichkeitsprüfung und die Erstellung von Umweltverträglichkeitserklärungen (EIS) vor der Durchführung von Test Miningaktivitäten wichtig, um einen effektiven Schutz der Meeresumwelt vor den schädlichen Auswirkungen des Bergbaus zu gewährleisten und ernsthafte Schäden an der Meeresumwelt zu vermeiden. Die Bewertung der Umweltbeobachtungen nach den Tests sollte ergänzend die in der Umwelterklärung vermuteten Schäden verifizieren. Abgesehen davon erfüllt sie auch eine wichtige Funktion, um die ISA sowie die Öffentlichkeit über die Pläne oder Absichten eines Vertragnehmers zur Durchführung von Test Mining zu informieren und eine angemessene Prüfung der Aktivitäten des Vertragnehmers zu ermöglichen, die andernfalls für Interessengruppen und Mitglieder der Öffentlichkeit nicht sehr sichtbar wären.

Tatsächlich erkennen die "Empfehlungen für die Anleitung von Vertragnehmern für die Bewertung möglicher Umweltauswirkungen, die sich aus Explorationsaktivitäten ergeben", die von der Rechts- und Fachkommission (LTC) der ISA (ISBA/25/LTC/6/Rev.1) herausgegeben wurden, die potenziellen Umweltschäden an, die durch Test Mining Aktivitäten entstehen könnten, und stellen ausdrücklich klar, dass bestimmte Tätigkeiten während der Explorationsphase, einschließlich Test Mining, den Vertragnehmer dazu verpflichten, mindestens 12 Monate vor den geplanten Testaktivitäten eine Umweltverträglichkeitserklärung einzureichen, und geben auch bestimmte Anforderungen und Hinweise in Bezug auf Inhalt und Umfang des Geltungsbereichs an. Durch die Entscheidung, dass die Vertragnehmer eine Umweltverträglichkeitserklärung einreichen, anstatt ein von der Aufsichtsbehörde geleitetes Verfahren zur Umweltverträglichkeitsprüfung zu durchlaufen, wird den Vertragnehmern jedoch ein großer Ermessensspielraum bei der Gestaltung dessen eingeräumt, was sie letztendlich bei der ISA einreichen würden. Das Fehlen von ISA-Anleitungen zu Managementzielen und -vorgaben, Bewertungsrahmen und -methodik sowie Verfahrensunterstützung zur Bewältigung der Aufgaben hinterlässt eine große Lücke, die jeder Vertragnehmer nach Belieben ausfüllen kann. Darüber hinaus hat die ISA weder Einblick noch eigene Kompetenzen in dieser Angelegenheit (abgesehen von Ressourcenbewertungen), und es gibt kein spezielles Umwelt- oder wissenschaftliches Gremium, das in dieser Hinsicht berät. Alle Kompetenzen in dieser Angelegenheit hängen von den wechselnden Mitgliedern des LTC ab, und es scheint kein institutionelles Gedächtnis zu existieren. Dies scheint für die umweltpolitische Steuerung einer neu entstehenden Hochrisikobranche unzureichend zu sein. Im Gegensatz dazu verfügt z.B. die US NOAA über einen eigenen Daten- und Erfahrungsschatz, den sie zur Festlegung eines Handlungsrahmens und der Bedingungen für Test Miningaktivitäten genutzt hat.

Bei der Prüfung der neu überarbeiteten Empfehlungen (ISBA/25/LTC/6/Rev.1) für die Anleitung der Vertragnehmer scheint es, dass die ISA sich selbst keine Steuerungsfunktion vorbehält, d.h. durch eine verfahrensmäßige Anleitung der Vertragnehmer mit einer ersten Scoping-Phase zur Bestimmung des voraussichtlichen Umfangs und Inhalts der in die Umweltbewertung und -erklärung aufzunehmenden Informationen, der zu erfüllenden Standards und der auf die Umwelterklärung anzuwendenden Bewertungskriterien. Die ISA sollte den Vertragnehmern Leitlinien und rechtliche Hinweise zu den anwendbaren Erhaltungsstandards, einschließlich des Schutzes vor Gewässerverunreinigung, sowie einen ersten Entwurf des Bewertungsrahmens zur Verfügung stellen, in dem die beteiligten Verfahrensschritte, der Prozess der Risikobewertung und das Management beschrieben werden. Insbesondere Empfehlungen zur wissenschaftlich sinnvollen Positionierung von Belastungs- und Erhaltungsreferenzzonen (Impact and Preservation Reference Zones), die für die Feststellung von Umweltänderungen durch Tätigkeiten im Rahmen von Tests entscheidend sind, sind unerlässlich, um alle Vertragnehmer in die Lage zu versetzen, ihre Vorher-Nachher-Kontrollproben in vergleichbarer Weise zu gestalten. Dies könnte z.B. die Charakteristik, Lage, die Größe der Kern- und Pufferzonen sowie den räumlichen und zeitlichen Abstand der Messstationen betreffen, um regionale Bewertungen und Vergleiche zwischen den Vertragspartnern zu erleichtern. Vorschläge für die systematische Auswahl von Test- und Abbaustandorten in einem Vertragsgebiet, z. B. durch Raumplanungsprozess, wären ebenfalls hilfreich, um von einem gemeinsamen Ausgangspunkt aus Erfahrungen zu sammeln. Im Hinblick auf das Monitoring der Umweltfolgen geben die ISA-Empfehlungen derzeit allerdings keine Hinweise auf den Zeitpunkt und die Abstände des Monitorings, die Prüfung von Kernparametern als Indikatoren, wie von der Wissenschaft empfohlen, und die erste Risikobewertung vor. Daher werden die Vertragnehmer über sehr unterschiedliche Ansätze berichten. Dies gilt umso mehr, als es keine Berichtspflichten gibt über a) die Meldung von Arten, Habitaten, Ökosystemen von besonderem Interesse anderer Stellen, z. B. EBSAs, VMEs oder vorgeschlagene MPAs im Vertragsgebiet; b) die Minderung von Auswirkungen; c) Alternativen; d) Unsicherheiten und e) Wissenslücken.

Umfassende, genaue, verlässliche, wissenschaftlich korrekte und reproduzierbare Daten und Ist-Zustandsinformationen über das Vertragsgebiet und insbesondere das Abbaugebiet oder Testgelände sind die wesentliche Grundlage für die Umweltrisiko- und -folgenabschätzung. Neben der Qualitätssicherung ist ein gewisses Maß an Standardisierung der Grundlagenuntersuchungen, des Monitorings und der Berichterstattung erforderlich, um regionale und zeitliche Analysen zu ermöglichen. Für die ISA als Regulierungsbehörde, die für einheitliche Bedingungen für alle Vertragnehmer im Gebiet zu sorgen hat, sollten solche Mindestanforderungen unerlässlich sein. Anreize könnten zu umfassenderen Untersuchungsprogrammen anregen.

Der Gesamteindruck ist, dass potenzielle Betreiber im Gebiet keine ausreichende Sicherheit darüber haben, welche Leistungen während der Exploration und im Fall von Mining Tests gefordert werden, e.g. welches die Mindestanforderungen für als ausreichend angesehene Grundlagenuntersuchungen, Monitoringpläne und Berichterstattung zu Umweltfragen sind. Dies wird besonders deutlich, wenn man es mit den Standards vergleicht, die z.B. von der ESPOO-Konvention (1991), der Aarhus-Konvention (1998) oder dem, was die Konvention über die biologische Vielfalt (Convention on Biological Diversity, 2012a) für Gebiete jenseits der nationalen Gerichtsbarkeit empfiehlt, gesetzt werden. Die ISA bietet auch nicht die gleiche Verfahrenssicherheit, wie sie z. B. Neuseeland den Offshore-Betreibern bietet (siehe Kapitel 5.5.2.3). Nur die technische und ressourcenbezogene Berichterstattung ist ziemlich klar. Eine mögliche Erklärung ist, dass die Betreiber von der ISA keine ernsthaften Einschränkungen der von ihnen geplanten Aktivitäten erwarten.

Die ISA sollte daher versuchen, die geforderte Berichterstattung des langfristigen Umweltmonitorings der durch die Tests entstehenden Umweltfolgen zu konkretisieren, und aus den von den Vertragnehmern berichteten Daten und Informationen einen eigenen Wissenspool aufzubauen, um z. B. erste Ansätze zu potenziellen Schadensindikatoren und -schwellenwerten, Indikatoren für den guten Umweltzustand, zu besten Umweltpraktiken und besten verfügbaren Technologien zu entwickeln. Mit der zunehmenden Anzahl von Test Mining Unternehmungen steigt der Bedarf an ISA-Leitlinien zu den oben genannten Themen deutlich an. Natürlich gibt es bisher nur begrenzte Erfahrungen und die ISA verfügt über keine eigenen Daten aus unabhängigem Monitoring von Eingriffen durch Mining Tests. Es könnte jedoch viel gewonnen werden, wenn alle historischen und kleinräumigen Umweltstudien zusammengetragen und ausgewertet würden, um eine erste institutionelle Beschreibung dessen zu schaffen, was "Beeinträchtigungen" ("harmful effects") und "erheblicher Schaden" ("serious harm") bedeuten (in Erweiterung der bestehenden wissenschaftlichen Beratung). Mit jedem neuen Test Mining werden mehr Erfahrungen gesammelt, so dass die Definitionen, Indikatoren und Erheblichkeitsschwellen verfeinert werden können.

In diesem Zusammenhang ist es überlegenswert, ob das ISA vorschreiben könnte, dass alle EIA/EIS, die bis zum Beginn des kommerziellen Abbaus erforderlich sind, in einen iterativen oder kontinuierlichen Prozess integriert werden. Es wäre denkbar, dass für jeden Auftragnehmer alle EIS und Berichte, die im Zusammenhang mit dem Test Mining während der Explorationsphase vorgelegt werden, kumulativ die letztendliche EIA/EIS hervorbringen, die in Verbindung mit dem Genehmigungsverfahren für die Ausbeutung zu erstellen ist. Abgesehen davon könnte man sich auch vorstellen, dass die Vertragnehmer in der Explorationsphase nur ein EIA für mehrere Test Miningprojekte (d. h. mit unterschiedlichen Standorten, Ausrüstungen, Systemen, Zeit, Dauer) durchführen und für jedes Projekt jeweils mehrere EIS erstellen. Mit anderen Worten: Wenn die Vertragnehmer ihre Test Miningpläne von Anfang an während der Explorationsphase festlegen können, und unter der Annahme, dass dies mehr als ein Test Miningprojekt umfasst, könnten die Vertragnehmer dies in einem EIA-Prozess zusammenführen, der zu mehreren EIS führt.

Der Endpunkt für dieses Verfahren ist, wenn ein Vertragnehmer zuverlässig angeben kann, a) welche Umweltfolgen für den geplanten kommerziellen Bergbaubetrieb zu erwarten sind und b) dass diese die Umwelt aller Voraussicht nach nicht erheblich beeinträchtigen. In der Praxis bedeutet dies, dass ein und dasselbe EIA-Format und die zugrundeliegenden Bewertungs- und Berichtsverfahren über alle Vertragsphasen hinweg gültig wären. Für die Vertragnehmer könnte dies die Durchführung von mehreren Tests attraktiver machen, da der Kern der EIA derselbe bleibt nur um aktuelle Erkenntnis ergänzt wird. Es muss also sichergestellt werden, dass neue Test- und Monitoringprogramme von Fall zu Fall hinzugefügt werden und dass die aus früheren Testprojekten gezogenen Lehren ordnungsgemäß analysiert werden, wobei alle verbleibenden EIAs für anstehende Testprojekte bei Bedarf entsprechend überarbeitet werden.

Zusammenfassung und Empfehlungen

Zusammenfassung

Die "*Recommendations for the guidance of contractors for the assessment of possible environmental impacts arising from exploration for minerals in the Area*", ISBA/25/LTC/6/Rev1:

- Geben den Vertragnehmern eine unzureichende Anleitung zum Umfang und Inhalt der EIS einschließlich der soliden Gestaltung der Umweltmonitoring Programme, die der ISA LTC vor jeder Test Mining Tätigkeit vorgelegt werden müssen;
- Unterlassen es, zumindest ein Minimum an Grundlagenuntersuchungen und Monitoring-Parametern der Vertragspartner so zu standardisieren, dass Vergleiche zwischen den Vertragspartnern und die Integration mit wissenschaftlichen und regionalen Daten möglich sind;
- Informieren nicht über Umweltziele, sowie vorläufige Erheblichkeitsschwellen und Bewertungskriterien, die bei allgemeiner Anwendung zur Weiterentwicklung des Bewertungsrahmens beitragen könnten, bis sie zum Zeitpunkt der Nutzungsanträge in für alle verbindlicher Form erforderlich sind;
- Überlassen zu vieler Aspekte dem Ermessen des Vertragnehmers, bzw. räumt der ISA keine Regulierungsbefugnisse ein, um aktiv einzugreifen (z.B. die Vertragnehmer anzuweisen, im EIA-Prozess und bei der Erstellung der EIS gründlicher vorzugehen, sowie die Befugnis, eine EIS abzulehnen, die als unangemessen, unzureichend oder unbefriedigend erachtet wird).

Es bleiben Bedenken, wann und wie viele Daten und Informationen öffentlich zugänglich gemacht werden, da fast alle Informationen mit der Ressource und/oder Technologie zusammenhängen, die Vertraulichkeitsbedingungen unterliegen.

Empfehlungen

- *Umstrukturierung des EIA Prozesses von der Anforderung eines allein durch den Vertragnehmer* *erstellten Umweltberichts hin zu einem ISA-geführten Prozess. Der Vertragnehmer wäre dann immer noch für den EIA-Prozess und die Lieferung der Umweltdokumente, einschließlich der EIS verantwortlich, aber die Inhalte, Bewertungskriterien und -methoden und insbesondere Alternativen und Maßnahmen zur Vermeidung sollten nach Anleitung der ISA und des Befürwortenden Staates (falls zutreffend), sowie mit Öffentlichkeitsbeteiligung durchgeführt werden. Damit soll die Vollständigkeit und Angemessenheit in allen Phasen gewährleistet und sichergestellt werden, dass der gesamte Prozess und das Ergebnis nicht vollständig dem Ermessen des Vertragnehmers überlassen wird.*

- ► Einführung einer Scoping-Phase, um das im jeweiligen Fall angemessene Format und die Elemente der Umweltverträglichkeitserklärung EIS zu entwickeln. Das Scoping könnte die Grundlage für alle folgenden Schritte setzen, wobei die Leistungen im Verhältnis zum Risikoniveau zunehmen. Alle Informationen aus vorangegangenen EIS und den eigentlichen Testaktivitäten (d. h. Testabbaustudien oder -berichte) sollten im Laufe des Explorationszeitraums schrittweise zu einem umfassenden Bericht akkumuliert werden, auf den sich der Vertragnehmer bei der Erstellung der EIS stützen würde, die er bei der Beantragung eines Ausbeutungsvertrags vorlegen muss.
- ► Ergänzung der Empfehlungen um die Meldung von Unsicherheiten und Wissenslücken, und wie die Vertragnehmer damit umgegangen sind;
- ► Ergänzung der Empfehlungen um die Meldung des Vorkommens von Arten, Lebensräumen, Ökosystemen, die dem Schutz durch andere Stellen unterliegen, z. B. EBSAs, VMEs oder vorgeschlagene MPAs im Vertragsgebiet.
- ► Einführung von Leitlinien für ressourcenabhängige StandardMonitoringsprogramme - z. B. Angabe der Zeitskala vor und nach einer Störung, räumlicher und zeitlicher Aufbau, Mindestmenge an Biota und Prozessen -, um die von verschiedenen Vertragnehmern stammenden Informationen synthetisieren zu können. Solange es keine solchen Vorgaben gibt, sollten Monitoring und Bewertung nach den besten wissenschaftlichen Standards gestaltet werden. Es sollte ein wissenschaftliches Gutachten dazu eingeholt werden.
- ► Festlegung eines wissenschaftlich empfohlenen Best-Practice-Beprobungsdesigns für die Vorher-Nachher-Kontrolle (Before-After-Control, BACI) als Handlungsrahmen für die drei Arten von Ressourcen, den die Vertragnehmer an ihre Gegebenheiten anpassen können. Die Parameter betreffen u.a. die zeitlichen und räumlichen Anforderungen, die Beprobung und Charakteristika der Impact Reference Zones und Preservation Reference Zones, ihrer Größe, Pufferzonen usw. Die Qualität des Probenahmeprogramms des Vertragnehmers sollte idealerweise von unabhängigen Experten überprüft werden.
- ► Ergänzung eines neuen Abschnitts zur Bewertung und Minderung der Umweltauswirkungen.
- ► Ergänzung der Berichtspflichten um Auswertungsberichte der Umweltschäden nach der Durchführung der Testaktivitäten sowie dem jährlichen oder periodischen Monitoring der Teststandorte, und einen Abschlussbericht am Ende des Vertrages. Diese Berichte können von der LTC verwendet werden, um Verfahren zur Risikobewertung sowie Kriterien und Schwellenwerte zu entwickeln, die für die Entscheidungsfindung über die Zulässigkeit von kommerziellen Abbauprojekten erforderlich sind. EIA-Berichte (Entwurf der Umweltverträglichkeitserklärungen), Monitoring- und Bewertungsergebnisse sollten so zeitnah wie möglich zur Verfügung gestellt werden, damit Experten und andere Akteure die Aktivitäten verfolgen können.
- ► Langfristig sollte die ISA versuchen, eine aktiv regulierende Behörde zu werden, sich auf das Umweltmonitoring außerhalb der einzelnen Vertragsgebiete mit ggf. multiplen und kumulativen Umweltauswirkungen vorbereiten, einen eigenen Wissenspool aufbauen und auch regionale strategische Umweltprüfungen durchführen, inkl. sozioökonomischer Bewertungen im Hinblick auf die Interessen des gemeinsamen Erbes der Menschheit. Dies muss notwendigerweise eine Bewertung der ökologischen Kosten des Bergbaus in Form von Ökosystemfunktionen und -dienstleistungen sowie in Form von verlorenen Chancen für andere Meeresnutzer beinhalten.

- Integration aller bis zur Aufnahme des kommerziellen Abbaus geleisteten Tests, die entsprechenden Umweltprüfungen und -berichte in ein iteratives Verfahren in welchem die EIAs für die verschiedenen Mining Tests kumulativ die EIA und den EIS, sowie den Umweltmanagementplan erstellen. Der Endpunkt der Erkundung ist erreicht, wenn ein Vertragnehmer die zu erwartenden Umweltfolgen für den geplanten kommerziellen Bergbaubetrieb zuverlässig angeben kann und diese nach den Regeln der ISA genehmigungsfähig sind.

Die ISA EIA/EIS in der Praxis

Kapitel 5 stellt fest, dass die mangelnde Spezifizität der ISA-Empfehlungen (siehe Kapitel 4) starke Auswirkungen nicht nur auf die Qualität der von den Vertragnehmern gelieferten UVE hat - wie bei bestmöglichem Bemühen anzunehmen ist -, sondern auch allgemein auf die Fähigkeit der ISA, eine "*einheitliche Anwendung der höchsten Standards zum Schutz der Meeresumwelt, die sichere Entwicklung von Aktivitäten in dem Gebiet und den Schutz des gemeinsamen Erbes der Menschheit*" zu gewährleisten (ITLOS, 2011, Abs. 159). Trotz der inhaltlichen Verpflichtung, eine Umweltverträglichkeitsprüfung (EIA) durchzuführen und eine Umweltverträglichkeitserklärung (EIS) abzugeben, ist der verfahrenstechnische und wissenschaftliche Rahmen für die Anleitung der Vertragnehmer zur Erstellung einer zweckmäßigen EIS in vielerlei Hinsicht unzureichend.

Die drei Vertragnehmer (siehe Kapitel 6.1 und 6.2) haben die Aufgabe gemeistert, eine EIS zu einem Zeitpunkt zu liefern, als die damals gültigen Richtlinien (ISBA/19/LTC/8) sie aufforderten, eine EIA mit unbestimmtem Inhalt und ohne Angabe eines Erhaltungsziels zu erstellen. Insbesondere das Fehlen eines Leitfadens für einen Rahmen für Monitoring und Bewertung führt dazu, dass jeder Vertragnehmer das Rad neu erfinden muss, und ein gemeinsamer Bewertungsrahmen für die Aktivitäten aller Vertragnehmer in einer Region, die eine Ressource erkunden, kann in der Praxis unmöglich entwickelt werden. Darüber hinaus ist ein Leitfaden wünschenswert, um die Vertragnehmer bei der Erstellung einer umfassenden, ökosystembasierten Betrachtung des anvisierten Ökosystems und seiner Komponenten zu beraten, bevor und nachdem es dem Druck der Exploration und der Tests ausgesetzt ist.

Idealerweise würde die ISA spätestens zu dem Zeitpunkt, an dem die Vertragnehmer die Nutzung beantragen und eine umfassende Umweltverträglichkeitsprüfung/-erklärung abgeben, eine grobe regionale Umweltgrundlagen- und -qualitätsanalyse erstellt haben. Dies würde es ermöglichen, die EIS und den Umweltmanagementplan des Vertragnehmers mit den Zielen des jeweiligen regionalen Umweltmanagementplans in Übereinstimmung zu bringen. Dies erfordert jedoch eine formale Verknüpfung mit den Verpflichtungen des Vertragnehmers. Darüber hinaus wird es für die ISA aufgrund des Mangels an eigenen Daten und Erfahrungen sowie des Fehlens unabhängiger wissenschaftlicher Beratung äußerst schwierig sein, die vom Projektträger vorgebrachten Begründungen zu bewerten, insbesondere in Bezug auf die Genauigkeit und statistische Aussagekraft von Vorher-Nachher-Kontrollmessungen.

Der Test Mining wird diesem vorausgehen, aber *umgekehrt* kann erwartet werden, dass alle Erfahrungen aus den Tests zur Erstellung einer aussagekräftigen vorherigen Umweltverträglichkeitsstudie im Zusammenhang mit der Entscheidungsfindung über die Ausbeutung beiträgt. Daher sollten die Vertragnehmer bereits in diesem frühen Stadium auf die Hürden aufmerksam gemacht werden, die zu überwinden sind, um für einen Abbauvertrag in Frage zu kommen. Ein verbindlicher vorsorgender und ökosystembasierter Rahmen, der vom ISA-Rat mit Expertenrat und nach öffentlichen Konsultationen vereinbart wird, wäre entscheidend, um die einheitliche Umsetzung der höchsten Schutzstandards für die Meeresumwelt, wie vom ITLOS gefordert, zu erreichen.

Es bedarf neuer Bestimmungen, um die Transparenz, die Einbindung von Experten, die Beteiligung von Akteuren/Stakeholdern, aber auch das ISA-geführte Scoping und andere kritische Elemente der

Good Governance zu verbessern, und so die behördliche Kontrolle und das Vertrauen der Öffentlichkeit zu stärken. In den aktuellen ISA-Regeln, Vorschriften und Verfahren fehlt jedoch beides. Wichtig ist, dass es derzeit keine Verpflichtung für Vertragnehmer oder die LTC gibt, Unsicherheiten oder Wissenslücken darzulegen. Tiefseebergbau wird ein risikoreiches Unterfangen für die Meeresumwelt sein, daher sollten Regulierungsmechanismen und -maßnahmen so gestaltet sein, dass sie das Risiko angesichts der Ungewissheiten mit dem Vorsorgeansatz kontrollieren. Expertenmeinungen können hier eine unschätzbare Ergänzung sein, um geeignete Politiken und Vorschriften zu informieren.

Test Mining ist eine der Möglichkeiten, die Wissensunsicherheiten anzugehen, die Abbautechnik und -praxis zu optimieren und die Störung der Umwelt zu minimieren. Je höher das Risiko und die Ungewissheit z.B. über die Umweltbeeinträchtigungen sind, desto vorsorgender müssen die Verpflichtungen der Vertragnehmer sein (z.B. Anwendung der besten verfügbaren Technik BAT anstatt die im ursprünglichen Arbeitsplan enthaltenen Bergbaupraktiken und -technologien immer weiter beizubehalten). Eine gute Governance-Praxis erfordert eine vorausschauende, vorsorgende und adaptive Governance sowie ein aktives wissenschaftliches Wissensmanagement durch die ISA. In Erwartung kommender Herausforderungen und Möglichkeiten sorgt ein Feedback-Zyklus des adaptiven Managements für strategische Planung, Analyse langfristiger Konsequenzen, Kapazitätsaufbau und Management aufkommender Technologien, solange ein solches Management noch möglich ist.

Die Fähigkeit der ISA, eine "*einheitliche Anwendung der höchsten Standards zum Schutz der Meeresumwelt" zu* gewährleisten, scheint derzeit ziemlich eingeschränkt zu sein. Die von den Vertragnehmern gelieferte EIS könnte sich, wenn sie nicht strenger reguliert wird und den Vertragnehmern weniger Ermessensspielraum eingeräumt wird, einfach als eine Formalität mit begrenzter Wirkung in der Praxis herausstellen. Es hat den Anschein, dass die ISA den Vertragnehmern nur empfehlen kann, ihren Betrieb anzupassen oder eine EIS zu verbessern, aber nicht die Möglichkeit hat, z. B. den Probeabbau in der Erkundungsphase zu verweigern, da derzeit keine Zustimmungs-/Entscheidungsfunktion vorgesehen ist. Aus diesem Grund konnten BGR und DEME/GSR mit dem Feldversuch im Jahr 2019 beginnen, bevor die LTC die Prüfung der EIS abgeschlossen hatte. Auch im Fall der von der indischen Regierung eingereichten EIS kann, obwohl sie aufgefordert wurde, den Monitoringplan zu verbessern und über alle vorgenommenen Änderungen zu berichten, im Prinzip fortgefahren werden, ohne auf die Forderungen des LTC einzugehen. Bis heute ist nicht öffentlich bekannt, ob und wie die Ansichten des LTC oder anderer Stakeholder berücksichtigt worden sind.

Die Umweltverträglichkeitsprüfung und die zugehörige Erklärung vor der Aufnahme einer Tätigkeit ist der kritische Punkt für die Ausübung der behördlichen Kontrolle über die Umweltauswirkungen, die durch eine Tätigkeit wahrscheinlich verursacht werden. Daher ist es von größter Bedeutung, dass es sich nicht nur um eine Formalität handelt und der Inhalt über die Fachkenntnisse und Kapazitäten der ISA hinausgeht. Die Erprobung von Abbaukomponenten oder -systemen *an Ort und Stelle* während der Erkundung, begleitet von einer vorherigen Umweltverträglichkeitsprüfung, dem Monitoring der Versuchsereignisse und der Berichterstattung über die Ergebnisse könnte, wenn sie richtig durchgeführt wird, nicht nur die formale Kontrolle sicherstellen, sondern auch den Grad der Umweltbeeinträchtigung ermitteln, der von verschiedenen Komponenten und Systemen in verschiedenen Umgebungen verursacht wird. Aus den Erfahrungen, die die Betreiber solcher Aktivitäten gemacht haben, könnte die Bewertung und Entscheidungsfindung über tolerierbare und nicht tolerierbare Umweltveränderungen, die durch solche Aktivitäten verursacht werden, informiert werden. Wenn solche Informationen allen Vertragnehmern zur Verfügung stünden, könnte dies Zeit und Aufwand sparen und unzureichende Arbeitsabläufe und Berichte vermeiden.

Tests sind auch erforderlich, um die Unsicherheit der Regulierungsbehörde und der Stakeholder über den Grad und Langlebigkeit der Umweltbeeinträchtigungen zu verringern, die durch Test Mining und insbesondere später durch den kommerziellen Abbau verursacht werden. Nach derzeitigem Kenntnisstand sind die Umweltfolgen durch ein oder mehrere Abbauunternehmungen im kommerziellen Maßstab noch nicht absehbar (Boetius und Haeckel, 2018). Idealerweise wäre ein kontrollierter, stufenweiser Ansatz zur Erprobung von Abbaukomponenten und -systemen *in situ* erforderlich. Die Vertragnehmer könnten dann die *in situ*-Tests der Ausrüstung für die Verfeinerung der Ist-Zustandsbeschreibung der jeweiligen Tiefseeumwelt, für den Wissenserwerb über ökologische Funktionen und Empfindlichkeiten, für die Entwicklung aller erforderlichen Verfahren und ihres Umweltmanagementsystems und für die Entwicklung eines am wenigsten invasiven Betriebsprozesses und einer Technologie für den Abbau nutzen. Die Erfahrungen würden in die zu entwickelnden Standards für beste Umweltpraktiken (BEP) und beste verfügbare Techniken (BAT) einfließen.

Nichtsdestotrotz sieht der Entwurf der Abbauregelungen der ISA (ISBA/25/C/WP.1, Teil VI, Abschnitt 2) vor, dass der Antragsteller in der Antragsphase des Abbaus eine EIS vorlegen muss. Zu diesem Zeitpunkt wird die Unsicherheit über die Umweltfolgen eines Abbaus im kommerziellen Maßstab hoch sein, da die darin beschriebenen zu erwartenden Beeinträchtigungen weitgehend auf Modellen und anderen Formen von Vorhersagen beruhen, die nicht *in situ* validiert oder verifiziert wurden. Nur eine Demonstration des späteren Abbausystems im Vorfeld an einigen der vorgeschlagenen Abbaustätten könnte zeigen, dass die Beeinträchtigungen voraussichtlich nicht die Erheblichkeitsschwellen überschreiten. Wenn die Informationen über die Auswirkungen eines vollständigen Bergbaubetriebs in kommerzieller Größe zu diesem Zeitpunkt nicht ohne weiteres verfügbar sind, sollte der Antragsteller verpflichtet werden, zumindest aussagekräftige Daten aus der Erprobung eines Prototyp-Bergbausystems *in situ* für eine angemessene Zeit zu liefern. Sobald der Vertragnehmer mit dem Abbau beginnt, müssen die vorhergesagten Umwelteinflüsse in einem stufenweisen Monitoringsansatz verifiziert werden, beginnend mit einer intensiven Validierungsphase bei Beginn der Aktivität, d.h. in einer zweiten Phase, bevor die kommerzielle Produktion aufgenommen werden darf.

Aus den oben genannten Gründen und aufgrund des öffentlichen Interesses an dieser neuen Art von Aktivitäten, die sich auf ein Gemeingut auswirken werden, ist es von größter Bedeutung, ein vollständig transparentes EIA-Verfahren zu etablieren, wie es von (Durden*et al.*, 2018) vorgeschlagen und diskutiert wird, mit einer verbindlichen Wirkung des Ergebnisses der EIA/EIS-Prüfung auf Nutzungsanträge. Ein solcher mehrstufiger Prozess wird nicht nur eine öffentliche Konsultation im Einklang mit der Aarhus-Konvention beinhalten, sondern auch Rückkopplungsschleifen zu den Befürwortenden Staaten und der ISA, um eine vollständige Kontrolle über die Aktivitäten und die damit verbundenen Auswirkungen zu erlangen.

Empfehlungen

ISA muss eine "*einheitliche Anwendung der höchsten Standards zum Schutz der Meeresumwelt, die sichere Entwicklung von Aktivitäten in dem Gebiet und den Schutz des gemeinsamen Erbes der Menschheit*" gewährleisten (ITLOS, 2011, Abs. 159). Um dieses Ziel zu erreichen,

- Ein schrittweises, mehrstufiges EIA-Verfahren (das möglicherweise zu mehreren EIS führt, wenn der Vertragnehmer mehrere Testaktivitäten durchführen möchte) sollte alle Aktivitäten von den ersten Komponententests und dem Testabbau während der Exploration abdecken (was die für die Abbauphase vorhergesagten Auswirkungen stützen würde). Alle Informationen würden in einem umfassenden Bericht über den Zeitraum der Exploration zusammenlaufen, der die Grundlage für die EIA/EIS und EMMP bilden würde, die zusammen mit dem Antrag auf Genehmigung eines Arbeitsplans für die Ausbeutung eingereicht werden müssen. Wenn in der Abbauphase weitere Tests erwartet werden, z.B. einige vollständige Abbausystemtests, sollte dies in der EIS berücksichtigt werden, die zusammen mit dem Antrag auf einen Abbauvertrag eingereicht wird (da dies unter die Auswirkungen fallen würde, die sich aus der kommerziellen Produktion ergeben würden). In der Tat werden einige Lehren aus dem allgemeinen EIA-Prozess auch im Zusammenhang mit der Bewertung der Umweltauswirkungen des Test Minings relevant sein. Zu den wesentlichen Verfahrenselementen können einige der folgenden gehören:

- Sinnvolle Beteiligung der Öffentlichkeit gemäß den Anforderungen der Aarhus-Konvention;
- Rückkopplungsschleifen zu den Sponsorstaaten und der ISA;
- Unabhängige Expertenberatung;
- Eine Scoping-Phase, in der der Projektträger und die ISA das Format und die Elemente der vorherigen EIA und EIS entwickeln, die für den jeweiligen Fall angemessen sind. Dies könnte dann auch die Verknüpfung mit dem jeweiligen REMP sicherstellen und dafür sorgen, dass es für höhere Risiken auch höhere Hürden gibt. Eine öffentliche und fachliche Konsultation ist erforderlich;
- Die gemeinsame (mit Experten und ggf. Stakeholdern) Erarbeitung und Prüfung von
    - Best-Practice-BACI-Design einschließlich Regeln für die Ausweisung von PRZ und IRZ,
    - Best-Practice-Monitoringprogramme,
    - Identifizierung von Umweltindikatoren und Schwellenwerten,
    - Ökologische Risikobewertung und Management,
    - Aussagekräftige Berichterstattung,
    - Kosten-Nutzen- und Risikobewertungen zur Information von Interessengruppen und der Öffentlichkeit.
- Identifizierung von Unsicherheiten und Risiken, Veröffentlichung von Begründungen von Ratschlägen oder Entscheidungen;
- Veröffentlichung des EIA-Berichts (Entwurf der EIS) und der Monitoring- und Bewertungsergebnisse so zeitnah wie möglich, damit Experten und andere Beteiligte die Umweltauswirkungen der Aktivitäten verfolgen können;
- Eine Test Mining Auswertung und ein Bericht nach der Aktivität und ein jährlicher oder periodischer sowie ein Abschlussbericht aller Explorationsaktivitäten am Ende des Vertrages, anstatt nur Daten zu liefern.
- Die ISA sollte explizit die Möglichkeit haben eine EIS abzulehnen, bzw. die EIS zu genehmigen, aber an bestimmte Bedingungen und Auflagen zu knüpfen.

Wissenschaftliche Sicht auf das Test-Mining

Kapitel 6 ergänzt die vorangegangenen Überlegungen aus der Perspektive der Umwelt-Governance durch eine praktische wissenschaftliche Betrachtung des Test Miningkonzepts in Bezug auf den Wissensbedarf für eine fundierte Bewertung der Umweltauswirkungen. In diesem Kapitel wird die Notwendigkeit adäquater Grundlagen über den Ist-Zustand des entsprechenden Gebietes als Ausgangspunkt hervorgehoben, die wiederum die aussagekräftige Gestaltung von Monitoringprogrammen informieren würden, um die Erfassung von Umweltveränderungen zu ermöglichen. Es werden Teile eines Handlungsrahmens für die EIS vor dem Beginn der Ausbeutung betrachtet. Es wird festgestellt, dass ohne Erkenntnisse aus dem Test Mining, sowohl aus Komponenten- als auch Systemtests in verschiedenen Maßstäben, Vorhersagen über die Arten, das Ausmaß und die Intensität potenzieller Umweltfolgen durch den Abbau im kommerziellen Maßstab unklar bleiben werden. Dadurch ist vorauszusehen, dass Managementmechanismen zur Sicherstellung eines effektiven Schutzes der Meeresumwelt eher weniger wahrscheinlich erfolgreich sein werden. Die Bewertung möglicher Veränderungen der Tiefsee-Ökosysteme als Folge des Test Minings ist bestenfalls eine Herausforderung, aber ohne zuverlässige Grundlageninformationen wird ein vollständiges Verständnis darüber, wie die Knollen-Ökosysteme und die damit verbundenen pelagischen Arten auf Störungen im Rahmen des Arbeitsplans reagieren werden, nicht möglich sein und daher eine fundierte Entscheidungsfindung behindern. Als solche ist das Verständnis des Ökosystems durch fundierte Forschung eines der wichtigsten Werkzeuge, um den Schutz und die Erhaltung der natürlichen Ressourcen durch den EIA-Prozess zu gewährleisten

(Bräger et al., 2020). Es ist auch wichtig zu bedenken, dass die kombinierten Grundlageninformationen der Vertragnehmer in der CCZ auch als Grundlage für regionale Strategische Umweltprüfungen dienen sollten (International Seabed Authority, 2011; Lodge et al., 2014), die nicht nur die kumulativen Auswirkungen aller Bergbauaktivitäten in der Region berücksichtigen, sondern auch zusätzliche anthropogene Auswirkungen, z. B. durch Verschmutzung oder Klimawandel (Brito-Morales*et al.*, 2020; Levin*et al.*, 2020; Ramirez-Llodra*et al.*, 2011). Grundlagenuntersuchungen zur Unterstützung von EIAs müssen maßgeschneidert sein, um sicherzustellen, dass sie für den Zweck geeignet sind. Nach Clark*et al.*(2020) sollte jedoch ein gewisses Maß an Konsistenz vorhanden sein, damit die wichtigsten ökologischen Parameter abgedeckt werden und diese vergleichbar sind und zwischen den Vertragnehmern zu einem regionalen Bild kombiniert werden können. Zu den wichtigsten Aspekten gehören:

- Welche Parameter gemessen werden sollen und in welchem räumlichen und zeitlichen Abstand sie gemessen werden sollen
- Die erforderliche Methode, Genauigkeit und Präzision der Messungen (was wird nach akzeptablen Standards gemessen)
- Welche ökologischen Schlüsselindikatoren müssen beim Übergang von der Grundlagenforschung zur Messung/Monitoring zukünftiger Veränderungen im Rahmen des Umweltmanagementplans bewertet werden?
- Welches Maß an Veränderung könnte im Hinblick auf die Abschwächung gegenüber generischen ökologischen Grenzen und Schwellenwerten (keine Managementziele) akzeptabel sein (Clark*et al.*, 2020).

Ohne aussagekräftige Umweltmonitoringprogramme wird die ISA nicht in der Lage sein, den wirksamen Schutz der Meeresumwelt zu überprüfen. Aus wissenschaftlicher Sicht sollte ein robustes Umweltmonitoringprogramm die folgenden Punkte beinhalten:

- Klare Ziele und kritische Parameter für das Monitoring.
- Eine detaillierte Beschreibung der Prüftechnik und -methodik.
- Identifizierung der zu erwartenden Auswirkungen des Tests.
- Eine detaillierte Beschreibung der Monitoringtechnologien und -methoden.

Darüber hinaus sollte das während der Grundlagenuntersuchungen gesammelte Verständnis für das Ökosystem in Kombination mit aktuellen Plänen für die Testabbauaktivität (einschließlich detaillierter Informationen zu den spezifischen Technologien, der Logistik und der praktischen Umsetzung) verwendet werden, um eine Risikobewertung zu vervollständigen (Durden et al., 2018). Der Prozess der Risikobewertung und des Risikomanagements zielt darauf ab, die mit der Aktivität verbundenen Risiken zu identifizieren, zu bewerten und in eine Rangfolge zu bringen sowie Wege zu finden, diese gemäß der Mitigationshierarchie bestmöglich zu mindern: erstens zu vermeiden/verhindern, zweitens zu minimieren, drittens wiederherzustellen, wenn möglich, oder schließlich alle Auswirkungen auszugleichen (Cormier, 2019; Durden et al., 2018; Van Dover et al., 2017a). Dies erfordert eine Konzentration auf die Hauptquellen der Auswirkungen, wie von Clark et al. (2020) empfohlen. Das Verfahren der Umweltrisikobewertung (ERA) erleichtert diese Prioritätensetzung, indem sie die Anwendung eines systematischen Problemformulierungs- und risikobasierten Entscheidungsfindungsrahmens vorsieht, um eine objektive Betrachtung der Akzeptanz bestimmter Risiken sicherzustellen. ERA sollte daher ein integraler Bestandteil des EIA-Prozesses sein (Clark et al., 2020; O et al., 2015).

Im Rahmen der Berichterstattung durch die Vertragnehmer an die ISA sollten die Ergebnisse der Test Miningaktivitäten innerhalb der EIA klar vermittelt werden und einem hohen Maß an struktureller Standardisierung folgen, um eine erhöhte Konsistenz, Überprüfbarkeit und Transparenz zu ermöglichen (Brägeret al., 2020). Die Berichterstattung sollte Interpretationen der Ergebnisse durch Vergleiche mit Peer-Review-Studien und Details zum Proben- und Datenmanagement sowie Veröffentlichungspläne enthalten, wobei für jeden Schritt ein Zeitrahmen angegeben werden sollte. Die Ergebnisse der Mining-Tests, einschließlich aller Daten und Proben, sollten öffentlich zugänglich gemacht oder in einem geeigneten und zugänglichen Repository gespeichert werden, um eine transparente, unabhängige Bewertung durch Experten und andere Stakeholder zu ermöglichen. Wenn möglich, sollten die Ergebnisse in wissenschaftlichen Fachzeitschriften mit Peer-Review veröffentlicht werden (Brägeret al., 2020).

Empfehlungen

- Vom Komponenten- bis zum 1:1 Test Mining sollten jede Art Tests als wesentliche Quellen für die Vorhersage von Art, Ausmaß und Intensität potenzieller Umweltfolgen durch den Abbau im kommerziellen Maßstab angesehen werden, Informationen, die für die Entscheidungsfindung über Nutzungsverträge zur Verfügung stehen müssen.
- Eine qualitativ hochwertige EIA beruht auf adäquaten Umweltuntersuchungen; es ist zu klären, welche Art/Qualität/Menge an Umweltinformationen als angemessen gilt und wie die Auswirkungen des Klimawandels angemessen berücksichtigen werden.
- Ein aussagekräftiger Monitoringplan, eine angemessene Risikobewertung und eine gründliche Auswertung und Berichterstattung sind ebenfalls für eine EIA erforderlich, ebenso wie ihre umfassende Bewertung durch unabhängige (*d. h.* nicht vom Vertragnehmer profitierende) Tiefsee- und Meeresmanagementexperten.
- Strategische Umweltziele werden als wesentlicher Ausgangspunkt für die Beurteilung der Umweltverantwortung und als Leitfaden für alle Entscheidungen benötigt.

Test Mining neu konzipieren

In Kapitel 7 wird eine Überarbeitung der bestehenden Funktionen und Regulierungsoptionen in Bezug auf Test Mining in der Explorations- und Gewinnungsphase vorgeschlagen, und zwar durch einen obligatorischen zweistufigen Ansatz für Test Mining, der auf einem Vorschlag basiert, den Deutschland im Oktober 2019 bei der ISA eingereicht hat. Eine Durchsicht des von Deutschland vorgelegten Vorschlags zeigt einen obligatorischen zweistufigen Ansatz für den Testabbau: erstens vor der Beantragung eines Gewinnungsvertrags und zweitens vor dem Beginn der kommerziellen Produktion in der Gewinnungsphase. Anders ausgedrückt: Nach dem deutschen Vorschlag sollten die Ergebnisse von Test Miningprojekten (*in situ*-Experimente), die von Vertragnehmern durchgeführt werden, zu den Faktoren gehören, die die Entscheidungsfindung der ISA in Bezug auf a) die Erteilung eines Abbauvertrags und b) ggf. die Fortsetzung der kommerziellen Produktion eines Vertragnehmers mit einem laufenden Abbauvertrag beeinflussen.

In Bezug auf die erste Phase wäre nach dem deutschen Vorschlag ein Vertragnehmer, der einen Explorationsvertrag besitzt und einen Antrag auf einen Abbauvertrag stellen möchte, verpflichtet, während der Explorationsphase Test Mining Aktivitäten durchzuführen. Die daraus resultierenden Ergebnisse würden zur Unterstützung seines Antrags auf einen Abbauvertrag herangezogen werden. Der Vorschlag sieht vor, dass der Vertragnehmer bei der Beantragung eines Gewinnungsvertrags unter *anderem* "Test Miningstudien" vorlegen muss, um seinen Antrag zu unterstützen. Solche Test Miningstudien würden auch in die eventuelle Umweltverträglichkeitserklärung einfließen, die ein Antragsteller mit seinem Antrag auf Genehmigung eines Abbauplans einreichen müsste. Die von Deutschland vorgeschlagene Einbeziehung von Test Mining würde, wenn sie akzeptiert wird, eine von 10 bis 12 Anforderungen sein, die einem Antrag auf einen Abbauvertrag beigefügt werden müssen. Darüber hinaus wird die eingereichte Test Miningstudie zusammen mit den vom Vertragnehmer vorgelegten Umweltplänen zur öffentlichen Einsichtnahme freigegeben (wobei vertrauliche Informationen unkenntlich gemacht werden), gefolgt von einer Überprüfung durch das LTC. Der Antrag des Vertragnehmers wird erst nach Abschluss dieses Prüfungsverfahrens berücksichtigt. Dementsprechend ist es wichtig, an dieser Stelle darauf hinzuweisen, dass die Ergebnisse der Test Miningprojekte des Vertragnehmers (wie sie in der besagten Test Miningstudie wiedergegeben werden) einer von mehreren Schlüsselfaktoren sein werden, die das LTC bei der Entscheidung, ob es die Genehmigung des Antrags empfiehlt oder nicht, berücksichtigen wird. In dieser Hinsicht würde die vom Vertragnehmer vorgelegte Test-Miningstudie als eine Form des Nachweises dienen, um das LTC über die technischen Fähigkeiten und die Kapazität des Vertragnehmers zu informieren, die Umweltanforderungen zu erfüllen. Dies ist eine bestehende Anforderung, welche in früheren Versionen der Draft Exploitation Regulations auftaucht.

Die zweite Phase erkennt an, dass die Beschaffung eines Abbauvertrages nur der Startpunkt der Tätigkeit ist, denn die kritische Phase für Umweltfolgen beginnt erst wenn der Vertragnehmer zur kommerziellen Produktion übergeht (d*. h.* Bergbau im großen Stil). In den meisten Fällen wird es bis zu 10 Jahre und mehr nach der Erteilung des Vertrages dauern, um Investitionen zu beschaffen, die notwendige Technologie zu entwickeln und zu bauen, sowie alle begleitenden Angelegenheiten zu regeln (z. B. Transport, Logistik, Verarbeitung, Marktbedingungen usw.). Die zweite Phase des Test Minings soll also sicherstellen, dass die Technologien und das Know-how, die der Vertragnehmer nach Erhalt des Abbauvertrags erwirbt, den technischen und umweltbezogenen Erwartungen der ISA entsprechen, wie sie in der vorherigen EIS und dem EMMP dargelegt sind, und hilft, den Inhalt dieser Dokumente nachträglich zu überprüfen. Es ist auch von Bedeutung, wenn sich die Technologien oder Techniken, die der Vertragnehmer zuvor während der Explorationsphase erworben und getestet hat, geändert haben oder modifiziert wurden, oder wenn der Vertragnehmer alternative Technologien oder Methoden verwenden möchte. In dieser Hinsicht führt der Vorschlag einen zweiten Kontrollpunkt für die ISA als Aufsichtsbehörde ein, um sicherzustellen, dass der Vertragnehmer in der Lage ist, die tatsächlichen Umweltfolgen, die sich aus der kommerziellen Produktion ergeben, auf dem vertraglich vereinbarten Niveau zu halten, bevor er die Erlaubnis zur Fortsetzung erteilt.

Schließlich ist anzumerken, dass der Vorschlag Deutschlands auch die Möglichkeit einer Befreiung von der Pflicht zum Test Mining während der zweiten Phase vorsieht, z. B. wenn die LTC feststellt, dass ein bestimmter Vertragnehmer bereits ein komplettes Test Mining (einschließlich vollständiger Systemtests) während der Explorationsphase zufriedenstellend durchgeführt hat. Dementsprechend scheint der Vorschlag die Vertragnehmer zu ermutigen, alle relevanten Testaktivitäten in der Explorationsphase durchzuführen, damit sie von weiteren Anforderungen während der Betriebsphase befreit werden können. Wie in früheren Kapiteln behandelt, liegt es im besten Interesse aller Beteiligten, einschließlich der ISA, des Vertragnehmers, der Befürwortenden Staates und aller Interessengruppen, so weit wie möglich sicherzustellen, dass alle erforderlichen Testaktivitäten (einschließlich vollständiger Systemtests) während der Explorationsphase durchgeführt werden.

Der zweiphasige Ansatz für den Testabbau hat möglicherweise einige Schwachstellen. Während die Stärke des Vorschlags darin besteht, dass er dem Vertragnehmer ein gewisses Maß an Flexibilität einräumt, einige Testaktivitäten auf die zweite Phase zu "verschieben", was für kommerzielle Vertragnehmer, die erst nach der Beschaffung des Betriebsvertrags mit umfangreichen Investitionen beginnen würden, sinnvoll sein könnte, könnte dies zu Unstimmigkeiten bei der Bewertung von Anträgen auf Betriebsverträge führen - da einige Vertragnehmer anders behandelt würden als andere. Außerdem wäre es einfacher, einen Antrag auf Genehmigung eines Arbeitsplans für die Ausbeutung abzulehnen, als einen Vertragnehmer daran zu hindern, später in die kommerzielle Produktion einzusteigen. In dieser Hinsicht wäre ein idealer Ansatz, allen Vertragspartnern die gleichen Anforderungen aufzuerlegen, das notwendige Test Mining während der Explorationsphase durchzuführen und diese Ergebnisse in Analysen, Berichten und der EIS, die dem Antrag auf einen Abbauvertrag beigefügt wird, zur Zufriedenheit der ISA nachzuweisen. In diesem Zusammenhang könnte ggf. auch die Auferlegung einer zusätzlichen vertraglichen Konstruktion wie der Vergabe eines "vorläufigen Betriebsvertrags", in Betracht gezogen werden. Unter diesem Szenario kann ein Antragsteller, der einige der geforderten Testaktivitäten während der Explorationsphase nur teilweise erfüllt hat, immer noch einen Antrag auf einen Ausbeutungsvertrag stellen, erhält aber nur einen vorläufigen Vertrag, der für etwa fünf Jahre gültig wäre. Während dieses Zeitraums kann der Vertragnehmer dann Technologien beschaffen und die restlichen erforderlichen Testaktivitäten durchführen, woraufhin (und vorbehaltlich der Genehmigung durch die ISA) der vorläufige Vertrag dann abgeschlossen würde. Es wird jedoch eingeräumt, dass dies vor allem für kommerzielle Vertragnehmer nicht attraktiv sein könnte, da ein vorläufiger Verwertungsvertrag als Sicherheitsinstrument im Gegensatz zu einem endgültigen Verwertungsvertrag mit Besitzstandsgarantie nicht so wertvoll erscheint. In jedem Fall wird der von Deutschland vorgeschlagene zweistufige Ansatz für den Test Mining, mit oder ohne Änderungen, zweifellos einen großen Beitrag zur Unterstützung einer fundierten Entscheidungsfindung bei der ISA leisten, insbesondere aus der Umweltperspektive, und verdient daher ernsthafte Beachtung.

Schlussfolgerungen und Empfehlungen

Kapitel 8 fasst den gesamten Bericht zusammen, indem es einen Überblick über die wichtigsten Diskussionen zum Test Mining in Bezug auf den entstehenden ISA Mining Code gibt, einige der Chancen und Herausforderungen hervorhebt, die mit der Forderung und Regulierung von Test Mining verbunden sind, und einige Empfehlungen diskutiert, wie Test Mining aus Sicht der Umweltpolitik richtig eingesetzt werden kann.

Gegenwärtig gibt es in den Regeln, Vorschriften und Verfahren der ISA keine formale regulatorische Anforderung für den Test Mining. Solange also keine Vorbedingung in den Draft Exploitation Regulations festgelegt ist, können Vertragnehmer theoretisch einen Abbauvertrag erhalten und mit der kommerziellen Produktion beginnen, ohne vorher ihre Fähigkeit nachzuweisen, im vertraglich vereinbarten Maße Abbauaktivitäten durchzuführen und für einen wirksamen Schutz der Meeresumwelt vor den entstehenden Beeinträchtigungen zu sorgen.

Aus wissenschaftlicher und umweltpolitischer Sicht sind Abbautests in verschiedenen Maßstäben unverzichtbar, um Kenntnisse und Erfahrungen über den Grad der Widerstandsfähigkeit der Tiefsee-Ökosysteme gegenüber Störungen verschiedener Arten und räumlicher und zeitlicher Skalen zu gewinnen. Für die Gesellschaft sind solche Erkenntnisse essentiell, um den Nutzen und die Kosten des Tiefseebergbaus für das gemeinsame Erbe der Menschheit bewerten zu können. Auch für die ISA, die den Auftrag hat, die Meeresumwelt vor schädlichen Auswirkungen bergbaulicher Aktivitäten zu schützen und im Namen der gesamten Menschheit zu handeln, ist das Testen eine wichtige Gelegenheit, etwas über die technische Entwicklung von Geräten und Systemen für den Tiefseebergbau zu erfahren, um

- Die Eignung von Prozessstandards und Richtlinien zu prüfen;
- Die biologischen Parameter, die die Auswirkungen des Bergbaus am zuverlässigsten erfassen zu identifizieren;
- Die vorläufigen Schwellenwerte für Belastungen und Auswirkungen zu ermitteln;
- Muster natürlicher Variationen der Umweltbedingungen zu ermitteln, anhand derer die Auswirkungen der Abbauversuche beurteilt werden sollen (Kontrollbereich);
- Die Gesamtausbreitung des durch die Tätigkeiten mobilisierten Sediments und des wiedereingebrachten Prozesswassers über längere Zeiträume zu beurteilen;
- Den geeigneten Standort von Referenzgebieten in Bezug auf kommerzielle Abbaugebiete zu definieren;
- Über die angemessene Größe und Lage von Abbaugebieten (wie viele, wie nah, Ausmaß der erforderlichen Pufferzonen zur Vermeidung grenzüberschreitender Auswirkungen usw.) zu informieren.

Solange Mining Tests nicht als langfristiger und nahezu maßstabsgetreuer Abbautest durchgeführt werden, bleibt es äußerst schwierig, Rückschlüsse auf die zu erwartenden Beeinträchtigungen eines oder gar mehrerer Abbauunternehmungen in kommerziellem Maßstab auf die Meeresumwelt zu ziehen. In dieser Hinsicht wird das Test Mining einige dringend benötigte Erkenntnisse liefern, um eine fundierte Entscheidungsfindung zu ermöglichen - ohne die die ISA Abbauanträge fast mit einer Augenbinde bewerten würde. Folglich wird es zu einer kritischen politischen Entscheidung, ob und wie viel des gemeinsamen Erbes der Menschheit direkt und indirekt geopfert wird und welcher zusätzliche Verlust an Ökosystemfunktionen und -dienstleistungen als akzeptabel angesehen wird - wohl wissend, dass keine Prognosen möglich sind, um die vollen Ökosystemauswirkungen eines oder mehrerer Tiefseebergwerke vorherzusagen.

Summary

Introduction

Deep seabed mining is a developing industry that will operate in the largely unknown deep-sea habitat located far offshore and with technologies that have not yet been tested. This report underscores the need to incrementally gain experience and knowledge about the extent of environmental damage that is to be expected from the mining equipment, systems and operations under development through test mining before the commercial exploitation of mineral resources in the Area is authorized.

The International Seabed Authority (ISA) is mandated to organize and exercise control over 'activities in the Area', which is defined as the exploration and exploitation of the mineral resources located in the Area. While marine scientific research and basic mineral prospecting can be conducted without receiving prior authorization from the ISA, the exploration and subsequent exploitation of minerals in the Area can only be legally con-ducted after an application has been approved by, and a contract concluded, with the ISA. Pursuant to its mandate, the ISA has the responsibility to develop rules, regulations and procedures to develop the resources of the Area, to design a financial regime and distribution mechanism to collect payments from exploitation contractors and equitably share the resulting financial and other economic benefits in accordance with Article 140(2) of UNCLOS, and to take necessary measures to ensure the effective protection of the marine environment from the harmful effects of activities in the Area in accordance with Article 145 of UNCLOS.

During the exploration stage, apart from exploring the prospects of resources extraction for the purposes of eventual exploitation, contractors are expected to gather environmental baseline data and monitor existing conditions (pre-disturbance). The exploration stage provides the contractor the opportunity to collect all necessary data, in particular environmental, to develop their technology, test it and measure its environmental impacts, and to begin preparing an application of a plan of work for future exploitation for submission to the ISA. This is critical from an environmental perspective, since applicants submitting an application of a plan of work for future exploitation would need to submit key documents such as an environmental impact statement and an environmental management and monitoring plan to support the said application. Subsequent to the approval of an application of a plan of work for exploitation and the conclusion of a contract, the contractor would enter into the exploitation stage, which generally entails two phases. The first phase is the pre-commercial production phase, where the contractor spends several years to prepare to move into the second phase, which is commercial production or the actual commercial extraction of minerals.

At the moment, while ISA recommendations, the exploration regulations and the current version of the draft exploitation regulations acknowledge that contractors can conduct testing activities, there is no compulsory requirement for testing to be carried out. This theoretically allows contractors to move from exploration to commercial production without having to practically demonstrate to the ISA that no unacceptable environmental harm will occur. This testing of technologies *in situ* (henceforth referred to as test mining) while monitoring environmental impacts is indispensable in an emerging industry to detect, prevent, or minimize adverse impacts of deep-sea mining activities on the highly knowledge-poor and sensitive deep-sea habitat. Without in situ equipment, system, and operational test mining, even predictive models cannot be validated and verified. Put differently, from a regulatory perspective, it is theoretically possible for a contractor to proceed from exploration into commercial production without conducting any form of *in situ* testing beforehand. This is quite alarming from an environmental perspective, to say the least. While it is expected that contractors would conduct some form of testing for their own purposes, *i.e.* to determine technical or economic feasibility, whether *in situ*, *ex situ* or in laboratories, there is no compulsion for testing activities to be carried out from an environmental angle.

The ISA acts on behalf of all humanity and controls the area and its mineral deposits, the common heritage of humankind. This includes the obligation to effectively protect the marine environment from the potentially harmful effects of mineral exploration and extraction activities. This means that the measures and rules adopted by the ISA must prevent the affected biota and ecosystems from being irreversibly damaged by the activities of the contractors. Equipment, systems and operational testing would be essential to provide vital knowledge for this purpose. Test mining would:

a) provide contractors with the necessary data and knowledge to prepare robust and accurate environmental assessments and environmental management and monitoring plans;

b) enable the ISA, as regulator, with the necessary data and knowledge to determine and revise its environmental objectives, thresholds, standards; and

c) allow the ISA, as regulator, to properly evaluate the technical capacity of the contractor, based on its demonstrated abilities during test mining, to manage and minimize the harmful effects of its mining activities.

This report examines the issue of test mining in the area from legal, regulatory, environmental and scientific perspectives.

Regulatory Framework and Legal Mandate for Test Mining

Chapter 2 explains the existing regulatory framework and the legal mandate for test mining. In particular shows that while test mining is permitted and possibly even encouraged under the current framework, it is not a compulsory requirement. Therefore, the ISA should seize the present window of opportunity, namely, the negotiations of the Draft Exploitation Regulations and its related themes, to make test mining a compulsory requirement. This has many advantages, and there are several options available to make this a reality.

Advantages of requiring test mining activities

- Uniform conditions (level playing field) for all contractors.
- Helps ensure that only contractors that are serious about the effective protection of the marine environment from the harmful effects of mining get to proceed to the exploitation stage and eventual into the commercial production phase.
- Lays the foundation for effective environmental management, which is the core interest of the ISA, sponsoring State, and contractor.
- Crucial for the ISA to develop applicable environmental indicators and harm thresholds, and for the contractor to design robust and useful EIAs and EMMPs.
- Generates reliable knowledge, validates models, and considers environmental assessment as a continuous and on-going process
- Helps determine ‘best environmental practices’ and ‘best available techniques’.
- Ensures the element of continuity between exploration and exploitation phases.
- Allows for informed decision-making and adaptive management, and in-line with the precautionary approach.

The chapter begins by considering the objectives, scope and possible definition for test mining. In terms of the current regulatory framework for test mining, the chapter analyses the relevant provisions under UNCLOS and the applicable rules, regulations and procedures as well as recommendations of the ISA to illustrate how test mining is currently treated. Subsequently, the legal mandate of the ISA to further regulate test mining is considered. Here, obligations pertaining to the need to conduct environmental impact assessments, to adhere to the precautionary approach, to apply best environmental practices, as well as the responsibilities of sponsoring States are considered in relation to the theme of test mining. In particular, it is argued that although test mining is not made compulsory under the rules, regulations and procedures of the ISA, the obligation to conduct test mining is implicit as part of the obligation of the ISA, sponsoring States and contractors to ensure the effective protection of the marine environment from the harmful effects of mining activities and to prevent serious harm to the marine environment. Moreover, even though the expectation and requirement to conduct test mining activities is implicit, it would be desirable to make this explicit. As such, options to make test mining compulsory within the ISA regime will be considered. Finally, it will also be debated if requiring test mining would also incentivises contractors and to create a level playing field in the context of activities in the Area. The following recommendations are suggested to improve the current environmental governance of mining activities with respect to test mining:

Recommendations

- The Council should immediately revisit the theme of requiring appropriate forms of guarantees prior to test mining at the exploration phase.
- The ISA should consider, in line with the precautionary approach, to effectively reverse the burden of proof on mining proponents to demonstrate, via test mining, that the commercial exploitation activities that they are seeking to eventually carry out do not exceed environmental thresholds and standards.
- The ISA should make clear and specify the obligation of contractors to conduct test mining activities, especially the scope of testing that is necessary to carry out during the exploration phase, in order to provide sufficient data and information to the ISA to facilitate informed decision-making with respect to an application for the approval of a plan of work for exploitation (and subsequently, as necessary, before proceeding to commercial production).
- The ISA should include the conduct of prior test mining as a compulsory contractual obligation by inserting a clause to that effect in the contract, or to adopt necessary Standards (legally binding) for test mining.
- The ISA should increase the awareness of sponsoring States with respect to the benefits of requiring contractors to conduct prior test mining.
- The ISA should commission a study to explore the viability of adopting a ‘provisional exploitation contract’ approach and of adopting a compulsory two-phased approach to test mining as part of the Draft Exploitation Regulations.

Current State of Exploration in the Area

Chapter 3 demonstrates that the technological development of seafloor mining tools and systems has advanced very differently depending on the resource. It is to date not evident, which type of mining will start first - if at all. The reason is that the environment in which of each of the three resources occur poses a different set of challenges to miners and their tools.

Overall, much about the talk on "*mining to begin soon*" and "*mining is on our doorstep*" seems to be exaggerated and very unlikely. If we look at the different contractors of ISA and their Sponsoring States, two things are apparent: States and their agencies, in particular those with a pioneer investor past have a different approach to seabed mining compared to the commercial companies coming into the game recently. Whereas the former mostly pursue a strategy of maintaining all options while developing technology slowly, but steadily, the latter come in based on a business model which requires short-term high-speed exploration and ambitions for starting exploitation in the near future.

As of December 2020, Japan is probably (with all uncertainties due to knowledge gaps) the country and contractor most ready for exploitation in the near future. However, this exploitation is likely to take place first in Japan´s national waters, and minerals from SMS and eventually crust mining will be supplied to the national, rather than the global market.

All of the State contractors may be positive about delivering the monitoring results of an *in situ* system test (pilot mining test) as part of their EIA when applying for exploitation (see further chapter 2). In fact, Japan, Korea and China are already testing system components and pre-prototype or even prototype systems in national waters. In this respect, it would appear that these governments or their sponsored contractors could rather easily conduct a full system test within their exploration contract period, including gathering *in situ* monitoring data for at least some years (depending on a further extension of their contracts).

The commercial contractors on the other hand, may be able to carry out some equipment tests at pre-prototype or prototype scale, though however, may not be able to invest in a full mining system prior to the awarding of an exploitation contract with the ISA. It is anticipated that the commercial contractors would only be able to procure substantial funding and be willing to invest heavily in technology once the exploitation contract is in their possession. Overall, their technology development seems to be early days, as the DEME/GSR development of a completely new model of nodule collector shows. Another company, DeepGreen, which has expressed that it wishes to start full scale production of nodules in 2024-2026, has not conducted any physical testing in any of the three contract areas with the ISA that it has involvement in, although it has issued press releases and public documents stating its intention to conduct testing of equipment in the near future (which may include even a riser system).

In order to prevent or minimise the harmful effects of mining related activities on the habitats and fauna of the deep-sea, the optimisation of technology at the source is particularly important, *i.e.* in order to minimise plume release, depth of sediment penetration, release of pollutants and so on. In this respect, contractors are expected to be required to demonstrate the application of Best Environmental Practices, Best Available Techniques (or Best Available Technologies), and conformity with Good Industry Practices, when applying for an exploitation contract with ISA.

Different from the pre-UNCLOS and in particular pre-1994 Agreement days, contractors are developing their technologies independently and as national or company efforts. This makes it near-impossible to get an overview of the environmental effects of different mining technological solutions. Furthermore, the lack of standardisation and of commonly agreed models for testing impacts and all other elements of scientific research act as a hindrance to come to conclusions on the bottle necks of technology development and the related environmental impacts.

Not only the technology itself, but also its operations in environmental practice are decisive for the type and scale of environmental impacts caused. 'Best Environmental Practice' is generally defined in the extractive industries to mean the application of the most appropriate combination of environmental control measures and strategies taking into account the criteria set by a particular regulator, all in all a very challenging undertaking for a newly developing industry.

Good technology in combination with good environmental practice can go a long way to reducing the overall extent of damage to the marine environment. However, so far no knowledge whatsoever exists on how operations will proceed and operators have a quasi-monopoly on their technology. Indeed, it would appear that the ISA is prepared to assume the role of a weak regulator (Ginzky et al, 2020) and allow for the current model of operations to place most of the contract-related burdens on the contractor to address at its own prerogative, who in turn, in the absence of a strong regulator, would develop its own self-monitoring and assessment eventually according to its own self-designed standards (Gerber and Grogan, 2018).

Until there are clear, binding and ambitious standards for the environmental quality to be maintained, no contractor will be able to optimise its technology and be certain that the ISA standards will be met. The ISA on the other hand, lacks own data, information and experience, and does not even have access to a wider pool of experts. Therefore, BAT and BEP will be impossible to determine, which will make it difficult to meet the mandate of a "*uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind*" (ITLOS, 2011, para. 159).

The only solution could be that contractors incrementally test their mining equipment and system *in situ* at an appropriate scale and duration until the effects of a commercial-scale mining operation on the environment can reliably be predicted. Only then would be the ISA be able develop its regulations and assessment criteria that would apply to all mining ventures. This framework must be in place before a mining application can be assessed and approved. Otherwise, contractors would have to demonstrate that no significant environmental damage would occur.

Environmental Impact Assessments for Test Mining

Chapter 4 considers environmental impact assessments in the context of test mining. This chapter recapitulates the requirements to conduct environmental impact assessments in the context of test mining. This is not to be confused with environmental impact assessments of exploitation activities (which applicants are required to submit alongside an application the approval of a plan of work for exploitation activities), although some lessons with the environmental impact assessment process there would also apply in the context of assessing the environmental impacts from test mining. In this respect, it is necessary to understand that test mining is essentially mining, albeit for a shorter period and at a smaller scale. That said, the environmental harm to the marine environment is understood to be potentially significant when compared to other exploration activities. Since genuine exploration contractors that wish to eventually submit an application for an exploitation contract would be required to submit necessary information and data to the ISA in order to facilitate informed decision-making, it would be essential to require them to already conduct sufficient degree of testing at the exploration phase. However, since applications for an exploration contract only require a preliminary assessment of potential environmental impacts – and not a full assessment of environmental impacts – it is quite clear that planned test mining activities during the exploration phase would require its own assessment of environmental impacts. Hence, the requirement to assess environmental impacts and to produce environmental impact statements prior to the conduct of test mining activities is an important one in order to ensure the effective protection of the marine environment from the harmful effects of mining, as well as to avoid serious harm to the marine environment. Moreover, the assessment of post-test mining environmental observations should be complementary in verifying the anticipated harm as indicated in the environmental impact statement. Apart from that, it also serves an important function to inform the ISA as well as the public of a contractor's plans or intentions to conduct test mining and to allow for proper scrutiny of the activities of the contractor, which would otherwise not be very visible to stakeholders and members of the public.

In fact, the 'Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration' activities issued by the ISA's Legal and Technical Commission (ISBA/25/LTC/6/Rev.1) recognizes the potential environmental harm that could occur from test mining activities and makes explicitly clear that certain activities during the exploration phase, including test mining, would require the contractor to submit an Environmental Impact Statement at least 12 months before the proposed testing activities take place, and also specifies certain requirements and indications in relation to contents and scope of coverage. By way of choosing that contractors submit an Environmental Impact Statement, however, rather than going through a regulator-guided Environmental Impact Assessment process, contractors are given a wide discretion on designing what they would finally submit to the ISA. The lack of ISA guidance on management goals and objectives, assessment framework and methodology and procedural support for how to master the tasks leaves a huge void which each contractor can chose to fill at will. In addition, ISA neither has nor does it gain insight or own competences on the matter (other than resource assessments), and there is no dedicated environmental or scientific body advising on this. All competence on the matter depends on the alternating members of the LTC, and no institutional memory seems to exist. This appears to be inadequate for the environmental governance of a nascent high-risk industry. By contrast, the US NOAA acquired an own set of data and experience which they used for determining an activity framework and conditions for test mining activities.

Scrutinising the newly revised recommendations (ISBA/25/LTC/6/Rev.1) for the guidance of contractors it appears that the ISA does not reserve a steering function for itself, i.e. through procedural guidance of the contractors with an initial scoping phase for determining the anticipated scope and content of the information to be included in the assessment and EIS, the required standards to be met, and evaluation criteria to be applied to the EIS. ISA should provide contractors with guidance and legal reference as to the applicable conservation standards, including on pollution control; and a first draft assessment framework, outlining the procedural steps involved, the risk assessment process and management. In particular, recommendations on the scientifically meaningful set-up of Impact and Preservation Reference Zones, crucial for detecting environmental impacts due to the activities, are essential for enabling all contractors to design their Before-After-Control sampling in a comparable way. This could for example address location, size of core and buffer zones, and the spatial and temporal spacing of monitoring stations to facilitate regional assessments and inter-contractor comparisons. Preliminary guidance on rules for choice of test and mine sites, e.g. in a systematic spatial planning process, would also help to gain experience from a common starting point. With regards to the monitoring of effects, the ISA recommendations do not provide for initial indications as to the timing and spacing of monitoring, test of core parameters as indicators as recommended by science, and first risk assessment. Therefore, contractors will report on very different set-ups. Even more so, as there are no reporting obligations on a) the reporting of species, habitats, ecosystems of particular concern of other bodies, e.g. EBSAs, VMEs, or proposed MPAs in the contract area; b) mitigation of impacts; c) alternatives; d) uncertainties and e) knowledge gaps.

Comprehensive, accurate, reliable, scientifically correct and reproducible data and baseline information on the contract area and in particular the mine or test site are the essential basis for risk and impact assessment. Apart from quality assurance, a certain degree of standardising baseline investigations, monitoring and reporting is required to enable regional and temporal analysis. For the ISAs as a regulator who has to provide for uniform conditions for all contractors in the Area such minimum requirements should be vital. Incentives might stimulate more comprehensive investigation programmes.

The overall impression is that potential operators in the Area do not have sufficient guidance which they can rely on as to the expected deliveries during exploration and testing of equipment, the minimum requirements for baseline investigations to be considered sufficient, monitoring and reporting on environmental issues. This becomes particularly evident when comparing to the standards set e.g. by the ESPOO Convention (1991), the Aarhus Convention (1998) or what the Convention on Biological Diversity (Convention on Biological Diversity, 2012a) recommends for areas beyond national jurisdiction. ISA also does not provide the same procedural certainty as for example New Zealand provides to offshore operators (see chapter 5.5.2.3). Only the technical and resource reporting is pretty clear. One possible explanation in this respect is that it could very well be that mining operators do not expect the ISA to impose serious restrictions on their planned activities.

The ISA should therefore seek to flesh out the required reporting of long-term environmental monitoring of environmental impacts arising from testing, and to build its own pool of knowledge from the data and information reported by contractors and use this, for example, to develop initial approaches to potential damage indicators and thresholds, indicators of good environmental status, best environmental practices, and best available technologies. With the number of mining tests increasing, the need for ISA guidance on the issues named above clearly increases. Of course, there is limited experience to date and the ISA itself does not hold any data from independent monitoring of disturbance through mining tests. However, much could be gained if all historic and small-scale environmental studies would be compiled and evaluated to provide a first institutional recognision of what "harmful effects" and "serious harm" mean (expanding on existing science advice). With each new mining test, more experience will be gained so the definitions, indicators and thresholds can be refined.

In this context, it is worth considering if the ISA could require for all EIAs/EISs that are needed up to the start of commercial mining to be integrated into an iterative or continuous process. It would be conceivable that for each contractor, all EIAs and reports submitted in connection with trial mining during the exploration phase would cumulatively result in the final EIA/EIS to be prepared in connection with the exploitation permitting process. Apart from that, it might also be possible to imagine that contractors at the exploration phase could undergo just one EIA process for several test mining projects (i.e. involving different locations, equipment, systems, time, duration), and produce several EISs for each project respectively. In other words, if contractors can determine their test mining plans from the outset during the exploration phase, and assuming this involves more than one test mining project, contractors might be able to merge this into one EIA process that result in several EISs.

The end point for this iterative or continuous process is when a contractor can reliably indicate a) the expected environmental consequences for the planned commercial mining operation and b) that these do not cause harmful effects/serious harm to the environment. Practically, this requires that one and the same EIS format and underlying assessment and reporting procedures are valid throughout the contract phases. For the contractors, this could make repeated testing more attractive, as the core of the EIA will remain the same, and several individual EISs be produced from that process. All that needs to be done is to ensure that new test and monitoring programmes need to be added on a case-by-case basis, and that lessons learnt from earlier tests projects are properly analysed, whereby any remaining EISs for upcoming testing projects are revised accordingly if necessary.

Summary and recommendations

Summary

The "Recommendations for the guidance of contractors for the assessment of possible environmental impacts arising from exploration for minerals in the Area", ISBA/25/LTC/6/Rev1:

- Fail to provide guidance to contractors on the scope and contents of the EIS and solid design of impact monitoring programmes to be submitted to ISA LTC ahead of any test mining activity;
- Fail to standardise at least a minimum set of baseline and monitoring activities by contractors in such a way as to enable inter-contractor comparisons, and integration with scientific and regional data;
- Do not provide any requirements or indications pertaining to environmental objectives, significance thresholds and assessment criteria, which could help develop the assessment framework further until required at the time of exploitation applications, and without which, would be left wholly and solely at the discretion of the contractor;
- Appears to leave too many aspects open for the contractor to exercise discretion and does not accord forceful regulatory powers for the ISA to actively intervene (i.e. to direct contractors to be more thorough in the EIA process and preparation of the EIS, as well as no explicit mention of the power to reject an EIS that is deemed to be inadequate, insufficient or unsatisfactory).

Concerns remain as to when and how much data and information will be made publicly available, as near to all information will be related to the resource and/or technology, which are subject to confidentiality terms.

Recommendations

- Reverse from requesting the delivery of an EIS by the contractor to an ISA guided EIA process. Here, the contractor would still be in charge of the EIA process and the delivery of the EIS, but the process is to be conducted in conjunction with guidance from the ISA and the sponsoring State (if applicable), in order to ensure comprehensiveness and adequacy in all phases as well as to ensure that the entire process and the outcome is not left wholly to the discretion of the contractor.

- Introduce a scoping phase to develop the format and elements of the prior EIS (Environmental Impact Statement) appropriate for the particular case. Scoping could set the standard for all following steps, with the deliveries increasing in proportion to the level of risk. All information from previous EISs and the actual testing activities (i.e. test mining studies or reports) should incrementally accumulate into one comprehensive report over the exploration period that the contractor would rely on when preparing the EIS that it would have to submit when applying for an exploitation contract.
- Request the reporting of uncertainties and knowledge gaps, and how contractors dealt with it;
- Request the reporting of the occurrence of species, habitats, ecosystem subject to conservation by other bodies, e.g. EBSAs, VMEs, or proposed MPAs in the contract area.
- Introduce guidance on resource-dependent standard monitoring programmes - e.g. specify time scale before and after a disturbance, spatial and temporal set-up, minimum set of biota and processes - in order to be able to synthesise the information coming from different contractors. As long as there are no such guidance, monitoring and assessment should be designed according to best scientific standards. Scientific opinion should be requested.
- Determine a scientifically recommended best-practice Before-After-Control, BACI, sampling design as a framework for the three types of resources for contractors to fit to their circumstances, including temporal and spatial requirements, sampling and the qualities of Impact Reference Zones and Preservation Reference Zones, their size, buffer zones etc. The robustness of the contractor sampling programme should ideally be verified by independent experts.
- Add a new section on assessment and mitigation of effects.
- Require individual test mining studies or reports post conduct of testing activity as well as annual or periodic monitoring of test sites, and eventually a final report at the end of the contract. These can be used by LTC to develop risk assessment procedures and criteria and thresholds required for decision-making on commercial mining EIAs.
- EIA reports (draft EIS) and monitoring and assessment results should be made available as timely as possible to enable experts and other stakeholders to keep track of the activities.
- In the long run, ISA should seek to be an active regulatory and prepare for monitoring cumulatively activities and impacts, establish an own knowledge pool and conduct also regional strategic assessments, incl. socio-economic assessments in view of the interests of the common heritage of mankind. This necessarily has to include an evaluation of the ecological cost in terms of ecosystem functions and services, as well as in terms of lost opportunities for other ocean users.
- Integration of all tests performed during the exploration phase as well as the corresponding environmental assessments and reports into one iterative process in which the EISs for the various mining tests cumulatively prepare the final EIA/EIS, as well as is used and feed into the preparation of the applicant’s environmental management and monitoring plan. The end point of exploration is reached when a contractor can reliably indicate the expected environmental consequences for the planned commercial mining operation up to the point that this can satisfy the approval of the exploitation application at the ISA.

The ISA EIA/EIS in practice

Chapter 5 notes that the lack of specification of the ISA recommendations (see chapter 4) has strong implications not only for the quality of the EIS delivered by the contractors - as can be assumed in best effort - but also generally on the ISA´s ability to ensure a "*uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind*” (ITLOS, 2011, para. 159). Despite the substantive obligation to carry out an environmental impact assessment, EIA, and deliver and environmental impact statement, EIS, the procedural and scientific framework for guiding contractors to deliver a fit-for-purpose EIS is insufficient in many respects.

The three contractors (see chapters 6.1 and 6.2) have coped with the task of delivering an EIS at a time when the then valid guidelines (ISBA/19/LTC/8) requested them to provide an EIA of undetermined content, and without specifying a conservation objective. In particular, the lack of guidance on a framework for monitoring and assessment results in every contractor to reinvent the wheel, and a common assessment framework for activities of all contractors in one region exploring for one resource may become impossible to develop in practice. In addition, a guidance is desirable to advise contractors in providing a comprehensive, ecosystem-based view on the targeted ecosystem and its components before and after being subject to pressure from exploration and testing.

Ideally, the ISA would have established a coarse regional environmental baseline and quality description at the latest by the time contractors apply for exploitation and deliver a full-scale environmental impact assessment/statement. This would enable the contractor EIS and Environmental Management Plan to fit with the objectives of the respective Regional Environmental Management Plan. However, this requires formal links to contractor obligations. In addition, the lack of own data and experience, and lack of independent scientific advice will make it extremely challenging for the ISA to evaluate the justifications raised by the proponent, in particular regarding the accuracy and statistical reliability of before-after-control measurements.

Test mining will predate this, but *vice versa* can be expected to contribute to the delivery of a meaningful prior environmental impact study in context with decision-making on exploitation. Therefore, already at this early stage, contractors should be made aware of the hurdles to be overcome in order to be eligible for an exploitation contract. A binding precautionary and ecosystem-based framework, agreed by the ISA Council with expert advice and after public consultations, would be instrumental to succeed in the uniform implementation of the highest protection standards for the marine environment, as requested by ITLOS.

Provisions are necessary to enhance transparency, expert involvement, stakeholder participation, but also ISA-guided scoping and other critical elements of good governance, which would enhance regulatory control and public trust However, both are missing in the current ISA rules, regulations and procedures. Importantly, there is currently no requirement for contractors or the LTC to spell out uncertainties or knowledge gaps. Deep seabed mining will be a high-risk endeavor to the ocean environment, hence regulatory mechanisms and measures should be designed to control the risk in view of the uncertainties in a precautionary way. Expert opinion can here be an invaluable supplement here to inform appropriate policies and regulations.

Test mining is one of the ways to address knowledge uncertainties, optimize mining techniques and practices, and minimise environmental disturbance. The higher the risk and the uncertainty about, for example, environmental disturbance, the more precautionary and stringent the contractors' obligations must be (e.g., applying best available technology and best available techniques, rather than continuing to maintain the mining practices and technologies included in the original work plan). Good governance practice requires anticipatory, precautionary and adaptive governance, as well as active scientific knowledge management by ISA. In anticipation of upcoming challenges and opportunities, a feedback cycle of adaptive management provides for strategic planning, analysis of long-term consequences, capacity building, and management of emerging technologies while such management is still possible.

The ISA´s ability to ensure a "*uniform application of the highest standards of protection of the marine environment*" seems to be rather restricted at present. The EIS delivered by contractors, if not regulated more stringently and with less discretion offered to contractors, may simply turn out to be a formality with limited effect in practice. It appears that the ISA can only recommend contractors to adjust their operations or improve an EIS, but does not have the means to deny, for example, test mining operations at the exploration phase because no consent/decision-making role is actually currently envisaged. This is why BGR and DEME/GSR were able to start the field trial in 2019 prior to the LTC having finalised the review of the EIS. Also, in the case of the EIS submitted by the Government of India, while asked to improve the monitoring plan and to report on any changes made, can, in principle, proceed without addressing the LTC requests. To this date, it is not publicly known if and how the views of the LTC or the views submitted by other stakeholders have been taken into account.

Environmental impact assessment and related statement prior to an activity taking place is the core process for exercising regulatory control over the environmental impacts likely to be caused by an operation. Therefore, it is of utmost importance that its submission is not just a formality, and the contents are not beyond the expertise and capacities of the ISA. The testing of mining equipment or systems *in situ* during exploration, accompanied by a prior environmental impact assessment, monitoring of the trial events and reporting of the results could, if done properly, not only ensure the formal control, but also the control on the severity of effects caused by various gears in various environments. Learning from experiences made by the operators of such activities, the assessment and decision-making over tolerable and intolerable environmental changes caused by such activities could be informed. If such information was available to all contractors, this might save time and effort and avoid insufficient operations and reporting.

Testing is also needed to reduce the uncertainty of the regulator and stakeholders about the severity and longevity of environmental effects resulting from test mining, and later from commercial mining. Based on current knowledge, the effects of one or more commercial-scale mines cannot yet be anticipated (Boetius and Haeckel, 2018). Ideally a controlled, staged approach to testing of collection equipment and systems *in situ* would be required. The contractors could then use *in situ* tests of equipment for refining the environmental baseline information, for knowledge acquisition on ecological functions and sensitivities, for developing all required procedures and its environmental management system, and for moving towards a least invasive operational process and technology for exploitation. The experience would inform standards to be developed for Best Environmental Practices, BEP, and Best Available Techniques, BAT.

Nonetheless, the draft exploitation regulations of ISA (ISBA/25/C/WP.1, Part VI, section 2) includes provisions for the applicant to submit an EIS at the application stage of exploitation. At this juncture, the uncertainty about the impacts of a commercial-scale mining operation will be high because the anticipated impacts will largely be reliant on models and other forms of predictions that have not been validated or verified *in situ*. Only a demonstration of the eventual mining system in advance at some of the proposed mining sites could show that the commercial activities are not expected to exceed the applicable threshold limits. If the information on the effects of a full commercial-size mining operation is not readily available at this point in time, then the proponent should be required to at least deliver meaningful data from testing of a prototype mining system *in situ* for an appropriate time. Once the contractor starts with exploitation, the predicted environmental effects will have to be verified in a staged approach to monitoring starting with an intensive validation phase upon the start of the activity, i.e. at a second phase before being allowed to proceed with commercial production.

For the reasons given above, and the public interest in this new type of activities which will be impacting on a common good, it is paramount to establish a fully transparent EIA process, such as proposed by and discussed in (Durden *et al.*, 2018), with a binding effect of the outcome of the EIA/EIS review on applications for exploitation. Such a multi-staged process will not only include public consultation in line with the Aarhus Convention, but also feedback loops to Sponsoring States and the ISA in order to gain full control over the activities and related impacts.

Recommendations

ISA has to ensure a "*uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind*" (ITLOS, 2011, para. 159). To reach this goal,

- ► One incremental, multi-staged EIA process (potentially resulting in several EISs, if the contractor wishes to conduct multiple testing activities) should cover all activities from the first components testing and test mining during exploration (which would serve as a verification of predicted impacts during exploitation). All information would accumulate in one comprehensive report over the exploration period that would form the basis of the EIS that is required to be submitted alongside the application for the approval of a plan of work for exploitation. If more testing is anticipated at the exploitation phase, for example, some full mining systems tests, that should be accounted for in the EIS submitted with the application for an exploitation contract (since it would fall under impacts that would arise from commercial production). Indeed, some lessons from the general EIA process will also be relevant in connection with the assessment of environment impacts of testing mining. The essential procedural elements may include some the following:
    - Meaningful public participation in line with requirements of the Aarhus Convention;
    - Feedback loops to Sponsoring States and the ISA;
    - Independent expert advice;
    - A scoping phase, where the proponent and ISA develop the format and elements of the prior EIA and EIS appropriate to the particular case. This could then also ensure the link to the respective REMP and that there are higher stakes for higher risks. A public and expert consultation is needed;
    - The joint (with experts and eventually stakeholders) elaboration and testing of
        - best-practice BACI design including rules for designating PRZ and IRZ,
        - best-practice monitoring schemes,
        - identification of environmental indicators and thresholds,
        - ecological risk assessment and management,
        - meaningful reporting,
        - cost-benefit and risk assessments to inform stakeholders and the public.
    - Identification of uncertainties and risks, publication of justifications of advice or decisions;
    - Publication of the EIA report (draft EIS) and monitoring and assessment results as timely as possible to enable experts and other stakeholders to keep track of the activities environmental impacts;
    - A test mining study or report post-activity and annual or periodic, and a final report of all exploration activities at the end of the contract, instead of delivery of data only.
    - The possibility of the ISA to reject an EIS, as well as to approve the EIS but subjecting it to specific conditions and requirements as the ISA may require, should be made explicit.

Scientific view on test mining

Chapter 6 supplements the previous considerations from an environmental governance perspective with a practical scientific view on the test mining concept in relation to the knowledge needs for making well-informed assessments of environmental impacts. This chapter emphasises the need for adequate baseline information as a starting point, which in turn would inform the robust design of monitoring programmes to enable capturing environmental change and considers elements of a framework for EIS prior to the start of exploitation. Indeed, without insights gained from test mining, both component and full-scale, predictions of the types, scales and intensities of potential commercial-scale mining impacts will remain unclear, making management mechanisms to ensure the effective protection of the marine environment less likely to be successful. Assessing any potential changes to deep-sea ecosystems as a result of test mining is challenging at best, but without a robust baseline, a full understanding of how nodule ecosystems and the pelagics associated will respond to disturbance under the plan of work will not be possible, and therefore will hinder informed decision-making. As such, environmental baseline data constitutes one of the main tools to warrant the protection and conservation of natural resources through the EIA process (Bräger et al., 2020). It is also important to remember that the combined environmental baseline data of the contractors in the CCZ should also serve as the basis for region-wide Strategic Environmental Assessments (International Seabed Authority, 2011; Lodge et al., 2014), which will account for cumulative impacts not only of all mining activities in the region, but also of additional anthropogenic impacts such as from pollution or climate change (Brito-Morales *et al.*, 2020; Levin *et al.*, 2020; Ramirez-Llodra *et al.*, 2011). Baseline studies to support EIAs have to be tailored to ensure they are fit for purpose. However, according to Clark *et al.* (2020), there should be a level of consistency so that core deep-sea ecological information demands are met, and these are comparable and can be combined between contractors to form a regional picture. The key aspects include:

- What parameters should be measured and the spatial and temporal interval at which they should be measured
- The necessary accuracy and precision of measurements (what is measured to acceptable standards)
- What key ecological indicators need to be assessed in transitioning from baseline data to measuring/monitoring future changes under the environmental management plan
- What level of change might be acceptable in terms of mitigation against generic ecological limits and thresholds (not management targets) (Clark *et al.*, 2020).

Without robust environmental monitoring programs in place, the ISA will not be able to verify the effective protection of the marine environment. From a scientific perspective, a robust environmental monitoring program should incorporate the following:

- Clear objectives and critical parameters for monitoring.
- A detailed description of the test technology and methodology.
- Identification of the anticipated impacts of the test.
- A detailed description of the monitoring technologies and methodologies.

Furthermore, the understanding of the environment gathered during the baseline study should be used in combination with up-to-date plans for the test mining activity (including detailed information on the specific technologies, logistics and practical implementation) to complete a risk assessment (Durden et al., 2018). The risk assessment and management process aims to identify, evaluate and rank risks associated with the activity, and to identify ways to mitigate these as best as possible according to the mitigation hierarchy: first to avoid/prevent, second to minimize, third to restore when possible, or finally to offset any impacts (Cormier, 2019; Durden et al., 2018; Van Dover et al., 2017a). This requires focus on the main sources of impact, as recommended by Clark et al. (2020). An Environmental Risk Assessment (ERA) facilitates this prioritization by providing for the application of a systematic problem formulation risk-based decision making framework to ensure an objective consideration of the acceptability of certain risks, and thus should be an integral part of the EIA process (Clark et al., 2020; O et al., 2015).

In terms of reporting, the processes for reporting the results from test mining activities should be clearly conveyed within the EIA and follow a high level of structural standardization to allow for increased consistency, verifiability and transparency (Bräger et al., 2020). The reporting should include interpretations of the findings through comparisons with peer-reviewed studies, and details of sample and data management as well as dissemination plans, with a timeframe given for each step. The results of mining tests, including all data and samples, should be placed in the public domain or stored in a suitable and accessible repositories for transparent independent evaluation by experts and other stakeholders and, if possible, results should be published in peer-reviewed scientific journals (Bräger et al., 2020).

Recommendations

- Both component and full-scale test mining should be seen as essential tools for predictions of the types, scales and intensities of potential commercial-scale mining impacts, information which needs to be available for decision-making on exploitation contracts.
- A high-quality EIA is underpinned by adequate baseline information; clarification of what levels of environmental baseline data are deemed as adequate is needed and appropriate and should take due account of the effects of climate change.
- A robust monitoring plan, adequate risk assessment and thorough reporting are also needed for an EIA, as well as its comprehensive assessment by independent (*i.e.*, who are not benefiting from the contractor) deep-ocean and marine-management experts.
- Strategic Environmental Goals and Objectives are needed as the essential starting point for assessing environmental responsibilities and to guide all decision-making.

Re-envisioning Test Mining

Chapter 7 proposes a re-envisioning of the existing functions and regulatory options pertaining to test mining at the exploration and exploitation stage, namely, through a compulsory two-phased approach to test mining that is based on a proposal submitted by Germany to the ISA in October 2019. A perusal of the proposal put forward by Germany reveals a mandatory two-phased approach for test mining: first, prior to the application for an exploitation contract and second, prior to the commencement of commercial production at the exploitation stage. Put differently, pursuant to the German proposal, the results of test mining projects (*in situ* experiments) performed by contractors should be among the factors that would inform the decision-making process at the ISA with respect to the decision to grant an exploitation contract in the first step, and to the decision on whether or not to allow a contractor with an ongoing exploitation contract to proceed with commercial production in the second step.

With respect to the first phase, pursuant to the German proposal, a contractor holding an exploration contract who wishes to proceed with an application for an exploitation contract would be required to conduct test mining activities during the exploration stage. The results therefrom would be used to support its application for an exploitation contract. In applying for an exploitation contract, the proposal foresees that contractor would have to submit, *inter alia*, 'test mining studies' to support its application. Such test mining studies would also feed into the eventual Environmental Impact Statement that an applicant would have to submit with its application for the approval of an exploitation plan of work. It is noteworthy that the inclusion of test mining studies that is proposed by Germany will, if accepted, feature as one of between 10 to 12 requirements that must accompany an application for an exploitation contract. Furthermore, the submitted test mining study, alongside the Environmental Plans submitted by the contractor, shall be made open to public review (with confidential information redacted), followed by a review by the LTC. The application by the contractor shall not be considered until this review process is completed. Accordingly, it is important to note here that the results of the test mining projects by the contractor (as reflected in the said test mining study) will be one of several key factors for consideration by the LTC in determining whether or not to recommend the approval of the application. In this regard, the test mining study submitted by the contractor would serve as a form of evidence to inform the LTC of the contractor's technical ability and capacity to meet environmental requirements, which is already a pre-existing requirement that appear even in earlier versions of the Draft Exploitation Regulations.

The second phase recognizes that the procurement of an exploitation contract is only the starting point of the activity, because actual exploitation will only take place when the contractor moves on to commercial production (*i.e.* large-scale mining). In most cases, it will take up to 10 years and even more after the granting of the contract to procure investments, develop and assemble the necessary technology, as well as to ensure all other related and ancillary matters are in order (e.g. transportation, logistics, processing, market conditions, etc.). Thus, the second phase of test mining is introduced to ensure that technologies and knowhow acquired by the contractor after receiving the exploitation contract would meet the technical and environmental expectations of the ISA as set out in the prior EIS and EMMP, and helps to subsequently verify the contents of those documents. It is also pertinent if the technologies or techniques earlier acquired and tested by the contractor during the exploration phase have changed or been modified, or if the contractor wishes to use alternative technologies or methods. In this respect, the proposal introduces a second checkpoint for the ISA, as regulator, to ensure that the contractor will be able to manage the actual impacts arising from commercial production before allowing it to proceed. Finally, it is to be noted that the proposal by Germany also acknowledges the possibility of an exemption of the compulsory test mining requirement during the second phase, for example, if the LTC determines that a particular contractor has already satisfactorily conducted all test mining activities (including full systems trials) during the exploration phase. Accordingly, the proposal appears to encourage contractors to conduct all pertinent testing activities at the exploration phase so that it may be exempted from further requirements during the exploitation phase. As covered by earlier chapters, it is in the best interest of all parties, including the ISA, the contractor, sponsoring States and all stakeholders to ensure, as far as possible, that all necessary testing activities (including full systems tests) take place during the exploration phase.

There potentially are some shortcomings to the two-phased approach to test mining. While the strength of the proposal is that it allows the contractor a certain degree of flexibility to 'postpone' some testing activities to the second phase, which may make sense for commercial contractors that would only start investing heavily upon procuring the exploitation contract, this may result in inconsistencies when evaluating applications for exploitation contracts – seeing that some contractors would be treated differently from others. Moreover, it would be easier to disapprove an application for the approval of a plan of work for exploitation than it would be to prevent a contractor from proceeding to commercial production later on. In this respect, an ideal approach would be to impose the same requirements on all contractors to conduct the necessary test mining activities during the exploration phase, and demonstrate these results in test mining studies and the EIS prepared to accompany the application for an exploitation contract, to the satisfaction of the ISA. In this respect, the imposition of an additional layer, i.e. the award of a "provisional exploitation contract", could also be considered if necessary. Under this scenario, an applicant that has only partially met some of the required testing activities during the exploration phase may still be eligible to submit an application for an exploitation contract, but shall only be awarded a provisional contract that would be valid for say five years. During this period, the contractor can then procure technologies and conduct the remainder of the required testing activities, after which (and subject to the approval of the ISA), the provisional contract would then be finalised. It is acknowledged, however, that commercial contractors especially may not find this appealing because a provisional exploitation contract would not appear to be as valuable as a security instrument in contrast to a final exploitation contract with security of tenure. In any event, the two-phased approach to test mining proposed by Germany, with or without any modifications, will undoubtedly go a long way to support informed decision-making at the ISA, particularly from the environmental perspective, and therefore deserves serious attention.

Conclusions and Recommendations

Chapter 8 summarizes the entire report by providing an overview of the key discussions on test mining with respect to the emerging ISA Mining Code, highlighting some of the opportunities and challenges involved in requiring and regulating test mining, and discussing some recommendations on how to properly utilise test mining from the perspective of environmental governance.

At present, there is no formal regulatory requirement for test mining in the rules, regulations and procedures of the ISA. Thus, unless a pre-condition is set in the Draft Exploitation Regulations, in theory, contractors are able to obtain an exploitation contract and proceed with commercial production without first demonstrating their ability to actually conduct mining activities and provide for effective protection of the marine environment from arising impacts

From a scientific and environmental governance point of view, mining tests of various scales are indispensable for gaining knowledge and experience with the degree of resilience of the deep-sea ecosystems to disturbances of various types and spatial and temporal scales. For society, such knowledge is essential to be able to evaluate the benefits and costs of deep seabed mining in the common heritage of mankind. Likewise, for the ISA, which is mandated to ensure the marine environment from harmful effects of mining-related activities and act on behalf of mankind as a whole, testing is an important opportunity to learn about the technical development of deep seabed mining equipment and systems to

- Check the suitability of process standards and guidelines;
- Identify the biological parameters that record the impact of mining most reliably;
- Indicate preliminary thresholds of pressures and impacts;
- Identify patterns in natural variations in environmental conditions against which impacts of the mining tests will be assessed (control area);
- Assess the total impact area affected by the plume of resuspended sediment from mining equipment and discharge of return process water over longer time scales;
- Help define the appropriate location of control sites in relation to commercial mine sites;
- Inform the appropriate size and location of mine sites (how many, how close, extent of buffer zones required to prevent transboundary impact etc.).

Unless conducted as a long-term and near to full-scale mining test, it will remain extremely difficult to conclude from trial mining on the effects to be expected from commercial-sized mining on the marine environment. In this respect, test mining will provide some much needed knowledge to facilitate informed decision-making – without which, the ISA would almost be evaluating mining applications with a blindfold on. Consequently, it becomes a critical policy decision whether and how much of the common heritage of mankind will be sacrificed directly and indirectly, and which added loss of ecosystem functions and services will be considered acceptable - knowing that no projections are possible to predict the full ecosystem effects of one or more deep seabed mines.

1 Introduction

Following nearly a decade of multilateral negotiations, the third UN Conference on the Law of the Sea (1973-1982) culminated in the adoption of the UN Convention on the Law of the Sea 1982 (UNCLOS). Part XI of UNCLOS is dedicated to the international seabed, otherwise known as 'the Area', and established the International Seabed Authority (ISA) to exercise authority over the mineral resources located in the Area. Part XI of UNCLOS confirms that the Area and its mineral resources are the common heritage of mankind and are to be used for the benefit of mankind as a whole, and mandated the ISA to establish a system of exploration and exploitation for these resources. Upon the adoption of UNCLOS, it became clear that a substantial number of States, mostly comprising of developed and industralised States, were not prepared to sign on to the treaty specifically due to objections to Part XI of UNCLOS. It was apparent that certain provisions of Part XI of UNCLOS would need to be modified to address the concerns of those withholding States, in order to convince them to join the treaty. Eventually, this resulted in the 1994 Agreement Relating to the Implementation of Part XI of UNCLOS, leading to many of the hesitant States to embrace UNCLOS, and paved the way for its entry into force shortly after that. Consequently, the ISA came into existence with its seat in Kingston, Jamaica. All parties to UNCLOS are automatically part of the ISA, and thus, the ISA today comprises of 167 Member States and the EU.

The ISA is mandated to organize and exercise control over 'activities in the Area', which is defined as the exploration and exploitation of the mineral resources located in the Area. While marine scientific research and basic mineral prospecting can be conducted without receiving prior authorization from the ISA, the exploration and subsequent exploitation of minerals in the Area can only be legally conducted after an application has been approved by, and a contract concluded, with the ISA. Applicants can be among Member States themselves or any state-owned enterprise or private actors that are sponsored by one or more Member States, provided that these entities are either nationals or under the effective control of nationals of the Member States sponsoring them. Pursuant to its mandate, the ISA has the responsibility to develop rules, regulations and procedures to develop the resources of the Area, to design a financial regime and distribution mechanism to collect payments from exploitation contractors and equitably share the resulting financial and other economic benefits with Member States., and to take necessary measures to ensure the effective protection of the marine environment from the harmful effects of activities in the Area. Hitherto, the ISA has adopted regulations for the exploration of three different type of mineral resources, namely, polymetallic nodules, polymetallic sulphides, and cobalt-rich ferromanganese crusts. As of December 2020, a total of 30 exploration contracts have been awarded. Negotiations over a draft version of the regulations for exploitation of minerals are currently ongoing at the ISA. Once these are adopted, the ISA will begin entertaining applications for exploitation contracts. Simultaneously, the ISA is also designing regional environmental management plan (REMPs) for certain regions of the Area that are the subject of mining interest. For now, only one exists for the Clarion-Clipperton Zone but several others are under development.

During the exploration stage, apart from exploring the prospects of resources extraction for the purposes of eventual exploitation, contractors are expected to gather environmental baseline data and monitor existing conditions (pre-disturbance). The exploration stage provides the contractor the opportunity to collect all necessary data, in particular environmental, and to begin preparing to submit an application of a plan of work for future exploitation. This is critical from an environmental perspective, since applicants submitting an application of a plan of work for future exploitation would need to submit key documents such as an environmental impact statement and an environmental management and monitoring plan to support the said application. Subsequent to the approval of an application of a plan of work for exploitation and the conclusion of a contract, the contractor would enter into the exploitation stage, which generally entails two phases. The first phase is the pre-commercial production phase, where the contractor spends several years to prepare to move into the second phase, which is commercial production or the actual commercial extraction of minerals.

In this respect, the theme of test mining is very pertinent. Test mining is essential not only for contractors, be it exploration or exploitation, to ascertain the economic and technical feasibility of their activities, but also for environmental purposes. The importance of testing technology *in situ* while monitoring the environmental effects in a nascent industry cannot be overstated. How else could harmful effects of activities in the Area on the marine environment be ascertained, prevented or minimised? This is even more so in the case of deep seabed mining, given that the future industry wants to operate in a highly knowledge-deficient and sensitive area such as the deep sea. While the use of models can be useful to a certain extent to provide some basic predictions, these need to be validated and verified through *in situ* testing.

Moreover, test mining presents a great opportunity to uncover the environmental risks of deep seabed mining activities so that these risks can be better ascertained, managed and regulated. As the regulator, the ISA needs to be convinced that the effective protection of the marine environment from the harmful effects of mining is ensured, and that the extraction methods and techniques that contractors plan to use do not, under any circumstances, cause serious harm to the marine environment. Test mining will assist in demonstrating the appropriateness and effectiveness of the technologies and operational practices that are planned to be used, before these are deployed at a commercial-scale, thereby allowing both the regulator and the contractor to reflect on the matter with foresight rather than in hindsight. In this respect, reference to the EU Biodiversity Strategy for 2030 is instructive, where the following is said: "*In international negotiations, the EU should advocate that marine minerals in the international seabed area cannot be exploited before the effects of deep-sea mining on the marine environment, biodiversity and human activities have been sufficiently researched, the risks are understood and the technologies and operational practices are able to demonstrate no serious harm to the environment, in line with the precautionary principle […]*."

At the moment, while ISA recommendations, the exploration regulations and the current version of the draft exploitation regulations acknowledge that contractors can conduct testing activities, there is no compulsory requirement for testing to be carried out. Put differently, from a regulatory perspective, it is theoretically possible for a contractor to proceed from exploration into commercial production without conducting any form of *in situ* testing beforehand. This is quite alarming from an environmental perspective, to say the least. While it is expected that contractors would conduct some form of testing for their own purposes, *i.e.* to determine technical or economic feasibility, whether *in situ*, *ex situ* or in laboratories, there is no compulsion for testing activities to be carried out from an environmental angle.

The ISA bears the responsibility to act on behalf of mankind as a whole and exercise control over the common heritage of mankind. It is explicitly obligated to ensure the effective protection of the marine environment from the harmful effects of mineral exploration and exploitation activities, which means ensuring that contractor activities do not lead to harmful effects on the affected biota and ecosystems. Equipment, systems and operational testing would be essential to provide vital knowledge for this purpose. Test mining would:

a) Provide contractors with the necessary data and knowledge to prepare robust and accurate environmental assessments and environmental management and monitoring plans;

b) Enable the ISA, as regulator, with the necessary data and knowledge to determine and revise its environmental objectives, thresholds, standards; and

c) Allow the ISA, as regulator, to properly evaluate the technical capacity of the contractor, based on its demonstrated abilities during test mining, to manage and minimize the harmful effects of its mining activities.

Given that environmental impact statements and environmental management and monitoring plans are required to be submitted along with an application for the approval of a plan of work for exploitation, it would be sensible to expect contractors to gather all necessary environmental baseline and monitoring data (pre-disturbance), as well as to conduct a sufficient degree of test mining at a large enough scale to provide sufficient indication of what the environmental effects of commercial mining would look like already, at the exploration stage. Thereafter, once the application is approved and an exploitation contract is awarded, it would also be necessary to first require the contractor to conduct a full, commercial scale mining test and validate the expected environmental impacts (as ascertained in the EIS) as well as to ensure the sufficiency of the steps to manage them (as elaborated in the EMMP).

This report explores the theme of test mining in the Area from legal, regulatory, environmental governance and scientific perspectives. Chapter 2 describes the current regulatory framework for test mining and explores the legal mandate of the ISA to require more in terms of test mining, while chapter 3 explores the current status of exploration activities in the Area, including equipment testing. Chapters 4 and 5 discuss environmental impact assessments in the context of test mining and review three recent environmental impact statements submitted for the *in situ* testing of mining equipment, while chapter 6 provides a scientific view on test mining, Chapter 7 provides an overview on re-envisioning test mining for exploration and exploitation activities, premised on a proposal made by Germany in 2019 on a compulsory two-phased approach to test mining, and finally, chapter 8 concludes the report. This report is accurate as at 31 March 2021.

2 Regulatory Framework and Legal Mandate for Test Mining

Chapter 2 describes the concept of test mining in the Area by identifying its objectives, elaborating on its scope and attempting to provide a suitable definition. The chapter then proceeds to provide a comprehensive overview on the regulatory framework for test mining, before exploring the legal mandate of the ISA pertaining to test mining.

2.1 Introduction

Activities in the Area, as described under the UN Convention on the Law of the Sea 1982 (UNCLOS), covers the exploration and exploitation of the mineral resources located on the international seabed ("the Area"),[1] which is designated as the common heritage of mankind.[2] Activities in the Area come under the remit of the International Seabed Authority (ISA), which is mandated to develop rules, regulations and procedures to govern deep seabed mining activities, as well as to exercise control over such activities by considering applications of plans of work, concluding contracts where such applications are approved and ensuring compliance by contractors, for the benefit of mankind as a whole.[3] With respect to contract areas approved by the ISA, the UNCLOS appears to regard both the exploration and exploitation stages as separate and consequential, *i.e.* exploration takes place before exploitation. In fact, under the current practices of the ISA, both stages are the subject of distinct sets of regulations, with regulations to govern the latter currently being negotiated at the ISA.

In this regard, it is pertinent to note that a party that conducts mineral prospecting in the Area or a contractor that contracts with the ISA to undertake exploration activities is under no legal obligation to proceed with an application for exploitation. Conversely, a contractor that proceeds to submit an application for exploitation over an area that has not been satisfactorily explored (prior to the said application) runs the risk for the said application to be turned down, since approving the application without there being sufficient environmental baseline data would entail too much environmental risk and would be improper.[4] Moreover, the approval of such an application will – in any event – arguably be in contradiction with the UNCLOS, specifically the obligation of the ISA to ensure the effective protection of the marine environment from activities in the Area.[5]

As it currently stands, the ISA is at an advanced stage of finalizing the Draft Exploitation Regulations, the pivotal instrument that would govern the shift from mineral exploration activities to mineral exploitation activities in the Area. Among the many pressing concerns that arise from this transition is the theme of test mining. Test mining here essentially refers to the testing of components, equipment, processes and systems prior to the conduct of actual commercial scale mining. It is possible to understand test mining in two ways: first, as an exercise to determine the commercial feasibility of conducting activities in the Area (from a financial and technical perspective), and second, as a measure to ascertain the potential effects that activities in the Area could inflict upon the marine environment with more confidence. As it stands, while the Exploration Regulations (for all three mineral resources) and the pre-negotiation version Draft Exploitation Regulations do refer to test mining, permitting (and possibly even encouraging) its conduct, the said instruments do not make it an obligatory measure. It is important to understand that test mining by a contractor does not only provide useful outcomes

[1] Articles 1(1)(1) and 1(1)(3), as well as Article 133 of UNCLOS.

[2] Article 136 of UNCLOS.

[3] Articles 137(2), 140(1), 153(1) and 157(1) of UNCLOS.

[4] See generally, Cordes, E. and Levin, L. (2018), 'Exploration before exploitation', Science 359:6377, p. 719, which makes the case as to why it is essential to first conduct detailed and thorough exploration before considering exploitation, albeit with respect to the case of offshore hydrocarbon activities in national jurisdiction.

[5] See for example the Report of the Secretary-General (ISBA/19/A/2) at paragraph 6, which confirms that the "prerequisite [to ensure that adequate measures are in place for the protection of the marine environment] is the establishment of an environmental baseline against which to assess the impacts of mining on the marine environment.

with respect to the specific mining site; more importantly, it provides vital information and knowledge that can be utilized for better environmental governance in the Area.

It is argued here that the conduct of a comprehensive test mining endeavor, specifically one that provides the ISA with the requisite knowledge to set appropriate environmental standards and thresholds for the Area, adopt necessary measures for the effective protection of the marine environment (such as via Regional Environmental Management Plans), as well as to verify and scrutinize Environmental Plans submitted by contractors (Environmental Impact Assessments/Statements, Environmental Management and Monitoring Plans, and Closure Plans). Moreover, in the case of a specific mining site, it allows contractors to evidently demonstrate that the harmful effects to the marine environment from their mining activities do not go beyond the levels or thresholds that have been pre-determined by the ISA, as well as provide evidence to support that they possess the necessary technical expertise to manage the environmental harm that could potential arise from their activities.

At its core, the ISA's mandate and the current design of its regulatory regime embeds a system of exploration and exploitation of the mineral resources of the Area. Typically, the regime anticipates that an operator will conduct some prospecting activities for a particular mineral resource before applying for an exploration contract with the ISA in order to obtain exclusive rights to survey a particular area. At the exploration stage, an operator expects to be able to gather sufficient data and familiarity with the license area in order to obtain information such as resource abundance and environmental baseline data. This information would potentially augment its technical ability and financial capacity to harvest the intended resource, as well as provide the ISA with the requisite knowledge to better govern the conduct of further activities in the license area, which specifically includes the potential exploitation activities that might subsequently follow. Upon the expiration of an exploration contract (which may be extended), an operator would then decide, premised on the experiences gained at the exploratory stage, whether to proceed with an application for an exploitation license (which would expectedly cover a specific sub-area(s) of the initial exploration contract area).

It is important to note here that although the operator has priority to apply for an exploitation contract over the said explored area, an operator is not compelled to follow through with exploitation activities after conducting exploration activities. This decision predominantly hinges on commercial feasibility, necessity, and/or technical ability. If the operator does decide to follow through with exploitation, the operator would then submit an application for an exploitation contract. However, if the operator decides not to follow through with exploitation, the exploration contract area would then be open for the Enterprise (if operationalized) or any other applicant to include in an application for an exploitation contract, or alternatively, the ISA might even choose to designate some parts of it as an area of particular environmental interest (APEI) or as no-mining areas.

2.2 Test Mining: Objective, Scope and Definition

This section is divided into three parts. It starts off by explaining the objectives of test mining activities, followed by a description of the scope of such activities, and ends with a tentative attempt to define test mining.

2.2.1 Objective

The objectives of project-specific test mining activities are threefold, namely, for the contractor to demonstrate – and for the ISA to ascertain – the following: (a) the contractor's technical ability to conduct specific mining operations, (b) the economic efficiency of the activity, and (c) the extent of the environmental impacts that arise therefrom. Contemporary understanding suggests that contractors will inevitably conduct some form of test mining of their own, but these efforts appear to be more associated with the intention of acquiring and improving technical ability and economic efficiency – and not with the primary focus of determining environmental impacts and measures to address them. Hence, it is necessary to cast further light into test mining as a means to ascertain and address environmental impacts arising from activities in the Area.

Furthermore, the knowledge obtained through test mining – in particular with regard to the effects on the marine environment and how this can be effectively managed – would better equip the ISA to develop necessary rules, regulations, procedures, standards and guidelines, as well as environmental thresholds and limits, in order to ensure the effective protection of the marine environment (provided the ISA adopts appropriate mechanisms to ensure the incremental interpretation of incoming information, of course).[6] In practical terms, this would contribute to the ability of the ISA to ensure the adequate implementation of the common heritage of mankind principle. From a purely scientific perspective, test mining could contribute towards advancing marine scientific research and improve current understanding of the deep sea and how it functions, as well as raise new and important questions for scientists to consider in future. Indeed, interests in deep sea mineral resources has, to a large extent, led to numerous scientific discoveries to date. In this respect, test mining could also foster more intense cooperation between scientists and contractor, and for the reasons mentioned above, such cooperation could then be mutually beneficial

Finally, this knowledge will also serve in the best interests of sponsoring States, whom are obligated to exercise due diligence and control over those acting under their sponsorship in engaging in activities in the Area.[7] As will be discussed later (see e.g. chapter 2.4.5.4), sponsoring States may be held responsible under international law for the environmental harm arising from the activities of the contractors that they sponsor. In this sense, requiring sponsored contractors to conduct prior test mining would contribute towards the gathering of essential knowledge that allows for a more accurate prediction of the potential environmental impacts that would occur once mining activities are up-scaled, thereby allowing the sponsoring State to require contractors to develop or adopt better techniques and technologies to manage those impacts. The fact that a sponsoring State had required its sponsored contractor to conduct prior test mining in order to ascertain the potential environmental impacts of exploitation activities and take necessary measures to reduce, control or avoid such impacts might play an important role in demonstrating that a sponsoring State had met its due diligence obligation in respect to exercising oversight over the activities of the sponsored contractor.

2.2.2 Scope

In addition, while the scope of test mining covers both stages of exploration and exploitation, it is necessary to distinguish test mining conducted during the exploration stage and test mining conducted during the exploitation stage. Four main considerations are pertinent here. One, the approval of a plan of work for exploration and the conclusion of an exploration contract between the ISA and the contractor confers upon the latter the exclusive right to explore for the resource type within the contract area throughout the entire duration of the contract. Two, it is important to recall here that contractors that obtain an exploration contract are under no legal obligation to proceed with an application for an exploitation contract thereafter. Three, it stands to reason that the ISA should only approve an application for a plan of work for exploitation if the relevant decision-making bodies determine that there is

[6] Ginzky, H., Singh, P. and Markus, T. (2020), 'Strengthening the International Seabed Authority's knowledge-base: Addressing uncertainties to enhance decision-making', Marine Policy 114:103823, pp. 6-7. Komaki, K., Fluharty, D. (2020), 'Options to Improve Transparency of Environmental Monitoring Governance for Polymetallic Nodule Mining in the Area', Frontiers in Marine Science 7:247.

[7] Markus, T. and Singh, P. (2016), 'Promoting Consistency in the Deep Seabed: Addressing Regulatory Dimensions in Designing the International Seabed Authority's Exploitation Code', Review of European, Comparative and International Environmental Law 25:3, 347.

sufficient knowledge pertaining to the proposed contract area, including environmental baseline information among others, in order to support its decision.[8] The information provided with the application will allow the decision-making organs to assess and determine the ability of the contractor to meet its environmental performance obligations[9] In other words, a contractor that is keen to proceed with an application for exploitation would presumably have to expand a proportionate amount of time, initiative and effort during the exploration stage in order to develop a compelling application for exploitation. Fourth and finally, it is necessary to acknowledge that exploration is different from exploitation. Exploitation activities will entail a significantly greater amount of effort and investment in comparison to exploration activities. Indeed, it is anticipated that some contractors will only fully invest in the activity, including purchasing the necessary equipment and securing all related arrangements, upon procuring the exploitation contract. Moreover, even within the exploitation stage, the UNCLOS differentiates two separate phases: pre-commercial production and commercial production, with the greatest environmental impacts expected to come from the latter phase.[10]

Accordingly, due to the costs involved, it is likely that when conducted during the exploration stage, test mining will be carried out at a reduced capacity, as opposed to the exploitation stage where testing is anticipated to be in the range of advanced or full capacity. Nonetheless, the environmental monitoring of testing during the exploration phase should be such that reliable conclusions as to the impact of a commercial-sized operation can be drawn, serving as input to the environmental assessment which accompanies the application for exploitation. While isolated equipment tests may be useful for contractors to further develop machinery and appropriate techniques as well as monitoring patterns, these tests are too small-scale for enabling an accurate upscaling of results that could provide reliable estimates of the levels of environmental harm that can be expected during the exploitation stage. Moreover, given that applicants are required to submit an EIS (emanating from an EIA process) with their application for a plan of work for exploitation, it seems necessary for the contractor to already conduct a series of testing over a sufficient duration during the exploration stage in order to be able to prepare a robust and reliable EIS.

Consequently, it is reasonable that test mining at the exploration stage is expected to comprise of individual equipment testing, including testing of the various components of any such equipment, e.g. collector testing, and individual systems testing, whereas testing at the exploitation stage is envisaged to comprise of the comprehensive testing of all parts of the mining system and eventually a full-scale testing of the entire mining operation. In this regard, useful reference can be made to technological readiness levels (TRL) characteristics of the mining system – alongside an appropriate and corresponding environmental readiness levels (ERL) assessment system – at the ISA as proposed by the Netherlands in 2017, in order to capture the realities of both the exploration and exploitation stages (see chapter 4.3).[11]

At this juncture, it is sufficient to clarify that the scope of test mining activities is anticipated to correspond with the relevant stage in question, *i.e.* exploration or exploitation. In addition, while initial efforts via modelling and laboratory experiments are important, it is argued here that a realistic assessment of the potential environmental impacts that will arise from activities in the Area with meaningful results for the extrapolation to the effects of commercial production is only possible through testing

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[8] The requirement on the sufficiency of information should be covered by an ISA Environmental Standard and/or be verified by independent experts, see e.g. Belgian non-paper submitted to the ISA on 'Strengthening Environmental Scientific Capacity of the ISA' dated 22 June 2018, pages 2-4, available at: https://www.isa.org.jm/files/files/documents/belgium-capacity.pdf.

[9] See Draft Regulation 13 of the current version of the Draft Exploitation Regulations under negotiations (ISBA/25/C/WP.1).

[10] See e.g. Articles 17(2)(b) and (c) of Annex III to UNCLOS, read in light with Section 1, paragraph 5(f) to the Annex of the 1994 Implementation Agreement on Part XI.

[11] See ISBA/23/C/5, paragraphs 15-20.

via field experiments, which include both *ex-situ* experiments (*i.e.* off-site at a relevant and comparable environment) and *in-situ* experiments (*i.e.* on-site and specific to the contract location in the Area).[12] Accordingly, in order to ensure the effective protection of the marine environment from activities in the Area, it is reasonable to expect contractors to demonstrate their ability to avoid, minimize and mitigate the environmental impacts that arise from their activities to match the predetermined limit values for environmental disturbances through testing programs that involve field experiments, particularly *in-situ*, at both stages of exploration and exploitation.

2.2.3 Definition

Finally, it would be necessary to render a definition for test mining activities. In this regard, some guidance can be found from existing attempts to clarify test mining and activities in the Area.[13] Premised on these, the following working definition is proffered:

> "1. Test mining includes the use and testing by contractors of:
>
> (a) recovery systems and equipment and the component parts of a mining system, including sea-floor collectors, riser systems and equipment and discharge systems and equipment, as well as systems and equipment relating to shipboard processing, transfer to transportation vessels and onboard waste management directly above the mine site; and
>
> (b) a fully integrated and functional mining system including collection systems and water discharge systems.
>
> 2. Test mining in this context specifically involves *in situ* field experiments, although prior and continuing laboratory and *ex situ* experiments are strongly encouraged."

Accordingly, test mining encompasses equipment and component testing [paragraph 1(a)] as well as fully functional mining systems [paragraph 1(b)]. In this respect, it is important to clarify that test mining involves testing of equipment and systems that do not amount to commercial-scale recovery. As observed by an ISA brochure: "The mining systems for these tests are assumed to be similar to commercial systems, but would operate for much shorter periods" and that such "test operations would provide the first opportunity for the accurate assessment of environmental impacts from long-term, commercial mining".[14]

In addition, test mining in this context specifically refers to *in situ* field experiments, albeit recognizing the relevance and importance that prior and continuing laboratory and *ex situ* experiments would

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[12] Clark, M. (2019), 'The development of environmental impact assessments for deep-sea mining'. In: Sharma, R. (ed.), Environmental issues of deep-sea mining: Impacts, consequences and policy perspectives (Cham: Springer), at p. 459.

[13] For example, see the LTC Recommendations ISBA/25/LTC/6/Rev.1 (this will be discussed again later). In addition, the 2011 Advisory Opinion on the Responsibilities and Obligations of States sponsoring persons and entities with respect to activities in the Area, delivered by the Seabed Disputes Chambers of the International Tribunal for the Law of the Sea (Case No. 17 of ITLOS), available at: https://www.itlos.org/fileadmin/itlos/documents/cases/case_no_17/17_adv_op_010211_en.pdf, also provides some clarification on specific type of 'activities in the Area' and the environmental harm that arises from exploration and exploitation activities, which include the following:

a) "drilling, dredging, coring, and excavation; disposal, dumping and discharge into the marine environment of sediment, wastes or other effluents; and construction and operation or maintenance of installations, pipelines and other devices related to such activities" [paragraph 87];
b) "shipboard processing immediately above a mine site of minerals derived from that mine site" [paragraph 88];
c) "recovery of minerals from the seabed and their lifting to the water surface" [paragraph 94];
d) "evacuation of water from the minerals and the preliminary separation of materials of no commercial interest, including their disposal at sea" [paragraph 95]; and
e) "transportation between the ship or installation where the lifting process ends and another ship or installation where the evacuation of water and the preliminary separation and disposal of material to be discarded take place" [paragraph 96].

[14] ISBA (2008), 'Protection of the Seabed Environment (ISA Brochure, March 2008).

bring to the equation. Requiring *in situ* testing ensures that local, on-site characteristics are properly accounted for and allows for any prior *ex situ* testing results to be properly validated.

2.3 The Current Regulatory Framework Applicable to Test Mining

This section briefly covers the legal position of test mining pursuant to the UNCLOS, read in the light of the 1994 Implementation Agreement on Part XI, as well as the Mining Code with respect to exploration activities. Since the exploitation regulations are still in a draft form that is being negotiated at the ISA, it should be particularly noted that the legal implications of the parts that do refer to test mining currently is still uncertain and inconclusive.

2.3.1 UNCLOS and the 1994 Implementation Agreement on Part XI

The UNCLOS, read in the light of the 1994 Implementation Agreement on Part XI ("the 1994 IA"), does make several references to 'testing'. In particular, Article 17(2) of Annex III of UNCLOS contains a number of paragraphs that are worthy of scrutiny. For example, one paragraph refers to the exploration stage to "be of sufficient duration to permit a thorough survey of the specific area, the design and construction of mining equipment for the area and the design and construction of small and medium-size processing plants for the purpose of testing mining and processing systems", while another two addresses the exploitation stage which involve the "construction of large-scale mining and processing systems" and the commercial production phase which entails "large-scale production rather than production intended for information gathering, analysis or the testing of equipment or plant". Despite these provisions, however, the UNCLOS and the 1994 IA does not firmly establish test mining as an obligation or mandatory requirement. Nevertheless, it does appear to presume that contractors will conduct test mining programs at both the exploration and exploitation stages.

Relevant Provisions to Test Mining under UNCLOS and the 1994 IA

UNCLOS, Annex III, Article 17(2)

(b) Duration of operations:

(i) Prospecting shall be without time-limit;

(ii) Exploration should be of sufficient duration to permit a thorough survey of the specific area, **the design and construction of mining equipment for the area and the design and construction of small and medium-size processing plants for the purpose of testing mining and processing systems**;

(iii) The duration of exploitation should be related to the economic life of the mining project, taking into consideration such factors as the depletion of the ore, the useful life of mining equipment and processing facilities and commercial viability. Exploitation should be of sufficient duration to permit commercial extraction of minerals of the area and should include a reasonable time period for **construction of commercial-scale mining and processing systems**, during which period commercial production should not be required. The total duration of exploitation, however, should also be short enough to give the Authority an opportunity to amend the terms and conditions of the plan of work at the time it considers renewal in accordance with rules, regulations and procedures which it has adopted subsequent to approving the plan of work.

(c) Performance requirements:

[…] The Authority shall establish a maximum time interval, after the exploration stage is completed and the exploitation stage begins, to achieve commercial production. To determine this interval, the Authority should take into consideration that **construction of large-scale mining and processing systems cannot be initiated until after the termination of the exploration stage and the commencement of the exploitation stage**. Accordingly, the interval to bring an area into commercial production should take into account the time necessary for this construction after the completion of the exploration stage and reasonable allowance should be made for unavoidable delays in the construction schedule […].

[…]

(g) Commercial production:

Commercial production shall be deemed to have begun if an operator engages in sustained large-scale recovery operations which yield a quantity of materials sufficient to indicate clearly that the principal purpose is **large-scale production rather than production intended for information gathering, analysis or the testing of equipment or plant**.

1994 IA, Annex I, Section 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: […]

(f) Adoption of rules, regulations and procedures necessary for the conduct of activities in the Area as they progress. Notwithstanding the provisions of [UNCLOS] Annex III, article 17, paragraph 2 (b) and (c), of the Convention, such rules, regulations and procedures shall take into account the terms of this Agreement, the prolonged delay in commercial deep seabed mining and the likely pace of activities in the Area;

[…]

(i) Acquisition of scientific knowledge and monitoring of the development of marine technology relevant to activities in the Area, in particular technology relating to the protection and preservation of the marine environment;

2.3.2 The Draft Exploitation Regulations

The 2019 version of the Draft Exploitation Regulations (ISBA/25/C/WP.1) barely makes any reference to test mining, except for when clarifying the use of terms (such as 'commercial production'),[15] and in relation to the powers of inspectors to test contractors' machinery or equipment as well as to require contractors to undertake specific tests or monitoring.[16]

General Definitions (ISBA/25/C/WP.1)

Schedule: Use of terms and scope

'Commercial Production' shall be deemed to have begun where a Contractor engages in sustained large-scale recovery operations which yield a quantity of materials sufficient to indicate clearly that the **principal purpose is large-scale production rather than production intended for information-gathering, analysis or the testing of equipment or plant**.

'Exploit' and 'Exploitation' mean the recovery for commercial purposes of Resources in the Area with exclusive rights and the extraction of Minerals therefrom, including the **construction and operation of mining**, processing and transportation systems in the Area, for the production and marketing of metals, as well as the decommissioning and closure of mining operations.

'Explore' and 'Exploration', as applicable, mean the searching for Resources in the Area with exclusive rights, the analysis of such Resources, **the use and testing of recovery systems and equipment**, processing facilities and transportation systems and the carrying out of studies of the environmental, technical, economic, commercial and other appropriate factors that must be taken into account in Exploitation."

More importantly, the Draft Exploitation Regulations do not foresee the testing of equipment or mining systems as a precondition for providing an application for exploitation. It merely requests that the results from any testing activities conducted during exploration to be reported pursuant to the templates for the Mining Workplan and Environmental Impact Statement (Annex II and Annex IV, 1.3 of

[15] ISBA/25/C/WP.1, Schedule

[16] ISBA/25/C/WP.1, Draft Regulations 98(1)(e) and 99(1)(d).

the Draft Regulations, respectively). In other words, a contractor may apply for an exploitation contract (and eventually proceed with commercial production) without first successfully demonstrating, via testing, its ability to avoid, minimize and mitigate the harmful effects that will arise from its activities *in situ* to levels which conform with either the standards set in the applicable Regional Environmental Management Plan or eventual ISA Standards and Guidelines. As will be observed later on, the Draft Exploitation Regulations could make it a requirement for contractors to submit compulsory test mining studies as part of the items required to accompany an application for an exploitation plan of work, which will be considered by the ISA in deciding whether or not to approve the application.

Items to accompany an application for a plan of work for exploitation (ISBA/25/C/WP.1)

Draft Regulation 7(3)

"An application shall be prepared in accordance with these regulations and accompanied by the following:

(a) The data and information to be provided pursuant to section 11.2 of the standard clauses for Exploration contracts, as annexed to the relevant Exploration Regulations;
(b) A Mining Workplan prepared in accordance with annex II to these regulations;
(c) A Financing Plan prepared in accordance with annex III to these regulations;
(d) An Environmental Impact Statement prepared in accordance with regulation 47 and in the format prescribed in annex IV to these regulations;
(e) An Emergency Response and Contingency Plan prepared in accordance with annex V to these regulations;
(f) A Health and Safety Plan and a Maritime Security Plan prepared in accordance with annex VI to these regulations;
(g) A Training Plan in fulfilment of article 15 of annex III to the Convention, prepared in accordance with the Guidelines;
(h) An Environmental Management and Monitoring Plan prepared in accordance with regulation 48 and annex VII to these regulations;
(i) A Closure Plan prepared in accordance with regulation 59 of and annex VIII to these regulations; and
(j) An application processing fee in the amount specified in appendix II."

Furthermore, while the Draft Exploitation Regulations do make reference to a document known as a 'feasibility study', which much be submitted at least 12 months prior to the proposed commencement of commercial production, there is no explicit requirement for testing activities to be conducted to support the preparation of this study. In other words, *ex situ* testing and modelling could be used to prepare this study, without the contractor actually being required to conduct *in situ* testing. The feasibility study could eventually play an important role, since it influences the decision on whether or not a plan of work should be revised prior to commercial production. In this respect, it is also a concern that the determination of whether or not a 'material change' to the plan of work is needed is placed in the hands of the ISA Secretary-General and not the Legal and Technical Commission (LTC) or Council of the ISA. The concept of a feasibility study and how this can be viewed alternatively (namely, in the context of a provisional exploitation contract) is discussed further in chapter 2.4.5.5.

"Feasibility Study" under the Draft Exploitation Regulations

Draft Regulation 25(1)

At least 12 months prior to the proposed commencement of production in a Mining Area, the Contractor shall provide to the Secretary-General a Feasibility Study prepared in accordance with Good Industry Practice, taking into account the Guidelines. In the light of the Feasibility Study, the Secretary-General shall consider whether any Material Change needs to be made to the Plan of Work in accordance with regulation 57 (2). If he or she determines that any such Material Change needs to be made, the Contractor shall prepare and submit to the Secretary-General a revised Plan of Work accordingly.

Schedule: Use of terms and scope

"Feasibility Study" means a comprehensive study of a mineral deposit in which all geological, engineering, legal, operating, economic, social, environmental and other relevant factors are considered.

2.3.3 The Exploration Regulations

With respect to the Mining Code and the Exploration Regulations, taking the example of the regulations governing the exploration of polymetallic nodules (ISBA/19/A/9), 'exploration' is defined as to include "the use and testing of recovery systems and equipment, processing facilities and transportation systems." Contractors are also required to provide a "guarantee of its financial and technical capability to comply promptly with emergency orders", which should be made "prior to the commencement of testing of collecting systems and processing operations". Finally, in its annual reports and the submission of data and information at the expiry of the exploration contract, contractors are required to submit "information in sufficient detail on [...] the equipment used to carry out the exploration work, including the results of tests conducted of proposed mining technologies, but not equipment design data", as well as a "statement of the quantity of polymetallic nodules recovered as samples or for the purpose of testing". Thus, similar to the provisions of the UNCLOS, the Exploration Regulations for all three mineral types do not specifically require contractors to conduct test mining activities, although the wording adopted seemingly suggests that testing of equipment during the exploration stage is presumed or at least expected.

General Definitions (ISBA/19/A/9)

Part I, Regulation 1

3. For the purposes of these Regulations:

(a) "Exploitation" means the recovery for commercial purposes of polymetallic nodules in the Area and the extraction of minerals therefrom, including the **construction and operation of mining, processing and transportation systems**, for the production and marketing of metals;

(b) "Exploration" means the searching for deposits of polymetallic nodules in the Area with exclusive rights, the analysis of such deposits, the use and **testing of recovery systems and equipment, processing facilities and transportation systems** and the carrying out of studies of the environmental, technical, economic, commercial and other appropriate factors that must be taken into account in exploitation;

...

(e) "Prospecting" means the search for deposits of polymetallic nodules in the Area, including estimation of the composition, sizes and distributions of deposits of polymetallic nodules and their economic values, without any exclusive rights;

2.3.3.1 Recommendations by the Legal and Technical Commission

The last set of instruments for consideration are recommendations made by the Legal and Technical Commission (LTC) of the ISA. While these recommendations are strictly speaking of a non-binding nature, they possess a "strong persuasive influence, and contractors are expected to comply with them".[17] Two of such LTC recommendations are relevant here. The first is the 2015 LTC 'Recommendations for the guidance of contractors for the reporting of actual and direct exploration expenditure' (ISBA/21/LTC/11). Proceeding on the premise that "some element of the costs of developing a mine site to be set off against the eventual income from production", the LTC recommends that actual and

[17] Markus, T. and Singh, P. (2016), 'Promoting Consistency in the Deep Seabed: Addressing Regulatory Dimensions in Designing the International Seabed Authority's Exploitation Code', Review of European, Comparative and International Environmental Law 25:3, 347

direct expenditure arising from "the use and testing of recovery systems and equipment, processing facilities and transportation systems" at the exploration stage, including field investigations for mining technology development, be included in financial reports submitted by contractors.

The second is the 2020 version of LTC 'Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area' (ISBA/25/LTC/6/Rev.1). This revised version of the recommendations covers the topic of test mining in the context of exploration activities (see also chapter 5.4). It is to be noted, therefore, that the said recommendations do not apply to the exploitation stage. The salient points are as follows:

- In the document, test mining is largely viewed with an environmental perspective. This affirms that test mining is a useful activity to more realistically ascertain the environmental impacts that will occur from activities in the Area. It is emphasized that the "baseline, monitoring and impact assessment studies are likely to be the primary inputs of the environmental impact assessment for commercial mining". Testing and monitoring the related effects is also instrumental to "establish procedures to demonstrate that no serious harm to the environment" will be caused by activities in the Area.
- Test mining is considered among the activities which cause considerable impacts on the marine environment and therefore require its own environmental impact assessment.
- Contractors are required to provide the ISA with an Environmental Impact Statement, EIS.
- The requirement for contractors to demonstrate their ability to manage the associated environmental impacts of their exploration activities, including test mining, is a critical requirement, as well as reinforces the earlier averment that information and knowledge gathered through test mining will strengthen the ability of the ISA to better govern and regulate activities in the Area.
- Gathering environmental information before test mining, as well as the extensive monitoring of conditions prior to, during and after test mining, are indispensable measures with a view to enable the prediction of changes to be expected from the development and use of larger-scale commercial systems.
- Contractors are required to provide the ISA "some or all" of the information on the outcome of e.g. test mining activities listed in sections C and D "depending on the specific activity to be carried out".
- The information will be reviewed by LTC only for completeness, accuracy and statistical reliability, which is the basis for recommending the inclusion of the EIS in the contractor´s work programme.
- Contractors can conduct test mining activities individually or collaboratively.

Thus, the recommendations to contractors clearly consider that test mining projects during the exploration stage would cause negative environmental effects, and thus an environmental impact assessment is needed. Furthermore, the recommendations provide a framework within which the individual contractors can chose their direction. As there are no compulsory minimal standards set for e.g. the monitoring programme accompanying the test and criteria for a decision-making do not address the scientific quality of the programme, operators seem to be free to design not only the technical aspects of an *in situ* test but also control the monitoring output (see e.g. chapter 5.4). Finally, the utilization of the information gathered by the test mining projects is not clearly systematized with the aim of putting the ISA in the position to better manage the conduct of activities in the Area.

2.3.3.2 Liability for Test Mining and Guarantees Prior to Test Mining at the Exploration Stage

Test mining in itself is a mining activity, and therefore can cause significant environmental impacts (see LTC Recommendations ISBA/25/LTC/6/Rev.1). As clarified by the 2011 Advisory Opinion delivered by the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea, contractors and sponsoring States are responsible under international law for their conduct of activities in the

Area and the consequences arising therefrom, which encompasses both the exploration and exploitation stages. Thus, contractors are contractually liable for any wrongful acts and sponsoring States (if such wrongful acts are attributable to them) may be responsible under international law for failing to meet due diligence or direct obligations. This potential to attract liability applies equally to test mining as it applies to other activities of the contractor that are capable of causing significant environmental harm, such as sampling, and of course, commercial production.

As with the case under any other circumstances, if serious harm or a threat of serious harm does occur during test mining activities in the exploration stage, the contractor must take immediate measures to rectify the situation (which may include stopping operations). It also entails the possibility of the Council issuing emergency orders.[18] If a contractor fails to comply with such orders, the Council shall immediately step in to take necessary measures (by itself or via arrangements with others on its behalf) to prevent, contain and minimize such serious harm or threat of serious harm.[19] Here, sponsoring States also have a direct obligation to "take measures to ensure the provision of guarantees in the event of an emergency order by the Authority for protection of the marine environment".[20]

In this regard, all three sets of Exploration Regulations require the contractor to provide a guarantee, before testing of collecting systems and processing operations, of its financial and technical capability to comply with emergency orders, and recognizes the need to the Council to be able take immediate measures in the event of the failure or inaction of the contractor to comply. For example, the Exploration Regulations for Polymetallic Nodules (ISBA/19/C/17) provide as follows:

> *"In order to enable the Council, when necessary, to take immediately the practical measures to prevent, contain and minimize the serious harm or threat of serious harm to the marine environment referred to in paragraph 7, the contractor, prior to the commencement of testing of collecting systems and processing operations, will provide the Council with a guarantee of its financial and technical capability to comply promptly with emergency orders or to assure that the Council can take such emergency measures. If the contractor does not provide the Council with such a guarantee, the sponsoring State or States shall, in response to a request by the Secretary-General and pursuant to articles 139 and 235 of the Convention, take necessary measures to ensure that the contractor provides such a guarantee or shall take measures to ensure that assistance is provided to the Authority […]."*[21]

However, the form and scope of such a 'guarantee' remain unclear to this day. Since the Council is required to take action in instances where serious harm has occurred or if a threat of serious harm persists due to testing operations and the contractor fails to comply with emergency orders, it would seem to be reasonable that a contractor's guarantee should include recourse to the necessary financial resources needed to address the situation. Indeed, a debate on 'appropriate forms of guarantee' did take place at the Council when the initial regulations for the exploration of polymetallic nodules were under negotiations. In adopting the regulations in 2000, the Council, mindful of the importance to "ensure effective protection for the marine environment from harmful effects that may arise at the phase of testing of collecting systems and processing operations", simultaneously decided to:

a) Revisit and consider the need for appropriate forms of guarantee, prior to the phase of testing of collecting systems and processing operations, to enable the Council to take immediate and

[18] Regulation 33(6) of ISBA/19/C/17.

[19] Regulation 33(7) of ISA/19/C/17.

[20] ITLOS, 2011. Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to Activities in the Area, Case No. 17, Advisory Opinion (ITLOS Seabed Disputes Chamber Feb. 1, 2011), para 138, at https://www.itlos.org/fileadmin/itlos/documents/cases/case_no_17/adv_op_010211.pdf.

[21] Regulation 33(8) of ISBA/19/C/17.

necessary action to "implement an emergency order in the event of failure or inability on the part of a contractor to comply with such orders"; and

b) Request the Secretariat to "carry out studies of appropriate instruments or arrangements […] and to report to the Council on the outcome […] prior to consideration of the matter".[22]

As far as it is known, the Secretariat has not prepared this study, and neither has the Council returned to this topic for further debate. Moreover, it is not known if any of the contractors planning to conduct testing operations in the near future have indeed provided any form of guarantee to the Council, as required by the Exploration Regulations. Given the fact that *in situ* testing of collecting systems in the Area are expected to take place in 2021, the ability of the contractors to respond to emergency orders in the event that testing operations goes awry, and the ability of the Council to step in if this becomes necessary, is called into question. Consequently, it is essential for the Council to revisit this topic as a matter of priority.

Finally, it is pertinent to note that while the current version of the Draft Exploitation Regulations contains express provisions on requirements for environmental performance guarantees and insurance,[23] the Exploration Regulations do not provide for any such requirements. Consequently, it is ever so important to ensure that appropriate forms of guarantees are made available prior to testing during the exploration stage.

2.4 The Legal Mandate to Require Test Mining

2.4.1 Legal Mandate of the ISA

Article 145 of UNCLOS covers to the environmental dimension of the ISA's mandate over the resources of the Area. This includes the obligation to ensure that necessary measures are taken to ensure the effective protection of the marine environment from activities in the Area. Article 153(4) requires the ISA to exercise 'such control over activities in the Area' to ensure compliance with UNCLOS, the Mining Code, as well as individual licenses (plan of works). There are also ample provisions in Part XI of UNCLOS and the 1994 IA that empower the ISA to impose necessary requirements for environmental protection.[24] Moreover, certain provisions from Part XII of UNCLOS (on the protection and preservation of the marine environment would also support the compulsory requiring of test mining as a necessary measure to ensure the protection of the marine environment.[25] Apart from that, in carrying out its responsibilities, the ISA is committed to meet established and emerging norms of international law, such as the common heritage of mankind, sustainable development, the precautionary approach and adaptive governance. In fact, given that the ISA is entrusted to act on behalf of and for the benefit of mankind as a whole, the ISA is entitled to pursue measures that help safeguard the interests of humanity. As such, the ISA has the power to require test mining prior to the conduct of actual mining activities either through 'rules, regulations and procedures' that it may adopt or by inserting specific requirements into the contract (*i.e.* plan of work) that it enters into with the operator. While it is prudent for the ISA to insert specific requirements on test mining into each plan of work (which then make it a contractual obligation for contractors), it is necessary for the ISA to adopt clear and binding rules, regulations or procedures on testing mining so as to establish a transparent and level playing field.

2.4.2 Test Mining and the Obligation to Assess Environmental Impacts

There is a clear obligation for contractors to assess the environmental impacts of their activities in the Area. Moreover, sponsoring States have a due diligence obligation to ensure that the environmental

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[22] Council decision dated 13 July 2000, ISBA/6/C/12.

[23] ISBA/25/C/WP.1, Draft Regulation 26 and 36, respectively.

[24] See, e.g. Article 165(2)(f) and Annex III, Article 17(2(f) of UNCLOS; Section 1(5)(g), (h) (i), (k) of the Annex to the 1994 IA.

[25] See, e.g. Article 192, 194(1) and (5), 196, 197, 199, 200, 201, 204, 205, 206, and 209 of UNCLOS.

impacts of activities carried out by their sponsored entities are appropriately assessed as required by the rules, regulations and procedures of the ISA, any applicable standards, guidelines or recommendations, as well as contractual terms. The failure to conduct an environmental impact assessment when this is required under the rules, regulations and procedures of the ISA as well as under the terms of a contract could result in liability on the part of the contractor (pursuant to the contract) and the sponsoring State (pursuant to international law). In this respect, the 2011 Advisory Opinion delivered by the Seabed Disputes Chamber of the International Tribunal for the Law of the Sea is instructive.[26]

Excerpts from the 2011 Advisory Opinion on Environmental Impact Assessments

"141. The obligation of the contractor to conduct an environmental impact assessment is explicitly set out in section 1, paragraph 7, of the Annex to the 1994 Agreement as follows: "An application for approval of a plan of work shall be accompanied by an assessment of the potential environmental impacts of the proposed activities […]". The sponsoring State is under a due diligence obligation to ensure compliance by the sponsored contractor with this obligation.

142. […] The sponsoring State is obliged not only to cooperate with the Authority in the establishment and implementation of impact assessments, but also to use appropriate means to ensure that the contractor complies with its obligation to conduct an environmental impact assessment.

[…]

144. As clarified in [the applicable LTC Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area], certain activities require "prior environmental impact assessment, as well as an environmental monitoring programme"

145. It should be stressed that the obligation to conduct an environmental impact assessment is a direct obligation under the Convention and a general obligation under customary international law."

At this juncture, it is important to acknowledge test mining as a means of assessing "the potential environmental impacts of the proposed activities", since systems and operational testing at a large-enough scale and long-enough duration during the exploration or pre-commercial exploitation stage respectively would help reveal the potential environmental impacts of commercial exploitation with greater reliability and accuracy. In this sense, it is arguable that the requirement to conduct test mining activities is indispensable if contractors are to truly meet their contractual obligations, as well as sponsoring States their due diligence obligations. That said, test mining is a mining activity and is capable of resulting in significant environmental harm in itself. As such, proposed test mining activities are subjected to its own environmental impact assessments (see also chapter 4, and ISBA/25/LTC/Rev.1). In order to better understand the requirements to assess environmental impacts at the various stages, it would be necessary to consider them in turn, namely, the preliminary assessment when submitting an application for the approval of a plan of work for exploration, the assessment of environmental impacts during the exploration stage, and the submission of an environmental impact statement when submitting an application for the approval of a plan of work for exploitation (as per the current Draft Exploitation Regulations).

2.4.2.1 Preliminary assessment of environmental impacts: prior to the exploration stage

When submitting an application to the ISA for the approval of a plan of work for exploration activities, an applicant would have to submit, among others, information on the following: "a general description and a schedule of the proposed exploration programme, including a programme of activities for the

[26] ITLOS, 2011. Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to Activities in the Area, Case No. 17, Advisory Opinion (ITLOS Seabed Disputes Chamber Feb. 1, 2011), at https://www.itlos.org/fileadmin/itlos/documents/cases/case_no_17/adv_op_010211.pdf [hereinafter Advisory Opinion].

immediate five-year period, such as studies to be undertaken in respect of the environmental, technical, economic and other appropriate factors that must be taken into account in exploration", "a description of the programme for oceanographic and environmental baseline studies [...] that would enable an assessment of the potential environmental impact", and "a preliminary assessment of the possible impact of the proposed exploration activities on the marine environment".[27] In this respect, it is understood that the submission of initial data and the preliminary assessment of impacts will be of a general nature that is mostly descriptive and to a large extent reliant on minimal data obtained during prospecting as well as predominantly premised on the results of predictive modelling. In other words, the threshold of environmental information required from an applicant at this stage is low, which is understandable since proper exploration activities are yet to begin.

2.4.2.2 Assessment of environmental impacts for certain activities: during the exploration phase

If an applicant is successful in its application for an approval of a plan of work for exploration activities, an exploration contract will be drawn up by the ISA and executed by the parties. Thus, now as an exploration contractor, the contractor would have exclusive rights to explore for the resource type within the contract area. As will be explored later in Chapter 4, exploration activities are considered to be less harmful to the marine environment (as opposed to actual commercial mining), and as a general rule, contractors are not required to assess the environmental impacts of their exploration activities. However, it should be stressed that this is a general rule, and for certain exploration activities that are capable to cause environmental impacts, an assessment will be required. This is confirmed by in the LTC's Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area (ISBA/25/LTC/6/Rev.1), and test mining explicitly requires prior environmental impact assessment, as well as an environmental monitoring programme to be carried out during and after the specific activity. In this respect, it is to be noted that if a contractor does not plan to conduct test mining activities during the exploration stage, for example, if it does not desire to subsequently apply to exploit the resources, there would be no need to conduct environmental impact assessments. However, when an exploration contractor wishes to conduct the testing of equipment or systems during the course of the exploration contract, an environmental impact assessment is necessary and a contractor must submit the environmental impact statement to the ISA at least one year prior to the activity. It appears to be entirely possible for a contractor to combine several test mining projects into one environmental impact assessment process, procedurally speaking, provided separate EISs and monitoring programmes are prepared in accordance with document ISBA/25/LTC/6/Rev.1 for the individual testing projects as necessary.

2.4.2.3 Environmental impact assessment: prior to the exploitation stage

Pursuant to the current version of the Draft Exploitation Regulations, an applicant submitting an application to the ISA for the approval of a plan of work for exploitation is required to submit an environmental impact statement alongside the application. It is important to stress here that this environmental statement will assess the impacts that are expected to occur during the subsistence of the plan of work for exploitation activities, including and especially concerning the commercial-scale extraction of the resource type of the proposed mining operation. In this respect, it is understood, especially at the initial stages of the transition by the ISA from exploration to exploitation, that an exploration contractor desiring to eventually apply for an exploitation contract would make full use of the duration of its exploration contract to gather all information and data that are necessary to complete its application to the ISA. This includes, obviously, already undergoing the necessary environmental impact assessment process during the exploration phase in order to produce the environmental impact statement as

[27] See Regulation 18 of the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area and related matters (ISBA/19/C/17), as well as Regulation 20 of both the Regulations on Prospecting and Exploration for Polymetallic Sulphides in the Area (I SBA/16/A/12 Rev. 1) and the Regulations on Prospecting and Exploration for Cobalt-rich Ferromanganese Crusts in the Area (ISBA/18/A/11) respectively.

required under the Draft Exploitation Regulations. Test mining activities conducted during exploration and the results obtained from all the accompanying monitoring programmes, further supported by models, would obviously feed into this process.

2.4.2.4 Analysis

The first point to note is that the current version of the Draft Exploitation Regulations do not anticipate any further environmental impact assessments once the application for exploitation activities has been approved. It will be recalled that this is in contrast with the exploration stage, where the ISA recommendations require environmental impact statements for certain activities such as test mining projects. This distinction in treatment is fully understandable, because exploration activities are generally not deemed to be harmful to the marine environment (with the exception of certain specific activities such as testing), whereas exploitation-related activities, due to its very nature of large-scale extraction, lifting and waste discharge, are known to cause environmental impacts. As such, test mining activities that are conducted within the exploitation stage would be covered by the earlier environmental impact statement, provided that the type of technology or method of extraction remains the same. Indeed, it would be worth considering if the ISA should require an exploitation contractor whose technologies or methods have changed drastically since the earlier environmental impact assessment to undergo a new assessment process, as well as to conduct fresh impact assessments if it wishes to test new technologies or methods that were not included in the previous assessment. Currently, the Draft Exploitation Regulations envisages that a contractor may wish to modify its plan of work, as well as to revise its Environmental Management and Monitoring Plan, or be required to do so by the ISA. In this case, a material change would require the approval of the ISA, however, this does not appear to have any implications in relation to requiring a new environmental impact assessment process or to revise the previously submitted – and already accepted when considering the exploitation application – environmental impact statement.

Another point to stress is that from an environmental management perspective, it would be necessary for most, if not all, testing activities to already take place at the exploration stage, so that the possible impacts from commercial scale mining can already be foreseeable and necessary measures can be taken. Thus, testing activities during the exploration phase can comprise of one or more projects, until the contractor has shown that its mining system is functional and the environmental impacts can be minimised and controlled. This would mean that the mining system, including its riser, should be sufficiently tested out at the exploration phase to an extent that the environmental impacts from upscaling can be reliably predicted and the ISA determines that this does not go beyond the applicable environmental thresholds. Of course, the ISA must first ensure that it has the necessary expertise to evaluate the test mining results.

The final point to observe is that the conduct of test mining, be it at the exploration or at the exploitation phase, is not compulsory under the Exploration Regulations and the current version of the Draft Exploitation Regulations. This is not satisfactory, as will be discussed in Chapter 6, given that it would be very difficult – if not impossible – to properly assess the environmental impacts that are to be expected during commercial mining without having a sufficient amount of pilot or small-scale activities (and robust monitoring programmes that accompany these activities) in order to gather reliable data that can be used to validate predictive modelling. Therefore, given that vast amount of scientific uncertainties and unknowns about the impacts of commercial mining on the deep sea and its ecosystems, at least at the initial stages of the transition from exploration to exploitation, the ISA should recognise that the use of models alone will not suffice and contractors must be compelled to conduct *in situ* testing. Indeed, Chapter 7 will consider how test mining should be re-envisioned, including to impose compulsory requirements for test mining in order to provide sufficient effective and reliable data for the ISA to evaluate mining applications and make informed decisions. In any event, even though test mining is not currently made compulsory in the regulations of the ISA, it is argued here that the obligation to assess environmental impacts in relation to activities in the Area (as discussed earlier on) already requires the conduct of test mining albeit implicitly. This argument is premised on the fact that it would not be possible to properly ascertain the extent of the environment impacts of commercial mining without sufficient *in situ* testing activities especially during the exploration phase. Moreover, since test mining during the exploration phase is mining and known to cause environmental harm, these activities also require its own environmental impact assessments. In the following, further support for this argument to obligate contractors to conduct test mining will be explored.

2.4.3 Test Mining, the Precautionary Approach and Adaptive Management

It is now trite that the precautionary approach (or principle) is applicable to deep seabed mining activities in the Area. The 2011 Advisory Opinion delivered by the Seabed Disputes Chamber of ITLOS made this explicitly clear,[28] and this viewpoint is also firmly supported in literature.[29]

Excerpts from the 2011 Advisory Opinion on the Precautionary Approach

"127. The provisions of the aforementioned [Exploration] Regulations transform this non-binding statement of the precautionary approach in the Rio Declaration into a binding obligation. The implementation of the precautionary approach as defined in these Regulations is one of the obligations of sponsoring States.

[…]

131. Having established that under the [Exploration] Regulations, both sponsoring States and the Authority are under an obligation to apply the precautionary approach in respect of activities in the Area, it is appropriate to point out that the precautionary approach is also an integral part of the general obligation of due diligence of sponsoring States, which is applicable even outside the scope of the Regulations. The due diligence obligation of the sponsoring States requires them to take all appropriate measures to prevent damage that might result from the activities of contractors that they sponsor. This obligation applies *in situ*ations where scientific evidence concerning the scope and potential negative impact of the activity in question is insufficient but where there are plausible indications of potential risks. A sponsoring State would not meet its obligation of due diligence if it disregarded those risks. Such disregard would amount to a failure to comply with the precautionary approach.

[…]

133. […] Thus, the precautionary approach […] is a contractual obligation of the sponsored contractors whose compliance the sponsoring State has the responsibility to ensure."

It is particularly relevant to activities in the Area "*because it helps to compensate for the paucity of standardised environmental data that is needed for robust decision-making*" and "*protect both the environment and the common heritage of mankind*".[30] Nevertheless, even if the precautionary approach may apply under particular circumstances, warranting the exercise of caution in decision-making in cases of scientific uncertainty and potential environmental risks, it does not necessarily mean that then the burden of proof is reversed, *i.e.* placed on the proponent of a proposed activity to show that it is safe.[31] In fact, it is typical in most cases that the burden of proof is not reversed, unless there is clear

[28] The 2011 Advisory Opinion, at paragraphs 125-135.

[29] See especially, Jaeckel, A., 2017. The International Seabed Authority and the Precautionary Principle: Balancing Deep Seabed Mineral Mining and Marine Environmental Protection. Brill/Nijhoff; Halfar, J. and Fujita, R.M., 2002. Precautionary management of deep-sea mining, Marine Policy 26:2, 103-106.

[30] Durden, J.M., Murphy, K., Jaeckel, A., Van Dover, C.L., Christiansen, S., Gjerde, K., Ortega, A., Jones, D.O.B., 2017. A procedural framework for robust environmental management of deep-sea mining projects using a conceptual model. Marine Policy 84 (Supplement C), 193-201.

[31] Trouwborst, A., 2016. Precautionary Rights and Duties of States, Martinus Nijhoff, at pp. 222-227.

evidence supporting such reversal.[32] It has been observed that in the case of the ISA regime, although there is a presumption that deep seabed mining activities are harmful, the general burden of proof is not reversed in a strict sense.[33] One reason cited for this observation is that contractors or applicants for mining contracts "*do not have to prove an absence of risk*" under the current rules, regulations and procedures of the ISA (in contrast to an earlier draft that contained a provision stating that *'activities in the Area shall only take place if they do not cause serious harm to the marine environment.').*

In this respect, it may be possible to make use of the Draft Exploitation Regulations as a window of opportunity by inserting provisions that make test mining a compulsory pre-requisite to obtain an exploration contract and to proceed with commercial exploitation (see chapter 7 for a through discussion on a proposal made by Germany in 2019 to this effect). This could effectively reverse the burden of proof, at lease on a *prima facie* level, by requiring mining proponents to demonstrate that deep seabed mining activities will not cause serious harm to the marine environment, or even that the effective protection of the marine environment from the harmful effects of such activities can be ensured. Of course, if such a reversal of the burden of proof is to become possible, the ISA would first have to comprehensively determine environmental and conservation objectives, as well as thresholds of harm and the accompanying indicators for "serious harm", "harmful effects" and "effective protection" (or at the very least, for "serious harm").[34]

Coincidentally, the recent EU Biodiversity Strategy for 2030 delivers a strong statement to the effect that exploitation activities should not be allowed to commence until "*the technologies and operational practices are able to demonstrate no serious harm to the environment, in line with the precautionary approach*".[35]

Excerpt from the EU Biodiversity Strategy for 2030

"In international negotiations, the EU should advocate that marine minerals in the international seabed area cannot be exploited before the effects of deep-sea mining on the marine environment, biodiversity and human activities have been sufficiently researched, the risks are understood and the technologies and operational practices are able to demonstrate no serious harm to the environment, in line with the precautionary principle [...]."

Thus, it is clear that test mining can play an important role in the environmental governance of activities in the Area and "*provide opportunities to adapt practices and management to ensure that precaution is prioritised*".[36] If the conduct of test mining is further regulated and imposed as a compulsory obligation for contractors from an environmental perspective, this could be seen as an implementation of a strong form of precaution, thereby increasing the legitimacy of exploitation activities in the Area.

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32 See e.g. the decision of the International Court of Justice in the Pulp Mills on the River Uruguay (Argentina v. Uruguay), Judgment, ICJ Reports 2010, p. 14, paragraph 164, at https://www.icj-cij.org/public/files/case-related/135/135-20100420-JUD-01-00-EN.pdf.

33 Jaeckel, A., 2017. The International Seabed Authority and the Precautionary Principle: Balancing Deep Seabed Mineral Mining and Marine Environmental Protection. Brill/Nijhoff, at pp. 270-272.

34 Kirkham, N., Gjerde, K., Wilson, M., 2020. DEEP-SEA mining: Policy options to preserve the last frontier - Lessons from Antarctica's mineral resource convention. Marine Policy 115: 103859. For an analysis on 'serious harm' in the context of deep seabed mining, see Levin, L.A., Mengerink, K., Gjerde, K.M., Rowden, A.A., Van Dover, C.L., Clark, M.R., Ramirez-Llodra, E., Currie, B., Smith, C.R., Sato, K.N., Gallo, N., Sweetman, A., Lily, H., Armstrong C., Brider, J., 2016. Defining "serious harm" to the marine environment in the context of deep-seabed mining. Marine Policy 74, 245-259.

35 EU Biodiversity Strategy for 2030: Bringing nature back into our lives, 20 May 2020, COM/2020/380, at https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590574123338&uri=CELEX%3A52020DC0380

36 Durden, J.M., Murphy, K., Jaeckel, A., Van Dover, C.L., Christiansen, S., Gjerde, K., Ortega, A., Jones, D.O.B., 2017. A procedural framework for robust environmental management of deep-sea mining projects using a conceptual model. Marine Policy 84 (Supplement C), 193-201.

Apart from the precautionary approach, another important approach when dealing with uncertainty especially in relation to nascent and anticipated high-risk activities such as deep seabed mining is adaptive management.[37] At its essence, adaptive management is "*a form of structured decision-making that addresses this uncertainty by monitoring the effects of the management plan and assessing the results of the monitoring with the intention to learn from the results and incorporate findings into revised models for management actions*".[38] In particular, it seeks to foster flexibility in environmental management so as to enable quick adaptation of activities in the light new discoveries, information or knowledge as well as experience.[39] Adaptive management strategies can be applied by the ISA, as regulator, e.g. through rules, regulations and procedures but more quickly through standards or guidelines as well as recommendations (although the latter two are non-binding), and by contractors through a continuous revision of their plan of work and other instruments such as the Environmental Management and Monitoring Plan (EMMP).[40] However, in order for this strategy to work, it is necessary to have clear and measurable environmental management objectives beforehand.[41]

Given that the ISA is tasked to represent mankind as a whole when developing the mineral resources of the Area and must ensure the effective protection of the marine environment from the harmful effects of mining activities despite the many uncertainties, it has been argued that the ISA must strive to strengthen its knowledge base.[42] As such, the ISA should actively aim to reduce uncertainties,[43] and therefore adopt an "active adaptive management" strategy (*i.e.* learning by doing),[44] unless circumstances justify a "passive adaptive management" strategy (*i.e.* learning while doing).[45] In any case, given the novelty of the activity and the fact that the environmental impacts cannot be easily modelled or predicted, one option that could be considered by the ISA is a "contingent" or "staged" approvals mechanism, wherein a provisional approval to exploit (limited in scale and scope) is granted at first, and subsequently subject to expansion if the contractor can demonstrated acceptable environmental outcomes.[46] In this respect, "*adaptive management might include permitting test mining operations […] in order to then assess the environmental effects and adjust policies and environmental management*

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37 Jones, D.O.B., Durden, J.M., Murphy, K., Gjerde, K.M., Gebicka, A., Colaço, A., Morato, T., Cuvelier, D., Billett, D.S.M., 2019. Existing environmental management approaches relevant to deep-sea mining. Marine Policy 103, 172-181.

38 Jones, D.O.B., Durden, J.M., Murphy, K., Gjerde, K.M., Gebicka, A., Colaço, A., Morato, T., Cuvelier, D., Billett, D.S.M., 2019. Existing environmental management approaches relevant to deep-sea mining. Marine Policy 103, 172-181.

39 Frohlich, M. F., C. Jacobson, P. Fidelman, and T. F. Smith. 2018. The relationship between adaptive management of social-ecological systems and law: A systematic review. Ecology and Society 23(2):23.

40 Jones, D.O.B., Durden, J.M., Murphy, K., Gjerde, K.M., Gebicka, A., Colaço, A., Morato, T., Cuvelier, D., Billett, D.S.M., 2019. Existing environmental management approaches relevant to deep-sea mining. Marine Policy 103, 172-181.

41 Jaeckel, A., 2016. Deep Seabed Mining and Adaptive Management: The Procedural Challenges for the International Seabed Authority. Marine Policy 70, 205-211.

42 Ginzky, H., Singh, P.A., Markus, T., 2020. Strengthening the International Seabed Authority's knowledge-base: Addressing uncertainties to enhance decision-making. Marine Policy, 103823.

43 Ginzky, H., Singh, P.A., Markus, T., 2020. Strengthening the International Seabed Authority's knowledge-base: Addressing uncertainties to enhance decision-making. Marine Policy, 103823.

44 Hyman, J., Stewart, R.A., Sahin, O., 2021. Adaptive management of deep-seabed mining projects: a systems approach. Integrated Environmental Assessment and Management DOI: https://doi.org/10.1002/ieam.4395.

45 See International Seabed Authority, 2016. Environmental Assessment and Management for Exploitation of Minerals in the Area, Technical Study No. 16, at https://isa.org.jm/files/files/documents/ts16_finalweb_0.pdf, p. 25.

46 Craik, N., 2020. Implementing adaptive management in deep seabed mining: Legal and institutional challenges, Marine Policy 114: 103256; International Seabed Authority, 2013. Towards the development of a regulatory framework for polymetallic nodule exploitation in the Area. International Seabed Authority, Technical Study No. 11, Kingston, Jamaica, pp. 1-89.

based on the new information gained".[47] Knowledge obtained from test mining can then inform the progression of the industry, including to make future stages of exploitation "contingent on the successful ability to predict and take action to minimize impacts and associated biodiversity loss".[48]

Hence, test mining clearly has a role to play in terms of integrating adaptive management into the ISA decision-making processes,[49] in particular with respect to the testing of technologies through well-designed trials.[50] Two obstacles arise, however. First, such contractors may view this approach as commercially unviable, seeing that they may be required to do far more than what they have bargained for and at potentially much higher costs than they are willing to invest, especially without the absolute certainty that they would be able to proceed with commercial exploitation in the end.[51] Second, since the relationship between the ISA and the contractor is governed by a contract, and security of tenure is assured by the terms of the contract, it would be difficult for the ISA to impose any major changes in the contract once it has been awarded.[52] However, requiring test mining and having functional regulatory checkpoints where appropriate are clearly necessary if the ISA is to truly meet its obligation to ensure the effective protection of the marine environment (see chapter 7).

2.4.4 Test Mining in the Light of Best Available Scientific Evidence, Best Environmental Practices and Best Available Techniques

In terms of 'Best Available Scientific Evidence' (BASE), 'Best Environmental Practices' (BEP) and 'Best Available Techniques' (BAT), the current version of the Draft Exploitation Regulations makes widespread references to all three terms.

BASE, BEP and BAT under the Draft Exploitation Regulations

Schedule: Use of terms and scope

"Best Available Scientific Evidence" means the best scientific information and data accessible and attainable that, in the particular circumstances, is of good quality and is objective, within reasonable technical and economic constraints, and is based on internationally recognized scientific practices, standards, technologies and methodologies.

"Best Available Techniques" means the latest stage of development, and state-of-the-art processes, of facilities or of methods of operation that indicate the practical suitability of a particular measure for the prevention, reduction and control of pollution and the protection of the Marine Environment from the harmful effects of Exploitation activities, taking into account the guidance set out in the applicable Guidelines.

"Best Environmental Practices" means the application of the most appropriate combination of environmental control measures and strategies, that will change with time in the light of improved knowledge, understanding or technology, taking into account the guidance set out in the applicable Guidelines.

47 Jaeckel, A., 2016. Deep Seabed Mining and Adaptive Management: The Procedural Challenges for the International Seabed Authority. Marine Policy 70, 205-211.

48 Niner, H.J., Ardron, J.A., Escobar, E.G., et al, 2018. Deep-Sea Mining With No Net Loss of Biodiversity—An Impossible Aim. Frontiers in Marine Science 5 (53).

49 International Seabed Authority, 2017. Towards An Environmental Strategy for the Area, ISA Technical Study 17, at https://isa.org.jm/files/files/documents/berlinrep-web.pdf.

50 Durden, J.M., Murphy, K., Jaeckel, A., Van Dover, C.L., Christiansen, S., Gjerde, K., Ortega, A., Jones, D.O.B., 2017. A procedural framework for robust environmental management of deep-sea mining projects using a conceptual model. Marine Policy 84 (Supplement C), 193-201.

51 Craik, N., 2020. Implementing adaptive management in deep seabed mining: Legal and institutional challenges, Marine Policy 114: 103256; Thompson K.F., Miller, K.A., Currie, D., Johnston, P., Santillo, D., 2018. Seabed Mining and Approaches to Governance of the Deep Seabed. Frontiers in Marine Science 5:480.

52 Jaeckel, A., 2016. Deep Seabed Mining and Adaptive Management: The Procedural Challenges for the International Seabed Authority. Marine Policy 70, 205-211.

Draft Regulation 44: General obligations

The Authority, sponsoring States and Contractors shall each, as appropriate, plan, implement and modify measures necessary for ensuring effective protection for the Marine Environment from harmful effects in accordance with the rules, regulations and procedures adopted by the Authority in respect of activities in the Area. To this end, they shall:

[...]

(b) Apply the Best Available Techniques and Best Environmental Practices in carrying out such measures;

(c) Integrate Best Available Scientific Evidence in environmental decision-making, including all risk assessments and management undertaken in connection with environmental assessments, and the management and response measures taken under or in accordance with Best Environmental Practices; [...]

The Draft Exploitation Regulations also prescribe that the Environmental Plans (e.g. EIS, EMMP) to be submitted by contractors alongside an application for a plan of work for exploitation shall be prepared in accordance with BASE, BEP and BAT. In this respect, it is plausible to associate test mining activities with the quest to ascertain BASE, BEP and BAT, since testing would provide the valuable information that underpins them. If the (Draft) Exploitation Regulations requires contractors to prepare documents premised on BASE, BEP and BAT, it is arguable that contractors should be compelled to conduct test mining activities in order to gradually gather knowledge and gain experience to that end (see chapter 4.5). Indeed, it has been pointed out that “a large part of good and eventually best practice will emerge as equipment is designed and tested, mine plans are developed, EIAs and EMMPs are completed and once mining (be it test, pilot, or full-scale) commences”. [53]

2.4.5 Obligating Test Mining as a Due Diligence Obligation of Sponsoring States

Pursuant to the Seabed Disputes Chamber’s Advisory Opinion of 2011, it is arguable that sponsoring States have an obligation of due diligence to ensure that entities under its sponsorship conduct test mining operations prior to commercial exploitation activities. The Advisory Opinion lays down the obligation of sponsoring States, to wit, the duty to ensure that necessary measures are taken such as the conduct of environmental impact assessments prior to the conduct of a potentially harmful activity, adherence to the precautionary approach, and the adoption of best environmental practices. Furthermore, seeing that activities in the Area conducted by sponsored entities fall within their jurisdiction or control, sponsoring States have various obligations under Part XII of UNCLOS pertaining to the protection of the marine environment that are applicable.

Requiring sponsored contractors to conduct prior test mining would contribute towards the gathering of essential knowledge that allows for a more accurate prediction of the potential environmental impacts that would occur once mining activities are up-scaled, thereby allowing the sponsoring State to require contractors to develop or adopt better techniques and technologies to manage those impacts. The fact that a sponsoring State has, for example, taken steps to require its sponsored contractor to conduct prior test mining in order to ascertain the potential environmental impacts of exploitation activities and take necessary measures to reduce, control or avoid such impacts might play an important role in demonstrating that a sponsoring State had met its due diligence obligation in respect to exercising oversight over the activities of the sponsored contractor, if liability eventually comes into question.

Conversely, it might be possible to view a sponsoring State’s failure to require the conduct of test mining prior to commercial exploitation (specifically to ascertain extent of environmental harm) by its sponsored entity as a breach of due diligence obligation. In any case, it is in best interest of sponsoring

[53] Murphy, K. (2020), ‘Assuring Environmental Compliance in Deep-Sea Mining: Lessons from Industry and Regulators’, at https://www.pewtrusts.org/-/media/assets/2020/06/seabed_mining_white_paper_final.pdf.

States to ensure that test mining has been conducted to ascertain potential harm, in order to absolve themselves of possible liability with respect to actual environmental harm (i.e. serious harm to the marine environment) that might occur when commercial exploitation takes place subsequently.

Given the fact that requiring test mining could be seen as a means to properly and more accurately assess the environmental impacts of commercial mining activities, to apply the precautionary approach and help generate best environmental practices, compounded by the fact that sponsoring States are under a direct obligation to assist the ISA and to provide guarantees in the event of an emergency order being issued by the Council for the protection of the marine environment, all of which were raised as direct obligations in the 2011 Advisory Opinion, it is arguable that imposing test mining as a compulsory requirement for all sponsored contractors would fit squarely within the 'due diligence obligations' of the sponsoring State. As explained by the Seabed Disputes Chamber, meeting its due diligence obligations essentially requires the sponsoring State to take all necessary measures that are reasonably appropriate for securing compliance with its contractual obligations and requirements under UNCLOS and the rules, regulations and procedures of the ISA by persons under its jurisdiction. Indeed, it is consequential that requiring initial test mining projects before actual mining would properly allow for the assessment of the extent of the potential environmental impacts that could occur later on during commercial mining. As will be considered in later chapters, especially Chapter 6, it would be difficult to predict environmental impacts, and accordingly justify the approval of exploitation contracts, without generating sufficient and reliable data through targeted and controlled test mining. Thus, it is only logical to consider that imposing test mining as a compulsory requirement would therefore fall within the proper exercise of diligence on the part of the sponsoring State, which is expected under UNCLOS. In addition, if the number of sponsoring States that decides to make prior testing mining a compulsory requirement as part of the conditions of sponsorship begins to increase, it would make the argument that this forms part of the obligations required of a sponsoring State much stronger.

A final point to note here is that a considerable number of existing sponsoring States that have sponsored exploration contractors have not actually enacted national legislation governing activities in the Area. While this does not absolve the sponsoring State from liability under international law, the absence of national legislation may make it problematic to enforce the contractual obligations owed by the contractor to the ISA via the applicable domestic legal system. As explained earlier, even though the environmental impacts from exploration activities are expected to be less harmful as compared to commercial exploitation, test mining projects during the environmental stage can cause significant, even serious, environmental harm. Hence, it is important to ensure that all sponsoring States promptly enact appropriate national legislation, including liability clauses, in respect of activities in the Area.

In this respect, sponsoring States may which to consider inserting provisions in their national legislation that allows them to impose certain conditions to the sponsorship arrangement. If a sponsored contractor fails to meet conditions that are deemed as fundamental to the contract, the sponsoring State would have the option to either take action for non-compliance or to terminate the sponsorship agreement, or may decide, in the case of an exploration contract, to not to further sponsor the said contractor in an application for an exploitation contract unless the conditions are first met. In this respect, sponsoring States can require the sponsored entity to conduct prior test mining to the satisfaction of the sponsoring State as a specific condition of sponsorship, even if this is not required by UNCLOS or under the rules, regulations and procedures of the ISA. Indeed, it would obviously be in the best interest of the sponsoring State to impose such a condition in order to demonstrate that it is fulfilling its due diligence obligation and general responsibility to protect the marine environment from activities within its control. Imposing additional environmental requirements over and above what is required by the ISA is legally permissible, as UNCLOS stipulates that:

"States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from activities in the Area undertaken by vessels, installations, structures and other devices flying their flag or of their registry or operating under their authority, as the case may be. The requirements of such laws and regulations shall be no less effective than the international rules, regulations and procedures [established in accordance with Part XI to prevent, re-duce and control pollution of the marine environment from activities in the Area]".

Accordingly, if sponsoring States decide to embrace this approach, it could be considered as an indication of state practice, thereby strengthening the normative value of compulsory testing obligations. This would, however, require a significant amount of time and the acceptance of a considerable number of States before it can be seen as a legal requirement. A decision by the Council (or recommendation by the LTC) that encourages or requires sponsoring States to oblige contractors to conduct prior testing might lend a strong hand towards this end.

2.4.6 Options for the ISA to Further Regulate Test Mining

There are several foreseeable options for the ISA to further regulate test mining, for example, by imposing test mining as an obligation via the contract between the ISA and the contractor, requiring test mining through Standards and Guidelines or Recommendations, treating the requirement of test mining as a due diligence obligation of sponsoring States, creating a 'provisional exploitation contract' phase to accommodate testing, or introducing compulsory test mining via the rules, regulations or procedures of the ISA.

2.4.6.1 Imposing Test Mining as a Contractual Obligation

As mentioned earlier, the relationship between the ISA and the contractor is a contractual one. Indeed, UNCLOS makes this clear, and no exploration or exploitation may legally take place in the Area without a contract with the ISA.[54] Contracts concluded between the ISA and contractors are typically treated as confidential; however, such contracts are expected to contain the standard clauses as found in the Exploration Regulations (see for example, Annex IV of ISBA/19/C/17 in relation to the exploration of polymetallic nodules) or in the Draft Exploitation Regulations (see Annex X of ISBA/25/C/WP.1). Among the standard clauses are undertakings that the contractor is obligated to meet, such as to comply with obligations created by the rules, regulations and procedures of the ISA, to abide by decisions of the relevant organs of the ISA, to accept control by the ISA over contractor activities, and to carry out its activities with due regard to the impacts of its activities in the environment. In this respect, it is possible for the ISA to make test mining a contractual obligation that the contractor must perform. In terms of existing or future exploration contracts, however, it might be problematic to amend the contract because this would require a revision of existing contracts (thereby requiring the consent of the contractor) and would unfairly discriminate future contractors if such conditions were imposed on them and not existing contractors.[55] Given that no exploitation contract has been awarded as of yet, and since the Draft Exploitation Regulations are currently under negotiations, it may be possible to include a contractual obligation for contractors to carry out compulsory test mining at the exploitation stage, for example, prior to being allowed to commence with commercial production. There are other options to oblige contractors to conduct compulsory test mining, as will be considering in the following, however, in addition to possibly embracing some of those options, it would still be prudent to also include specific conditions in the contract that would bind the contractor to conduct test mining.

2.4.6.2 Requiring Test Mining through Standards and Guidelines or Recommendations

Another potential option to require test mining is through what is known as "Standards" and "Guidelines". While both "Standards" and "Guidelines" are explicitly given effect to in the (Draft) Exploitation

[54] UNCLOS, Article 153(3) and Annex III, Article 3(5).

[55] UNCLOS, Annex III, Article 19 and Article 6(3) and Regulation 23(3) of ISBA/19/C/17 (Exploration Regulations for Polymetallic Nodules).

Regulations in the context of environmental protection, the Exploration Regulations only makes reference to what is known as "Recommendations for the Guidance of Contractors" that are issued by the LTC.[56] Indeed, the LTC has indeed issued a document entitled "Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area", in which test mining is extensively covered.[57] As explained earlier, while the said Recommendations identify test mining as an activity that requires a prior environmental assessment, it does not make test mining during the exploration stage a compulsory requirement. Hence, the conduct of testing at the exploration stage is a choice that is left to the contractor. Moreover, LTC Recommendations are non-binding, although contractors are expected to observe them "as far as reasonably practical".[58] Guidelines issued pursuant to the forthcoming Exploitation Regulations are also non-binding and may be issued by the LTC or the Secretary-General, whereas Standards, which are adopted by the Council, are legally binding on contractors. In this respect, further requirements relating to test mining can be issued as Recommendations (applicable to the exploration stage and non-binding), as Guidelines (applicable to the exploitation phase and non-binding), or as Standards (applicable to the exploitation stage and binding). At minimum, the LTC should issue Guidelines for test mining in the exploitation stage that correspond with the Recommendations it had already issued with respect to the exploration stage. However, since test mining is mining, and because testing at the exploitation stage is anticipated to be more advanced and elaborate (thereby likely resulting in more significant harm when compared to the exploration stage), it is only rational that legally binding Standards be adopted by the Council to require and regulate test mining activities at the exploitation stage prior to commercial production.

2.4.6.3 Necessitating Joint or Collaborative Test Projects and Operationalizing the Enterprise

Moreover, as regulator, the ISA could authorize a joint test mining project for a particular region, especially in the light of developing Regional Environmental Management Plans (REMPs) for the said region. In fact, the LTC's 'Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area' (ISBA/25/LTC/Rev.1) already acknowledges this possibility of collaborative test mining.[59] It should be noted that as the regulator, the ISA may authorize contractors to collaborate with each other in conducting joint test mining projects, but should however refrain from taking charge of such a project. Nevertheless, this would be an interesting point for consideration if the Enterprise, the independent organ and entrepreneurial arm of the ISA, is duly operationalized and is tasked to take charge of this endeavour. Since it is the entrepreneurial arm of the ISA and is effectively a contractor on its own right (albeit representing mankind as a whole), the Enterprise would be well-poised for this purpose. In fact, this would serve the additional benefit of empowering the Enterprise with the relevant expertise and knowhow, which is an obligation under UNCLOS read in light with the 1994 Implementation Agreement on Part XI. As such, the operationalization of the Enterprise and charging it with a regional test mining endeavour with the collaboration of other existing contractors in the region might be an effective way to move forward.

2.4.6.4 Obliging Test Mining Through Regional Environmental Management Plans (REMPs)

As part of meeting its responsibility to take necessary measures to ensure the effective protection of the marine environment from the harmful effects of activities in the Area, the ISA has undertaken to establish REMPs for marine regions in the Area that are subject to mining interests. As will be explored in later chapters, there currently exists one precedent of an REMP for the Clarion-Clipperton Zone

[56] See, e.g. Regulation 39 of ISBA/19/C/17 (Exploration Regulations for Polymetallic Nodules).
[57] ISBA/25/LTC/6/Rev.1.
[58] See, e.g. Section 13.2(e), Annex IV of ISBA/19/C/17 (Exploration Regulations for Polymetallic Nodules).
[59] ISBA/25/LTC/6/Rev.1, at paragraph 37, as well as paragraphs 49 and 59-62.

(since 2012), while several others are currently in the development process or have been identified for priority development. An REMP is expected to manage mining activities in the region, as well as to design a network of 'Areas of Particular Environmental Interest' or APEIs (where mining would not take place in the short term) that would be useful for monitoring and possibly, to some extent, short term conservation purposes. It is also seen as an avenue to determine and set overarching environmental objectives and thresholds that would apply to the region, as well as to identify potential limitations and the need to restrict further activities according to the capacity of the region to withstand additional pressures, which would in turn inform the ISA when it is making decisions in relation to approving exploration and exploitation activities in the region. It is expect that exploitation activities will not be allowed to commence in regions that do not have a corresponding REMP, and in this respect, it is possible for REMPs to function as an avenue that also requires individual contractors to conduct all necessary test mining activities before an exploitation application can be entertained in the region. Joint test mining activities could also be coordinated by the ISA through an REMP, for example, which was discussed earlier. Moreover, data and information gathered through test mining activities that take place in the region would also contribute significantly towards evaluating the performance of the REMP as well as inform the necessary revisions that need to be made in order to ensure that the effective protection of the marine environment from the harmful effects of mining activities in the Area, including the impacts that are predicted from future commercial mining based on test mining results, is safeguarded and all appropriate measures can be taken pursuant to the REMP (such as restricting any further activities or staggering the conduct of existing activities).

2.4.6.5 Creating a 'Provisional Exploitation Contract' Phase to Accommodate Testing

This option entails the creation of a transition phase between exploration and commercial production, whereby premised on a prefeasibility study, a 'provisional exploitation contract' is awarded to a contractor at the end of the exploration stage to allow the contractor some time to conduct a pilot commercial operation. Premised on this pilot commercial operation, the contractor may apply for a tenured exploitation contract by submitting a detailed feasibility study and a comprehensive EIA, which in turn would provide the ISA with the necessary data and information to evaluate whether a full-scale mining operation could be undertaken in an acceptable and minimally environmentally invasive way. The 'provisional exploitation contract' approach is elaborated in ISA Technical Study 11, titled 'Towards the Development of a Regulatory Framework for Polymetallic Nodule Exploitation in the Area" and premised on a consultancy that was undertaken and developed with the guidance of the ISA Secretariat,[60] as follows (page 28): "[...] the ISA will need to develop a regulatory method, based upon foreseeable events, to ensure slow, measured development and sufficient regulatory control over a project before it advances to the stage where, if problems arise, it can no longer be clawed back, modified or terminated. One way to accomplish this is to provide for a 'provisional' mining licence that would mandate that an operator demonstrate competence in deep ocean engineering and mining and associated environmental responsibility to the ISA before receiving a 'tenured' mining licence.

Excerpts from ISA Technical Study No. 11, at pp. 4-6

"It is suggested that, prior to the expiration of an exploration licence, the contractor (if interested in proceeding to the mining phase) be required to first apply for a provisional mining licence based upon preparation and submission of a prefeasibility study and work plans to undertake a detailed bankable feasibility study based upon a pilot PN mining operation in the contract area. The suggested validity of a preliminary mining licence is three years. The application for a provisional mining licence would include inter alia:

1. The technical, fiscal and environmental qualifications of the proposed operator.

[60] International Seabed Authority (2013), 'Towards the Development of a Regulatory Framework for Polymetallic Nodule Exploitation in the Area', ISA Technical Study 11, at https://isa.org.jm/files/files/documents/tstudy11.pdf.

2. Approved funding.
3. A prefeasibility study based on the contractor's previous exploration, transportation, processing and testing data, and analysis including an environmental impact assessment based upon the contractor's work during the exploration stage.
4. Plans of work for the term of the provisional mining licence including, inter alia:
    a. Plans for undertaking a detailed feasibility study based upon a pilot commercial site.
    b. Expenditure schedules.
    c. Development schedules.
    d. Mining methods.
    e. Production estimates for the pilot site during the term of the provisional licence and a tenured mining licence.
    f. Environmental management plans including closure and rehabilitation.
    g. Transportation and logistical specifics (including accident prevention) for the operation.
5. Performance assurances and guarantees.
6. Host and/or sponsoring government specifics.
7. Training and corporate social responsibility.
8. Size and area of concession.

The exact requirements of a prefeasibility study are included as a point of recommended future work.

Using information contained in the application for a provisional mining licence, including a prefeasibility study and environmental impact assessment, the ISA would be able (based upon a recommendation to develop an assessment methodology as future work) to determine whether the technical, environmental and economic analysis and conclusions reached would support the grant of a provisional mining licence to undertake a pilot commercial operation. If the pilot commercial operation is successful and a full detailed bankable feasibility study, including a full environmental assessment, indicates that a full-scale mining operation could be mounted and funded, the contractor could apply for a 'tenured' mining licence. An application for a tenured mining licence would include the data, information, analysis and conclusions of the detailed bankable feasibility study and full environmental impact assessment and proposed work plans. In turn, this would provide data, information and analysis allowing the ISA to determine (again, based upon a recommendation to develop an assessment methodology as future work) whether a full-scale mining operation could be undertaken in an acceptable and minimally environmentally invasive way.

It is suggested that an application for a tenured mining licence should include and be conditional upon:

1. Successful completion of the pilot commercial study under the provisional licence.
2. ISA approval of a detailed bankable feasibility study and full environmental impact study.
3. The technical, fiscal and environmental qualifications of the proposed operator.
4. Approved funding for the operation.
5. Plans of work for the term of the tenured mining licence including, inter alia:
    a. Expenditure schedules.
    b. Development schedules.
    c. Mining methods.
    d. Production estimates for the term of the tenured mining licence.
    e. Environmental management plans including closure and rehabilitation.
    f. Transportation and logistics specifics (including accident prevention) for the operation.
6. Performance assurances and guarantees.
7. Host and/or sponsoring government specifics.
8. Training and corporate social responsibility.
9. Size and area of concession.

In summary, a staged or phased licensing process, including the requirement of a prefeasibility study for a provisional licence, would allow the ISA to make an intermediate decision whether or not to allow a pilot project to fully demonstrate viability and safety, and the provisional licence would provide an important measure of control and power to claw back the project should unforeseeable problems arise, without having to suspend or terminate a full-scale mining project."

From the above, it can be gleaned that the pilot commercial operation envisioned via the 'provisional exploitation contract' is actually a full-scale test mining operation. The benefit of such an approach is obvious, at least from the regulator's perspective, whereby the ISA would retain the power to not approve the application for a tenure exploitation contract if the data and results from the pilot commercial operation are not satisfactory from an environmental perspective. From the perspective of the contractor, it could also be seen as an advantage, given that a contractor that manages to obtain a tenure exploitation contract would essentially have a paved path to commercial production.

The 'provisional exploitation contract' essentially allows the ISA to circumvent the 'security of tenure' provision under UNCLOS and in the standard clauses of a contract, whereby a contractor that has been awarded an exploitation contract essentially has exclusive rights to exploit the resource in question, and this cannot be terminated, suspended or revised except with the consent of the contractor or in cases of emergency.[61] Another matter of particular importance to note, given that a provisional exploitation contract is not a tenured contract, is that the holder of a provisional contract would not be able to use it as a security to leverage funds to finance the operation, as opposed to a tenured exploitation contract, which is expected to span over 30 years.[62]

2.4.6.6 Introducing Compulsory Test Mining via the Rules, Regulations and Procedures of the ISA

It is necessary to return again to the rules, regulations or procedures of the ISA, such as through regulations that govern exploration activities (the Exploration Regulations) and regulations that govern exploitation activities in future (which is now being negotiation in a draft form), as covered earlier in this chapter (see Chapter 2.3), as an option to impose compulsory test mining. This would indeed be an optimal manner to comprehensively regulate and standardise compulsory test mining requirements. This option will be explored in greater detail in chapter 7, wherein a proposal by Germany in 2019 to introduce a compulsory two-phased approach to test mining in the (Draft) Exploitation Regulations that is currently under consideration at the Council will also be scrutinsed.[63].

2.5 Test Mining as an Incentive for Operators and for the Facilitation of a Level Playing Field

Apart from seeing test mining as imperative from a conceptual or technical perspective, test mining should also be seen as indispensable from a practical perspective. In this regard, the ISA considers an operator's development costs to include costs incurred for the research and development of mining technologies (e.g. equipment and instruments) as well as testing, and foresees that such costs could be off set against the eventual income from production.[64] Accordingly, it would also be in the best interest of operators to design, develop and test their mining equipment and systems to utilize this opportunity.

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[61] See UNCLOS, Article 153(6), Annex III, Articles 16 and 19, and Draft Exploitation Regulations, Annex X, Section 4.

[62] ISBA/25/C/WP.1, Draft Regulation 22.

[63] Comments on the Draft Regulations on Exploitation of Mineral Resources in the Area (ISBA/25/C/WP.1), Submitted by the Federal Republic of Germany, 15 October 2019, at https://isa.org.jm/files/files/documents/191015_ISA%20draft%20exploitation%20regulations_comments%20Germany.pdf.

[64] See, e.g. Recommendations for the guidance of contractors for the reporting of actual and direct exploration expenditure (2015), ISBA/21/LTC/11.

Moreover, by conducting comprehensive testing of mining equipment, systems and processes, contractors would be able to systematically reduce scientific, environmental and technical uncertainties of their operations at the project-level, as well as continuously build priceless experience, expertise and capacity to carry out their activities at an optimal level. Importantly, test mining activities would greatly assist contractors to prepare key documents such as the EIS and EMMP, which must accompany an application for an exploitation plan of work, and which the ISA will rely upon when deciding whether or not to approve the said application. In this respect, requiring test mining would subject each contractor to the same standards, requirements and expectations.

Crucially, requiring test mining would also help to weed out contractors that are not able to meet high environmental standards, comply with best environmental practices or adopt best available techniques. In this respect, it may very well be the case that some contractors may not take environmental protection as seriously as other contractors. The possibility of contractors to use the exploitation contract as security for the purposes of raising funds to meet its obligations, as permitted under the Draft Exploitation Regulations,[65] might be open to abuse especially if the business model of a particular contractor is predominantly profit-centric, rapacious or exploitative. In this respect, making test mining compulsory already at the exploration stage would help facilitate a level playing field, ensuring that only serious and responsible contractors are allowed to proceed to the exploitation stage, and subjecting all contractors to equal, uniform and non-discriminatory treatment as required under UNCLOS.[66]

Given that contractors have clear contractual obligations to meet environmental requirements when conducting activities in the Area, test mining also affords contractors the opportunity to ensure that they do not exceed the relevant thresholds, limits, standards or guidelines that apply to them. For example, if the testing of certain equipment or systems reveal that the cumulative impacts of operating at full-scale would result in exceeding the applicable environmental thresholds, limits, standards or guidelines, the contractor in question may make necessary adjustments in their operation to ensure that it does not breach its contractual obligations. Likewise, this would also be pertinent for sponsoring States that have due diligence obligations over the contractors that they sponsor and may be held responsible under international law under certain circumstances for the shortcomings of the sponsoring entity.

2.6 Conclusions

This chapter has elucidated on the existing regulatory framework and the legal mandate for test mining. In particular, it has been shown that while test mining is permitted and possibly even encouraged under the current framework, it is not a compulsory requirement. In this respect, this chapter argued that the ISA should seize the present window of opportunity, namely, the negotiations of the Draft Exploitation Regulations and its related themes, to make test mining a compulsory requirement. This has many advantages, and there are several options available to make this a reality.

Advantages of Requiring Test Mining Activities

- Uniform conditions (level playing field) for all contractors.
- Helps ensure that only contractors that are serious about the effective protection of the marine environment from the harmful effects of mining get to proceed to the exploitation stage and eventual into the commercial production phase.
- Lays the foundation for effective environmental management, which is the core interest of the ISA, sponsoring State, and contractor.

[65] ISBA/25/C/WP.1, Draft Regulation 22.

[66] UNCLOS, Article 152 and Annex III, Article 6(3).

- Crucial for the ISA to develop applicable environmental indicators and harm thresholds, and for the contractor to design robust and useful EIAs and EMMPs.
- Generates reliable knowledge, validates models, and considers environmental assessment as a continuous and on-going process
- Helps determine 'best environmental practices' and 'best available techniques'.
- Ensures the element of continuity between exploration and exploitation phases.
- Allows for informed decision-making and adaptive management, and in-line with the precautionary approach.

We conclude on the following recommendations to improve the current environmental governance of mining activities with respect to test mining:

Recommendations

- The Council should immediately revisit the theme of requiring appropriate forms of guarantees prior to test mining at the exploration phase.
- The ISA should consider, in line with the precautionary approach, to effectively reverse the burden of proof on mining proponents to demonstrate, via test mining, that the commercial exploitation activities that they are seeking to eventually carry out do not exceed environmental thresholds and standards.
- The ISA should include the conduct of prior test mining as a compulsory contractual obligation by inserting a clause to that effect in the contract, or to adopt necessary Standards (legally binding) for test mining.
- The ISA should increase the awareness of sponsoring States with respect to the benefits of requiring contractors to conduct prior test mining.
- The ISA should commission a study to explore the viability of adopting a 'provisional exploitation contract' approach and of adopting a compulsory two-phased approach to test mining as part of the Draft Exploitation Regulations.

3 Current State of Exploration in the Area

Chapter 4 introduces the evolution of the current state of play of ISA exploration contracting and the progress of contractors towards developing the necessary technological equipment for being able to proceed to exploitation of minerals in the Area or in areas within national jurisdiction. An overview of past and present mining tests is given, including an overview of the numerous related environmental studies and scientific disturbance experiments.

3.1 Exploration Contracts in the Area

As of 31 December 2019, the International Seabed Authority had entered into 30 contracts for the exploration of mineral resources in the Area. Of these contracts, 18 cover the exploration of poly-metallic nodules, with 16 contract areas being located in the Clarion-Clipperton Fracture Zone, one in the Indian Ocean and the most recent one in the western Pacific Ocean (ISBA/26/C/4; see

Table 1). Seven contracts relate to the exploration of seafloor massive sulfides, SMS, with three contracts covering the Mid Atlantic Ridge north of the equator and south of the Azores, and four contracts on the central and southern Indian Ocean Ridge. Five contracts allow for the exploration of cobalt-rich ferromanganese crust, four of these located in the western Pacific and one in the Atlantic Ocean off the EEZ of Brasil. This latter contract may be overtaken by a recommendation by the UN Commission on the Limits of the Continental Shelf, UNCLCS, responding to a submission by Brazil as to the extension of its extended continental shelf in that area.

The 30 contracts have been concluded with 21 different entities and are sponsored by 17 States. One further contract application for the exploration of polymetallic nodules in the Clarion-Clipperton Zone by Jamaica was approved end 2020. Overall, 12 entities (the Interoceanmetal Joint Organisation, IOM made up of 6 States counted as one, Brasil, China, Cook Islands, France, Germany, India, Japan, Kiribati, Korea, Poland, Russia) sponsor exclusively state agencies or otherwise state-owned entities, while 5 States sponsor exclusively private companies (Belgium, Nauru, Tonga, Singapore, UK). China is a special case as it sponsors 5 contracts with three different state-owned entities, and acts as a developed as well as a developing State (contracting reserved areas).

Exploration contracts for polymetallic nodules cover up to 75000 km² of the Area each, usually allocated to two or more separate sites which result from the mineral exploration of an original 150000 km² (ISBA/19/C/17, Reg25). Contrary to the large fields of nodules on more or less plain seafloor, both the deposits of seafloor massive sulfides, SMS, and cobalt-rich ferromanganese crusts, CRC, are located in generally rugged terrain associated with mid-ocean ridges and/or seamounts. Due to the more localised occurrence of these deposits, the size of the exploration contract areas for polymetallic sulphides is limited to 10,000 km² in total, consisting of a maximum 100 blocks no larger than 100 km² (ISBA/16/A/12rev, Reg. 12.1). For cobalt-rich ferromanganese crusts, the exploration areas include a maximum of 3,000 km², consisting of 150 blocks no larger than 20 km² (ISBA/18/A/11 Reg. 12.1).

An important part of the common heritage principle is the equal access of all States to the mineral resources of the Area, realised by a site banking system of so-called reserved areas which can only be contracted by developing States. Reserved areas arise from the exploration of contract areas by developed States who, in the case of nodules, have to relinquish in a step-wise process 50% of their original exploration area, effectively establishing two parts of comparable mineral value (ISBA/25/LTC/8). It is up to the LTC to choose which of the halves shall be banked by ISA, and made available for applicants from developing countries together with the associated exploration information (ISBA/19/C/17, Reg25), In the case of SMS, 50 % of the original contract area have to be relinquished by the end of the 8th year from date of contract, another 25% by the end of the 10th year (ISBA/16/A/12 /Rev.1, Reg. 27) for cobalt-rich crust the corresponding regulation requires at least one third relinquishment after 8 years, and two thirds after 10 years (ISBA/18/A/11, Reg. 27).

In the case of SMS and crust exploration, contractors can choose between relinquishing an area of equal value to what they retain, or offering an equity interest in a joint venture with the ISA´s own, not yet established "Enterprise" (Reg. 27 of ISBA/16/A/12rev and ISBA/18/A/11, respectively). So far, all applicants for exploration of SMS have chosen the latter option and there are no reserved areas(International Seabed Authority, 2019a). In the case of CRC, only one out of five contractors – the Russian Federation – took the option to contribute a reserved area (International Seabed Authority, 2019a).

Pioneer Investors Regime

In order to ensure an immediate commencement of mining activities upon the entry into force of UNCLOS, the "Preparatory Commission for the International Sea-Bed Authority and for the International Tribunal for the Law of the Sea" (the Preparatory Commission), established after the signature of UNCLOS by 50 States in 1983, defined a so-called "pioneer regime" to safeguard and enable recovery of the prior investments of States and industry who carried out deep sea mineral exploration and test mining in the 1960-1980s.

Resolution II of the Preparatory Commission sets out that certain protections were granted to qualifying seabed miners (investment of at least 30 Mio US $ prior to 1983/85) who applied to the Commission and were registered by it to conduct pioneer activities. Seven Pioneer Investors were registered during the life of the Preparatory Commission under the interim Pioneer Investor regime. These were, the Government of India, the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER/AFERNOD), Deep Ocean Resources Development Company, DORD (Japan), the State Enterprise Yuhzmorgeologiya (USSR), China Ocean Mineral Resources Research and Development Association, COMRA (China), Interoceanmetal Joint Organization (then: Bulgaria, Vietnam, the German Democratic Republic, Cuba, Poland, the USSR and Czechoslovakia) and the Government of the Republic of Korea.

The resolution of spatial conflicts between the entities applying for pioneer investor status was a precondition for being registered as such. Therefore France, Japan and the Soviet Union, as well as the Netherlands sought a "provisional understanding" with Belgium, the Federal Republic of Germany, Italy, the United Kingdom and the United States, including an agreement of the date of 1 January 1988 as the earliest date for the start of exploitation (Dixon, 1988). Ultimately, any action outside the Preparatory Commission negotiations, including through national legislation, were condemned as being incompatible with the UNCLOS and related resolutions (Dixon, 1988). The issue was settled and registration proceeded in 1987, when India was registered as the first pioneer investor by the Preparatory Commission (Hayashi, 1990).

With respect to the quality and size of areas to be designated as exploration/reserved areas, pioneer investors like the later ISA contractors had to prepare two areas of equal economic interest from which the LTC would choose one as a reserved area. A rather complicated set of obligations required the first three pioneer contractors to also contribute sites in the central nodule zone of the CCZ so that the "Enterprise" would be able to start a quality mine and in return allowed to determine a portion of the area for own use (Hayashi, 1990), p, 276 f..

All of the pioneer investors became exploration contractors with the ISA in 2001 and 2002 (Table 1), however still benefit from their status as pioneer investors.

Table 1: Exploration contracts of ISA as of 31 December 2019. The table is ordered by Sponsoring State. PMN means polymetallic nodules, PMS polymetallic sulphides (SMS), PMC polymetallic crust.

Sponsoring State	Exploration Entity	Mineral	Region	Contract period
Belgium	Global Sea Mineral Resources NV	PMN	Clarion-Clipperton Zone	2013-2028
Brasil	Companhia de Pesquisa de Recursos Minerais S. A.	PMC	Rio Grande Rise in the South Atlantic Ocean	2015-2030
Bulgaria, Cuba, Czechia, Poland, Russian Federation, Slovakia	Interoceanmetal Joint Organization	PMN	Clarion-Clipperton Zone	2001-2016 2016-2021
China	China Ocean Mineral Resources Research and Development Association, COMRA	PMN	Clarion-Clipperton Zone	2001-2016 2016-2021
	China Ocean Mineral Resources Research and Development Association, COMRA	PMS	South-west Indian Ridge	2011-2026
	China Ocean Mineral Resources Research and Development Association, COMRA	PMC	Western Pacific Ocean	2014-2029
	China MinMetals Corporation	PMN	Clarion-Clipperton Zone (reserved areas from Ru, IOM, COMRA)	2017-2032
	Beijing Pioneer Hi-Tech Development Corporation	PMN	western Pacific Ocean	2019-2034
Cook Islands	Cook Islands Investment Corporation (cooperation with GSR)	PMN	Clarion-Clipperton Zone (reserved area from Belgium)	2016-2031
France	Institut Français de Recherche pour l'Exploitation de la mer, IFREMER	PMN	Clarion-Clipperton Zone	2001-2016 2016-2021

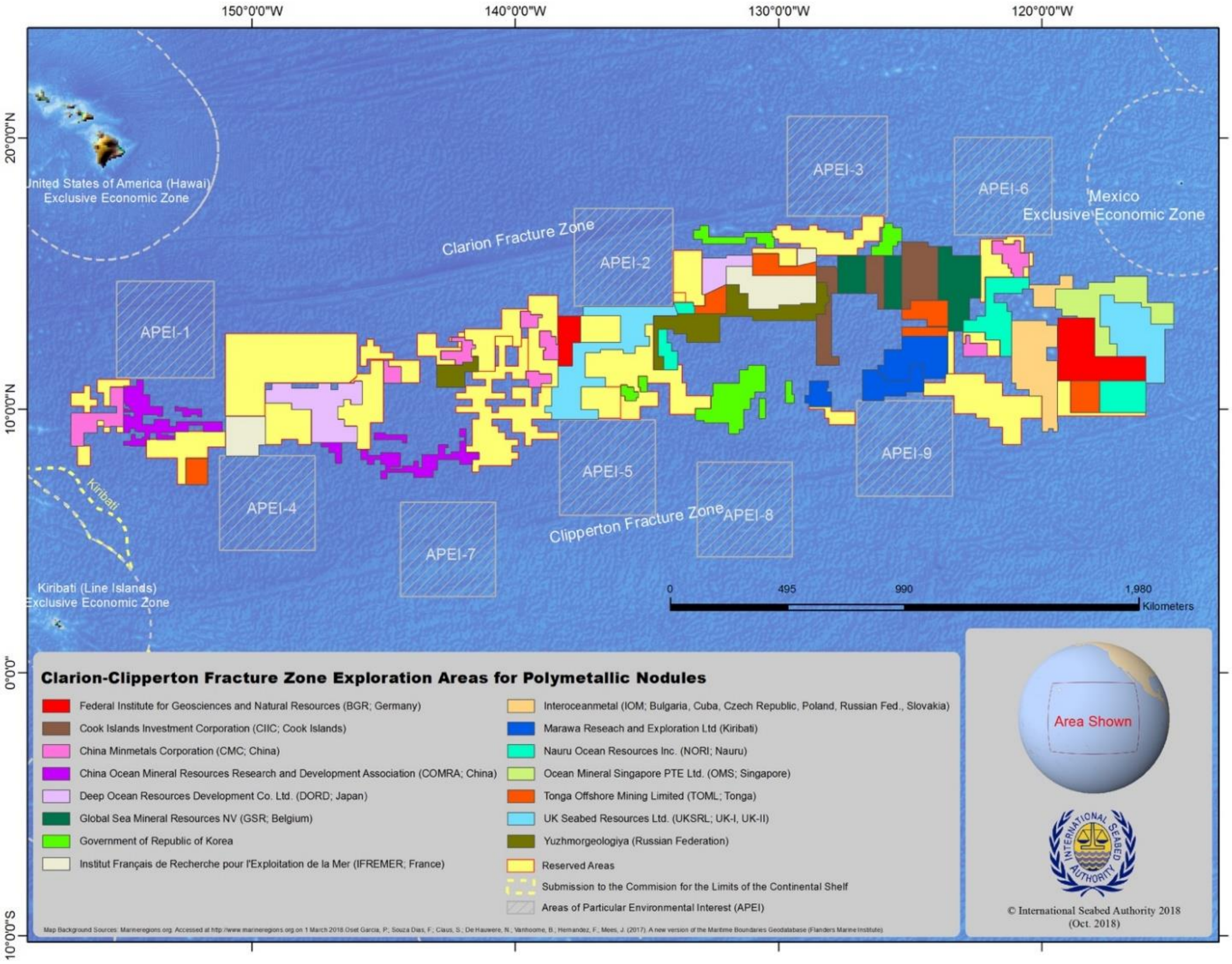
Sponsoring State	Exploration Entity	Mineral	Region	Contract period
	Institut Français de Recherche pour l'Exploitation de la mer, IFREMER	PMS	Mid-Atlantic Ridge	2014-2029
Germany	Federal Institute for Geosciences and Natural Resources, BGR	PMN	Clarion-Clipperton Zone	2006-2021
	Federal Institute for Geosciences and Natural Resources, BGR	PMS	Central Indian Ridge and South-East Indian Ridge	2015-2030
India	Government of India	PMN	Central Indian Ocean Basin	2002-2017 2017-2022
	Government of India	PMS	Indian Ocean Ridge	2016-2031
Jamaica	BlueMinerals Inc.	PMN	Clarion-Clipperton Zone	not yet signed
Japan	Deep Ocean Resources Development Co. Ltd., DORD	PMN	Clarion-Clipperton Zone	2001-2016 2016-2021
	Japan Oil. Gas and Metals National Corporation	PMC	Western Pacific Ocean	2014-2029
Kiribati	Marawa Research and Exploration Ltd.	PMN	Clarion-Clipperton Zone (reserved area, from Korea)	2015-2030
Korea	Government of Korea	PMN	Clarion-Clipperton Zone	2001-2016 2016-2021
	Government of Korea	PMS	Central Indian Ocean	2014-2029
	Government of Korea	PMC	East of the Northern Mariana Islands in the Pacific Ocean	2018-2033
Nauru	Nauru Ocean Resources Ltd., NORI (DeepGreen)	PMN	Clarion-Clipperton Zone (reserved area)	2011-2026
Poland	Government of Poland	PMS	Mid-Atlantic Ridge	2018-2033

Sponsoring State	Exploration Entity	Mineral	Region	Contract period
Tonga	Tonga Offshore Mining Ltd., TOML (DeepGreen)	PMN	Clarion-Clipperton Zone (reserved area from GER, DORD, Korea and IFREMER)	2012-2027
United Kingdom of Britain and Ireland	UK Seabed Resources Ltd., UKSRL	PMN	Clarion-Clipperton Zone	2013-2028
	UK Seabed Resources Ltd., UKSRL	PMN	Clarion-Clipperton Zone	2016-2031
Russian Federation	JSC Yuzhmorgeologiya	PMN	Clarion-Clipperton Zone	2001-2016 2016-2021
	Ministry of Natural Resources and Environment of the Russian Federation	PMS	Mid-Atlantic Ridge	2012-2027
	Ministry of Natural Resources and Environment of the Russian Federation	PMC	Magellan Mountains in the Pacific Ocean	2015-2030
Singapore	Ocean Mineral Singapore, OMS	PMN	Clarion-Clipperton Zone (reserved area from UK)	2013-2028

The ISA website can be sourced for maps of current exploration areas in the different oceans.[67] As of 2021, the latest map of exploration and reserved areas, as well as Areas of particular environmental Importance, APEIs in the Clarion-Clipperton Zone is displayed in Figure 1.

[67] https://www.isa.org.jm/minerals/maps

Figure 1 Clarion-Clipperton Fracture Zone exploration areas for polymetallic nodulesy



Source: International Seabed Authority 2018 [68]

3.2 U.S. Contracting

The United States issued four exploration licenses in 1984, well after the signature of UNCLOS, in parallel to ongoing negotiations of the Preparatory Commission, and under national law (1980 Deep Seabed Hard Mineral Resources Act, Public Law 96-283, section 309, see also (NOAA, 1984), (NOAA, 1993). To overcome the void prior to UNCLOS coming into force, in particular since the US and other western States refused to sign the 1982 text[69] in September 1982, the United States, the United Kingdom, the Federal Republic of Germany and France signed a preliminary agreement to communicate on seabed mining issues (Reciprocating States Agreement), e.g. on eventual mining claim overlap, the location of reference areas and cooperation of information of at-sea environmental research (e.g. agreement with Japan/DORD and Russia/Yuzmorgeologiya Association) (NOAA, 1993). In parallel, under the umbrella of the Preparatory Commission, comparable negotiations to settle disputes regarding the overlapping deep seabed mining sites took place with other States (Dixon, 1988).

[68] https://isa.org.jm/files/maps/01-clarion_clipperton_fracture_zone.jpg, for copyright conditions see https://www.isa.org.jm/authority/term-and-conditions-use-international-seabed-authority-website

[69] for developments with respect to the U.S. acceding UNCLOS please see https://www.gc.noaa.gov/gcil_los.html

Figure 2 displays the deep seabed mining operating areas as of 1991, including a "Provisional Interim Preservational Reference Area", as provided by the USA and the UK (NOAA, 1993, Fig. 3, p. 6). It is evident that the primary shapes and sizes of exploration areas as they exist today, date back to at least the 1980s, prior to UNCLOS and the Implementing Agreement 1994 entry into force.

Figure 2: US and other States´ deep seabed mining operating areas in the Clarion-Clipperton Fracture Zone as of 1991

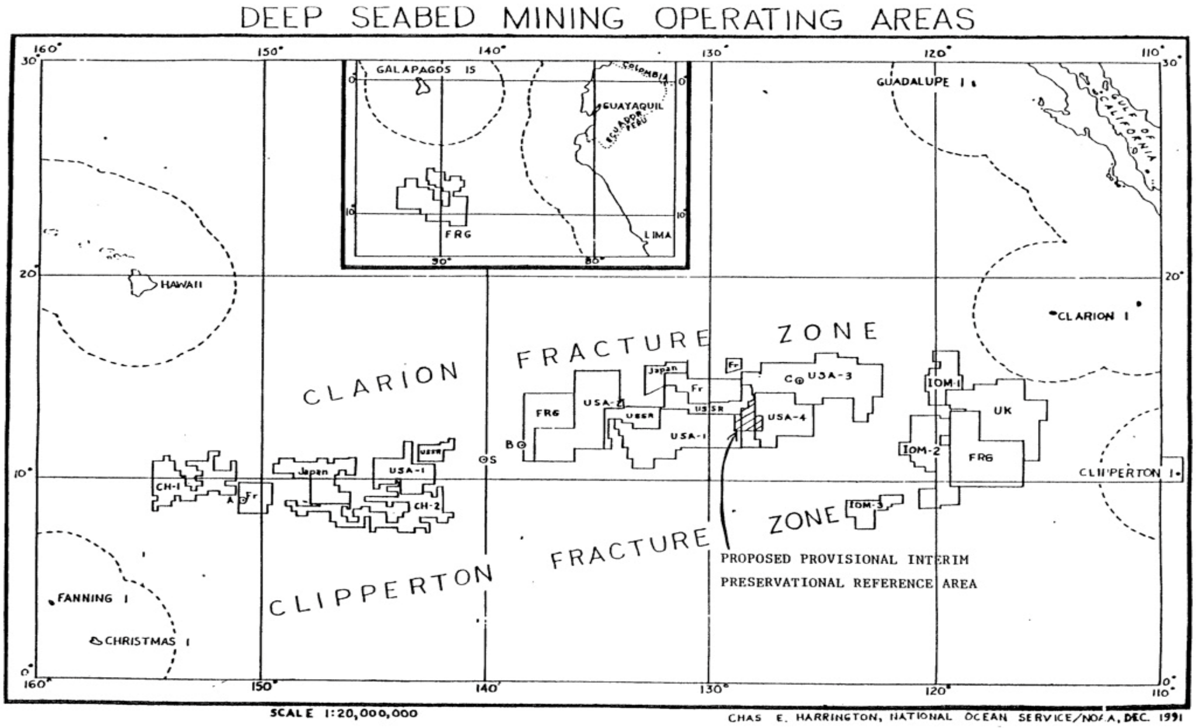


Figure 3. U.S. and Foreign Operating Areas and Proposed Provisional Interim Preservational Reference Area (USA-4 and UK areas surrendered May 21, 1993)

Source: NOAA, 1993, Fig. 3, p. 6

Figure 2 indicates the location of the exploration areas of the four US-based mining consortia licensed in 1984. Ocean Minerals Company, OMCO, was licensed to operate in the westernmost areas, USA-1, split in two parts. Ocean Management, Inc., OMI, worked in area USA-2, Ocean Mining Associates, OMA in USA-3 and the Kennecott Consortium, KCON, in USA-4., the latter three areas all about 12° N and between 140 and 120°W. The area delimitation displayed above is the result of a prior bilateral resolution of eventually conflicting boundaries with French and Japanese consortia/States. The data of relinquished areas were exchanged. The exploration licenses were timed for a period of in total 10 years with an extension of another 5 years, and came with an annual reporting obligation. During this period, none of the consortia had further sea-going activities. NOAA, on the other hand, continued to investigate the biological effects of sedimentation on the seafloor due to seabed mining operations, *i.e.* finishing off the Benthic Impact Experiments carried out in collaboration with Russia, Japan and IOM (see chapter 4.4.1.1).

While KCON returned its license already in 1993, the other three licenses were extended until 1999 (NOAA, 1993). OMCO took over the exploration license for USA-4 in 1994 (NOAA, 1995). In 1995, OMCO was dissolved and remaining activities consolidated under Lockheed Martin Missiles and Space, LMMS (NOAA, 1995). The license expired in 2004.[70]

In 2012, NOAA approved a 5-year extension of Lockheed Martin Corporation's USA-1 and USA-4 exploration licenses and amended exploration plan in the Clarion-Clipperton Zone of the Pacific Ocean under the Deep Seabed Hard Mineral Resources Act ("Deep Seabed Act"). This licensing was challenged by a national NGO, the Center for Biological Diversity, in 2015 arguing that NOAA had not conducted a prior environmental impact assessment in line with the National Environmental Policy Act (NEPA).[71] This was not successful, and NOAA argued that the license extension merely served to maintain the legal status and did not cover substantial work at sea.[72] It was emphasised that any sea-going activities, including testing, would be subject to EIAs, and that the knowledge base for assessing commercial operations was currently insufficient.

In 2020, by Executive Order, the outgoing President Trump declared a National Emergency and called for action to address "any potential national security threat posed by the nation's reliance on critical mineral imports, securing a domestic supply chain, and funding projects to increase critical mineral production within the United States".[73] Based on this, funding for data collection and analysis on the outer continental shelf was published by the US Department of Interior,[74] which however is not responsible for implementing the Deep Sea Hard Minerals Act in areas beyond national jurisdiction. Here, NOAA is responsible under the Department of Commerce. Eventually, these acts will result in a newly revived interest in deep seabed mining.

3.3 Technologies for Deep Seabed Mining: State of the Art

3.3.1 Introduction

The ISA is concerned with the regulation of activities in the Area, defined as '*all activities of exploration for, and exploitation of, the resources of the Area*.' (UNLOS, article 1(1)(3)). This definition was clarified by the ITLOS Seabed Chamber in its Advisory Opinion (ITLOS, 2011) to include, "*first of all, the recovery of minerals from the seabed and their lifting to the water surface*", as well as "*activities directly connected [therewith] such as the evacuation of water from the minerals and the preliminary separation of materials of no commercial interest (including their disposal at sea*). Should shipboard processing take place then this would also fall under these activities. Therefore, all activities related to the prospecting, exploration and exploitation of minerals *in situ* up to the point where either transshipment to transport barges takes place, or the transport barges leave the waters above the mine site are considered to be "*activities in the Area*", which should be tested *in situ* to gain experience with the environmental effects caused by the different technologies and their operation.

Focusing on testing operations ahead of commercial exploitation, several major components and associated systems for mining have to be scrutinised (Figure 3):

- The collection and extraction tools operating on the seafloor, including the effects of pollutants arising from sediment disturbance and crushing of material, the exhaust plumes and the waste management of overburden and other sediment;

70 https://www.biologicaldiversity.org/campaigns/deep-sea_mining/pdfs/Deep-seaMiningFAQ.pdf

71 https://www.biologicaldiversity.org/campaigns/deep-sea_mining/pdfs/Deep-seabedMiningComplaint_05-12-2015.pdf

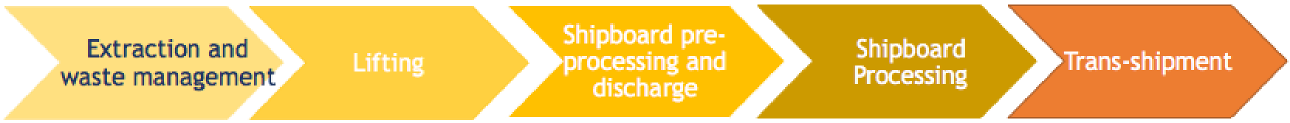
72 https://www.federalregister.gov/documents/2015/12/30/2015-32889/extension-of-deep-seabed-exploration-licenses-response-to-comments

73 https://www.whitehouse.gov/presidential-actions/executive-order-addressing-threat-domestic-supply-chain-reliance-critical-minerals-foreign-adversaries/

74 https://dsmobserver.com/2020/11/the-united-states-moves-towards-exploration-and-exploitation-of-critical-mineral-resources-in-the-deep-ocean/

- The lifting system transporting the material to the surface for provisions to prevent breaking or leakage;
- The surface platform or production support vessel, essential for running the remotely operated mining system *in situ*, and for processing/dewatering of material on board and transfer to the transport barge;
- The discharge unit releasing sediment-loaded back to sea water after dewatering of the material.;
- In the case of shipboard processing (benefication, partial treatment or full treatment), the waste management system will be of importance;
- Transshipment should not lead to losses of ore.

Figure 3: Steps in the seabed mining process chain of relevance for testing equipment, monitoring and assessment of environmental impacts



Source: own illustration, IASS

Generally, it can be expected that the technology required for the mining of the different minerals targeted have to be tailor-made due to the different operating depths, sea states to be expected, accessibility and consistence of minerals. In terms of developing a full scale commercially operating mining system, the current lack of experience requires *in situ* operating tests for all parts of the system a) to test the technical performance and feasibility of the gear and b) to monitor and assess the environmental impacts of its operation. This development is likely to proceed in a stepwise process, from conceptualising, through down-sized modelling, tests in tanks and shallow water to finally tests in the Area, in the envisaged area for mining. Different components of the system can be developed and tested in parallel or one after the other before being compiled to one mining system.

3.3.2 Technological Readiness Levels (TRLs)

Technological readiness assessment and related maturation plans originate from high risk air, space and nuclear technology development, and are used in various context with developing technology[75]. A number of guidance documents for the assessment of technological readiness expressed as levels of a stepwise maturation process (technological readiness levels, TRLs) exist. This method can be applied to the developing technologies for the mining of minerals in the deep sea. Usually technology readiness assessment has to be included in applications for funding, *i.e.* with the U.S. government, in order to provide an easily understandable measure for the progress of certain projects. This is also the case for offshore oil and gas projects.

In the case of technology development by exploration contractors and related technology projects and companies, the relevant information is not disclosed to the public. It may be that the ISA LTC and Secretariat, through the mandatory reporting system of ISA, have more information, however it is not known that ISA keeps track of technological development in that sense.

[75] see e.g. https://basicknowledge101.com/pdf/km/Technology_readiness_level.pdf

A study commissioned by the European Commission, and launched in 2014, for the first time applied the concept of TRLs to seabed mining technology development (Ecorys, 2014a, b) using a categorisation as suggested by the European Commission in its Horizon 2020 Work programme[76]. The EC distinguishes 9 categories between TRL 1 - 9, which follow closely the original NASA TRL categories, as adopted by the European Space Agency[77], and are described as follows Table 2:

Table 2: Technology Readiness Levels, TRLs, as categorised by European Commission (2013), and described by NASA. Source: ECORYS (2014b)

TRL	Definition EC*	Definition NASA**	Description as provided by NASA
TRL 1	Basic principles observed	Basic principles observed and reported	This is the lowest "level" of technology maturation. At this level, scientific research begins to be translated into applied research and development.
TRL 2	Technology concept formulated	Technology concept and/or application formulated	Once basic physical principles are observed, then at the next level of maturation, practical applications of those characteristics can be 'invented' or identified. At this level, the application is still speculative: there is not experimental proof or detailed analysis to support the conjecture.
TRL 3	Experimental proof of concept	Analytical and experimental critical function and/or characteristic proof of concept	At this step in the maturation process, active research and development (R&D) is initiated. This must include both analytical studies to set the technology into an appropriate context and laboratory-based studies to physically validate that the analytical predictions are correct. These studies and experiments should constitute "proof-of-concept" validation of the applications/concepts formulated at TRL 2.
TRL 4	Technology validated in lab	Component and/or breadboard validation in laboratory environment	Following successful "proof-of-concept" work, basic technological elements must be integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance for a component and/or breadboard. This validation must be devised to support the concept that was formulated earlier, and should also be consistent with the requirements of potential system applications. The validation is "low-fidelity" compared to the eventual system: it could be composed of *ad hoc* discrete components in a laboratory.

[76] "Technology readiness levels (TRL)"(http://ec.europa. eu/research/participants/data/ref/h2020/wp/2014_201 5/annexes/h2020-wp1415-annex-g-trl_en.pdf)(PDF). European Commission, G. Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014)4995.

[77] "Technology Readiness Level (TRL) - The ESA Science Technology Development Route"(http://sci.es a.int/sre-ft/50124-technology-readiness-level/.) European Space Agency, Future Missions Ofice, Technology Preparation Section.

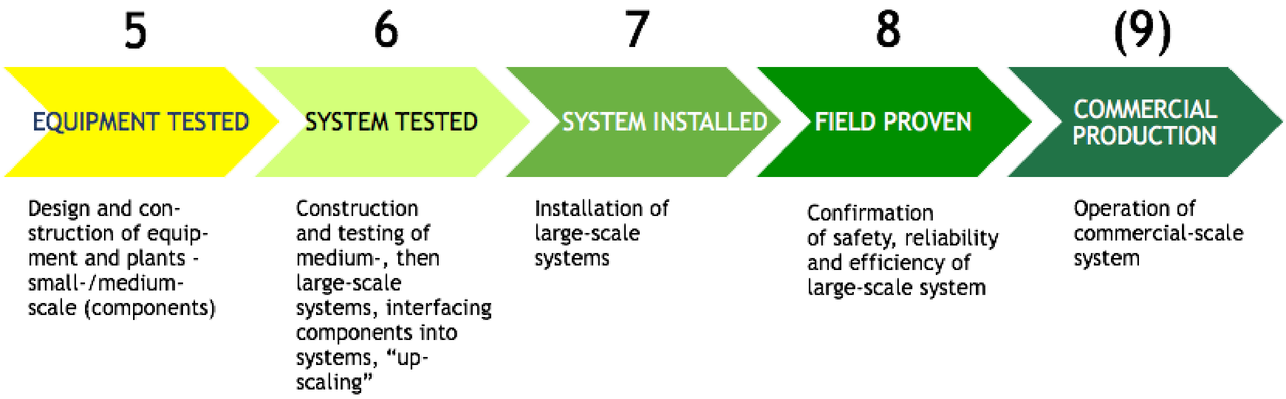
TRL	Definition EC*	Definition NASA**	Description as provided by NASA
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)		At this level, the fidelity of the component and/or breadboard being tested has to increase significantly. The basic technological elements must be integrated with reasonably realistic supporting elements so that the total applications (component-level, sub-system level, or system-level) can be tested in a 'simulated' or somewhat realistic environment.
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	A major step in the level of fidelity of the technology demonstration follows the completion of TRL 5. At TRL 6, a representative model or prototype system or system - which would go well beyond ad hoc, 'patch-cord' or discrete component level breadboarding - would be tested in a relevant environment. At this level, if the only 'relevant environment' is the environment of space, then the model/prototype must be demonstrated in space.
TRL 7	System prototype demonstration in operational environment	System prototype demonstration in a space environment	TRL 7 is a significant step beyond TRL 6, requiring an actual system prototype demonstration in a space environment. The prototype should be near or at the scale of the planned operational system and the demonstration must take place in space.
TRL 8	System complete and qualified	Actual system completed and 'flight qualified' through test and demonstration (ground or space	In almost all cases, this level is the end of true 'system development' for most technology elements. This might include integration of new technology into an existing system.
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)	Actual system 'flight proven' through successful mission operations	In almost all cases, the end of last 'bug fixing' aspects of true 'system development'. This might include integration of new technology into an existing system. This TRL does not include planned product improvement of ongoing or reusable systems.

*Technology readiness levels (TRL)"(http://ec.europa. eu/research/participants/data/ref/h2020/wp/2014_201 5/annexes/h2020-wp1415-annex-g-trl_en.pdf). European Commission, G. Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014)4995.

**"Technology Readiness Level (TRL) - The ESA Science Technology Development Route"(http://sci.es a.int/sre-ft/50124-technology-readiness-level/.) European Space Agency, Future Missions Ofice, Technology Preparation Section.

According to these categories, the testing of mining equipment will have to have TRL 4 or 5. Systems tests will take place once TRL 7 or 8 are reached, aiming to complete the development at TRL 9 (Figure 4).

Figure 4: The need for testing expected of the developing mining technology (TRLs in line with EC categories) in relation to the phased approach as foreseen in the legal framework for mining in the Area (color-coding as in Ecorys, 2014a, b)



Source: own illustration

The primary purpose of using technology readiness levels has been to reduce the risks associated with management decisions concerning the funding, development and transitioning of technology.[78] Therefore, a number of assessment tools have been developed to enable a standardised assessment of the TRL in different context. The positive effect can be that

- a common understanding of technology status is achieved
- risks and uncertainties are revealed so they can be addressed.

On the other hand, readiness does not necessarily fit with appropriateness or technology maturity.[79]

In practice, the above categories do not exist as such but are a continuum of engineering steps. Looking at the overall mining capabilities to be achieved, all equipment tests other than integrated into a mining system would lead to TRL 5 at most. For example, the development of the mining device, the collector operating on the seafloor, goes through a series of steps from construction, model-size trials, pre-prototype to prototype and commercial device building and testing. All this would be accommodated in TRLs up to 5 because the collector is only one part of the mining system required. System tests, as some ISA contractors are carrying out are here summarised here according to the general state of progress towards an operational commercial system.

TRLs are used here to enable an overview of the state of development of mining equipment, as far as known. Different from its original purpose, based on the information publicly available, TRLs are broadly assigned to the observed state of progress, in particular where tests are planned. (Ecorys, 2014a, b) provided a first review of the state of technology development. They conclude that "*that for many technologies required for exploiting seabed minerals, TRL levels are still far from the desired*

[78] https://en.wikipedia.org/w/index.php?title=Technology_readiness_level&oldid=834189220

[79] Ben Dawson (31 October 2007)."The Impact of Technology Insertion on Organisations"(http://www.hfi dtc.com/research/process/reports/phase-2/HFIDTC-2- 12-2-1-1-tech-organisation.pdf). Human Factors Integration Design Technology Centre.

proven system. The majority of research efforts till date have focused on the exploratory part and in particular on exploration itself and on resource assessment and evaluation (and to a lesser extent mine planning). Apart from a few tests there has been no fully working system applied in a relevant environment". Their compilation shows, that amazingly not even the problem of resource estimation has been solved with high confidence for any of the three resources. Excavation, vertical transport and surface operations for rank low to moderate at best.

However, since then some progress has been achieved, not least through financing by EU Horizon 2020, and a number of field tests have been carried out in national waters or are planned for the Area in due time (Tables 7-9 below). Therefore, below in chapter 4.4 an update on testing activities is provided, in particular in view of the envisaged testing activities.

Some developments so far have not yet left the design stage: The North America Consortium for Responsible Ocean Mining, NACROM, recently presented an innovative nodule mining technology system for mining polymetallic nodules based on an innovative type of semi-automatic swarm robotics.[80] With this system, nodules would be picked individually and buoyancy-lifted in cages to the surface. The system, can be scaled up over time and if operational, might greatly reduce the impacts on the benthic environment and reduce the extent of plumes considerably.

A Russian company, Krypton Ocean is working on a similar modular concept with a large number of small buoyant mining units excavating the nodules.[81] This system does not pick the nodules, but a rotating chain-bucket hydraulic tool, 10 meters wide collects the nodules and sends them to the hopper, from where the nodules are conveyed by an elevator to the storage tank in the vehicle, crushed an sent with vertical hydrotransport system with intermediate pumping stations to the surface.

Deep Reach Technology Inc. is an American company with historic ties to the early mining consortia which works for U. S. government bodies, among others on developing an airlift for vertical transport of nodules and developed improved methods for mining of SMS, crusts and other seafloor hard rock deposits. The patented “Vertical Mining System” uses a subsea hydromill, vertical riser or cable and seafloor anchors to control an excavating operation without the need for a heavy seafloor vehicle to support cutter heads.[82]

3.3.3 Classification and Certification

The safety of operation of all equipment operated underwater, in particular deep seabed-related excavation systems and its operations according to best environmental practice should be ensured by

- developing globally applicable technical, safety, environmental and operational standards; and
- an inspection and certification of conformity process, leading to
- a classification of technologies and operations admitted for deep seabed operations.

These tasks could be done by the ISA, however the better approach would be to cooperate with existing standard and classification bodies to benefit of the broad expertise available. Private international classification societies inspect and certify the conformity of usually ships, submarines and offshore installations to certain safety norms, such as for example in terms of ice breaking capacity, condition of the hull or safety of operation. Such certification is required for insurance or for entering national waters and ports. The classification rules are designed to ensure an acceptable degree of stability, safety, environmental impact, etc.

[80] https://vimeo.com/463231053, presentation at 2020 UMC Underwater Minerals Conference
[81] http://www.kryptonocean.com/rcuma-en.html
[82] https://www.deepreachtech.com/about1-ciyo

One of the classification societies, the American Bureau of Shipping, is the default classification body for all American vessels and installations, and has issued a "*Guide for Subsea Mining"* (ABS, 2020)[83] in October 2020, according to which the cobalt-crust mining system of China Merchants Industry, CMI, obtains an Approval in Principle (AIP) for its deep-sea mining system design. No further information is available. The Subsea Guide only determines which of the more detailed rules apply to which equipment.

Also, the operation of deep seabed mining could be made safer, and more environmentally friendly through standardisation of the main construction requirements of equipment. The development of such technical standards need not necessarily be in the hands of the ISA or national regulators, but could also be promoted through a non-governmental body such as the International Organization for Standardization, ISO, made up of the national standards bodies in 165 countries (Seta, 2019). While its principal target is to reduce technical barriers to free trade, it also developed standards for environmental management (ISO 1400x), environmental risk assessment (ISO 31000). Its technical committee TC8, ships and marine technology, and subcommittees is dealing with marine and submarine issues. There are nine standards for marine environmental protection under development, however so far none in relation deep seabed mining-related issues. Among the four existing marine technology standards and 11 under development there are two which may be of relevance for environmental governance (ISO/CD 23730 "Marine Environment impact assessment (MEIA) — General technical requirement on marine environment impact assessment" and ISO/DIS 23731 "Marine environment impact assessment (MEIA) — Performance specifications for *in situ* image-based surveys in deep seafloor environments, meiofauna" (Seta, 2019).[84]

A preliminary assessment of the legal basis by the Netherlands in its submission to the 2017 Annual Meeting of the ISA Council (ISBA/23/C/5), concludes that such a certification is within the remit of the ISAs RRPs. The development of appropriate mining technology and practice is put in context with adaptive governance (here falsely seen as a "learning-by-doing-approach"), initiating constant improvement of mining practice over time in order to minimise environmental impacts. A type of certification process is proposed with respect to the environmental suitability and sufficiency of equipment, operational procedures and processes employed during deep seabed mining in the Area to safeguard against unexpected and unrecoverable impacts of activities in the Area. The Council was invited to request the LTC to consider

a) the development of an assessment methodology for equipment, operational procedures and processes used in deep sea mining exploitation activities and
b) the development of an approval process to ensure that equipment, operational procedures and processes used for exploitation activities meet requirements that are yet to be established for avoiding or minimizing adverse environmental impacts.

No progress was made since then.

3.4 Equipment Tests by Exploration Contractors[85]

Development of deep-sea minerals mining technology is underway, often building on machinery already in use in shallow water environments, though the great depths involved present additional challenges compared. The three mineral-bearing substrates require very different approaches to excavate and recover (1) polymetallic sulphides can be either dredged or drilled, before they are piped up to the

[83] subsea-mining-guide-oct20.pdf, https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/offshore/318_guideforsubseamining/subsea-mining-guide-oct20.pdf

[84] A DOSI working group contributes to this. See https://www.dosi-project.org/topics/new-technologies-for-environmental-impact-assessments-in-the-deep-sea/

[85] this chapter benefited of research done by Dr. Anneke Denda on IASS contract 62340-408440-19-076.

surface (2) polymetallic nodules, which litter the ocean floor beneath a blanket of silt, can be mechanically combed or sucked up from the seabed by ROV-collectors, crushed and then piped to the surface. Innovative technologies seek to pick them with buoyant modules. (3) Fe-Mn crusts will have to be grinded from the host rock likely resulting in a slurry of rock and crust being piped to a surface vessel.

The different types of mineral accretions on the deep seafloor pose different challenges to miners, e.g. does the harvesting of polymetallic nodules from abyssal plains not only involve greatest depths, but also semi-liquid sediment on which to operate machinery to retrieve the potato sized nodules, while the potential excavation of seafloor massive sulphides, while at mid-ocean depth, will stand the strains of a hot vent environment. Cobalt-rich crust on the other hand will need to be scraped off the host rock in rugged terrain (Miller et al. 2018).

So far, no commercially and routinely employed technology exists and the technology developments until today seem to have reached no further than at most a pre-prototype stage of individual equipment and, in a few exceptional cases, of mining systems. Therefore, not only the technology needs to be tested *in situ*, but in particular environmental monitoring is required to develop the Best Available Technology in conjunction with Best Environmental Practice on order to a) assess the overall acceptability of environmental impacts caused by a commercial mining activity, and b) optimise recovery methods to minimise environmental harm.

As described below, historic pilot mining in the 1970s, and several benthic impact studies, BIEs carried out in different areas with the same disturbance methodology contributed most to the current understanding of how mining could proceed and which mining impacts it might involve (Jones *et al.*, 2017a). However, it is time to revise the picture of limited spatial and temporal impacts. As shown by several modern biological investigation programmes, deep sea biological research has made quantum progress and today can identify and assess functional responses to disturbances previously unknown (Gollner *et al.*, 2017b; Gooday *et al.*, 2017; Lindh *et al.*, 2018; Macheriotou *et al.*, 2020; Orcutt *et al.*, 2018; Volz *et al.*, 2020) (see further chapter 4.4.1.1).

The chapter below presents an account of past technology tests, a full list of scientifically controlled mining (equipment) tests until today, and an attempt to describe the state of technology development by current ISA exploration contractors, including their plans for future testing and exploitation as far as known.

3.4.1 Equipment Tests Prior to the ISA regime

All mining tests carried out by the early industry consortia and pioneer investors prior to the coming into force of UNCLOS targeted the exploitation of polymetallic nodules in the region limited by the Clarion and Clipperton Fracture Zones, now termed Clarion-Clipperton-Zone, CCZ, in the Pacific.

3.4.1.1 Technology Development and Testing

Interest in the possible commercial exploitation of manganese nodules was first raised by J. L. Mero and his famous book "The Mineral Resources of the Sea" of 1965 (Sparenberg, 2019), which sparked the attention of Avid Pardo and ultimately led to the anchoring of Part XI in the UN Law of the Sea. Already in the 1970s, a first sediment map of the Clarion-Clipperton Zone produced by the Deep Sea Drilling project in the frame of the International Decade of Ocean Exploration (IDOE) directed the attention of miners to the Northeast Pacific equatorial region as a prime manganese nodule zone (Golder Associates, 2013).

In parallel to the first negotiations on a future Law of the Sea,[86] several multi-national industrial consortia formed, made up of private and state actors from mostly the industrialised global north, to develop manganese nodules as an economic resource from the high seas. These consortia benefited of

[86] the three UN Conferences on the Law of the Sea, in particular the Third conference 1973-1982

substantial support from their respective governments (Sparenberg, 2019). Therefore, at the end of the 1970s, coinciding with high metal prices and a perceived insecurity of minerals supply due to multiple decolonisation processes worldwide, technology development peaked with at least three successful pilot-scale mining tests. The consortia Ocean Minerals Inc., OMI, Ocean Mining Associates, OMA, and Ocean minerals Company, OMCO, all managed to lift several hundred tons of manganese nodules to a surface vessel and back to land (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The French AFERNOD/GEMONOD efforts started very early, however were not successful and abandoned:

Table 3 Historic mining tests, all related to polymetallic nodule recovery

Consortium/company	Year	Location	Type of test	TRL	References
Deepsea Ventures Inc.	1970	Atlantic off Florida coast, 1000 m, then CCZ	First test of hydraulic miner	5	(Morgan *et al.*, 1999)quoting Gemindert and Lecourt, 1972
AFERNOD/GEMONOD[1]	1970-1979 1980 1984-1989[6]	CCZ	1970-1979 tests of the CLB system (the two-ship system). 1980 test of a free shuttle mining system. 1984-89 reorientation to hydraulic lifting system with a motorized collector /Archimedes type. Mining system designed.		Herrouin, G. in (International Seabed Authority, 2001), ISA 2017 - Chennai report and websites
Kennecott Manganese Nodule Consortium, KCON (1972-1980/1974-1993?)[2] successor: Deep Reach Technology, DRT Inc.?	?	US granted licenses	Towed nodule pick-up system, a hydraulic lift system, and various transport and metallurgical processing systems.	5	(Golder Associates, 2013)
Ocean Mining Associates, OMA[3] (1974)	1977 and 1978	CCZ	Integrated mining system, a few hundred tons of nodules recovered monitored for environmental impact assessment by the US Government NOAA (DOMES-C).	6	(Golder Associates, 2013)
Ocean Management Inc., OMI[4] (1975)	1976 and 1978	CCZ, 5000 m	1976 collector development sea trials in CCZ 1978 OMI mining system test - 900 t of nodules recovered - only known successful fully integrated trial. Ni, Cu and Co extracted in both pyrometallurgical and hydrometallurgical trials	7	Technical description of PMT in Brockett et al. in ISA TS Chennai workshop 2008, 2017, (Ramboll, 2016)

Consortium/company	Year	Location	Type of test	TRL	References
			Monitored for environmental impact assessment by the US Government NOAA (DOMES-A).		
Ocean Minerals Company, OMCO[5] (1975)	1976, 1979	CCZ	Test of collector, crusher, a seafloor to surface slurry riser system, the first industrial scale dynamic positioning system for a vessel and a metallurgical processing plant	6	(Chung, 2009; Golder Associates, 2013; Spickermann, 2012, quoted by Golder, 2013)
PREUSSAG/GEMONOD			Scalable collector test planned for 1985 - not realised		(Ramboll, 2016)

1 Association Francaise d'études et de recherche des Nodules océaniques (1974-1985). then: Groupement pour la mise au point des MOyens nécessaires à l'exploitation des NODules polymétalliques, GEMONOD (1984-1988)

2 Successor: Deep Reach Technology, DRT Inc.

3 From subsidiaries of Tenneco, US Steel, Union Minière and Jamco (5 japanese companies); now Essex Minerals, Union Seas, Sun Ocean Venture, Samin Ocean Inc

4 INCO US Inc, Metallgesellschaft AG, Preussag AG, Salzgitter AG, AMR, Deep Ocean Mining Co., DOMCO (20 Japanese companies) Sumitomo, Japan; SEDCO

5 Lockheed Billiton (Shell), Amoco (Standard Oil). Shell Billiton and Bos Kalis, Netherlands, abandoned in 1986 and Cyprus Minerals Co. replaced Amoco. Late 1995 Cyprus and withdrew all interest were taken over by Lockheed Martin Missiles & Space, a subsidiary of Lockheed Martin, USA. Omco requested a permit for exploration on the surface by KCON released in 1993.

6 1985 test together with Preussag on RV Sonne.

3.4.1.2 Environmental Disturbance Research

Notably, all of the field tests listed in Table 4 have been accompanied by substantial environmental research and monitoring programmes, including environmental baseline surveys, and multiple campaigns to measure the effects of benthic and pelagic plumes (DOMES, Benthic Impact Experiments, BIE, see Table 4).

Whereas the BIEs delivered mostly scientific knowledge on small-scale benthic impacts and recovery, the Deep Ocean Mining Environment Study, DOMES, conducted by the US National Oceanic and Atmospheric Administration, NOAA (USA) between 1972–81 (DOMES 1976) aimed at preparing Environmental Impact Assessments and Statements for the US industry. Studies to inform planned guidelines for the industry, and to feed and guide an Environmental Impact Assessment of a deep-sea mining operation (NOAA, 1981) were carried out in a multi-year sampling programme at three representative sites in the CCZ (DOMES A, B, C). Located between equatorial current and counter current, each consisted of an array of north-south sampling stations to deliver an environmental baseline and predictive capability for determining potential environmental effects and recovery potential (NOAA, 1981).

Already since 1969, investigations of the environmental impacts of nodule mining systems took place in various locations in the Clarion-Clipperton Zone (Amos and Roels, 1977). In 1978, NOAA then monitored the environmental impacts arising from two of the pilot-scale mining system tests, namely the test conducted by Ocean Mining Inc., OMI (site DOMES-A, Burns et al. 1980) and by Ocean Mining Associates, OMA (site DOMES-C, (Ozturgut *et al.*, 1981). The study measured the concentration of particulate in the surface discharge, and assessed the biological impacts due to the surface as well as benthic plumes which led to prioritisation of effects based on likelihood of occurrence and degree of impact to be expected. Although the U.S.A. are still no member of the ISA, much of this work has fed into the later ISA regulations and recommendations, among others through various experts which have brought-in their expertise.

Technology development and field tests came to an end after the above-mentioned successful pilot mining tests were carried out and the consortia dissolved (Sparenberg, 2019). The remaining interest was directed at the environmental effects of mining, in particular on the effects of sedimentation on the benthic fauna. As summarised by Morgan *et al.* (1999) three further studies funded by the U.S. investigated the recovery of benthic fauna in the former experimental mine sites (ECHO-1 1983, RUM-III 1988, QUAG MIRE expedition 1990), however limited sampling and technical problems precluded meaningful results.

Interest in the environmental impacts of potential future mining activities in Germany developed from the long-term involvement of the "Arbeitsgemeinschaft meerestechnisch gewinnbarer Rohstoffe, AMR" in the OMI consortium, the experience with the exploration of metal-rich mud from Red Sea brine pools (Thiel *et al.*, 2015) and strong academic deep-sea research. Due to lack of interest from industry, the 1989, the government-funded Disturbance and Recolonisation Experiment, DISCOL, deliberately disturbed an area as large as possible with scientific means in the Peru Basin in 1989, at the time a possible location for an exploration application of Germany to the later founded ISA (Thiel *et al.*, 2001).

This experiment, as well as the other test mining and experimental disturbances carried out in the CCZ and Indian Ocean by the former pioneer, later exploration contractors to ISA, namely IOM, Japan, India, Russia with China (and the U.S.), are all of high interest to investigating the long-term impacts of small to medium-scale disturbances (Jones *et al.*, 2017a). Most of the experimental sites have been revisited several times, and results are published. Nevertheless, inconsistencies in the sampling and analysis routines make the actual comparison across the different experiments and over time difficult (Jones *et al.*, 2017a). The authors therefore highly recommend to better standardise future monitoring of the effects of disturbance tests, follow strict statistically meaningful sampling schemes in time and space, as well as taxonomic standardisation to allow for before-after analysis. They conclude that any future disturbance experiment has to be "*large enough to be representatively and accurately sampled over time (probably at least many square kilometers). This may mean that a mining test might be the only practical way to obtain these data*" (Jones *et al.*, 2017a, Discussion and Table 2).

Table 4: Scientifically controlled disturbance tests until today

Funding source	Project	Year of Test and revisit	Location	Activity	TRL	Reference
EU Horizon 2020	Blue Nodules Blue Mining Blue Harvesting	2018, 2019, 2021	North Atlantic	optimise collector, separator and sediment discharge to minimise plumes	5+	
national funds	JPIO MiningImpact and MIT	2021	CCZ	Monitor hydraulic collector test GSR		(BGR, 2018; GSR, 2018)
NZ	NIWA	2018-2021	Chatham Rise	Benthic Disturber (DSSR?)+Lab experiments		ROBES website**

Funding source	Project	Year of Test and revisit	Location	Activity	TRL	Reference
US	MIT	2018	California Bight	Pelagic sediment plume dispersal experiment+modelling		(Kulkarni *et al.*, 2018)
UK NERC	ULTRA/ MarineE-Tech	2017	Tropic Seamount, Atlantic	Benthic sediment dispersal experiment+modelling		(Spearman *et al.*, 2020)
ISA exploration contractors	several	2014 -	CCZ contract areas (B, D, F, IOM, UK)	localised sampling of nodules with dredges and epibenthic sledges		(Jones *et al.*, 2017a)
India	INDEX	1997 2001-2005	CIO	BIE with DSSRS*, suspension, redeposition Monitoring		(Government of India, 2020; Nath *et al.*, 2012; Rodrigues *et al.*, 2001; Sharma, 2001, 2010, 2015; Sharma *et al.*, 2001; Sharma *et al.*, 1995)
IOM	IOM with COMRA	1995 1997 2000 2015	CCZ	BIE with DSSRS*, suspension,redeposition		(Radziejewska, 2014; Radziejewska and Stoyanova, 2000; Tkatchenko *et al.*, 1997)
Japan	JET	1994-97 2011-12	CCZ	BIE with DSSRS*, suspension,redeposition		(Fukushima and Tsune, 2019)
Japan	JOGMEG	2008 2017	Okinawa Trough	Baseline survey, predictive model and conservation measures Disturbance experiment		(Matsui *et al.*, 2018)
Germany	DISCOL	1989 1992 1996 2015	Peru Basin	BIE with plough-harrow		(Thiel, 2001), revisited by JPIO EcoMining
US/Russia	NOAA	1992/93 1994	CCZ	BIE II with DSSRS*, suspension,redeposition		(Trueblood *et al.*, 1997)
USA	OMCO	1978 1988 2004	CCZ			(Jones *et al.*, 2017a; Miljutin *et al.*, 2011)
USA	OMA - monitored by US NOAA - DOMES II	1978/79	CCZ-DOMES C	Surface discharge and benthic plumes and biological impacts		(Ozturgut and Lavelle, 1984; Ozturgut *et al.*, 1981)

Funding source	Project	Year of Test and revisit	Location	Activity	TRL	Reference
		1982 1984 1983, 1988, 1990		Application for exploration license with NOAA NOAA EIS OMA to revisit: recolonisation, acute mortality, critical dose experiment		
USA	OMI - monitored by US NOAA	1978	CCZ-DOMES A	surface discharge and benthic plumes and biological impacts		(Ozturgut and Lavelle, 1984; Ozturgut *et al.*, 1981)
France	AFER-NOD/GEMON OD/ Nodinaut	1974 2004 2015	CCZ-NORIA, NIXO45 NIXO41 ECHO-1 and BIE sites	Baseline investigations Reference state and impact evaluation revisit		(Tilot, 2019)
USA	NOAA - DOMES I	1969-1976	CCZ near DOMES C	Reference state and impact evaluation CLB, airlift and dredges		(Amos and Roels, 1977; NOAA, 1981)

* DSSRS Deep-sea sediment resuspension system

** https://niwa.co.nz/coasts-and-oceans/research-projects/resilience-of-deep-sea-benthic-fauna-to-sedimentation-from-seabed-mining

3.4.2 Equipment Tests for Mining under ISA Contracts

3.4.2.1 State of Technological Development

Several authors have stated that since the testing of the great consortia in the 1970s, little progress has been made (Chung, 2009; Chung *et al.*, 2002; Ecorys, 2014b; Golder Associates, 2013), and this seems to be the case until today. Since then, no full-scale mining test has ever taken place, and the technological development seems to be limited to design already found useful in the 1970s, such as machines for dredging up the nodules. Modern design with multiple robotic units, virtually picking manganese nodules, such as promoted e.g. by the North America Consortium for Responsible Ocean Mining, NACROM, the company Krypton Ocean and some technical research institutes (see chapter 4.3.2) are widely to be considered unrealistic for commercial purposes due to the limited "yield". Furthermore, predominantly the State or State Agencies contractors to ISA have chosen a slow, step-by-step-approach to an incremental design process of the mining systems rather than a high investment for quick development. The latter strategy seems to be preferred by the commercial contractors, which only recently joined the suite of exploration contractors. This results in the commercial contractors (DeepGreen, DEME/GSR, eventually UKSRL), although technologically only in the starting phase, now pushing the field forward vocally.

Other than in the pre-UNCLOS days, the cooperation among the different contractors is limited to explicit scientific cooperation, or real business joint ventures, such as those between UKSRL and Ocean

Minerals Singapore or DEME/GSR with Cook Island Investment Corporation. DeepGreen, on the other hand profits from having exploration rights in three contract areas sponsored by Nauru, Tonga and Kiribati. Technology is generally, with the exception of EU funded research projects, being developed on a contractor basis rather than cooperatively, and the ISA confidentiality policy prevents substantial information from being published. All of this results in an overall low level of knowledge on the state of technological development. The information on the technological readiness in Tables 6-8, are a composite of publications, presentations and reports of update meetings, as for example the ISA organises from time to time. In addition, press releases and websites are sometimes helpful to note special achievements such as successful field tests in national waters.

A comprehensive analysis of the state of technological development of deep seabed mining systems commissioned by the European Commission concluded in 2014 that the overall TRL of the sampling technology could be rated as TRL 4-5, sediment separation techniques TRL 3, nodule crushing system TRL 2 (Ecorys, 2014a, b). In particular, Ecorys (2014a) found that the concentration of crushed nodules prior to sending the slurry up to the support vessel are not being considered in any project. Also, the option of stockpiling nodules or SMS on the seafloor prior to sending to the surface, which could be beneficial in case of non-continuous or small-scale excavation of material, has not been developed apart from first considerations by Nautilus Minerals.

Ecorys (2014b, see also Table 5) summarises as follows: as regards vertical transport systems, three systems are in development these days: a) air lift system, a method proven to work with the OMI mining test (TRL 5), but very energy-demanding; b) hydraulic pump systems, also applied in deep water oil and gas industry. Modern versions have the pumps on the surface vessel, however the systems need field testing in deep seabed mining context (TRL 3); and c) batch-cable lifting, which was conceptually designed (TRL 2), however not yet tested in the field. So far, a functional riser-and-lift system has not yet been demonstrated that will carry unprocessed ore to the surface support vessel and return tailings or a dewatering plume to the seafloor or mid-water. This is considered to be the last major hardware gap that must be bridged before commercial mining can commence.[87]

The dewatering of the mineral material on board of the support vessel is a critical process, but technically well-known and feasible (TRL 7). However, here the quality of the discharged water-sediment mixture is of importance, as well as the discharge design process. Concentration and processing of the mined minerals on board are quite unlikely due to the large space and energy requirements.

Transshipment from the surface support vessel to the bulk carriers is prone to sea state and general weather conditions in the open oceans and need safety procedures to enable operations in such conditions (TRL 5).

So far, outside the scientific sphere (Da Ros *et al.*, 2019), there seem to be no approaches at all to conceptualise monitoring and site remediation after mine closure.

[87] http://dsmobserver.com/2020/09/tools-of-ore-surveying-the-current-state-of-deep-sea-mining-technology/

Table 5 The Technological Readiness Levels, TRL, of deep seabed mining technology (Ecorys, 2014b).

Ore Deposits	Technique	Comments	Tech. readiness level
Extraction			
SMS	Conceptual drum cutter (ROV)	Based on methods used for terrestrial coal mining, the vehicle minimises the production of ultra-fine particles. Experiments have been conducted at the depths of 1,600m, but no material was collected.	3
SMS	Auxiliary cutter (ROV)	Used to flatten the service, enabling the drum-cutter to excavate resources on the seabed.	2
SMS	Rotating Cutter Head (ROV)	Originally based on deep-sea diamond mining. With a rotating cutter head, it is more flexible to operate than a drum-cutter. However, further testing is needed to find out if it is applicable in a deep-sea environment.	2
SMS	Clamshell grab (ROV)	Not used for excavation, but rather to remove top layers of SMS deposits. Its applicability for gathering rock is uncertain, along with its economic viability.	2
Polymetallic Nodules	Passive Collectors	Advantageous due to its simplistic design and low operating costs. However, it has become an abandoned method, due to lack of control of the quality and quantity of nodules collected, along with great environmental hazards in form of large sediment plumes.	5
Polymetallic Nodules	Hydraulic collector system	The system applies a type of seawater spray in order to separate the nodules from the seabed which results in a limited environmental impact. Hydraulic machines have been tested at shallow depths.	4
Ferromanganese crust	-	Due to the difficulties of mining this resource, an economically attractive option has not been proven yet. The basic principles have been observed but the methods have yet to develop further.	1
Lifting systems			
Seabed ores	Continuous Line Bucket system	A series of buckets on a line which is towed across the seabed. The method was first tested in 1972, but was however abandoned due to a lack of control of the system along with large environmental impact.	5
Seabed ores	Air-lift system	The system is based on injecting compressed air into a pipe and the ore is pumped up to the surface. It has been tested in very deep waters, but is it very vulnerable to clogging and requires large amounts of energy.	5
Seabed ores	Hydraulic Pump system	A simple and reliable system with high lifting capacity, often applied during the drilling for oil and gas. The concept appears to be a promising concept for DSM, but further research beyond the prototype stage is needed	3
Seabed ores	Batch cable – lifting	Similar to what is applied in terrestrial mining, this is essentially a hoisting system and therefore much more simple than the hydraulic or air-life equivalents. The question lies mainly with if it will be efficient enough to be commercially viable.	2
Surface platforms			
Seabed ores	Dewatering	One of the simplest techniques to upgrade the value of ore. This is crucial in order to increase the economic viability of DSM. The system is well known, and should with ease be applicable to vessels or off-shore platforms.	7
Disposal			
Tailings	-	Due to the fact that large scale commercial operations have yet to take place, this is a highly unexplored area. A clear plan for the handling of tailings is needed.	1

3.4.2.2 Manganese Nodules

Contrary to the volume of discussions and public attention, there is only slow progress with regards to the technology development for the exploitation of manganese nodules. Only Korea has its mining system developed to such a state, that it can recover manganese nodules at prototype scale (Hong *et al.*, 2019). Others, like GSR and India, are still in the pre-prototype phase of equipment construction and plan to carry out collector tests *in situ* under exploration contract conditions in the near future (see chapter 6).

European-funded research projects (EU H2020 BlueNodules, BlueMining, BlueHarvesting),[88] made up of consortia of academia and industry, may contribute to advancing commercially viable technologies for nodule mining: In particular the Dutch company Royal IHC, (a subsidiary of the Keppel Offshore and Marine, Singapore, which also owns Ocean Minerals Singapore and collaborates with GSR on lifting systems)[89] built and tested the Apollo II nodule collector and conducted a plume and disturbance study in conjunction with the Blue Nodules project. This small-scale crawler system is primarily designed to test operational systems and environmental impacts before scaling up to larger systems. European funding may prove essential for the progress made in offshore mining developments.

Several contractors have announced to carry out equipment or system tests under their exploration contract with ISA, or in national waters. Japan, China and Korea choose to develop and test their mining systems in national waters first, whereas others do not have this option (Table 6). However, there are currently only two types of nodule collectors (GSR, India) to be tested in three contract areas in the CCZ sponsored by Belgium, Germany and India (BGR, 2018; Government of India, 2020; GSR, 2018), notified to the ISA. More information on these tests is provided in chapter 6.

Table 6: Tests in preparation of mining polymetallic nodules under national or ISA contract.

Sponsoring State	Consortium/ company	Field test Year	Location	Type of test	TRL	Reference
Belgium	DEME/GSR	2017 2019, now 2020, 2021 2023 2024-25 2028	CCZ, B contract area CCZ, B and D contract areas	Tracked Soil Testing Device, TSTD Patania I pre-prototype collector test System test with riser integrated system trial and application exploit Commercial operations	4 5	(BGR, 2018; GSR, 2018, 2019)

[88] references Blue nodules, mining, harvesting ...

[89] see e.g. Greenpeace 2020. Deep trouble. The murky world of deep sea mining. 22 pp. https://www.greenpeace.org/static/planet4-international-stateless/c86ff110-pto-deep-trouble-report-final-1.pdf, https://www.greenpeace.org/international/publication/45835/deep-sea-mining-exploitation/

Sponsoring State	Consortium/ company	Field test Year	Location	Type of test	TRL	Reference
China	COMRA	2001 2016 2021	lake, 140 m 1000 m South China Sea, 1700 m	partial system test Envir. baselines, system test system test and environment	4	Chapter 10 in (International Seabed Authority, 2017b) Page, 2018 Xiangyang 2020, pers. com ws Italy NRC
China	CMC	until 2022		To set up laboratory and offshore platforms for testing key technologies	2	(CMC, 2019)
Consortium Russia, Bulgaria, Cuba, Poland, Czech Republic, Slovakia	IOM	1995 no date	CCZ	BIE experiment Nov 2020: Focus on developing technology for pilot mining system test now	2-4	Kotlinski et al. in ISA 2017, Abramowski 2018, pers. com. 2020), (IOM, 2017)
Germany	BGR	2021	CCZ contract area	no own technology test, partner EU projects	2	(Ramboll, 2016)
India (pioneer Investor, 1981)	National Institute of Ocean Technology, NIOT[1]	1997-2005 2000 2006+7 2009/10 2010 2021	Indian Ocean basin national waters, 410 m national waters 450 m CIO 3000m/ 5200 m national waters, 500 m IO, contract area	BIE disturbance and monitoring partial system partial system in-situ soil tester, collector new collector type and crusher crawler, collector and crusher pre-prototype	4 5	(Government of India, 2020; India, 2019; Sharma, 2010, 2011) Atamand et al. in ISA 2017 ISA 2017, p.14
Korea	KIOST/KORDI	2003 2013 2015 2018	national waters 1370 m national waters 1200 m national waters 500 m	first collector test Mining robot, 4 modules Mine system	6	Websites*

Sponsoring State	Consortium/ company	Field test Year	Location	Type of test	TRL	Reference
				full mining system, prototype mine robot		
Nauru	NORI - subsidiary of DeepGreen Minerals	end 2021-2023 2025 2026	CCZ, contract area	full scale seabed to surface PMT Production license full production	2	DSM Observer 2019***, pers. com. DeepGreen workshop, 2020
Russia	Yuzhmorgeologiya	no information	CCZ?	full-scale system test after exploration	2	(International Seabed Authority, 2017b)
Tonga	TOML - subsidiary of DeepGreen Minerals	until 2022	CCZ	Complete pilot testing Application?	2	(Tonga, 2019)Web news**
UK	UKSR Ltd.[2]	2022 or 2023	CCZ		6?	??

*KIOST [3]: Korea Institute of Ocean Science & Technology (KIOST) Official website. News>Press releases>World's First Verification Test of Deep-sea Manganese Nodule "Lifting System" . Date: 2016-01-20. http://www.kiost.ac.kr/cop/bbs/BBSMSTR_000000000281/selectBoardArticle.do?nttId=13810&kind=&mno=sitemap_12&pageIndex=5&searchCnd=&searchWrd=

KIOST [2]: Korea Institute of Ocean Science & Technology (KIOST) Official website. News>Press releases>Development of core technologies for underwater construction robots in Korea. Date: 2019-01-17. http://www.kiost.ac.kr/cop/bbs/BBSMSTR_000000000281/selectBoardArticle.do?nttId=19420&kind=&mno=sitemap_12&pageIndex=1&searchCnd=&searchWrd=

** https://www.offshore-energy.biz/deepgreen-gets-mining-rights-with-acquisition-of-toml/

*** DSM Observer [4]: DeepGreen's vision for the next generation of deep-sea mining. 2018/10. http://dsmobserver.com/2018/10/deepgreens-vision-for-the-next-generation-of-deep-sea-mining/

1 in cooperation with W. Schwarz, University of Siegen, Germany

2 "At time of the application, UKSRL stated that it held rights granting it access to certain data, resources and subject matter expertise of Lockheed Martin Corporation (LMC) related to polymetallic nodule resource surveying, analysis and recovery methods. Furthermore, they stated that LMC was the prime contractor and the technology provider for the Ocean Minerals Company (OMCO) consortium, which was one of the leading participants in seabed minerals efforts in the 1970s and 1980s. In addition, LMC has more than 50 years of experience in large-scale ocean systems design and development, including multiple deep-water efforts. Therefore, UKSRL may seek to capitalize upon the extensive polymetallic nodule experience and technical capabilities developed through the historical work, recent analyses and ongoing efforts of LMC" (ECORYS 2014)

3.4.2.3 Seafloor Massive Sulphides

Compared to the number of trials planned for the retrieval of polymetallic nodules, little movement can be seen towards developing and testing the technology for SMS mining at hydrothermal deposits (Table 7). A full-scale mining system for seafloor massive sulphides (TRL 7) has been developed and assembled for Nautilus Minerals in recent years, however its fate is uncertain as the company has ceased to exist.[90] The machines have never been tested *in situ*.

Japan, planning to mine in its own EEZ for national mineral supply, is far ahead of any other party, having carried out successfully excavation, crushing and ore lifting tests, verifying the prototype stage (Okamoto *et al.*, 2018; Okamoto *et al.*, 2019b). Several potential sites of interest have been verified off the coast of Okinawa, however the resource potential, accessibility and costs have to be evaluated yet. Therefore, it is as yet undecided whether commercial mining will ever become viable in context with Japan´s energy strategy.[91] Commercial extraction could begin at the earlies between 2026 and 2028.[92]

Korea must have come quite far in the development of a mining system for SMS, as it had announced mining trials for its exploration areas in Tonga for 2014/15. However, no more recent information is available, except that there is a substantial controversy in Korea about the economic feasibility and environmental responsibility of seabed mining.[93]

The next SMS recovery testing activity may be carried out by a German-based industry consortium in the German contract area in the Indian Ocean in 2023. Most of the technology needed is existent or proven to be functional in other context, however, nothing concrete is known about the plan of work apart from the intention to test a vertical mining system described by (Spagnoli *et al.*, 2016). A similar type of vertical mining systems has been developed by Japanese engineers (Keisuke *et al.*, 2015; Yoshiyasu *et al.*, 2016), but has not been tested yet.

Also Norway makes great efforts to explore the hydrothermal vents in the northern North Atlantic, in particular at Mohns Ridge (German *et al.*, 2011), within its national jurisdiction.[94] Currently, the resource volume is being established, and the technology concept is being designed. In early 2021, Norway announced that it could license companies for deep-sea mining after a parliamentary vote as early as 2023/24, with preparations for an environmental impact assessment and public consultations starting now.

Despite exploration contracts covering all active vents on the northern Mid Atlantic Ridge and the Central and Southern Mid Indian Ocean Ridge, there are multiple obstacles to exploitation: Reconnaissance of deposits not related to an active or inactive hydrothermal vent is very difficult, in particular due to the eventually thick sediment overburden (Van Dover, 2019); the SMS deposit/resource volume cannot yet be estimated properly (German *et al.*, 2015; Petersen *et al.*, 2016), and the biological characteristics of at least all the active hydrothermal vent fields subject to exploration contracts are unique and irreplaceable (Van Dover *et al.*, 2018).

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[90] http://dsmobserver.com/2020/05/the-last-days-of-nautilus-minerals/

[91] Henriques, Martha, 2019. Japan's grand plans to mine deep-sea vents. https://www.bbc.com/future/article/20181221-japans-grand-plans-to-mine-deep-sea-vents

[92] https://www.reuters.com/article/us-norway-deepseamining-insight-idUSKBN29H1YT

[93] https://www.nature.com/news/south-korean-survey-ships-open-up-to-science-1.16663

[94] https://www.gceocean.no/news/posts/2020/may/increased-allocations-for-mapping-of-seabed-minerals/
https://www.maritime-executive.com/article/norway-discovers-seabed-mineral-deposits-in-norwegian-sea

Table 7: Tests in preparation of mining SMS under national or ISA contract

Sponsoring State	Consortium/ Company	Year	Location	Type of test	TRL	Reference
China	COMRA	until 2021	Indian Ocean contract area	equipment tests	4?	(COMRA, 2019b)
Japan	JOGMEG	2012 2017	EEZ, Okinawa Trough	Drilling survey, crawl and first pilot mining test Excavation, crushing and ore lifting test SMS	6	(JOGMEG, 2017; Okamoto *et al.*, 2019a)
Germany	Industry consortium	2023	Indian Ocean contract area	Pilot mining test, commercial system test, incl. vertical trench cutter	6?	Rongau et al. 2013*, Damman, 2018**, (DSMA, 2019; Spagnoli *et al.*, 2016), pers. com.
Korea?						
Norway	NTNU		North Atlantic	Conceptual design exploration systems SMS	1	UMC 2020 (Ellefmo, Steinar)

* Rongau, J., Waquet, B., Spagnoli, G., 2013. ABYSS MINER: Design of a deep-sea vertical continuous excavator. https://www.martec-era.net/lw_resource/datapool/_items/item_145/abyss_miner_-_technip.pdf

** Damman, 2018. Deep Sea Mining of Massive Sulphides. A completely new technical approach. Presentation at NMMT Konferenz "Maritime Zukunftsmärkte und Innovation", Berlin.

3.4.2.4 Cobalt-rich Ferromanganese Crusts

Since the 1970s, cobalt-rich crusts from seamounts and polymetallic nodules have been recognised as separate resources with economic potential. Following on from early seamount resource exploration by Mero and Russian researchers, a German cruise led by P. Halbach carried out the first systematic investigations in 1981 (Hein *et al.*, 2000). In particular Japan invested in extensive exploration surveys in the 1980s, including in the equatorial region of the Central Pacific Ocean (Chung *et al.*, 1996) and started with conceptualising a crust mining system. Nonetheless, due to the difficult terrain and the problems arising due to having to separate the coating crust from the host rock, the technology for mining the crust is still in its infancy.

The separation of the actual crust from the substrate is the most important step in the mining of ferromanganese crusts. If not successful, the average grades of the ore would greatly deplete. Therefore, crust mining involves five steps, fragmentation, crushing, lifting, pickup, and separation (Hein *et al.*, 2000). The proposed method of crust recovery consists of a self-propelled bottom-crawling vehicle attached to a surface mining vessel steering the bottom vehicles by means of an electrical umbilical and receiving the mined material via a hydraulic pipe lift system. The miner would fragment Fe-Mn crusts and separate the substrate rock collected. The efficiency depends on the micro topography and the variability of the crust thickness (Hein *et al.*, 2000). The authors consider mechanical separation in connection with hydraulic lifting to be superior to a crust separation by washing in combination with a continuous line bucket system, as investigated by the Japan Resource Association. Water jet stripping and *in situ* leaching are also being considered for separating crust from rock. An early scenario for crust recovery is described by (Halkyard, 1985).

China, Japan, Korea and Russia hold contracts for the exploration of cobalt-rich crust on seamounts in the western Pacific Ocean, in an area bordered by the EEZ of the US (Wake Island, Northern Mariana Islands), Marshall Islands, Micronesia and the Japanese Minami-Torishima Islands). Here exploration contracts for cobalt-rich crust and manganese nodules (China BPHDC) are directly adjacent.

Japan has carried out a cobalt crust mining test in 2020. However, the experimental recovery seems to have involved a recovery of crust with host rock attached, as similar equipment was employed as in a previous SMS trial.[95] The technology, as well as the methodologies to assess the crust resources on seamounts are still being developed and commercial-scale recovery is considered not yet technologically feasible (Du *et al.*, 2018).

Also China´s COMRA may have carried out a cobalt crust mining test already in 2019 (COMRA, 2019a), a test which was neither publicly announced nor an EIS submitted if it took place in the ISA contract area. No further information is available. And in January 2021, the classification society American Bureau of Shipping, ABS, testified conformity (Approval in Principle, AIP) of the cobalt crust mining system developed by China Merchants Industry (CMI) with the rules specified in its ABS "Guide for Subsea Mining" of October 2020. According to the China Merchants Group Marine Engineering R&D Centre, the cobalt-rich crust mining vehicle test comprised the "*separate operations of seabed walking, cutting and crushing, sample acquisition, and other seabed functional tests, and cooperated with the 'Deep Sea Warrior' manned submersible. In joint operations, in-situ real-time monitoring and sampling were continuously carried out in the mining test area, and the environment before and after the test were sampled and investigated respectively*." No further information is available.

The available information is compiled in Table 8.

Table 8: Tests in preparation of mining crust under national or ISA contract

Sponsoring State	Consortium/ company	Year	Location	Type of test	TRL	Reference
Japan	JOGMEG	since 2012 2020 2022 2023 2028	NW Pacific and EEZ	Field tests Using a crust-excavation testing machine, 649 kg of Co- and Ni-rich seabed crust collected Scaled-up mining and processing tests Identify mine site Commercial operation	6	JOGMEG, 2020; (Yamamoto, 2020)
Japan	JOGMEG	2025-2030	NW Pacific	Verification of technology	2	(JOGMEG, 2019)
China	COMRA	2019	NW Pacific	develop and test of mining technology	TRL 7?	(COMRA, 2019a)

[95] http://dsmobserver.com/2020/09/tools-of-ore-surveying-the-current-state-of-deep-sea-mining-technology/

3.5 Recommendations on Test Mining Design to be Informative for Environmental Governance

The overall purpose of requiring test mining as an obligatory delivery by applicants for mineral exploitation is to inform the ISA and mankind as a whole on the environmental consequences to be expected from commercial-scale mining operations in the Area. Therefore, such testing has to take place in the Area, preferably in the respective exploration contract area unless a joint testing exercise was undertaken.

Joint testing may be an option at the scale of long-term mining system testing, while small scale, short term equipment testing will best serve for developing appropriate monitoring schemes and for getting a general idea about the scale of impacts to be expected. System test means all (pre-tested) components of the mining system are assembled and mining operations are tested and optimised while environmental effects are measured in scientifically sound, statistics-proof BACI sampling design, building on the experiences gained with prior equipment tests.

System tests to TRL 7 are required for being able to get information on environmental impacts all over the water column. This can be somewhat scaled down, however the crucial information will only be delivered if the duration of the system test enables the acquisition of cumulative impact data. A continued duration of at least 60 days of such a system test prior to exploitation has already been suggested by (Morgan *et al.*, 1999), based on projections of the U.S. Dept. of Commerce (see Table 9). Others recommend the continued operations of a test mining system to last for several months to several years. Such an extensive test period would enable the development of best environmental practices and, if different equipment is tested under the same condition as the identification of the best available technique in terms of least environmental impact.

Table 9: Proposed duration of test mining operations prior to commercial mining compared to envisaged duration of equipment tests 2021-22.

Who	What	Duration	Location	Source
Exploration contractors	The testing of systems for commercial recovery .. may involve any activity up to and including full scale testing of prototype commercial operations	no sustained operations for long periods	in exploration contract areas	NOAA (1984)
Exploration contractors	prototype mining system, incl. metallurgical processing	at least 5 years of testing, incl. 60 days full-scale operation	in exploration contract areas	(Morgan *et al.*, 1999),based on projections of US Dept. of Commerce
Consortium of early developers and investors	full-scale (test) mining	10 y	OMCO area	(International Seabed Authority, 2001)

Who	What	Duration	Location	Source
All contractors individually or jointly as a cooperative test	all components of the mining system tested earlier will be assembled and the whole process of ... will be executed	up to several months	unspecified - It is envisioned that one comprehensive [cooperative] test will deliver enough knowledge to enable a general assumption on impacts which can be adapted to contractor-specific circumstances and allow subsequent mining tests with much less effort.	(International Seabed Authority, 1999), Chapter 8.2
Exploration contractors individually or collaboratively	testing of mining components or test-mining	not specified - but monitoring shall allow the prediction of changes to be expected from the development and use of larger-scale commercial systems	in exploration contract area	ISBA/25/LTC/6/Rev.1, §37
Germany	Full-scale testing of systems for commercial recovery	5 y, including 90 d testing phase *in situ*	German PMN exploration area	(Ramboll, 2016)
DEME-GSR	Test of collector	4 days	in two PMN contract areas	(GSR, 2018)
India	Test of collector	up to 3 h at 2-3 sites	PMN exploration contract area	(Government of India, 2020)

Longer-duration system tests would also be instrumental to joining capacities to developing knowledge on appropriate indicators and thresholds for the environmental changes to be expected due to mining. In parallel, the knowledge on the natural environmental baseline and its variability in space and time could be completed. The latter is the essential basis for distinguishing man-made changes from natural variation.

ISA could do a lot to help establish a common knowledge base for contractors by establishing an expert body responsible for evaluating the contractor reports and scientific publications in terms of useful information on best environmental sampling, evaluation, assessment and interpretation. Regional quality status reports such as foreseen in the CCZ Environmental Management Plan (International Seabed Authority, 2011) are a tool to inform States, stakeholders and the public on progress made by ISA to safeguard the values of the Area.

3.6 Conclusions

As shown above, the technological development of seafloor mining tools and systems has advanced very differently depending on the resource. It is to date not evident, which type of mining will start first - if at all. The reason is that the environment in which of each of the three resources occur poses a different set of challenges to miners and their tools.

While the mining of nodules from abyssal plains seems the most easily feasible, and resource estimation simple because they are spread out in 2-D and not attached to substrate, the semi-liquid sediments cause problems for operating mining vehicles and the polymetallic composition not only varies spatially but also requires special processing at high cost. On top, the extremely fine, clayey deep-sea sediment is prone to be stirred up at the slightest touch, causing plumes of very fine material to remain in the water column for a long time.

Seafloor massive sulphides, on the other hand, are straight-forward to process and refine. Here, the resource estimate is still difficult because of the 3-D type of deposits, and a metal concentration gradient with the top layer concentration is usually much higher than in the older layers below. In addition, active hot vents, which can be found easiest by way of locating the venting plumes shall be off-limits for ecological reasons and in addition would put highest demands on the wear of the materials. Older deposits from extinct vent sites on the other hand may be extensive, however likely to be not far from the ridge axis, buried underneath meters of sediment overburden, and of as yet unknown metal grade.

Cobalt-rich crust again poses very high technical challenges on the resource estimate, which so far relies on extrapolations from drilling the crust thickness. The rugged and inclined terrain poses risks to machine operation, and an efficient crust separation mechanism still needs to be invented. Importantly, it is known from relevant experiences with deep water trawling that the seamount fauna is fragile, long-lived, slow to reproduce and thus not likely to recover.

State of Play

Overall, much about the talk on "*mining to begin soon*" and "*mining is on our doorstep*" seems to be exaggerated and very unlikely. If we look at the different contractors of ISA and their Sponsoring States, two things are apparent: States and their agencies, in particular those with a pioneer investor past have a different approach to seabed mining compared to the commercial companies coming into the game recently. Whereas the former mostly pursue a strategy of maintaining all options while developing technology slowly, but steadily, the latter come in based on a business model which requires short-term high-speed exploration and ambitions for starting exploitation in the near future.

As of December 2020, Japan is probably (with all uncertainties due to knowledge gaps) the country and contractor most ready for exploitation in the near future. However, this exploitation is likely to take place first in Japan´s national waters, and minerals from SMS and eventually crust mining will be supplied to the national, rather than the global market.

Also, South Korea has pursued such a long-term technology development programme and might be able to mine nodules and SMS in the Area or in national waters any time soon, if it gains the social licence for doing so.[96] China and India[97] may have recently geared up their programmes and investments to develop resources and technologies, while Russia and IOM seem to be limited due to lack of funding - or maybe lack of urgency given the rising value of land-based resources. Germany and France, on the other hand, seem to both refrain from developing own seafloor mining industries be-

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[96] see footnote 93

[97] http://dsmobserver.com/2019/11/india-dramatically-expands-its-plans-to-explore-the-deep-ocean/

cause a) the national industry does not see it as a promising industry other than for technology development and b) environmental concerns and a strong civil society make it difficult to pursue business-as-usual with exploitation of the deep-sea. For comparison, Norway makes a different case with ambitions to transit its high-tech oil and gas industry to the exploitation of minerals on the seabed of the Norwegian EEZ and extended continental shelf.[98]

The private contractors act quite differently, in particular those under the sponsorship of Small Island Developing States (UK Seabed Resources under sponsorship of the UK may be a different case, as it is owned by Lockheed Martin Inc., which owns the patents and other developments made by the OMI consortium): DeepGreen (with 3 nodule contract areas in the CCZ, sponsored by Nauru, Tonga, and Kiribati) and DEME/GSR with one nodule contract area in the CCZ under Belgian Sponsorship, and a cooperation with the Cook Islands for another nodule contract area plus licenses in the Cook Island EEZ. Both companies aim at developing resources in large scale on a purely commercial basis - as made possible by the 1994 Agreement. In order to secure funding, these companies need a minimised financial risk, such as guaranteed by an ISA exploitation code which not only determines a fixed rate of profit to the investor, but also provides for a stable legal framework and reliable regulatory processes.

Also, the funding provided by the European Union has to be taken into consideration. This research funding allows European companies like IHC Merwede and others to profit from public research, government agencies´ work as well as subsidies for developing technology for deep seabed mining. Amazingly, the projects are as in-transparent as the ISA and no information other than press releases or theses are publicly available. Given some 15 years of support for EU "BlueNodules", "BlueMining" and "BlueHarvesting" next to a number of other projects, the European model of a collector and a vertical lifting system has been developed and tested in European waters. It is unclear how much of the DEME-GSR collector tested in 2021 is in fact based on EU-funded work.

Likelihood of Contractors to Carry Out System Tests during Exploration

All of the State contractors may be positive about delivering the monitoring results of an *in situ* system test (pilot mining test) as part of their EIA when applying for exploitation (see further chapter 2). In fact, Japan, Korea and China are already testing system components and (pre-)prototype systems in national waters. These contractors could easily apply for a system test within their exploration contract period, including gathering *in situ* monitoring data for at least some years (depending on a further extension of their contracts).

The commercial contractors on the other hand, may be able to carry out some equipment tests at pre-prototype or prototype scale, however may not be able to invest in a full mining system prior to the signature of an exploitation contract with the ISA. Overall, their technology development seems to be early days, as the DEME/GSR development of a completely new model of nodule collector shows. DeepGreen, the company that wants to start full scale production of nodules in 2026, has not yet released anything beyond press releases about the technology being developed.

Developing Best Available Technologies

In order to prevent or minimise the harmful effects of mining related activities on the habitats and fauna of the deep-sea the optimisation of technology at the source is particularly important, *i.e.* in order to minimise plume release, depth of sediment penetration, release of pollutants. Contractors have to demonstrate the application of Best Available Technologies when applying for an exploitation contract with ISA (International Seabed Authority, 2019b).

[98] https://www.reuters.com/article/us-norway-deepseamining-insight/norway-eyes-sea-change-in-deep-dive-for-metals-instead-of-oil-idUSKBN29H1YT

Different from the pre-UNCLOS and in particular pre-1994 Agreement days, contractors are developing their technologies independently and as national or company efforts. This makes it near-impossible to get an overview of the environmental effects of different mining technological solutions.[99] Furthermore, the lack of standardisation and of commonly agreed models for testing impacts and all other elements of scientific research act as a hindrance to come to conclusions on the bottle necks of technology development and the related environmental impacts.

In the current regulatory system, only the ISA, namely the LTC, may get an overview on the matter *via* the Environmental Impact Statements and the annual reporting accompanying any testing. Provided the monitoring, assessment and reporting is in a useful format (see further chapters 5 and 6), the information could be used to elaborate on the environmental effects accompanying the different tests with a view to rank the different technologies tested by the degree of environmental impact caused.

This, however, requires that the ISA carefully analyses the reports and monitoring data of contractors with a view to conclusions on best available technology in line with an ambition to learn and gain experience with this new industry for enabling effective regulation (Ginzky *et al.*, 2020). Related ISA capacities and competences, as well as the necessary transparency will have to be built up as soon as possible (Komaki and Fluharty, 2020).

Importance of Best Environmental Practice

Not only the technology itself, but also its operations in environmental practice are decisive for the type and scale of environmental impacts caused. 'Best Environmental Practice' is generally defined in the extractive industries to mean the application of the most appropriate combination of environmental control measures and strategies taking into account the criteria set by a particular regulator, all in all a very challenging undertaking for a newly developing industry (Gerber and Grogan, 2018).

Good technology in combination with good environmental practice can go a long way to reducing the overall extent of damage to the marine environment. However, so far no knowledge whatsoever exists on how operations will proceed and operators have a quasi-monopoly on their technology. The current model of operations places all the burden on the contractor, who in turn provides self-monitoring and assessment, eventually according to self-chosen standards (Gerber and Grogan, 2018). This is further elaborated in chapters 5 and 6.

Until there are clear, binding and ambitious standards for the environmental quality to be maintained, no contractor will be able to optimise its technology and be certain that the ISA standards will be met. The ISA on the other hand, lacks own data, information and experience, and does not even have access to a wider pool of experts. Therefore, BAT and BEP will be impossible to determine, which will make it difficult to meet the mandate of a "*uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind*" (ITLOS, 2011, para. 159).

The only solution could be that contractors incrementally test their mining equipment and system *in situ* at an appropriate scale and duration until the effects of a commercial-scale mining operation on the environment can reliably be predicted. This knowledge has to be existent prior to submitting an application for exploitation.

[99] See International Seabed Authority, 2001, e.g. chapter 20 conclusions and recommendations: "A great deal of interesting and sophisticated engineering work has been applied by the individual pioneer investors in support of national R&D programmes. Much of it appears to be duplicative and while a certain amount has been a necessary learning experience, there is a suggestion that we may have been reinventing the wheel."

4 Environmental Impact Assessments for Test Mining

In this chapter, first, the history of environmental impact assessments, EIA, in relation to test mining and resulting recommendations will be described (chapter 4.2). Then present-day conditions for ISA exploration contractors as specified in the "*Recommendations for the guidance of contractors for the assessment of possible environmental impacts arising from exploration for minerals in the Area*", issued by the LTC since 2001, are discussed (chapter 4.4). In the final step, experience gained from several international and national EIA procedures in context with offshore deep water mining (chapter 4.5) is used for comparison with the current performance of the most recent LTC recommendations (chapter 4.6):

4.1 Introduction

Project-specific Environmental Impact Assessment, EIA, such as required for the testing of deep seabed mining equipment and mining systems, should be embedded into a tiered environmental governance framework from global (ISA Environmental Policy/Strategy, see (Christiansen *et al.*, 2019b)) to regional (Regional Environmental Management Plans, ideally building on an ecosystem approach to management and strategic assessment; see (Christiansen and Singh, 2021). This framework does not yet exist. Yet, contractors would like to know the scope of their EIA obligations as early as possible. At present, the draft exploitation regulations (International Seabed Authority, 2019b) lack a lot of detail on e.g. the preconditions for and all steps to be taken in an EIA process prior to permitting exploitation operations, including the roles, timelines, participation and review, as well as performance criteria for the environmental reports and assessment have yet to be developed. Funding and institutional changes need to be clarified (to ensure an independent EIA).

The chapter 5 below will investigate, whether and how the ISA guides contractors which want to carry out an equipment or system test in their exploration area. At first, the roots for the present ISA system of LTC recommendations are shown, culminating in a synthesised set of recommendations which would greatly improve today´s LTC´s Recommendations for the guidance of contractors (chapter 5.2). These are presented and discussed with a view to whether the recommendations are fit for purpose, *i.e.* to enable ISA to protect of the environment from harmful effects (chapter 5.4). The demands from international conventions and agreements, the experiences with offshore industry EIAs in national waters, and recommendations made by science on how to design an effective EIA process will be used to compare the performance of the ISA recommendations and deduce recommendations.

4.2 Distinguishing Environmental Impact Assessments for Test Mining and Environmental Impact Assessments for future Exploitation Activities

At the outset, it is important to clarify that this chapter will focus on the assessment of environmental impacts for test mining activities. Accordingly, it is necessary to distinguish the conduct of EIAs and the submission of EISs for test mining and the conduct of EIAs and the submission of EISs to support applications for the approval of plans of work for future exploitation activities (as anticipated under the current version of the Draft Exploitation Regulations. Indeed, this has already been covered in Chapter 2.4.2. That said, there are some parallels and it is obvious that the results obtained from test mining activities, i.e. submitted to the ISA through reports or studies, will be essential information that will feed into and form the basis of the subsequent assessment of environmental impacts of commercial exploitation activities. Finally, it is necessary to also clarify that procedurally speaking, the EIA processes that contractors will have to undertake for test mining projects and for the eventual assessment of commercial mining activities are similar. In fact, useful lessons can be learned from EIA processes from other regimes, sectors or activities, and to ensure that good practices from those regimes, sectors or activities are incorporated into the EIA processes for test mining activities. Accordingly, the following will draw on a wide range of literature and experience in order to envisage how the EIA process for test mining, particularly at the exploration stage, should look like at the ISA.

4.3 Past Recommendations and Environmental Impact Assessments for Mining Tests

4.3.1 The DOMES Investigations and Environmental Impact Assessments

In 1981, NOAA published a Programmatic Environmental Impact Statement, PEIS, for a first generation deep seabed mine site[100] in the Clarion-Clipperton Zone (NOAA, 1981). This PEIS based on the Deep Ocean Mining Environmental Study, DOMES, a five-year project designed to examine potential effects from nodule mining (see chapter 4.4.1.2). The PEIS would set the framework for control of operations carried out by U.S. nationals to take place as high seas freedoms, based on the US Deep Seabed Hard Mineral Resources Act[101] which prohibits the mining of hard mineral resources of the deep seabed unless licensed through the appropriate government body. NOAA considered that deep seabed mining would proceed in areas beyond national jurisdiction, and therefore probably in cooperation with other nations. This cooperation would be enabled through a system of reciprocal state agreements, or the ISA, upon UNCLOS entering into force. From 1975-81, 28 public meetings with governmental and non-governmental organisations, including several public hearings and briefings accompanied the elaboration of the PEIS.

In particular, NOAA (1981) emphasises that the conclusions drawn and measures taken in the PEIS have to be seen as preliminary, "*new information from exploration and research will allow NOAA to update this PEIS at a later date prior to commercial mining* in 1988."

Apart from a general license for the exploration of nodules in the Clarion-Clipperton-Zone, operators need to acquire a supplementary site-specific EIS from NOAA, based on additional baseline data and the mining system characteristics submitted to NOAA at least one year prior to any scheduled tests (NOAA, 1984). In 1982, OMA applied for pre-prototype testing in the CCZ, and NOAA (1984) issued an assessment of environmental impacts which concludes that

- The activities related to prospecting and exploration [are tentatively determined to] "*cannot be reasonably be expected to result in a significant adverse effect on the quality of the environment*". Recommending the exploration license, NOAA in particular refers to exploration to "*provide a better understanding of the environmental impacts of deep seabed mining and to reduce the reliance on and impacts of land based mining*".
- NOAA attaches the following terms, conditions and restrictions, TCR, on the OMA license, with a caveat that it is authorised to amend the TCRs if required in light of new knowledge for the conservation of natural resources, protection of the environment and safety of life and property at sea. The TCR are detailed in Appendix 8 of the EIS (NOAA, 1984):

  c) Monitoring of endangered species such as whales;
  d) Report and protect cultural heritage discovered;

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[100] This wording relates to the tentative plan for the long-term development of manganese nodule industry in areas beyond national jurisdiction as explained in NOAA, 1981, p. 7: " *The first generation (discussed in detail in Appendices 5 and 6) from 1988 until about 1995 could involve the initial consortia (four with United States' involvement and perhaps a French group called AFERNOD) mining nodules at rates in harmony with world demand for nickel, the primary nodule metal in terms of economic interest. Second generation mining, from 1995 to 2005 or 2010, could involve an additional five to 10 mining consortia, some associated with large processing plants that service two or three mine sites. Third generation growth could be maintained until 2030 or 2040 depending on the exact size of the nodule resource in the area and the rate of exploitation. During this period, the mature industry could level off at about 25 to 30 operational sites at one time and 10 to 20 processing plants worldwide."*

[101] Deep Seabed Hard Mineral Resources Act (1979-80). https://www.congress.gov/bill/94th-congress/house-bill/6017

e) Provide a monitoring plan and environmental baseline information in accordance with NOAA Technical Guidance Document (TGD) at least one year in advance of any proposed equipment test.

Such monitoring would be required "to assess the adequacy of NOAA's previous prediction of no significant environmental impacts from site delineation or testing activities" (NOAA, 1984). NOAA expects contractors to measure a set of DOMES parameters, prior to mining tests, in order to augment the DOMES findings. To verify compliance, NOAA reserves the right to place observers on board the vessels.

As emphasised by Morgan *et al.* (1999), the NOAA programmatic EIA (NOAA, 1981) and the EIS in relation to the exploration license of OMA (NOAA, 1984), both emphasise the need for exploration in light of gaining further knowledge of the environment and experience on impacts from mining activities. Test operations are seen as indispensable step to enable a sufficiently based full assessment of the environmental impacts to be expected from commercial-size mining operations. It was expected that at-sea tests be carried out under the exploration license which due to their short duration were not prone to causing significant environmental impacts.

According to the US law, exploration includes the development phase of the commercial mining operation, including the testing of equipment for mining and processing:

> *The testing of systems for commercial recovery which may take place under the terms of a license may involve any activity up to and including full scale testing of prototype commercial operations. The difference between the activities under the license and under the permit, is that in the development and testing phase, operations would not be sustained for long periods. They would probably be more varied in that several systems might be developed and evaluated at the same time or sequentially, and they would generally involve more intensive scrutiny and instrumentation. (section 3.4.1, p. 248)*

This indicates that the development of equipment and mining systems up to the prototype stage (TRL 7) should best happen during the ISA exploration contract period. Should the 15-year period of contract be insufficient for carrying out resources assessment, environmental baseline studies and technology development, it is suggested to add a second phase for technology development, however this may require an amendment of the respective exploration regulations.

4.3.2 A Consortium Approach to EIA Proposed to ISA

Early developers and investors of deep seabed mining technology soon noticed that duplication of efforts in technical and environmental research is costly and not very effective in as large a region as the Clarion-Clipperton Zone (International Seabed Authority, 2001). A proposal was launched to the former consortia and now ISA pioneer investors to form a cooperative venture in order to jointly carry out a demonstration mining operation. This project should determine the environmental impacts caused by the full-scale (test) mining over a period of approximately 10 years and be located in the former OMCO claim area, then licensed under US law (ISA 2001, chapter 18). The idea was to also jointly develop technology, with the shared costs of the operation being outweighed by the profits made with the marketing of the metals.

As ISA had started its operations in 1994, such a cooperative effort would have to take place under ISA regime. Therefore, the question was raised (in 1996) whether ISA would agree to a programmatic environmental impact assessment of the CCZ based on such a demonstration project, to be used as a basis for the individual EIAs required by the individual ISA contractors. For this purpose, ISA would have to provide the cooperation partners with an exclusive operating license.

The proposal was discussed at an ISA workshop in 1999 (International Seabed Authority, 2001), however, it was not approved due to the difficult legal situation of the proposed site (licensed under US law), the costs involved *vis à vis* the timing of spending ongoing by the various contractors, and a general feeling that the mining of manganese nodules was not economically viable - not due to the metal prices but due to the metal grade in the nodules being too low to be profitable (p. 372-380).

Interestingly, already at that workshop, it was suggested that a small team of experts be gathered under the auspices of the ISA to analyse in detail the environmental information available, in particular the one presented at the 1998 ISA workshop (International Seabed Authority, 1999) to organise an appropriate model or models for use by all involved parties (p. 393), an activity which was pursued only in relation to developing a geological model of the polymetallic nodule deposits in the CCZ (International Seabed Authority, 2015b). In 2019, a synthesis of biological information available from the CCZ was gathered by independently funded scientists and discussed at a ISA co-organised workshop.[102]

4.3.3 Guidelines for the Assessment of the Environmental Impacts from Exploration and Testing

Two technical workshops organised by the ISA in 1998 and 2004 (International Seabed Authority, 1999, 2007) produced scientific recommendations for guidelines submitted to LTC (ISBA/11/LTC/2 for crusts and sulphides) for standardising environmental baseline acquisition of physical and biological data during exploration of polymetallic crusts and sulphides. Both groups of participants, contractors and science, asked that non-binding language be avoided and concrete methods be named in the guidelines to give contractors definite requirements with respect to baseline data collection and monitoring to ensure the later comparability and usefulness for the compilation of regional environmental baseline data.

The Guidelines (ISA 1999, 2007) both include a list of activities with potential for causing environmental harm which can be used as a first proxy for development an assessment framework. It is assumed that each Plan of Work for exploration comprises general survey operations as well as engineering tests conducted to develop and demonstrate mining technologies.

Test mining activities have played a large role in all ISA workshops and in particular in the recommended guidelines for contractors. Particular detail is provided on the design of a monitoring programme to verify the effects of test mining, including the option for refining the test mining plan prior to testing, and the requirement that the test mining plan ought to include "*strategies to assure that sampling is based on sound statistical methods, that equipment and methods are scientifically accepted and that the personnel who are planning, collecting and analysing data are scientifically well qualified* ... "(p. 225).

It is expected that mining tests

> *"are <u>carried out by all contractors</u>, unless they use mining equipment which has already been tested by other contractors. In a mining test, <u>all components of the mining system</u> tested earlier in various engineering tests will be assembled and the whole process of mining, lifting ... and discharge will be executed. This will be the first occasion in which all impacts occur. As this will be an endurance test for the engineering, it is assumed that the mining test will have a <u>duration of up to several months</u> and may be done with a somewhat scaled-down system" (International Seabed Authority, 1999).*

For being able to assess the environmental impacts, it is emphasised that it is most important to monitor and investigate carefully the effects on the environment before, during and after the tests. It is envisioned that one comprehensive [cooperative] test will deliver enough knowledge to enable a general

[102] https://www.isa.org.jm/event/deep-ccz-biodiversity-synthesis-workshop

assumption on impacts which can be adapted to contractor-specific circumstances and allow subsequent mining tests with much less effort.

The selection of Impact and Preservation Reference Zones prior to the mining test is instrumental to enabling the monitoring of mining effects on the environment. The monitoring goal is to verify whether the effects measured are in line with those predicted and to detect unanticipated harm. As such testing is required to develop the monitoring and modelling capabilities to such an extent that reliable predictions of the harm caused by commercial-sized operations.

As tests and monitoring develop, it is recommended that the ISA promotes the unification and standardization of research and development methods and technologies, including instruments and equipment, quality assurance, collection, treatment and preservation of samples, determination methods and quality control on board vessels, analytical methods and control in laboratories, and data processing and reporting. This was required to allow for comparison of results across contractors and research, and enable the selection of critical parameters for monitoring.

4.3.4 Conclusions

Drawing on the above, the following conclusions can be drawn to inform a reformulation of the test mining regime in the ISA rules, regulations and procedures.

Conclusions

- As demonstrated in the NOAA approach, the knowledge base and assessment of environmental impacts due to minerals mining activities in the Area has to grow in proportion to the scale of the expected environmental damage, requiring different set-ups for exploration, test mining and commercial mining (see 5.2.1);
- As required by NOAA, the exploration phase should include the development of equipment and mining systems up to the prototype stage (TRL 7). Should the 15-year period of contract be insufficient for carrying out resource assessment, environmental baseline studies and technology development, it is suggested that a second phase for technology development could be added, which however requires an amendment of the respective exploration regulations (see 5.2.1);
- A mining test shall comprise the assembly of all components of the mining system tested earlier in various engineering tests and the whole process of mining, lifting ... and discharge for a duration of up to several months and may be done with a somewhat scaled-down system (see 5.2.3).
- Sound scientific methods and statistics-proof sampling designs are crucial to verify the effects of test mining (see 5.2.3);
- In order to enable inter-contractor comparisons and regional integrations, scientists recommend to ISA to promote the unification and standardization of research and development methods and technologies, including instruments and equipment, quality assurance, collection, treatment and preservation of samples, determination methods and quality control on board vessels, analytical methods and control in laboratories, and data processing and reporting (see 5.2.3).

4.4 ISA Exploration Contractor Rights and Obligations

Under an exploration contract concluded with the ISA, the Contractor gains the exclusive right to explore for polymetallic nodules, seafloor massive sulfides or polymetallic crust, respectively in the exploration area in accordance with the terms and conditions of this contract. The initial contract duration is 15 years, with options for extension by periods of up to 5 years each. The Authority shall ensure that no other entity operates in the exploration area for a different category of resources in a manner that might [unreasonably][103] interfere with the operations of the Contractor (International Seabed Authority, 2015a).

Contracts are concluded after the Council adopted the application, including an initial 5-year Plan of Work, including a time schedule of activities, upon the recommendation of the LTC. The Plan of Work becomes part of the contract and the contractor is obliged to carry out exploration activities and budget expenses as indicated therein.

During the exploration phase, contractors have the general obligation to "*take necessary measures to prevent, reduce and control pollution and other hazards to the marine environment arising from its activities in the Area as far as reasonably possible applying a precautionary approach and best environmental practices*." Prior to the commencement of exploration, each contractor is also required to submit to the Secretary-General

a) a contingency plan to respond effectively to incidents arising from its activities at sea in the exploration area that are likely to cause serious harm or a threat of serious harm to the marine environment;
b) an impact assessment of the potential effects on the marine environment of the proposed activities;
c) a proposal for a monitoring programme to determine the potential effect on the marine environment of the proposed activities; and
d) data that could be used to establish an environmental baseline against which to assess the effect of the proposed activities.

Over the course of exploration, contractors shall establish environmental baselines "*against which to assess the likely effects of the Contractor's activities on the marine environment*" and implement the above programme to monitor and report on such effects on the marine environment. The results of this monitoring shall be reported annually. None of these documents is made publicly available.

Prior to the commencement of <u>testing</u> of collecting systems and processing operations, the Contractor shall submit to the Authority:

a) a site-specific prior environmental impact statement of activities related to such tests, including the environmental baseline data as acquired to that point to enable
b) an assessment of the effects on the marine environment of the proposed tests of collecting systems;
c) a proposal for a monitoring programme to determine the effect on the marine environment of the equipment that will be used during the proposed mining tests.

Further detail is provided in the LTC´s recommendations for the guidance of contractors (chapter 4.5). The contractor EIS are made publicly available and are to be subject to stakeholder commenting (chapter 4.5.2).

Each contractor has to submit an annual report on its programme of activities in line with the standard clauses of the contracts (ISBA/19/C/17, Annex IV) and additional guidance issued by the LTC. This report is being reviewed by the LTC (and the Secretariat) and not disclosed to any other ISA organ or the public. Every five years, the contractor and the Secretary General undertake a joint a periodic review of the implementation of the plan of work with a view to the contractor submitting a subsequent plan

[103] in the Nodules Regulation ISBA/19/C/17, Reg. 24 (as printed in International Seabed Authority, 2015) the word "unreasonably" does not exist, however the Standard Clauses for Exploration Contracts, section 2.2 names unreasonable interference

of work for the following 5-year period. No information other than the brief report released by the Secretary General to the Council and LTC is publicly available.

A minimalistic standard information on contractors´ plans of work and implementation has been added to the ISA website in 2020.[104] The breadth and quality of information presented varies widely.

4.5 Present ISA Requirements for Testing during Exploration

4.5.1 Introduction

The broad obligations set in the contract standard clauses are elaborated in somewhat more detail in the "Recommendations for the guidance of contractors for the assessment of possible environmental impacts arising from exploration for minerals in the Area", issued by the LTC since 2001 (ISBA/7/LTC/1/rev1, then revised ISBA/16/LTC/7) to be revised every 5 years. These first versions only applied to the exploration of polymetallic nodules. After the approval of the exploration regulations for all three types of deep-sea minerals in 2012, a united set of recommendations was agreed in 2013 (ISBA/19/LTC/8), based a.o. on the recommendations from a ISA scientific workshop which took place 2004 (International Seabed Authority, 2007). In 2020, the latest version of the recommendations was published (ISBA/25/LTC/6/Rev.1/Corr.1, from here termed "the recommendations"), and replaces the former version.

None of these documents benefited from a public or wider expert consultation. The latest version had been consulted with the contractors, but not even the experts of member States.

4.5.2 Present Requirements related to Test Mining

The presently applicable recommendations (ISBA/25/LTC/6/Rev.1/Corr.1) update the requirements for contractors to carry out environmental baseline studies, and provide further detail on the Environmental Impact Assessment/Statements required a) in relation to ongoing exploration work as covered by the approved Plan of Work, and b) in relation to testing activities carried out in the contract area which exceed certain disturbance size limits. There is clearly no need or encouragement to carry out mining tests during exploration, however, contractors may choose to do so.

Part B. of the recommendations provides a list of activities which necessarily require an environmental impact assessment, accompanied by an environmental monitoring programme to be carried out during and after the activity (ISBA/25/LTC/6/Rev.1/Corr.1; para 33):

(a) Use of sediment disturbance systems that create artificial disturbances and plumes on the sea floor;

(b) Testing of mining components;

(c) Test-mining;

(d) Testing of discharge systems and equipment;

(e) Drilling activities using on-board drilling rigs;

(f) Sampling with epibenthic sled, dredge or trawl, or similar technique, in nodule fields, that exceeds 10,000 m^2;

(g) Taking of large samples to test land base processes.

Most of the named activities indeed relate to either the testing of equipment, systems or processing, or serve to scientifically evaluate the degree of environmental impact/recovery. Exploration contractors who want to carry out a mining test which falls under the above criteria have to provide the ISA with

[104] https://www.isa.org.jm/exploration-contracts/polymetallic-nodules; and for the other resources respectively.

an Environmental Impact Statement, EIS, at least one year prior to the event (para 34). This EIS has to comprise "*a properly designed monitoring programme that should be able to detect impacts in time and space and to provide statistically defensible data*" (para 35). For monitoring impacts arising from the test, the designation of an impact reference zone and preservation reference zone is required (para 35, further details in paragraph 38 (o)). The monitoring of the testing of mining components or test-mining should "*allow the prediction of changes to be expected from the development and use of larger-scale commercial systems*" (para 37).

The tasks of contractors are given in more detail in the box below:

Contents of the EIS (ISBA/25/LTC/6/Rev.1/Corr.1, Annex I, § 64-68)

66. The contractor will submit to the Authority a plan for such testing, including the details for monitoring the environment, at least one year before testing begins.

- A plan for testing of mining components or test-mining shall include provision for monitoring of those areas impacted by the contractor's activities which have the potential to cause serious environmental harm, even if such areas fall outside the proposed test site.
- The programme will include, to the maximum extent practicable, specification of those activities or events that could cause suspension or modification of the tests owing to serious harm, including if the specified activities or events cannot be adequately mitigated.
- The programme will also authorize refinement of the test plan prior to testing and at other appropriate times, if refinement is necessary.
- The plan will include strategies to ensure that sampling is based on sound statistical methods, that equipment and methods are scientifically acceptable, that the personnel who are planning, collecting and analysing data are well qualified and that the resultant data are submitted to the Authority in accordance with specified formats.

67. During exploration test-mining, the notification of a proposed impact reference zone and a preservation reference zone is recommended.

68. The monitoring programme proposed by the contractor must provide details of how the impacts of the testing of mining components and test-mining activities will be assessed. [Recommendation VI.D.40]

(emphasis added)

For the first time, this new set of recommendations to contractors mentions stakeholder consultation as a recommended procedural step in conjunction with carrying out one of the above listed activities (Section E, para 41 (d-f)). This can either be done under the auspices of the Sponsoring State (d) or through publication on the ISA website with a call for stakeholder comments. All comments received, together with those of the LTC will be forwarded to the contractor, who will respond to the Secretary-General, who will forward the response to LTC for considering to recommend inclusion in the contractors´ work programme. The Council will be informed by the Chair of LTC during its next session. Stakeholders will not receive any feedback.

4.5.3 Review of the LTC

After submission of the Environmental Impact Statement with a test plan to the ISA, the LTC will consider the report with a view to "*completeness, accuracy and statistical reliability*" for inclusion in the current plan of work of the contractor. The environmental studies shall "*enable results from monitoring to establish that there is no serious harm from any activities*" (section E and Annex I, para64ff.).

These evaluation criteria are not further specified so that it remains unclear, how LTC will check the accuracy (of what?) and the statistical reliablility, in particular since it does not have any own data and experience and completely relies on the information provided by the contractor. Also, statistical reliability is a challenging evaluation criterium as so far no rules for e.g. the required taxonomic, spatial and temporal resolution exist.[105] It also remains unclear how contractors could "*establish that there is no serious harm from any activities*", given the absence a definition as well as an assessment framework for what is to be understood as "*serious harm*" and how this relates to the "*harmful effects*" to be avoided acc. Art. 145 UNCLOS?

Yet, neither LTC nor the Council need to adopt the contractor EIS as no decision-making process is linked to the required submission of an EIS prior to testing activities in the contract areas. The only possible action is a communication between first the Secretariat and the contractor if a document does not fulfil the criterium of completeness, then between LTC and contractor if there are questions on the contents of the submitted EIS. It is unclear what the consequences are if contractors fail to deliver a satisfactory EIS or fall short of their monitoring and reporting obligations.

4.5.4 Discussion of the Deliverables of the EIS

ISBA/25/LTC/6/Rev.1/Corr.1 sets out a comprehensive list of deliverables which the contractor should provide when submitting the EIS (see box below), *i.e.* ahead of the activity:

ISBA/25/LTC/6/Rev.1, Section C

Information and measurements to be provided by a contractor performing an activity requiring an environmental impact assessment during exploration.

38. The contractor is to provide the Secretary-General with some or all of the following information, depending on the specific activity to be carried out, following the template in annex III:

(a) Mineral collection technique (passive or active mechanical dredge, hydraulic suction, water jets, etc.);

(b) Depth of penetration in the sediment or rock and the lateral disturbance caused by the collector;

(c) Running gear (skis, wheels, caterpillars, Archimedes screws, bearing plates, water cushion, etc.) which contacts the seabed, and the width, length and pattern of the collector tracks on the sea floor;

(d) Ratio of sediment separated from the mineral source by the collector, volume and size spectra of material rejected by the collector, size and geometry of seabed-disturbance plumes and the trajectory and spatial extent of the plumes relative to the particle sizes within;

(e) Methods for separation on the sea floor of the mineral resource and the sediment, including washing of the minerals, concentration and composition of sediment mixed with water in the seabed-disturbance plume, height above the sea floor of discharge plumes, modelling of particle size dispersion and settlement, estimates of depth of sediment smothering with distance from the mining activity, and estimates (based on plume models) of the spread of the plumes in the water column horizontally and vertically, including particle concentrations as a function of distance from, and duration of, the proposed mining activity;

(f) Processing methods at the seabed, if any;

(g) Mineral crushing methods;

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[105]. So far likely not a single contractor, and also no scientific investigation has sampled enough replicates to describe e.g. the megabenthic community diversity with some accuracy and statistical power (Ardron, J.A., Simon-Lledó, E., Jones, D.O.B., Ruhl, H.A., 2019a. Detecting the Effects of Deep-Seabed Nodule Mining: Simulations Using Megafaunal Data From the Clarion-Clipperton Zone. Frontiers in Marine Science 6.)

(h) Methods for transporting the material to the surface;

(i) Separation of the mineral resource from the fines and the sediment on the surface vessel;

(j) Methods for dealing with the abraded fines and sediment;

(k) Volume and depth of discharge plume, concentration and composition of particles in the discharged water, chemical and physical characteristics of the discharge and behaviour of the discharged plume at the surface, in mid-water or at the seabed, as appropriate;

(l) Location of the mining test and boundaries of the test area;

(m) Probable duration of the test;

(n) Test plans (collecting pattern, area to be perturbed, monitoring, etc.);

(o) Delineation of the impact reference zone and the preservation reference zone for the impact assessment of test-mining.

(p) Baseline maps (e.g. side-scan sonar, high-resolution bathymetry, sea floor bottom type) of the deposits to be removed;

(q) Status of regional and local environmental baseline data.

It is evident, that in the first instance, the prior EIS will have to contain the technical details of the testing operation, information on the physical consequences in terms of disturbance area and plume development. But contrary to the outline structure in Annex III, no impact assessment seems to be required as part of the prior EIS.

The assessment of the effects on the physical, chemical and biological environment shall be investigated based on the "observations and measurements to be made after undertaking an activity that requires an environmental impact assessment during exploration" (Part VI, Section D, para 40), including

- Changes in species composition, diversity and abundance of pelagic (where applicable) and benthic communities, ..., bioturbation rates, chemical effects and changes in behaviour of key species (subjected to impacts such as smothering by sedimentation);
- Possible changes in communities, including microbes and protozoa, in adjacent areas ...;
- Changes in the characteristics of the water at the level of the discharge plume during the mining test, and changes in the behaviour of the biota at and below the discharge plume;
- Levels of metals found in key and representative benthic biota subjected to sediment from the operational and discharge plumes;
- Resampling of local environmental baseline data and evaluation of environmental impacts;
- Changes in fluid flux and response of organisms to changes in hydrothermal settings.

The observations listed could be instrumental to broadly guide the design of the monitoring programme of a test mining activity. No particular detail of the information required is requested, and no indications are given of how contractors are expected to evaluate and assess the monitored changes in terms of relevance for the wider ecosystem, the gravity of effects and the potential for upscaling to commercial dimensions for mining. The actual test mining activities and the monitored results (descriptive?) will be reported afterwards as part of annual reporting in line with the requirements of ISBA/21/LTC/15 (see chapter 5.4.5.4).

4.5.4.1 Quality Assurance

For the first time, ISBA/25/LTC/6/Rev.1/Corr.1 provides contractors with an outline structure for a EIS, as attached in Annex III. However, as with the lists in para 38 and 40 above, the structure provided only determines the major headlines of the contents, and does not provide any guidance as to the depth of contents to be provided or the methodology, incl. criteria to be used for assessing impacts. It is likely, that the results reported by contractors will remain largely descriptive, and/or vary in the evaluation of the degree of risk and gravity of harm.

The general lack of specification indicates that as a result the EIS delivered by the contractors will be very contractor-specific. The varying information level delivered may prevent inter-contractor comparisons and a lack of detail on environmental impacts may also prevent the ISA from developing its own knowledge base on technology-related impacts, monitoring and mitigation.

Meaningful and defensible results of monitoring programmes based on the above requirements will to a large extent depend on the comprehensiveness of the baseline investigations (before and in parallel to the activity) and whether ecologically and statistically meaningful data are acquired over as long a time as possible prior to the test/activity to be able to differentiate between natural variablity, sampling variability, other scientific uncertainties and real effects. It would be of utmost importance to specify also uncertainties and lack of knowledge.

As concerns the general sampling methodology, *i.e.* "types of data to be collected, the frequency of collection and the analytical techniques in accordance with the present recommendations" Part IV, section A only sets out that the best available methodology should be applied, as well as an "international quality system and certified operations and laboratories". This, however, does not ensure that all contractors sample a minimum set of variables with comparable methods - given the broad range of scientifically appropriate methods that could be employed during environmental baseline studies and monitoring of test operations.

In the recommendations, para. 37 points to the importance of standardising the methodology and reporting of the results, covering instruments and equipment, quality assurance in general, as well as field sampling and laboratory methods. Yet the standardisation is only recommended for activities of one contractor, not to enable exchange between contractors of allow for comparisons across contractors [Recommendation IV.A.19].

However, some level of consistency is deemed necessary to ensure core demands on ecological information in a comparable way across contractors (Clark, 2019). A core set of parameters would include a) what is measured, when and with which acceptable standards to indicate operational activities and related effects, b) which indicators to be assessed to inform on changes from mining, c) the level of acceptable change and how can it be measured? Initial suggestions for all of these parameters can be found in the recent deep sea mining-related literature, such as by (Jones *et al.*, 2017a). Work on such a standard framework will proceed incrementally based on incoming reporting from contractors and new scientific research and should start as soon as possible.

In the same vein, while also reminding that knowledge and understanding of the deep sea is likely to remain incomplete, Clark (2019) names several avoidable problems with EIAs, such as

- Lack of standardization of data or sampling procedures;
- Poor integration of all available data;
- No assessment of what is an adequate baseline dataset;
- Inadequate baseline survey design (often not enough thought);
- Insufficient regional setting for studies done at a smaller-scale site of interest;
- Insufficient assessment of potential cumulative impacts;
- Limited expression or acknowledgement of uncertainty.

The ISA EIA framework may need to address some of these avoidable problems. In addition, it remains unclear what the minimum threshold of the required quantity and quality of the EIS contents and subsequent reporting is, and how ISA will make sure that all contractors are treated equal.

4.5.4.2 Monitoring

Environmental monitoring has to "*ensure that no serious harm is caused to the marine environment from activities during prospecting and exploration*" as well as during and after testing of mining components (ISBA/25/LTC/6/rev1/Corr.1, section II C, para 11). This definition of scope seems inappropriate to satisfy the UNCLOS Art. 145 requirement to "*ensure the protection of the marine environment from harmful effects which may arise from ... activities*".

Technically, contractors who want to carry out mining tests are required to submit a "properly designed monitoring programme that should be able to detect impacts in time and space and to provide statistically defensible data" (see paragraph 38 (o)), including "provision for monitoring of those areas impacted by the contractor's activities which have the potential to cause serious environmental harm, even if such areas fall outside the proposed test site". Contractors shall specify those activities or events that "could cause suspension or modification of the tests owing to serious harm, including if the specified activities or events cannot be adequately mitigated. The programme will also authorize refinement of the test plan prior to testing and at other appropriate times, if refinement is necessary. The plan will include strategies to ensure that sampling is based on sound statistical methods, that equipment and methods are scientifically acceptable, that the personnel who are planning, collecting and analysing data are well qualified and that the resultant data are submitted to the Authority in accordance with specified formats" (ISBA/25/LTC/6/rev.1/Corr.1, Annex I, para 66).

This could mean, if the underlined wording in para 66 "*monitoring of those areas impacted by the contractor's activities which have the potential to cause serious environmental harm*" is interpreted in the spatial sense, that contractors only have to monitor those areas within or beyond the proposed test site, from which it is to be expected that they may suffer serious harm. In addition, para 68 requires the contractor to demonstrate how impacts will be assessed. This raises a number of questions: Given that there is currently no ISA definition of what constitutes harmful effects or serious harm,

- Who determines where contractor activities have the potential to cause serious harm and based on which criteria?
- How does this relate to the "harmful effects" to be avoided acc. Article 145 UNCLOS?
- Is it up to the contractor to design an assessment scheme? Why does ISA not provide an assessment framework for all contractors to apply?
- What indicators will be applied (e.g. change in meiofauna presence/absence or abundance or propagation or reproduction rates?)
- What does it mean for the water column, resp. the benthopelagic fauna?

Apart from the uncertainty as to the degree of harm to be monitored and assessed, including on ecosystem functions and services, the current recommendations do not provide actual guidance on the implementation of appropriate monitoring programmes, *i.e.* in terms of pre- and post activity period, continuity and intensity of sampling and observation, eventually a set of recommended monitoring tools (landers, sediment traps, links to ARGOS system etc).

To provide for the successful monitoring and assessment of effects from an activity, a dedicated Before-After-Control, BACI experimental design is required (see 5.4.5.2), including measurements at the impacted site (the place where test mining takes place up to the limits of plume effects, impact reference zone, IRZ) and control sites (the preservation reference zone, PRZ). The quality of the experimental set-up will influence the reported results (ISBA/25/LTC/6rev, section III A, para 13), in particular in relation to "*statistical reliability*": changes in species and community composition or water quality over time or after an activity can only be interpreted, if the recipient environment is well known, serves to identify critical variables to be monitored during and after the activity, and qualified unimpacted control site(s) are designated.

In order to get a thorough understanding of the environmental impacts related to the activity,

- Environmental baseline investigations at and around the location of the later testing activity need to start long enough in advance to enable the complete description of the fauna and communities in relation to environmental properties, functional relationships and their natural variability, including the trend of change due to global warming;
- A limited set of parameters has to be chosen from the baseline investigations to best serve for monitoring a) the health of the control site(s), PRZ(s) and b) the changes observed due to the activity in the IRZ(s), which is the site of the test zo the extent of the plume effects, and
- The monitoring has to continue spatially and temporally until no further effects can be found and recovery sets in.

In the deep-sea, in particular in areas of extremely high microscale heterogeneity, as yet unknown fauna and slow ecological processes such as in the Clarion-Clipperton-Zone, this requires a carefully designed experimental programme (Clark *et al.*, 2016). The sampling programmes not only have to have the power to detect changes of significance, but also the degree of effect should be measurable, which requires substantial effort (Jones *et al.*, 2018).

After analysing the results of all available major deep-sea disturbance experiments of the last decades Jones *et al.* (2017a) recommend a list of actions to be observed to enable robust assessments of the impact of future test mining cases:

- Integrate plan to collect environmental data into plan for test mining;
- Accurately and precisely quantify the nature and extent of the mining impact in space and time;
- Follow a predefined sampling design;
- Obtain sufficient sample numbers and sample sizes;
- Achieve high spatial accuracy in sampling, being necessary for reinvestigations of disturbance tracks, and of areas with different sedimentation regimes:
- Assess multiple impacted and control sites prior to impacts and during all subsequent studies;
- Standardise methodologies to improve comparability between studies;
- Provide comprehensive metadata and raw data in an accessible way

The scale of temporal and spatial resolution and sampling patterns is of particular relevance to reliably allow for the separation of effects due to the test operations from natural variability and changes caused by climate change. In low abundance, high diversity biomes such as the deep sea floor, this requires sufficient sample size and replications to enable the identification of unusual patterns or deviations from the normal background, in particular if to be statistically significant (Ardron *et al.*, 2019a; Jones *et al.*, 2018). The scaling depends ultimately on the objectives of testing and monitoring and Clark *et al.* (2016) recommend, rather than to diversify sampling, to prioritise some sampling strands which should then be investigated in more detail to reduce uncertainties. Other factors of importance for the sampling design are sample independence, replication and environmental linkage, *i.e.* the link between physical habitat characteristics and community property.

All of this is challenging for nodule areas because of the low statistical power of affordable sampling, and is particularly challenging for SMS and cobalt-crust mining tests due to the unlikelihood of finding adequate control sites (Jones *et al.*, 2018).

4.5.4.3 Preservation and Impact Reference Zones

In the current recommendations, the criteria named for PRZ and IRZ are (ISBA/25/LTC/6/rev.1/Corr.1, section C, para 38 (o)):

a) PRZ should

- be within the contractor's area if possible;
- be large enough to be representative of local environmental conditions/should have a species composition comparable to that of the impacted areas;
- address benthic (incl. benthopelagic) and pelagic communities;
- be far enough away not to be affected by testing activities.

b) An IRZ should be the site where the test-mining and related direct impacts are to occur. Physico-chemical and biological disturbances shall be detected within and beyond the IRZ, including in the far field from the test-mining site (>10 km).

This means that a spacing of several IRZ or monitoring sites along the impact gradient of direct and indirect impacts will be required, extending eventually beyond the boundaries of the contract area (Jones *et al.*, 2018). It is recommended to model the timescale over which each test-mining by-product causes significant environmental impact. Significance must be determined. The dispersal potential of sediment plumes must be investigated over timescales that range from the tidal frequencies to the largest of these environmental impact timescales, eventually, and until modelling is sufficiently ground-truthed and reliable, over long time scales. Additional design considerations are given in Jones *et al.* (2018).

Test mining is crucial not only to test the initial type and spread of impacts from the disturbance in space and time, but also to learn about the effort required to establish sufficient baseline knowledge, suitable parameters for assessing change, and the placing of IRZ and PRZ. Therefore, the analysis of the contractors´ experience would be highly valuable to determine more meaningful directions for the qualities, dimension and spacing of PRZ and IRZ. In order to promote meaningful reporting by contractors, ISA should determine overall monitoring objectives and agree on a scientifically recommended best-practice BACI design as a framework for the three types of resources for contractors to fit to their circumstances This could for example address location, size of core and buffer zones, and the spatial and temporal spacing of monitoring stations to facilitate regional assessments and inter-contractor comparisons. Jones *et al.* (2018) recommend to verify the robustness of the contractor sampling programme by independant experts. Scientists recommend to operationalise the objectives of PRZ and IRZ in a staged process for the three mineral types, in a first instance based on general principles and precautionary assumptions (International Seabed Authority, 2018; Jones *et al.*, 2018).

4.5.4.4 Assessment and Mitigation

A section on assessment and mitigation of effects is completely missing, except as topic of the EIS given in Annex III of the recommendations. The only mention of assessing the effects of activities on the environment is in (ISBA/25/LTC/6/rev.1/Corr.1, Annex I, para 67) which says "*The monitoring programme proposed by the contractor must provide details of how the impacts of the testing of mining components and test-mining activities will be assessed*" [Recommendation VI.D.40]. Again, it is completely up to the contractors to determine not only the indicators measured but also threshold values for designating significance of change and severity of impact. Not even the process to be followed, e.g. to carry out an environmental risk assessment is indicated and no suitable references are given (e.g., Elliott *et al.*, 2017; ICES, 2013; Kaikkonen *et al.*, 2018a; O *et al.*, 2015; UNECE, 2012; Washburn *et al.*, 2019).

4.5.4.5 Reporting

Section C of Part IV of the Recommendations sets out that the "*assessed and interpreted results of the monitoring shall be periodically reported to the Authority together with the raw data*" in the format of the annual reports (ISBA/21/LTC/15). With regards to the contents of the reporting on "*Mining tests and proposed mining* technologies", ISBA/21/LTC/15, Part V requires the following (para 12):

a) Data and information on the nature of the mining equipment designed and tested, where applicable, as well as data on the use of equipment not designed by the contractor;
b) A description of the equipment, the operations and the results of the mining tests;
c) A description of the nature and results of the experiments (where applicable);
d) With regard to mining technologies, information on the technological progress made by the contractor with its mining system (e.g. collectors, riser, production vessel or other) development programme;
e) With regard to processing technologies:
    i. Information on the mineral processing and metallurgical testing and processing routes, for instance whether three metals, five metals, rare earth elements or other;
    ii. Information on other methods.

The above requirements in relation to reporting on testing activities do not include the reporting of the environmental monitoring data and results, but only relate to the technical design and operation of the gear tested. This is likely covered by section IV, "*Environmental baseline studies (monitoring and assessment)*" (ISBA/21/LTC/15). Here, section IV B, Environmental Assessment, para. 10 (a) requires that contractors provide information on the "*environmental impact of exploration activities including before, during and after specific activities with the potential for causing serious harm*" which is likely to include mining tests. The information shall comprise an assessment of statistical robustness/power, the estimation of recovery times and an evaluation of different sampling and analysis methods. Neither the reporting on uncertainties, nor mitigation measures and alternative are required.

The recommendations comprise more than a hundred different relatively detailed sampling actions recommended to be carried out during baseline investigations (Bräger *et al.*, 2018), however these are not grouped or prioritised and in effect contractors are free to investigate, monitor and assess along their own choice as long as "*collection and analytical techniques follow best practices such as those developed by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization and available at world data centres, national oceanographic data centres or those recommended by the Authority*" (ISBA/25/LTC/6/Rev.1/Corr.1., Annex, para. 54).

Contrary to these broad but open requirements to sampling and direction on reporting environmental data and information (in ISBA/21/LTC/15), a much more directing guidance exists in ISBA/25/LTC/6/Rev.1/Corr.1 in Annex V, for reporting on the mineral resource. This is a "*reporting standard setting out the required minimum standard for all documents submitted to the Authority that include the reporting for mineral exploration results assessments, mineral resources and mineral reserves,*" including terminology and a checklist of assessment and reporting criteria.

4.5.4.6 Data Accessibility

The cruise reports related to testing operations have to be submitted to the ISA within one year ISBA/25/LTC/6/Rev.1, Part IV B). Within four years after the cruise, "*data and information that are necessary for the formulation by the Authority of rules, regulations and procedures concerning protection and preservation of the marine environment and safety, other than proprietary equipment design data (including hydrographical, chemical and biological data), should be made freely available for scientific analysis",* including in a freely accessible web database including the metadata. Assessed and interpreted results of the monitoring shall be periodically reported to the Authority together with the raw data in accordance with the recommendations for the guidance of contractors on the content, format and structure of annual reports.

It remains to be seen whether and how much of the information reported will be made publicly available at all, as the annual reports of contractors are not published and the new database allows only a limited overview of the activities of contractors which are not otherwise published. The web-accessible database is operational since July 2019.[106] According to the website, "*DeepData contains information on mineral resource assessment (geological data) and environmental baseline/assessment data. However, only the environmental data will be accessible to the public. This will include biological, physical and geochemical parameters of the marine ecosystems from the seafloor to the ocean surface. The geological data is formally identified as confidential in the regulations on prospecting and exploration of mineral resources* (ISBA/19/A/9, ISBA/19/C/17, ISBA/16/A/12/Rev.1, and ISBA/18/A/11)."

In a recent webinar,[107] it became clear, that not only the mapping of minerals falls under this confidentiality clause, but also high-resolution bathymetric mapping of the seafloor. Apart from the fact that it seems dubious why the mineral resources of the common heritage should not be disclosed, information on e.g. the extent and density of nodules or the seafloor microscale topography is also essential for scientific work, due to the relationship with small- and micro-scale habitat and community distributions (Durden *et al.*, 2020; Lindh *et al.*, 2017; Peukert *et al.*, 2018; Van Gaever *et al.*, 2010; Vonnahme *et al.*, 2016).

Apart from these general restrictions, the data accessible by the public lack meaningful metadata and are not searchable and downloadable through practical search masks. The user manual provided on the DeepData website[108] provides a table of variables that are downloadable, demonstrating that the biological information may be of interest to taxonomists, but precludes any ecological analysis. Neither contractor annual reports, cruise schedules or reports, nor related publications, which are all to be submitted to ISA, are listed anywhere since the prior existing respective databases for this have ceased operation.[109]

The non-disclosure of comprehensive environmental data, including the assessments provided by the contractors, therefore hampers scientific work, in particular in a regional context as required for the operation of Regional Environmental Management Plans, REMPs.

4.5.5 Conclusions: Problems with ISA Regulatory Control and Transparency

No substantial changes can be noted in comparison to the prior version of the recommendations (ISBA/19/LTC/8), except for an update of the recommended baseline investigations and a little bit more detail on the EIS procedure (which was called EIA in the prior version). Therefore, the general conclusions on the deficiencies remain the same as noted in (Christiansen *et al.*, 2019b, p. 190)*:*

> *As it stands, each contractor can run its own design of monitoring programme - each using different instrumentation, different spatial and temporal sampling and recording patterns, investigating an own selection of parameters. This will render the comparison between different contractors and the environmental impacts caused by their activities extremely difficult. To sum up, there is currently*
>
> *No prior review and reflection of the necessity of the disturbance/alternatives, the design of the technology used, and the design of the monitoring programme;*

[106] https://isa.org.jm/deepdata
[107] https://isa.org.jm/news/isa-workshop-deepdata-focusing-data-management-strategy-21-25-september-2020
[108] https://www.isa.org.jm/index.php/deepdata/manual#block-seabed-page-title
[109] International Seabed Authority, Central data repository.

No standardised minimum temporal and spatial monitoring programme design with a minimum set of compulsory indicators and assessment procedures;

No post activity assessment of environmental impacts by ISA for gathering experience with the environmental effects of certain activities and technologies, thus no option for developing BEP or BAT over time, and no way to influence the design of the next contractor´s activity design from the learning experience.

No transparency.

Some of the above elements certainly need development over time and may be spurred by scientifically monitored testing of equipment. However, in order to develop uniform standards for all contractors, ISA will need to initiate a process which enables a learning process integrating information from all areas within a region and all contractors.

One of the weaknesses of the discussed "*Recommendations for the guidance of contractors*" (ISBA/19/LTC/8 and ISBA/25/LTC/6rev1) is that these are not strictly binding for contractors (Jaeckel, 2016). The standard terms for exploration contracts require contractors *'[t]o observe, as far as reasonably practicable, any recommendations which may be issued from time to time by the Legal and Technical Commission*", however the caveats are clear. In addition, there is currently no option which would ISA LTC allow to reject any reports, EIS or applications received.

By way of choosing that contractors submit an Environmental Impact Statement, rather than going through a regulator-guided Environmental Impact Assessment process, contractors are made fully responsible for anything they submit to the ISA. On the other hand, the lack of ISA guidance on management goals and objectives, assessment framework and methodology and procedural support for how to master the tasks leaves a huge void which each contractor can chose to fill at will. ISA neither has nor does it gain insight or own competences on the matter (other than resource assessments), and there is no technical or scientific body advising on this. All competence on the matter depends on the alternating members of the LTC, and no institutional memory seems to exist. This appears to be inadequate for the environmental governance of a nascent industry. By contrast, the US NOAA acquired an own set of data and experience which they used for determining an activity framework and conditions for test mining activities (see chapter 4.3.1).

The recommendations for the guidance of contractors does not reserve a steering function for ISA (International Seabed Authority, 2013; Jaeckel, 2015, 2017a) at all, despite its mandate to ensure a "*uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind*" (ITLOS, 2011, para. 159). The present guidance of contractors, ISBA/25/LTC/6/Rev.1/Corr.1, provides (see also (Durden *et al.*, 2018))

- **No procedural guidance through ISA**, e.g. by detailing the EIA process as guided by ISA with an initial scoping phase for determining the anticipated scope and content of the information to be included in the assessment and EIS, the required standards to be met, evaluation criteria applied to the EIS, etc.;
- **No decision-making procedure** - there is no option to reject an EIS for a test mining project, independent of its scale, environmental impacts and the quality of the EIS;
- **No** role for **external scientific advice** and meaningful public consultation;
- **No** guidance and legal reference as to the **applicable conservation standards**, including on pollution control;
- Not even a first draft **assessment framework**, outlining the procedural steps involved, the risk assessment process and management, including hazard identification and exposure and

characterisation, risk evaluation in relation to the vulnerability of recipient biota and treatment (Christiansen *et al.*, 2019b, p. 199 ff.). In particular, guidance on the scaling of the vulnerabilities is of utmost importance for both contractors and the ISA;

- **No definition of significance thresholds**, incl. serious harm - level of change, a minimum set of indicators and thresholds should guide the assessments required from all contractors;
- **No operational guidance** or at least decision-support framework for the establishment of **Impact and Preservation Reference Zones**, although crucial to a **meaningful BACI set up**. This could for example address location, size of core and buffer zones, and the spatial and temporal spacing of monitoring stations to facilitate regional assessments and inter-contractor comparisons;
- **No guidance** as to appropriate initial timing and spacing of **monitoring**, test of core parameters as indicators as recommended by science, and first risk assessment;
- No reporting obligation on
    - the reporting of species, habitats, ecosystems of **particular concern** of other bodies, e.g. EBSAs, VMEs, or proposed MPAs in the contract area;
    - **mitigation** of impacts;
    - alternatives;
    - uncertainties and
    - knowledge gaps.
- **No guidance or rules for choice of test and mine site**: The presumption is that the contractor is free to chose the mine or test site according to his own criteria, *i.e.* resource density, and that ISA will only collect information on what happens. It would be better to
    - determine the test site and later mine site via contract area-scale SEA, based on systematic mapping of (benthic) environment or sampling and considering conservation criteria for species and habitats.
    - provide contractors with rules on minimum safe spacing of test and mine site locations.

A clear differentiation between an ISA EIA procedural standard and a sampling standard for baseline investigations has to be made. Concerns have been raised that standards or guidelines for baseline investigations should strike the balance between being prescriptive, but not fit for all purposes, and too general (Clark, 2019) given that each EIA case is likely to be specific when considering the details. However, unless the proponents produce accurate, reliable, scientifically correct and reproducible data and baseline information in the EIA, risk and impact assessment will be impossible. Apart from quality assurance, a certain degree of standardising baseline investigations, monitoring and reporting is required to enable regional and temporal analysis (Ginzky *et al.*, 2020). For the ISAs as a regulator who has to provide for uniform conditions for all contractors in the Area such minimum requirements should be vital. Incentives might stimulate more comprehensive investigation programmes.

Guidance is also needed to enable contractors and the LTC to "*establish that there is <u>no serious harm</u> from any activities"* covering a definition and over time an assessment framework for what is to be understood as "serious harm" and how this relates to the "harmful effects" to be avoided acc. Art. 145 UNCLOS (for a first consideration of the levels of harm see Christiansen *et al.*, 2019, chapter 3.4.6). In principle, the regulations for the exploration of minerals in the Area allocate these tasks to the LTC (e.g. Reg. 31 of ISBA/19/C/17):

The LTC shall develop and implement procedures for determining, based on the best available scientific and technical information, whether any proposed exploration activities would have serious harmful effects, and ensure that such activities are either managed to prevent such effects or not authorized to proceed. [110]

Also the LTC evaluation criteria *accuracy* (of what?) and *statistical reliablility* of an EIS (see ISBA/25/LTC/6/Rev.1, section E. 41(c) and Annex I, para 65) are not further defined. Until ISA as independent expertise, it will be difficult to check the plausibility of data and information reported by contractors, not to speak of the accuracy. The criterium "*statistical reliability"* could be challenged as no framework conditions in that respect exist.[111] One first measure to remedy this could be a) to check whether the mining test and the respective monitoring meet the standards of best environmental practice and best available scientific and technical practices (Sullivan *et al.*, 2006).[112] The related evaluations could b) be delegated to external advisory groups or external experts consulted, such as proposed by Belgium in 2019[113] and Ginzky *et al.* (2020). However, any critique would also have to have effect and oblige the EIS provider, the contractor, to remedy insufficiencies prior to inclusion of the test mining plan into the current work programme.

ISA should therefore seek to establish an own knowledge pool from the data and information provided by the contractors for e.g. developing views on potential environmental health and impact indicators and thresholds, Best Environmental Practices and Best Available Technologies. Only collecting the data coming in from the contractors´ annual reports in the DeepData database is not enough. All environmental information needs to be made accessible, as in particular for scientific analyses, it is crucial to not only retrieve sampling locations but also the associated metadata and analysis. For the broader public, in particular the reporting and analysis of impacts after test mining is particularly important.

The better the consistency of the data and assessment pool across the contractors for one resource in a particular region, the better are the chances for upscaling environmental observations, causal-risk assumptions and presumed risk and impact acceptance thresholds to the regional scale. For meaningful

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110 International Seabed Authority, Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, 2013 (ISBA/19/C/17), Kingston, https://ran-s3. s3.amazonaws.com/isa.org.jm/s3fs-public/documents/EN/Regs/PN-en.pdf.

111 It is unknown whether there are cases where contractor reports have been rejected based on a lack of statistical reliablity of the presented data. So far likely not a single contractor, and also no scientific investigation has sampled enough replicates to indicate only the megabenthic community diversity with some accuracy and statistical power Ardron, J.A., Simon-Lledó, E., Jones, D.O.B., Ruhl, H.A., 2019a. Detecting the Effects of Deep-Seabed Nodule Mining: Simulations Using Megafaunal Data From the Clarion-Clipperton Zone. Frontiers in Marine Science 6.

112 Sullivan et al., 2006 offer recommendations which are also relevant in the ISA context:

- Scientists, policymakers, and the public should become more familiar with the range of spatial and temporal scales, the types and levels of uncertainty, and the necessary suite of scientific disciplines associated with science-based solutions to today's environmental problems, and ensure that the most pressing information needs for decision making are met.
- Scientific professionals should do more to make good science widely recognized and available, invest more in establishing scientific literacy among nonscientists, and develop ways to more clearly communicate technical information to policymakers and the public.
- Scientific professionals should become more active in establishing broadly accepted criteria to distinguish sound science, to assess the quality of scientific information, to distinguish types and uses of "peer review," to define scientific debate, and to ensure that science is properly incorporated into policy.
- Resource management agencies should organize themselves so that scientific and regulatory arms are administratively independent, formally engage recognized advocates of best available science, and proactively guide democratization of the science relevant to agency missions.

113 During the second part of the twenty-fourth session of the Council, the delegation of Belgium submitted a non-paper entitled "Strengthening the environmental scientific capacity of the International Seabed Authority". The non-paper included suggestions for the independent evaluation of the environmental plans at the application stage and of environmental reviews and monitoring during the exploitation phase, and addressed matters relating to enhancing the environmental expertise of the Legal and Technical Commission and the secretariat.

REMPs, not only need the environmental objectives be harmonised to satisfy regional strategic and operational objectives, also the individual contractor EIS/EIA will have to be guided by regional strategic environmental (and other) assessments (Billett *et al.*, in prep.; Billett *et al.*, 2019; Jones *et al.*, 2019; Tamis *et al.*, 2017).

With the number of mining tests increasing, the need for ISA guidance on the issues named above clearly increases. Of course, there is limited experience to date and the ISA itself does not hold any data from independent monitoring of disturbance through mining tests. However, much could be gained if all historic and small-scale environmental studies would be compiled and evaluated to provide a first guess on what "harmful effects" and "serious harm" mean. First indications are given in (Jones *et al.*, 2017a). With each new mining test, more experience will be gained so the definitions, indicators and thresholds can be refined.

This calls also for a continuum of test mining EIAs, as suggested also by (Clark, 2019). It is proposed that for each contractor all EIAs and reports submitted in context with test mining during the exploration phase should incrementally produce the EIA in the exploitation approval process. The end point is when a contractor can reliably indicate a) the expected environmental consequences for the planned commercial mining operation and b) that these do not cause harmful effects/serious harm to the environment. Practically, this requires that one and the same EIS format and underlying assessment and reporting procedures are valid throughout the contract phases. For the contractors, this could make repeated testing more attractive, as the core of the EIS will remain the same, and only new test and monitoring programmes need to be added and lessons learnt from earlier tests analysed.

4.5.6 Summary and Recommendations

In the box below, the conclusions on the analysis of the "Recommendations for the guidance of contractors for the assessment of possible environmental impacts arising from exploration for minerals in the Area", (ISBA/25/LTC/6/rev1/Corr.1) are summarised and recommendations are made which might improve the guidance for contractors in some respects and enhance the regulatory force of the recommendations.

Summary and Recommendations

Summary

The "Recommendations for the guidance of contractors for the assessment of possible environmental impacts arising from exploration for minerals in the Area", ISBA/25/LTC/6/rev1/Corr.1

- Fail to provide guidance to contractors on the scope and contents of the EIS and solid design of impact monitoring programmes to be submitted to ISA LTC ahead of any test mining activity;
- Fail to standardise at least a minimum set of baseline and monitoring activities by contractors in such a way as to enable inter-contractor comparisons, and integration with scientific and regional data;
- Do not provide for a preliminary set of environmental objectives, significance thresholds and assessment criteria which could help develop the assessment framework further until required at the time of exploitation applications;
- Reflect the unwillingness of ISA to gain environmental competence and act as an active regulator to prevent significant harm from activities in the Area.

Concerns remain as to when and how much data and information will be made publicly available, as near to all information will be related to the resource and/or technology, which are subject to confidentiality terms.

Recommendations

- Reverse from requesting the delivery of an EIS by the contractor to an ISA guided EIA process.
- Introduce a scoping phase to develop the format and elements of the prior EIS (Environmental Impact Statement) appropriate for the particular case. Scoping could set the standard for all following steps, with the deliveries increasing in proportion to the level of risk. All information should incrementally accumulate into one comprehensive EIA report over the exploration period.
- Request the reporting of uncertainties and knowledge gaps, and how contractors dealt with it;
- Request the reporting of the occurrence of species, habitats, ecosystem subject to conservation by other bodies, e.g. EBSAs, VMEs, or proposed MPAs in the contract area.
- Introduce guidance on resource-dependent standard monitoring programmes - e.g. specify time scale before and after a disturbance, spatial and temporal set-up, minimum set of biota and processes - in order to be able to synthesise the information coming from different contractors. As long as there are no such guidance, monitoring and assessment should be designed according to best scientific standards. Scientific opinion should be requested.
- Determine a scientifically recommended best-practice Before-After-Control, BACI, sampling design as a framework for the three types of resources for contractors to fit to their circumstances, including temporal and spatial requirements, sampling and the qualities of Impact Reference Zones and Preservation Reference Zones, their size, buffer zones etc. The robustness of the contractor sampling programme should ideally be verified by independent experts.
- Add a new section on assessment and mitigation of effects.
- Require annual monitoring and impact assessment reports post activity, eventual a final report at the end of the contract. These can be used by LTC to develop risk assessment procedures and criteria and thresholds required for decision-making on commercial mining EIAs.
- EIA reports (draft EIS) and monitoring and assessment results should be made available as timely as possible to enable experts and other stakeholders to keep track of the activities.
- In the long run, ISA should prepare for monitoring cumulatively activities and impacts, establish an own knowledge pool and conduct also regional strategic assessments, incl. socio-economic

assessments in view of the interests of the common heritage of mankind. This necessarily has to include an evaluation of the ecological cost in terms of ecosystem functions and services, as well as in terms of lost opportunities for other ocean users.

- Test mining EIAs and reporting should incrementally produce the EIA in the exploitation approval process. The end point of exploration is reached when a contractor can reliably indicate the expected environmental consequences for the planned commercial mining operation.

4.6 Comparison with Other International and National EIAs, and those Proposed by Science

There are numerous models for EIA and SEA procedures in national legislation and international law (Espoo Convention 1991; (EU 2014; Abaza *et al.*, 2004; Bradley and Swaddling, 2018; Convention on Biological Diversity, 2012a; European Commission, 2013; OECD-DAC, 2006). Therefore, ISA could benefit of the multiple global experience, also in relation to offshore marine industries. Some countries already have experience with applications for deep seabed minerals mining applications, among others Papua New Guinea, Namibia, New Zealand, Mexico and the U.S.; in many more countries exploration is ongoing.

Furthermore, science is contributing with a range of suggestions and proposals how to implement appropriate EIA procedures in context with deep seabed minerals mining in the Area (Clark, 2019; Clark *et al.*, 2019; Clark *et al.*, 2017; Collins *et al.*, 2013; Durden *et al.*, 2018; Ellis *et al.*, 2017; Furushima *et al.*, 2019; Kaikkonen *et al.*, 2018a; Lallier and Maes, 2016; NRDC, 2016; Thornborough *et al.*, 2019; Washburn *et al.*, 2019).

In the following chapter, a selection of the available instruments, national regulations and scientific proposals will be presented in order to flesh out lessons that could or should be learned for improving the current approach of ISA to the assessment of impacts by way of monitoring the environmental changes caused by test mining.

4.6.1 International EIA Standards

4.6.1.1 ESPOO Convention and Protocol

The main intention of the ESPOO Convention on Environmental Impact Assessment in a Transboundary Context (1991)is to facilitate communication among neighbouring States on environmental concerns related to activities which potentially have transboundary effects. Building on the Rio Principles 15 (EIAs for activities likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority) and 19 (early notification of transboundary effects), the ESPOO Convention applies only to contracting parties in relation to certain activities within their jurisdiction that are likely to have transboundary impacts. Therefore, the provisions would apply to deep seabed mining within the respective national jurisdictions, but obviously excludes the Area. However, standards in international waters should not be less stringent than in national waters and *vice versa*. In addition, as an internationally agreed framework, it sets an important precedent and signpost for the standards to be met by EIAs when more than one party is affected. Therefore, the ESPOO Convention sets out

- obligations of Parties to assess the environmental impact of certain activities at an early stage of planning, and
- a general obligation of States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

Once the risks involved in certain activities have been considered as being generally acceptable, the formal Environmental Impact Assessment procedure of concrete project applications should lead to the environmentally least damaging project operation, after evaluation of alternative solutions and mitigation options. The results of consultations and the information gathered as part of the EIA must be taken into consideration in the development consent procedure.

A related protocol, the "*Protocol on strategic environmental assessment to the Convention on Environmental Impact Assessment in a Transboundary Context*" (2003) embeds the obligation for assessing the environmental impacts of certain activities into a broader perspective, which is of relevance to regions or sub-regions. The aim is to contribute to a "high level of protection" of the marine environment by

a) 'Ensuring that environmental, including health, considerations are taken thoroughly into account in the development of plans and programmes;
b) Contributing to the consideration of environmental, including health, concerns in the preparation of policies and legislation;
c) Establishing clear, transparent and effective procedures for strategic environmental assessment;
d) Providing for public participation in strategic environmental assessment; and
e) Integrating by these means environmental, including health, concerns into measures and instruments designed to further sustainable development' (Article 1, ESPOO SEA Protocol).

What Can Be Learnt from the ESPOO Convention and SEA Protocol?

The effects of test mining are not likely to cross the boundaries of the contract area; however, it cannot be excluded. In particular the later commercial mining activity could raise plumes which might extend to another contract area, the Area or to some locations also in national waters.

- Therefore, notification and consultation schemes with potentially affected parties (national, international, sectoral) should be built into the processes around the review and recommendation of EIS for test mining. This will also be beneficial when the scale of mining tests will increase to sub-commercial scale, and be available when commercial activity starts.
- A joint body of potentially affected parties, in the case of the Area including a broad range of stakeholders, will broaden not only the range of expertise and legitimacy, but also help address concerns prior to the start of the activity.
- Post-project verification of the predicted significant adverse [transboundary] effects of the activity through compliance monitoring and impact review shall enable consultation on the necessary measures to reduce or eliminate the impacts. In ISBA/25/LTC/6/Rev.1 currently no post-project analysis is foreseen on the side of ISA. However, this is necessary information to be shared with the public.
- Comparing the EIS template in Annex III of ISBA/25/LTC/6/Rev.1 with the required contents of the EIA documentation set out in Appendix II of the ESPOO Convention, then several important missing elements appear: a) the consideration of alternatives, b) mitigation measures to keep disturbance at a minimum, c) predictive methods and underlaying assumptions, as well as data used, and finally d) the indication of gaps in knowledge and uncertainties.
- Prior public consultation is determined an essential part of the assessment process, and detailed requirements call on the appropriate notification and identification of interested stakeholders as well as the enabling of providing opinions. In line with the Aarhus Convention (1998), this includes a right of the public on information on the application in question, roles and procedures as well as opportunities to participate. Importantly, "*due account*" shall be taken of the outcome of the public participation in the formulation of the decision (Art. 6 (8) Aarhus Convention). Not only has the public to be informed promptly about any decisions, it is also entitled to know "*the text of the decision along with the reasons and considerations on which the decision is based*".

Although ISBA/25/LTC/6/Rev.1 now recommends public consultation either in national or ISA context, and the public has the opportunity to provide comments, however, there is no feedback mechanism to the commentators, nor does any documentation of *the reasons and considerations on which the decision is based* provide for accountability towards the Council and the public (for the handling of EIS of test mining projects, see chapter 4.5.5).

- A prior scoping exercise of the applicant and the regulator (here: ISA), where appropriate with public consultation, is an important first step to determine contents and depth of the EIS by prioritising issues to be monitored and reported. Furthermore, it has to be clarified whether and how socio-economic aspects have to be considered, and whether and how alternatives (including the no-action alternative, kinds of alternative) have to be taken into account.

4.6.1.2 CBD Guidelines for SEA and EIA in Areas Beyond National Jurisdiction

By invitation of the Conference of the Parties (Decision IX/20), the CBD Voluntary Guidelines (Convention on Biological Diversity, 2012a, b) for the consideration of biodiversity in Environmental Impact Assessments, EIAs, and Strategic Environmental Assessments, SEAs, in marine and coastal areas including in areas beyond national jurisdiction, ABNJ (in line with decision X/29 (paragraph 50)) inform the implementation of EIAs and SEAs for activities ... which may have significant adverse impacts, with a view to ensuring that such activities are regulated in such a way that they "*do not compromise ecosystem integrity*" (para. 8 of Decision IX/20). The Guidelines build on those for terrestrial biodiversity-inclusive EIAs, which were endorsed in CBD COP decision VIII/28.

Key recommendations of CBD SEA and EIA Guidelines for Marine and Coastal Areas are

1. The effective participation of relevant stakeholders, including indigenous and local communities, is a precondition for a successful EIA.
2. Scoping is used to define the focus of the EIA study and to identify key issues which should be studied in more detail, including alternatives, mitigation measures and remedial action. It is used to derive terms of reference (sometimes referred to as guidelines) for the EIA study and to set out the proposed approach and methodology. The terms of reference should be unambiguous, specific and compatible with the ecosystem approach. An active role of the competent national, regional or global authority is envisaged, which

    - guide study teams on significant issues and alternatives to be assessed, clarify how they should be examined (methods of prediction and analysis, depth of analysis), and according to which guidelines and criteria
    - provide opportunity for stakeholder input
    - ensure that the resulting EIS is useful for decision-makers and understandable to the public.

3. The scoping phase for marine activities may be more complex and require "a wider pool of expertise, which includes global and regional experts as well as national experts on the potential impacts of the relevant activity. The diversity and geographic spread of both the stakeholder and expert communities could increase the time and costs associated with the scoping process";
4. The expected contents of an EIS is indicated by way of a comprehensive list of issues which should be addressed, including *i.e.*

    - Possible alternatives, including "*no net biodiversity loss*" or "*biodiversity restoration*" alternatives;
    - Expected biophysical changes and the influence of spatial and temporal variability, cumulative effects and human activities on the changes observed and consequences for connectivity;
    - If possible, positive and negative changes of ecosystem services shall be documented;

- Attention must be given to (i) sustainable use of ecosystem services; (ii) ecosystem-level diversity; (iii) non-protected biodiversity; and (iv) ecological processes and their spatial scale. For marine and coastal areas, the scientific criteria for identifying "ecologically or biologically significant areas" (EBSAs), and similar criteria such as the FAO criteria for "vulnerable marine ecosystems" (VMEs) may be relevant.

5. It is suggested that in most cases the assessment and evaluation of environmental risks and impacts will be based on a relatively high degree of uncertainties which should trigger precautionary decision-making. In the absence of good available data and experience from the same or other industries, and given the usually large distance from land, the costs of EIAs may be much higher because of comprehensive studies required. This also supports an incremental approach, starting from small-scale low impact to gradually increase over time *"with stringent conditions for monitoring and surveillance, so that the permitted activity becomes the source of better information for a more complete assessment of the impacts at potentially larger scales. Where possible, information from other areas of the world where this activity has taken place would be used to ascertain likely risk and impacts before allowing a small-scale activity to occur*".
6. The Environmental Impact Statement, EIS, consists of (i) a technical report with annexes, (II) an Environmental Management Plan EMP providing detailed information on how measures to avoid, mitigate or compensate expected impacts are to be implemented, managed and monitored, and (iii) a non-technical summary). It serves to guide the proponent to eliminate or minimise environmental impacts, and to inform the regulator for its decision-making, and the public. It should consider regional and transboundary impacts, taking into account the ecosystem approach. The EIS reporting should also address relevant authorities of the flag State, competent international organizations with functional responsibility for the activities involved, and non-governmental organizations. For activities such as mining in the Area multiple organisations may be responsible for the supervision of the planned activities, *i.e.* ISA, IMO, MARPOL and eventually the future high seas agreement. It is considered that in some cases several organisations may wish to jointly approve/disapprove and activity.
7. The review of the EIS should be carried out by independent experts. The effectiveness of the review process depends on the quality of the terms of reference defining the issues to be included in the study. Scoping and review are therefore complementary stages. Another crucial element is public participation including by indigenous and local communities;
8. Decision-making should realise precaution by requiring greater reliability and certainty of information where higher risks and/or greater potential harm to biodiversity prevail.
9. Monitoring serves to verify whether impacts and proposed mitigation measures occur as predicted in the EMP and ultimately rests with the flag state in ABNJ. In addition, the compliance of the proponent with the measures outlined in the EMP needs to be checked.

What Can Be Learnt from the CBD EIA Guidelines?

- A structured process with clear expectations on output should provide the basis for an EIA/EIS. This includes a regulator´s guidance on the contents to be provided, the assessments to be made and the procedures to be followed, including stakeholder consultation.
- Scoping is an important step in preparing an EIS - at this stage, the regulator, the proponent and in consultation the public determine the priorities of an EIA. A clear and detailed terms of reference derived from scoping will enable an effective review of the EIS and a cost-effective monitoring programme.
- Stakeholder input and expert review are crucial ingredients to independent decision-making.

4.6.2 National EIA/EIS in the Seabed Mining Context

Most national regulators of mineral resource exploitation follow an active licensing procedure: The government decides about opening up certain sea areas for exploration licensing. Such licenses give the right to explore for a certain mineral, but do not need to be exclusive, as in the case of petroleum licensing in Norway,[114] and have a validity of a limited number of years. The opening of new areas for production then follows is preceded by an assessment of various interests, such as in the case of Norway of the impact of the petroleum activities on trade, industry and the environment, and of possible risks of pollution, as well as the economic and social effects that may be a result of the petroleum activities. Public consultation and hearings reflect the societal importance of such licensing. There is no obligation of the King to grant a production license, and any change of operator has to be approved by the Ministry. The 10-year production license can be renewed if the determined work commitments were fulfilled. This way the national government has full control over the temporal and spatial extent of exploration and exploitation, as well as the operators.

For not yet established offshore industries, such licensing processes do not exist yet, although a number of Pacific Island States have provided exploration licenses for manganese nodules (Cook Islands) and SMS (Solomon Islands, Fiji, Papua New Guinea) based partly on such licensing rounds. In most cases, however, the industry reaches out to the government to apply for exploration and production licenses without previous government activity. This has been the case e.g. with SMS exploration in the of waters South Pacific island states, phosphates mining off Namibia, and phosphates rock and ironsand mining off New Zealand.

4.6.2.1 Case study: Nautilus Minerals in Papua New Guinea

Based on the scientific exploration carried out by various international researcher groups in the Bismarck Sea, and in particular the discovery of the hydrothermal vent field Solwara 1 in the Eastern Manus Basin by CSIRO in 1997, Nautilus Minerals applied for and was granted a commercial exploration license (EL) 1196 in November 1997. Commercial exploration started in 2005, Nautilus registered their intent to mine in 2007 and in 2008. In December 2009, Nautilus received the final Environmental Permit for the development of the Solwara 1 Project from the Department of Environment and Conservation (DEC) of Papua New Guinea, PNG, for a term of 25 years, expiring in 2035. In January 2011, a mining lease was granted with the State exercising its legal right to take a 30% contributing interest. This share was halved by court agreement in 2013, resulting in PNG to pay Nautilus 120 mio US$.[115]

[114] Act 29 November 1996 No. 72 relating to petroleum activities

[115] Nautilus received a non-refundable deposit of US$7 million immediately, and an additional US$113 million placed into escrow to cover the State’s prorata interest pending the satisfaction by Nautilus of certain conditions Nautilus Minerals Inc., 2013. Many Connections. One Focus. Nautilus Minerals Inc. Annual Report 2013, p. 68..

By 2020, Nautilus has been restructuring following their bankruptcy.[116] Due to continued and ever more comprehensive criticism of civil society of the mining lease in an important fishing area, the government of Papua New Guinea also seems to take the opportunity to not maintain their interest in deep seabed mining, indicating also support for a moratorium on deep-sea mining until 2030, initiated by other Pacific Island States (Fiji and Vanuatu).

Environmental Impact Assessments in Papua New Guinea

The Environment Act (2000, in force since 2004) is the main instrument to protect the environment and regulate environmental impacts in Papua New Guinea. It defines matters of national importance (Part II (5)), determines the process towards achieving the environmental objectives (Part II (6)), and defines the national environmental objectives (Part II, section 4). Activities that involve matters of national importance; or may result in serious environmental harm, may be prescribed as level 3 activities (e.g. the Solwara mine site project of Nautilus Minerals), which require environmental permits to be processed by the Department of Environment and Conservation (DEC).

Environmental Impact Assessments of level 3 activities which may result in serious environmental harm are carried out in several steps based on the Environment Act (2000, Division 3, section 47-59), in order to ensure that the national environmental objectives can be achieved. Until an environment permit in relation to the activity has been granted in accordance with the Environment Act, no other governmental authorities shall issue any permits for that activity. The procedure includes:

- The registration of the proponents´ intention to carry out preparatory work with the Director of Environment (section 15-16)
- The notification of the proponents´ intention to undertake environmental impact assessment - to be asked in return to do so;
- The environmental impact assessment phase involving
    - An inception report by the applicant, where applicable, following guidelines issued by the Director;
    - An environmental impact statement by the proponent in line with the national guidelines (Department of Environment and Conservation, GL-Env/02/2004};
    - The assessment carried out by the government. Expertise may be derived from requesting advice from individual experts to calling a conference or appointing a committee to conduct a public inquiry and report;
    - A public review of the environmental impact statement, however „confidential information", as defined in section 55 (5) is excluded.
- The acceptance of the environmental impact statement by the Director of Environment if the description of the physical, social and environmental impacts is adequate and all reasonable steps will be taken to minimise environmental harm and the activity will conform to all relevant policies and regulations;
- Referral by the Director to the Council;
- **Recommendation** by the Council to the Minister. The Council shall examine the EIS, the assessment report and any public submission and further information a) according to the same criteria as the Director, and with regard to b) a suite of further criteria in broader context;
- An **approval** in principle by the Minister.

After having received the approval of the EIS by the Minister, the project proponent has to apply for a **permit** to be granted by the Director of the Department of Environment and Conservation (DEC, see

[116] http://dsmobserver.com/2020/05/the-last-days-of-nautilus-minerals/

division 4 of the Environment Act, 2000). Sections 65 and 66 of the Environment Act 2000 provide criteria for granting and setting **conditions** of permits respectively.

The Solwara EIS

The Solwara project has been subdivided in two separate phases, of which only Phase 1 has been subject to Environmental Impact Assessment and permit (Coffey Natural Systems, 2008)

Phase 1: The recovered SMS ore deposits will be pumped to the Mining Support Vessel, dewatered and barged to a temporary holding facility at the Port of Rabaul and then shipped overseas to a processing facility and smelter.

Phase 2: The dewatered ore will be barged to a concentrator located in PNG for processing and the concentrate then shipped to an overseas smelter. A feasibility study will commence when Phase 1 has demonstrated the extraction and recovery process and the Project has successfully achieved commercial production.

This separation of the EIS in two phases, and particularly the lack of designation of the future concentrator location, has been criticized (Steiner, 2009). An Environmental Management Plan was required only 6 months before the start of commercial operations.

Throughout its exploration work, Nautilus Minerals has provided a comparatively high level of transparency on technical developments as well as in relation to environmental investigations. Nautilus involved scientific expertise for the environmental baseline studies conducted 2005-2008. However, the period of investigation until 2008 was insufficient to provide more than a snapshot on the local environmental conditions, in particular in view of the literally unknown regional deep water ecology.

Two extensive reviews of the Nautilus EIS (Coffey Natural Systems, 2008) were initiated by civil society groups, the Bismarck-Solomon Seas Indigenous Peoples Council (BSSIPC) (Steiner, 2009), and the Deep Sea Mining Campaign (Rosenbaum, 2011). Both raised a range of critical issues, including a general lack of a comprehensive regional ecological background, in particular also of the pelagic environment, insufficient baseline description of the mine site, flaws in the oceanographic modelling, lack of information on discharge plume water quality and toxicity, unrealistic mitigation measures, lack of consideration of a.o. waste rock disposal, and consequences for the regional megafauna and national-tuna fishery (Kaschinski *et al.*, 2018). The EIS is overall very descriptive and not likely to be very useful for a before-after evaluation of environmental impacts.

In addition, Nautilus aimed to satisfy the EIS requirements by initiating stakeholder consultations. However, they obviously failed to listen to the neighbouring coastal communities in the Bismark Sea who would be the most impacted and the local civil society organisations, address the concerns raised appropriately, or value the cultural traditions and customs (Childs, 2019; Filer and Gabriel, 2018; Kaschinski *et al.*, 2018). In addition, the PNG government failed to gather the free, prior informed consent of local people (acc. to the UN Declaration of the Rights of Indigenous Peoples, UN General Assembly (2007) before granting any permits as the question of all mineral resources in PNG are a national heritage subject to federal government management (Aguon and Hunter, 2019). However, the question of land/sea ownership for the sea and its resources beyond 3 nm from the coast is under debate between the national government and the coastal communities as traditional owners.

In 2015 Nautilus published an Environmental and Social Benchmarking Analysis (ESBA) of the Solwara 1 project (Batker and Schmidt, 2015) which was heavily contested on the grounds of failing "*to meet the well accepted requirements of a cost-benefit analysis* (CBA)", *i.e.* due to failure to take account of the social, cultural and economic values of oceans, as well as cumulative impacts on those (Rosenbaum and Grey, 2015). A subsequent cost-benefit analysis for case-studies within the Pacific region came to the conclusion that contrary to cobalt-rich crust mining in the Marshall Islands and possibly also polymetallic nodule mining in the Cook Islands EEZ, SMS mining by PNG could result in a net monetary benefit to the country (SPC, 2016). However, this did not change stakeholder perception.

What Can Be Learnt from Nautilus in PNG?

- Stakeholder mapping and analysis is a crucial step to gain a social license;
- Stakeholders, in particular those directly affected by an activity, need to be fully informed, their views and concerns (here: no job-effect, pollution of vital waters, disregard of local values and traditions, disregard of local ownership and rights) valued;
- It is critically important to not compare "apples (land-mined copper) with pears (copper from dsm)" and to take properly into account the full value and value-loss due to mining to not provide misleading policy advice;
- The historic experiences and legacies of other large-scale impacts on communities, such as land mining, nuclear testing and warfare remain in the communal memory and caution for new untested developments;
- The Nautilus application was setting a precedent for a mining lease, but also for the delivery of an EIS. Rather than going the easy way, the PNG Government should have convened an international expert forum to evaluate and advise the Nautilus EIS;
- The high transparency of Nautilus was crucial to gain support in science and policy, however this did not ensure a social licence to operate.

4.6.2.2 Case Study: Namibia Phosphate Mining

In national waters of Namibia, phosphate-rich deposits have raised the interest of industry to mine in offshore waters. In Namibia, the right to own licenses for strategic minerals, including phosphate, should only be issued to a state-owned company. The state-owned company may enter into joint ventures with interested parties for exploration and development.

Consequently, in 2008 the Namibia Marine Phosphate (NMP), a public-private joint venture was established and acquired the rights to exploration and exploitation of resources in more than 2200 km^2 of coastal waters. A related Environmental Impact Assessment and Environmental Management Plan submitted by the company in 2012 was initially accepted by the government without public consultation. The decision was, however, immediately challenged by stakeholders which led to an 18 months moratorium on the proposed mining in 2013. Initially a Strategic Environmental Assessment, to be carried out by the Norwegian SINTEF, should inform on the broader environmental consequences, in particular in relation to fisheries. However, in the end public pressure and a law suit filed by the Namibian fishing industry resulted in the suspension of the environmental clearance in 2016. This was successfully challenged by the industry in 2018, and is now back in court.[117]

[117] https://www.fishingindustrynewssa.com/2020/07/06/namibia-phosphate-mining-saga-goes-back-to-court/
https://www.fishingindustrynewssa.com/2018/07/04/marine-phosphate-mining-namibia/

What Can Be Learnt from Namibia Phosphate Mining?

- Good governance is crucial. Transparency and public consultation should not only be promised in legal documents, as was the case in Namibia, where elaborate laws and guidelines ensuring public participation in natural resource management exist (Environmental Management Act)[118].
- The broader consequences of new marine activities should be considered and assessed from the start, and definitively prior to issuing sectoral permits. Strategic Environmental Assessments are particularly suited to provide a comprehensive picture of interacting agents in a particular space.
- The success of the fishing industry law suit against the EIA was based on insufficient baseline investigations, actual knowledge on impact and predictive models.
- Being another new industry where no previous experience of environmental effects exist, monitoring by independant entities or the government within a strict legal framework, as in the Norwegian oil and gas industry, are recommended if mining goes ahead.

4.6.2.3 Case Study: New Zealand Seabed Minerals Mining

In New Zealand, several applications for permits for the exploitation of seabed minerals (iron sand, rock phosphorite deposit) in territorial waters, and in the EEZ, respectively, were initially rejected, because the planned environmental protection and monitoring was incompatible with the applicable law (Kim and Anton, 2014). In particular, the court

> *'as required, favoured caution and environmental protection. In doing so, we have also considered the extent to which imposing conditions ... might avoid, remedy or mitigate the adverse effects of the activity' (Trans-Tasman Resources Ltd Marine Consent Decision, section 59(2)(j)) 17).*

Roles and responsibilities: The responsible authority for giving a marine consent is the Environmental Protection Authority (EPA) which considers as a first step the applications, including the Environmental Impact Assessment, against the requirements of sections 38 (application requirements) and 39 (impact assessment requirements) of the EEZ Act (2012) for a determination of completeness (New Zealand, 2014; New Zealand Environmental Protection Authority, 2014). Hereafter, EPA gives public notice of the application received and directly informs all affected ministries, agencies, other authorities, customary title groups, customary rights groups, other stakeholders and regional councils. In addition to a comment period of 4 weeks, a public hearing ensures highest stakeholder opinion visibility and transparency. In addition, the applicant will have to demonstrate its own public consultation prior to the submission of the application.

Decision-making: An application will be considered by a decision-making committee of experts appointed by the EPA Board. If granted, a marine consent will set out what conditions (under section 63 of the EEZ Act) must be met to deal with the adverse effects of the proposed activity on the environment or existing interests. These conditions will be monitored and enforced by the EPA.

A decision is to be based on specific matters outlined in sections 59-60 of the EEZ Act which determine in detail the criteria to be taken into account by EPA in decision making based on best available information and taking into account uncertainties and inadequacies in the information available. The Act in section 61 requires that any decision is to be based on good information, supplied by the applicant and any submitters in the case. In case of doubt, the marine consent authority must favour caution and environmental protection, which means a high likelihood for an activity to be refused, in particular if adaptive management is not an option.

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[118] Ministry of Environment and Tourism, 2008. Procedures and Guidelines for Strategic Environmental Assessment (SEA) and Environmental Management Plan (EMP). Government Gazette of the Republic of Namibia, Windhook April 2008.

New Zealand Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act, 2012

Section 59 Environmental Protection Agency´s consideration of application

1) This section and sections 60 and 61 apply when the Environmental Protection Authority is considering an application for a marine consent and submissions on the application.

2) The EPA must take into account—

(a) any effects on the environment or existing interests of allowing the activity, including—

(i) cumulative effects; and

(ii) effects that may occur in New Zealand or in the waters above or beyond the continental shelf beyond the outer limits of the exclusive economic zone; and

(b) the effects on the environment or existing interests of other activities undertaken in the area covered by the application or in its vicinity, including—

(i) the effects of activities that are not regulated under this Act; and

(ii) effects that may occur in New Zealand or in the waters above or beyond the continental shelf beyond the outer limits of the exclusive economic zone; and

(c) the effects on human health that may arise from effects on the environment; and (d) the importance of protecting the biological diversity and integrity of marine species, ecosystems, and processes; and

(e) the importance of protecting rare and vulnerable ecosystems and the habitats of threatened species; and

(f) the economic benefit to New Zealand of allowing the application; and

(g) the efficient use and development of natural resources; and

(h) the nature and effect of other marine management regimes; and

(i) best practice in relation to an industry or activity; and

(j) the extent to which imposing conditions under section 63 might avoid, remedy, or mitigate the adverse effects of the activity; and

(k) relevant regulations; and

(l) any other applicable law; and

(m) any other matter the EPA considers relevant and reasonably necessary to determine the application.

(3) The EPA must have regard to—

(a) any submissions made and evidence given in relation to the application; and

(b) any advice, reports, or information it has sought and received in relation to the application; and

(c) any advice received from the Māori Advisory Committee.

(4) When considering an application affected by section 74, the EPA must also have regard to the value of the investment in the activity of the existing consent holder.

(5) Despite subsection (3), the EPA must not have regard to—

(a) trade competition or the effects of trade competition; or

(b) the effects on climate change of discharging greenhouse gases into the air; or

(c) any effects on a person's existing interest if the person has given written approval to the proposed activity.

(6) Subsection (5)(c) does not apply if the person has given written approval but the person withdraws the approval by giving written notice to the EPA—

(a) before the date of the hearing, if there is one; or

(b) if there is no hearing, before the EPA decides the application.

Section 60 Matters to be considered in deciding extent of adverse effects on existing interests

In considering the effects of an activity on existing interests under section 59(2)(a), the Environmental Protection Authority must have regard to—

(a) the area that the activity would have in common with the existing interest; and

(b) the degree to which both the activity and the existing interest must be carried out to the exclusion of other activities; and
(c) whether the existing interest can be exercised only in the area to which the application relates; and
(d) any other relevant matter.

Section 61 Information principles

(1) When considering an application for a marine consent, a marine consent authority must—

(a) make full use of its powers to request information from the applicant, obtain advice, and commission a review or a report; and
(b) base decisions on the best available information; and
(c) take into account any uncertainty or inadequacy in the information available.

(2) If, in relation to making a decision under this Act, the information available is uncertain or inadequate, the marine consent authority must favour caution and environmental protection.

(3) If favouring caution and environmental protection means that an activity is likely to be refused, the marine consent authority must first consider whether taking an adaptive management approach would allow the activity to be undertaken.

(4) Subsection (3) does not—...

(5) In this section, *best available information* means the best information that, in the particular circumstances, is available without unreasonable cost, effort, or time.

(for the full wording if section 61 see https://www.legislation.govt.nz/act/public/2012/0072/latest/DLM4464017.html?search=sw_096be8ed817c9082_section+61_25_se&p=1)

(emphasis added)

Subsequent to the decline of the initial applications of the mining companies, the original mining plans were substantially reduced and modified in order to contribute to substantiating the companies´ predictions about the potential environmental effects in their EIAs.[119] In addition to a spatial and temporal staging pattern, the commencement of one of the activities (New Zealand Environmental Protection Authority, 2017) was linked to a number of conditions, including quantified environmental conditions such as

- The applicant has investigated the bathymetry, physical characteristics of the seabed, and benthic ecology of the additional mining area;
- The plume modelling results have been confirmed based on current data for the additional mining area;
- The applicant has identified mining exclusion areas in the additional mining area;
- The Environmental Reference Group (made up of representatives of key stakeholders and scientists) has reviewed information gathered;
- The applicant has been granted a mining permit under the Crown Minerals Act 1991; and
- If total suspended solids concentrations exceed 50 milligrams per liter at a point five kilometers or greater away from the mining operations or at a point 50 meters or greater above the seabed the applicant must:
    - Undertake additional monitoring to confirm that the threshold is exceeded;
    - If the threshold is exceeded, advise the EPA;

[119] further reading: http://www.environmentguide.org.nz/activities/minerals/case-study-chatham-rise-phosphate-mining/

- Undertake investigations to identify the point at which total suspended solids reach 50 milligrams per liter and the point at which they reach 'background' levels;
- Within three months of advising the EPA, complete an assessment of responses which will avoid, remedy, or minimise total suspended solid levels. If a solution is identified, identify timeframes for implementation.
- If an adaptive management approach is to be implemented, implement it in accordance with the timeframe identified.

In addition, New Zealand authorities have issued

- Guidelines for the preparation of EIAs for offshore mining and drilling with indications of the recommended contents (Clark *et al.*, 2017);
- An environmental management framework including risk assessment for offshore industries (Ellis *et al.*, 2017; MacDiarmid *et al.*, 2014) and an experience report on adaptive management of offshore industries (Ministry for the Environment, 2016);
- A list of potential environmental impacts from various types of marine minerals mining together with a detailed description;
- Broad best practice considerations a. o. with respect to marine mammals, seabirds, biodiversity, monitoring and others to be applied to marine minerals exploration and mining.[120] Additional guidance exists for SMS, as well as manganese nodule and cobalt crust mining operations.

What Can Be Learnt from New Zealand Phosphate Mining?

- Information on an application received should be forwarded directly to all government bodies and stakeholders potentially affected or interested
- Government/agency-own expertise is essential for the evaluation of an application in context with legal framework and other licensed activities;
- A decision-making committee of experts can draw on a wide range of expertise and make decison-making independent of the likes of the government - enhances credibility, acceptance;
- A public hearing enhances the visibility and eventually impact of stakeholder concerns;
- It is essential to spell out uncertainties and gaps in knowledge to be able to evaluate the degree of knowledge deficit;
- Decision-making should err on the side of precaution, *i.e.* against the activity if the knowledge base was rated inadequate;
- Provide applicants with a framework for necessary documentation and assessment;
- Potential conflicts with other existing uses have to be considered;
- Direct and indirect, incl. cumulative effects beyond the licensed area of activity have to be kept under control;
- An economic benefit and cost analysis informs on national/CHM benefit and should include the loss of natural values for future generations;
- Use and development of natural resources should be resource-efficient - a provision which used to exist in UNCLOS prior to the 1994 Agreement (::::).

[120] http://www.environmentguide.org.nz/activities/minerals/best-practice/im:3388/

4.6.3 Science-recommended EIA Procedures

In recent years, a number of scientific publications have aimed to assist the ISA in developing its Environmental Impact Assessment procedures in line with the latest scientific advice and modern management standards (Clark, 2019; Clark *et al.*, 2019; Clark *et al.*, 2017; Collins *et al.*, 2013; Durden *et al.*, 2018; Ellis *et al.*, 2017; Furushima *et al.*, 2019; Kaikkonen *et al.*, 2018a; Lallier and Maes, 2016; NRDC, 2016; Swaddling, 2016; Thornborough *et al.*, 2019; Washburn *et al.*, 2019).

In the following, three recent publications are reviewed which focus on the procedural side of EIAs (Clark, 2019; Clark *et al.*, 2019; Durden *et al.*, 2018). Clark (2019) emphasises that EIA is not a one-off activity but a process which may require the synthesising of extensive baseline knowledge, predictive impact assessment and evaluation of possible mitigation measures and alternatives. A project EIA shall be nested in a multiple-tier management framework determined by ISA policy, strategic or regional environmental strategies, assessments and management plans on multiple scales of time and space.

In order to enable a robust EIA which provides for successfully anticipating, assessing and reducing environmental and social risks of a planned project, a preparatory phase is needed to set up the EIA process, including setting out the scope of the EIA, clarifying roles and timelines, scoping procedures, public participation and review as well as setting performance criteria for the environmental reporting and assessment (Clark, 2019; Clark *et al.*, 2019; Durden *et al.*, 2018). This will then provide for guiding the project planning and execution. Success criteria for good EIA/EIS are reproduced from Sénecal et al., 1999 by Clark (2019) as

- Purposive: be informative for decision-making;
- Rigorous: apply best practicable science;
- Practical: result in useful information and outputs;
- Relevant: provide useable information;
- Cost-effective: achieve EIA objectives within acceptable resource and time limits;
- Efficient: process should minimize cost burdens;
- Focused: concentrate on significant issues;
- Adaptive: adjustable to the specific situation but not compromise the process;
- Participative: inform and involve interested and affected parties;
- Interdisciplinary: involve multiple techniques and experts across a range of fields;
- Credible: a professional process, subject to independent checks/verification;
- Integrated: interrelationships of social, economic and biophysical aspects;
- Transparent: an open and informative process;
- Systematic: consider all relevant information and options.

In order to assist the ISA in improving their current EIA requirements to exploration contractors and future exploitation applicants, Durden *et al.* (2018) design an "ideal" EIA process which displays all the necessary steps as amalgamated from the experiences in other offshore industries: screening, scoping and assessment phases, contractor environmental management plan, external review by experts, stakeholder consultation, decision-making and regulatory review. Apart from emphasising the regulatory roles of the ISA and the Sponsoring States, the need to address uncertainties and to accommodate new knowledge through specified review processes and regulatory adaptation is emphasised (Clark *et al.*, 2019; Durden *et al.*, 2018).

Recommendations (Clark, 2019; Clark et al., 2019; Durden et al., 2018)

EIA process

- Needs to be nested in a broader framework within regional spatial context (REMPS, SEA) and the global legal and policy environment;
- Should provide for a "whole of the environment" approach across a range of sustainable development themes including integrated and sustainability assessments;
- Has to be clear and transparent, providing for clarification of the scope of the EIA, steps, roles and timelines, scoping procedures, public participation and review as well as performance criteria for contractor deliveries;
- Is ideally guided by several stages of environmental risk assessments, including of indirect effects;
- Should not be limited to assessing effects in the Area, but consider transboundary effects;
- Should be clearly linked to the decision-making on future approvals for exploitation.

Preparation of baseline studies

- must be of sufficient duration (several years);
- sufficient detail and quality;
- should provide critical understanding of the whole ecosystem (spatial, temporal, composition, structure and functions.

The mining plan to include

- sufficient detail on planned and unplanned activities, such as incidents, to provide for regulatory certainty/reduce likelihood of later modifications;
- sufficient information on risks and potential impacts
- explicit and detailed plans for adaptive management.

Stakeholder consultation

- in a formal stakeholder review process organised and managed by the regulator, as part of a
- procedural mechanism to deal with multiple comments transparently
- with easily accessible full documentation,
- enabling to fully incorporate comments in the decision-making process;
- including obligatory response to submissions by stakeholders.

Mechanisms are required to

- address uncertainty;
- assess cumulative pressures and impacts;
- ensure that proponents are able to provide a full EIA at the time of applying for exploitation contracts or include mandatory adaptation process post-approval;
- ensure that the result of the EIA influences decision-making on an application.

ISA needs to evolve to an administrative agency with sufficient capacity, that organises, carries out, and controls DSM activities in the Area, in order to avoid poorly informed decision-making, insufficient quality control of the EIA, and weak compliance and enforcement. The future independent "inspectorate" should be planned and set up without delay if mining is to commence any time soon.

4.7 Performance of ISA EIS vs. International Experience

In the following table, the best-practice of other international and national environmental impact assessment processes for deep seabed and offshore mining industries, and recommendations made by science, as discussed in this section, are listed and compared with the requirements set by ISA in its latest set of "*Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area*", ISBA/25/LTC/6/rev.1/Corr.1. It is evident, that the ISA Recommendations do not meet the standards of either established frameworks for international cooperation, such as the ESPOO Convention (1991), the Aarhus Convention (1998) or what the Convention on Biological Diversity (Convention on Biological Diversity, 2012a) recommends for areas beyond national jurisdiction. It also does not provide the same procedural certainty as for example New Zealand provides to offshore operators (see chapter 5.5.2.3).

The overall impression is that potential operators in the Area do not have sufficient guidance which they can rely on as to the expected deliveries during exploration and testing of equipment, the minimum requirements for baseline investigations to be considered sufficient, monitoring and reporting on environmental issues. Only the technical and resource reporting is pretty clear. Due to the lack of ISA regulatory guidance and lack of an organised, stepwise scoping process, contractors are left alone with determining data and information to be provided in the required Environmental Impact Statement. As will be seen in chapter 6, this may also result in surprises as to the evaluation through external reviewers or the LTC. Certainly nothing that operators wish to see.

In terms of control over activities to avoid, minimise, mitigate harmful effects on the marine environment, ISA does not yet have any of the tools necessary to comply with its mandates given in UNCLOS

- to adopt appropriate rules, regulations and procedures “to ensure an effective protection for the marine environment from harmful effects which may arise from such activities”. (UNCLOS Art. 145), including
  - prevention, reduction and control of pollution and other hazards
  - interference with the ecological balance
  - protection and conservation of natural resources and prevention of damage to the flora and fauna.
- to ensure a “uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind” (ITLOS, 2011, para. 159)
- to develop the common heritage for the benefit of humankind as a whole (UNCLOS Art. 150 (i)).

The current degree of guidance to contractors will not prevent surprises, being ill-informed or, on the contrary, does not enable the steering and regulation of activities in the Area.

Table 10: Comparison of EIS requirements as in ISBA/25/LTC/6/Rev.1/Corr.1 with experiences and recommendations from other international and national context as elaborated in chapter 5.

Source*	Provision	In ISA Recommendations? ISBA/25/LTC/6/rev.1/Corr.1
ESPOO, PNG, science	Notification and consultation schemes with potentially affected parties (national, international, sectoral) should be built into the processes around the review and decision-making of EIS for test mining	No corresponding requirement
ESPOO, CBD, New Zealand	Prior public consultation essential, detailed requirements in line with Aarhus Convention (1998)	Consultation of public only for comments on submitted EIS, no further process, e.g. of taking account or response
Namibia	Novel, high risk activities require a strict legal framework and independant monitoring and assessment/ a committee of experts	No provisions
New Zealand	Government/agency-own expertise is essential for evaluation of the application in context with the legal framework and other licensed activities;	So far no regulatory capacity and steering function of ISA
ESPOO	A *joint body* of potentially affected parties and stakeholders, will be helpful to address any concerns	No corresponding requirement
Namibia	Lack of good governance erodes public support	An ISA problem
ESPOO, CBD, science	A structured process, including a prior scoping exercise of the applicant and the regulator (ISA), where appropriate with public consultation, is an important first step to determine expectations on contents and depth of the EIS by prioritising issues to be monitored and reported	No provision
Namibia, New Zealand, Science	Insufficient baseline investigations open the door for law suits and rejection of permits	Law suits are not possible, but eroding standards
Science	Baseline studies must be of sufficient duration (several years); sufficient detail and quality; should provide critical understanding of the whole ecosystem (spatial, temporal, composition, structure and functions, incl. ecosystem services)	No detailed requirements
Science	The mining plan has to be detailed and informative	There are no legal obligations to deliver in line with the LTC Recommendations
New Zealand	Take account of user conflicts	No provision

Source*	Provision	In ISA Recommendations? ISBA/25/LTC/6/rev.1/Corr.1
Namibia, New Zealand, Science	The activities concerned have to be considered and assessed in a broader precautionary perspective under an ecosystem approach to management, e.g. through regional or strategic assessments, of direct and indirect, incl. cumulative effects beyond the licensed area of activity	No provision
New Zealand	Consider economic benefits vs. ecological and economic cost	No provision
New Zealand	In case of insufficient knowledge decide for precaution	A contractor EIS does not require approval - no decision-making is foreseen
ESPOO, New Zealand	consider a) alternatives, b) mitigation measures to keep disturbance at a minimum, c) predictive methods and underlaying assumptions, as well as data used, and finally d) indicate gaps in knowledge and uncertainties	Missing, no corresponding requirements
ESPOO	Post-project verification of predicted impacts is crucial	Missing, no corresponding ISA process exists
PNG	The social license to operate is crucial. Economic interests should not overrule interest of traditional owners and users of the sea, who might have a different view on the ocean as a heritage, and different experiences with other destructive activities	No provisions
PNG	Transparency is good for getting policy support, but not necessarily sufficient for gaining a social license.	ISA LTC evaluations are intransparent and not public

Sources: ESPOO Convention (see chapter 5.5.1.1), CBD (see chapter 5.5.1.2), PNG (see chapter 5.5.2.1), Namibia (see chapter 5.5.2.2), New Zealand (see chapter 5.5.2.3), science (see chapter 5.5.3).

5 Recent Environmental Impact Statements for field tests in the Area

For the first time since the establishment of the International Seabed Authority in 1994, two contractors set out to test mining equipment in the Area. DEME-GSR and India seek to test in their contract areas in the Clarion-Clipperton Zone, and the Indian Ocean basin, respectively. Both tests are of short duration and very small scale, compared with the endeavours undertaken by several consortia in the 1970s under other conditions. Therefore, also the existence and comprehensiveness of governing rules, regulations and procedures for such testing was challenged. In the following, the two endeavours are analysed for their performance against existing requirements. This reveals apparent gaps in the regulatory system which should be addressed to make the ISA EIA system fit for exploitation.

5.1 DEME/BGR Equipment Test in German and Belgian Contract Area in the CCZ

5.1.1 German Interest in Mining Tests

Ever since the involvement in the early mining consortia (see chapter 3.4), German stakeholders have advocated for the enabling of a new test mining in one of the exploration areas contracted by BGR (BDI, 2014; DSMA, 2019; Ramboll, 2016; Wiedicke-Hombach *et al.*, 2015). Test mining has been recognised as one element in the German exploration strategy and as a prior mandatory requirement for an exploitation contract (chapter 7)

However, despite expected direct and indirect positive impacts on the value-chain through provision of products and services for a deep seabed mining test the cost-benefit evaluation does not lend itself as a strong argument for investing in a pilot mining exercise ahead of German commercial mining (Ramboll, 2016). Furthermore, among the numerous German/European companies that are interested in providing services and technology for deep seabed mining, mining companies/consortia and those that could be responsible for the metallurgical processing of the materials do not presently exist (Ramboll, 2016). This calls for caution to make large national investments and calls for stronger interaction with European partners.

5.1.2 Cooperation of JPIO MiningImpact/BGR with DEME-GSR

DEME-GSR is one such corporate partner, a large trust specialised among others in marine dredging. It holds not only an ISA exploration license sponsored by Belgium in the eastern Clarion-Clipperton Zone but has also partnered in the EU Horizon2020 projects BlueNodules, BlueMining and BlueHarvesting. DEME-GSR is currently engineering a polymetallic nodules collector to operate in the CCZ license area, and plans design a lifting and transport system later on. As part of its technical engineering, the collector models need to be tested *in situ*, an exercise which is proceeding step by step: As a first step, a small-scale vehicle (named Patania I) was tested for its driving capabilities (no collection) in the CCZ contract area in 2016. This did not require a prior EIA to be submitted to the ISA.

However, for the subsequent step, the *in situ* testing of the locomotion and collection performance of the pre-prototype collector vehicle (Patania II) a prior Environmental Impact Statement, EIS, is required as prescribed by ISA in its recommendations for the guidance of contractors (ISBA/25/LTC/6/rev.1/Corr.1, at the time ISBA/19/LTC/8, see chapter 4.5). One of the elements of the required report is the design and plan for a long-term monitoring programme of environmental effects due to the test mining activity. An EIS was submitted one year before the planned test in 2019 (GSR, 2018) after public consultation in Belgium (ISBA/25/C/20).[121] It was approved by the sponsoring State Belgium and accepted after review by ISA secretariat, independent reviewers and the LTC

[121] all relevant documents can be found at https://economie.fgov.be/en/themes/enterprises/deep-sea-mining/workshops-and-public/environmental-impact-statement

(ISBA/25/LTC/4). Comments and responses were exchanged, however the report remained unchanged (see chapter 5.1.8).

The nationally funded, international cooperative scientific project under the European Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) "EcoMining/MiningImpact I" (2015-2017)[122] investigated the long-term effects of historic disturbance tests in the CCZ (see chapter 3.4.1.2), and is developing up to date methodology for investigating and monitoring mining impacts. Consequently, the upcoming DEME-GSR test was seen as an excellent opportunity for further developing and implementing scientific monitoring methodology and concepts in order to verify the short- and long-term environmental impacts from (test) mining activities into practical contractor work. The follow-up project "MiningImpact II" (2018-2022), was designed to independently accompany the testing of the Patania II gear in the DEME-GSR area, and a similar test in the BGR/Germany exploration contract area in the CCZ.

BGR has been a research partner in the JPIO MiningImpact projects and contributes e.g. the contract area and ship time to the project. As the technical trial will be carried out in the Belgian and German contract areas, BGR has also submitted a EIS to ISA (BGR, 2018), independently of the EIS of GSR. The submission was made in April 2018, prior to a public stakeholder hearing.[123] The German government finally approved the EIS after the hearing in December 2018 without further changes[124] and LTC accepted it after the planned period of the trial (ISBA/25/LTC/4). The responsible national agency, LBEG (Landesamt für Bergbau, Engergie und Geologie) responded in writing to the submissions and statements made by national NGOs in the national hearing. The German government expressly committed to a monitoring programme of longer duration than anticipated in the EIS (BGR, 2018).[125] The report has remained unchanged and valid also for the 2021 expedition (see 5.1.3) as the government considered the main issues to remain unchanged.

5.1.3 Actions and Timeline

Delayed by the technical problems in 2019 and the impacts of the COVID-19 pandemic in 2020, the new schedule for the equipment test was set for March-April 2021. DEME-GSR and the "MiningImpact" project will embark on separate vessels. The DEME-GSR crew will board a chartered vessel end of March in Balboa, Panama and return there 14 May. The MiningImpact project crew plans to board another chartered vessel in San Diego for a 42 days cruise (30 working days at sea) from 4 April to also return 15 May. The test in the Belgian contract area will take place 12-17 April 2021, with two additional days for plume monitoring. Sensors will be picked up and then deployed around the trial site in the German contract area. Here the trial period is 29 April-2 May plus 2 days plume monitoring. Sensors will have to be picked up immediately thereafter. Any delay in the vehicle test will prevent that the scientists can measure the effects of the trial as planned.

5.1.3.1 Technology Test

Previous experience taught that a lot can go wrong when working at abyssal depths. Therefore, the 23 working days expedition in April-May 2021 comes with substantial time reserves for technical failures. The campaign will have 2 major operational modes with an allocated working time of 7 and 4 days, respectively (GSR, 2018):

(1) *In-situ* validation and optimisation of the nodule collection system as tested in the laboratory (GSR technical department). The focus is on the optimisation of the collection process, with nodules being

[122] see final report at http://eprints.uni-kiel.de/46570/; http://www.jpi-oceans.eu/miningimpact

[123] https://www.lbeg.niedersachsen.de/startseite/bergbau/offshore/aktuelle_projekte/aktuelle-projekte-offshore-124111.html

[124] Letter of BGR to ISA 17 December 2018

[125] For this purpose, BGR has submitted an application for the extension of its exploration contract by 5 years end of 2020.

piled near the tracks on the seafloor. The main research topic is the *in situ* operational efficiency of the nodule collector head to validate lab tests and models. The effect of a) the height of the collector head above the seabed and b) speed variability on the collection process will be investigated.

(2) In collaboration with JPIO MiningImpact, the quality and dimension of the sediment plume generated by the vehicle and the related short (scale of days)- and long (scale of months or year)-term impact on the ecosystem shall be monitored and assessed during the trial.

The pre-prototype hydraulic suction collector vehicle (12 m long, 4 m wide, 4.5 m high, weight 15 t in water) will travel a continuous series of up- and down lanes of 50-150 m length (4 m wide) depending on the nodule density, for in total 340 m (this means an area of ca. 58m x 340 m will be totally cleared of nodules if the machine works properly). Only a limited quantity of nodules can be stored, therefore piles of nodules will be dumped every ca. 150 m on the side of the lane. The plume patterns will be investigated by a circular movement pattern, intercepting the original nodule pick-up track.[126] These collection tests will last four days each in both the Belgian and the German contract areas. It is expected that the collector vehicle will scrape the upper 5-15 cm of the sediment, release 57 t of sediment per hour, with a concentration of 500 mg per liter right behind the exhaust.

5.1.3.2 Environmental Monitoring

JPIO MiningImpact is conducted independently of DEME-GSR activities. DEME-GSR is responsible for obtaining all necessary permissions for its operations and does not receive any funding from the MiningImpact project. Neither does the MiningImpact project receive any financial contributions from DEME-GSR. DEME-GSR is further responsible to set up a monitoring programme for its industrial component trial as required by the International Seabed Authority.[127]

DEME-GSR monitoring[128]

The monitoring of DEME-GSR will mostly focus on the immediate and near-source effects of the operations of the collector vehicle and follows a before-after-control-impact, BACI design. The future mining area has been investigated in previous cruises and since 2017, long-term moorings have been deployed for measuring background currents, turbidity levels, vertical fluxes and sedimentation. A reference site was designated.

The Patania II vehicle is equipped with instrumentation to collect plankton, measure noise, turbidity and other parameters. In addition, a scientific working group from MIT will investigate near-field sediment plume behaviour in support for their plume models, including the effect of different operational set-ups and vehicle movement patterns of sediment dispersal and resedimentation. Next to measuring the remaining nodule abundance on the seafloor, the megafauna and thickness of resettled sediment will be assessed with optical tools. In addition, turbidity will be measured with autonomous vehicles and moorings placed around the trial area. In terms of influence on the biological communities, DEME-GSR will investigate

- The influence on megafauna behaviour along standardised visual transects;
- Resuspension of larvae, meiofauna and zooplankton with a plankton pump mounted on the vehicle and with water samples;
- The influence on the sessile macrofauna/megafauna through analysis of collected nodule bins;
- The noise emitted from the vehicle with a hydrophone mooring array.

[126] S. Smith presentation at JPIO MIningImpact Stakeholder Information day 2021, https://miningimpact.geomar.de/documents/1082101/1433168/Smith_StakeholderID_2021.pdf/392bba75-469e-41ea-af34-3f41ad1fa021

[127] http://www.jpi-oceans.eu/news-events/news/new-jpi-oceans-project-studying-environmental-impacts-and-risks-deep-sea-mining

[128] based on S. Smith presentation 2021, see footnote 126

The DEME/GSR and MIT activities therefore concentrate on the near-field behavior of the sediment plume during the trial plus two days after. It is unclear, whether any longer-term monitoring is planned.

MiningImpact2 monitoring

The JPIO MiningImpact2 project determines three major research interests concerning deep-sea mining:[129]

(1) the larger scale environmental impact caused by the suspended sediment plume;

(2) the regional connectivity of species and the biodiversity of biological assemblages and their resilience to impacts; and

(3) the integrated effects on ecosystem functions, such as the benthic foodweb and biogeochemical processes.

In this context, key objectives of the project are:

- To develop and test monitoring concepts and strategies for deep-sea mining operations;
- To develop standardization procedures for monitoring and definitions for indicators of a good environmental status;
- To investigate potential mitigation measures, such as spatial management plans of mining operations and means to facilitate ecosystem recovery;
- To develop sound methodologies to assess the environmental risks and estimate benefits, costs and risks;
- To explore how uncertainties in the knowledge of impacts can be implemented into appropriate regulatory frameworks.

The objective of monitoring the collector test in both contract areas is to compare the technical performance and resulting sediment plume in different terrain and nodule size/density: In the selected Belgian area, the terrain heterogenity is different with nodules larger in the Belgian than in the German trial area, with related differences in biological composition.

The monitoring will be carried out in parallel to the collector tests plus two days after the end of the trial period. It is unclear, whether any longer-term monitoring gear will be left in place or whether the planned cruise in 2022 will deploy a full set of new gear. BGR exploration campaigns are planned for 2022, 2023 and 2025, however this depends on the extension of the exploration contract in 2021.

5.1.4 Experimental Set-up in the German Contract Area

As detailed in BGR (2018, chapter 8) BGR has established a Preservation Reference Zone 60 km west of the anticipated mining area, called prospective area, PA1, which "conforms to the ISA recommendations for environmental assessment during exploration (ISBA/19/LTC/8, Para. 26(d))". This area has been subject to biological investigations on an annual basis.

The collector trial will take place within PA1, in a western box called PA1-West. The box has been mapped in detail and multiple cruises provided oceanographic, geological and biogeochemical data, and a large number of biological samples, a high optical coverage and experimental results exist from the area (see chapter 3).

Because of the limited dimension of the expected disturbance from the collector trial, a further control site was selected within PA1-West, about 8 km to the south-east of the envisaged trial area. In this area time-series analyses have been carried out throughout the last few years, and will therefore provide

[129] https://miningimpact.geomar.de/

for a solid environmental baseline. Other control sites may be added depending on the local plume development.

Near the site of the collector trial (estimated 100 x 900 m test area, ca. 0.1 km^2), an Impact Reference Zone (to monitor direct impacts) will be designated. In addition, the total extent of the operational sediment plume shall be monitored within a Plume Impact Reference Zone, PIRZ, validating dispersion and dilution modelling with stationary and mobile observations up to 30-50 m above seafloor.

5.1.5 Experimental Set-up in the Belgian Contract Area

The trial will take place in the B4 (middle) section of the three Belgian contract subareas (GSR, 2018). Here the database is considered to be the best, including 200 km^2 of high resolution mapping and sampling. An IRZ will be located here and sampling will extend along the plume gradient in the Plume Impact Reference Zone PIRZ, comparable to the German area. A control area was designated 11 km to the southwest of the trial area. However, sampling seems to be limited to one boxcorer and one multicorer taken during two cruises each (2018, Fig. 4), in the immediate trial area/IRZ, and the plume impact reference zone. Statistical analyses revealed that the control and future trial areas are by and large comparable in terms of environmental conditions. Based on a limited number of sampling stations, at least the meio and macrofaunal densities and composition did not show significant differences at the taxonomic levels investigated. Spatial heterogeneity, taxonomic resolution and the importance of rarity need more investigation (Glover *et al.*, 2018; Macheriotou *et al.*, 2020; Pape *et al.*, 2017; Smet *et al.*, 2017; Vanreusel *et al.*, 2016).

5.1.6 Expected Results and Applicability to Commercial-sized Mining

While DEME-GSR aims to validate the technical requirements for a full-scale polymetallic nodule collecting vehicle in the actual operational environment, in terms of environmental monitoring the trials in the Belgian and German exploration contract areas can be seen as a controlled experiment which will help to understand the impacts from sediment disturbance, plume development and resedimentation. However, the scale of this collector test is very limited and is not likely to produce notably new scientific insights into the environmental impacts of commercial-scale mining operations (M. Haeckel, pers. com. January 2021). So far, it is unknown, how the various environmental effects and impacts accumulate in a commercial-scale, continuously ongoing mining operation. The cumulative effects from one operation could scale up linearly, but could also become exponential at some tipping point. Unless the food web and functional linkages of the ecosystem are known, it cannot be predicted at which point the whole food web may break down. The current knowledge base does not yet allow for an ecosystem model with which to test reliably a societally acceptable disturbance limit.[130]

The sampling and monitoring design in the deep sea, limited by time, cost, and feasible effort is crucial for the ability to detect and predict benthic community responses to nodule mining, in particular if to be statistically reliable (Ardron *et al.*, 2019a).[131] The review of the early disturbance experiments in the CCZ (Jones *et al.*, 2017a) found that the lack of sampling consistency, small sample sizes and sometimes inappropriate control sites have led to low statistical power and hampered the interpretation of results. Already Jumars (1981) stated "*even relatively large impacts can easily go undetected via traditional before-after comparisons based on random sampling via a surface vessel*", The rarity of taxa/species sets limits to the sampling accuracy, and crucial life history and foodweb characteristics are unknown for basically all of the deep-sea fauna. Continuous observation of crucial environmental parameters is needed.

On the other hand, the JPIO MiningImpact projects have developed a suite of new high-tech scientific sampling, assessment and evaluation methods which advances deep-sea mining impact research. In

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130 From discussion at JPIO MIningImpact Stakeholder Information day, 21 January 2021.

131 See also Ardron, 2020, p. 85, Tab. 4-6 Summary of findings and recommendations.

particular, the MiningImpact2 project will advance the knowledge base on the behavior of sediment plumes, its dispersal properties and resedimentation characteristics. A whole new body of experience has already emerged from the project activities, indicating the potentially hydrographically forced footprint (Aleynik *et al.*, 2017, 2018), aggregation and flocculation of highly concentrated deep sea sediments when stirred up (Gillard *et al.*, 2019b), the capture of released metals ... and potential toxicity (Hauton *et al.*, 2017; Mestre *et al.*, 2017). However, the long-term fate of the very fine material with potentially attached metals remains unresolved. Here, microbial indicators may be of help in the future (Gillard *et al.*, 2019a).

There is one other factor which may limit the monitoring of the longer-term development of the sediment plumes: The JPIO cruise schedule provides only for monitoring the development of the collector test plume up to two days after the disturbance period. Unless some stationary monitoring equipment will remain in place until the next cruise, which is scheduled for one year after the test, this may result in a major gap in observing the development of the very fine fraction in the water column.

5.1.7 Performance of the BGR and DEME-GSR Environmental Impact Statements

In Table 1 below, an attempt is made to evaluate the contribution of the BGR 2018 and GSR 2018 EIS in terms of requirements as formulated in the latest LTC guidance to contractors (published after the submission of the EIS by both contractors).

Table 11: How the requirements of the ISBA/25/LTC/6/rev1/Corr.1 and earlier guidance have been addressed in the EIS of BGR and DEME-GSR.

Requirement acc. ISBA/25/LTC/6/rev1 /Corr.1 and earlier guidance	Performance of the BGR EIS report (BGR, 2019)	Performance of the DEME-GSR EIS report (DEME-GSR, 2019)
A plan for testing of mining components or test-mining shall include provision for monitoring of those areas impacted by the contractor's activities which have the potential to cause serious environmental harm, even if such areas fall outside the proposed test site.	Direct and indirect effects of the collector trial will be measured and sampled. The project aims at developing the basic criteria for grading harm, including serious harm. A comparison of measurements actually made with those recommended in ISBA/25/LTC/6/rev1 or earlier recommendations should be given, including reasoning for those not carried out.	Direct and indirect effects of the collector trial will be measured and sampled. GSR will monitor during the trial and in the immediate vicinity of the collector. A comparison of measurements actually made with those recommended in ISBA/25/LTC/6/rev1 or earlier recommendations should be given, including reasoning for those not carried out.
The programme will include, to the maximum extent practicable, specification of those activities or events that could cause suspension or modification of the tests owing to serious harm, including if the specified activities or events cannot be adequately mitigated.	BGR will not cause the disturbance, however it is responsible because DEME-GSR was invited to test the collector in the German contract area. Therefore, BGR in its EIS would also have to specify such activities. This is missing, and also mitigation measures should be named and discussed.	This is addressed in chapter 6, and emergency measures are outlined. A risk Register is annexed in Annex 12.5 and monitoring is expected to validate the impacts. Probability estimates should be added and a framework for environmental risk assessment and management for activities in the Area developed.

Requirement acc. ISBA/25/LTC/6/rev1 /Corr.1 and earlier guidance	Performance of the BGR EIS report (BGR, 2019)	Performance of the DEME-GSR EIS report (DEME-GSR, 2019)
The programme will also authorize refinement of the test plan prior to testing and at other appropriate times, if refinement is necessary.	This has taken place between 2019 and 2021, due to experience gained in the 2019 cruise where only experimental disturbance took place. However, it has not been documented in a revised EIS.	This has taken place between 2019 and 2021. The monitoring was extended. However, it has not been documented in a revised EIS.
The plan will include strategies to ensure that sampling is based on sound statistical methods, that equipment and methods are scientifically acceptable, that the personnel who are planning, collecting and analysing data are well qualified and that the resultant data are submitted to the Authority in accordance with specified formats.	In the EIS, the strategy for achieving statistically relevant effect measurements is not explicit. It can be assumed that the research project aims at statistically relevant sampling in line with best scientific methods.	No information is available.
During exploration test-mining, the notification of a proposed impact reference zone and a preservation reference zone is recommended.	A control area (PRZ for the test) was designated, (only benthic?) baseline conditions have been investigated on an annual basis since several years. An IRZ will be determined at the location of the trial, further plume monitoring stations will be selected.	A control area (PRZ for the test) was designated, (only benthic?) baseline conditions have been investigated on an annual basis since several years. An IRZ will be determined at the location of the trial, further plume monitoring stations will be selected.
The monitoring programme proposed by the contractor must provide details of how the impacts of the testing of mining components and test-mining activities will be assessed. [Recommendation VI.D.40]	The report is entirely descriptive. Neither an assessment nor a significance framework is presented. These may become project results.	The report is mainly descriptive. Neither an assessment nor a significance framework is presented.
LTC evaluation criteria	**Performance of the BGR EIS report (BGR, 2019)**	**Performance of the DEME-GSR EIS report (DEME-GSR, 2019)**
Completeness*	Missing when compared to EIS template in ISA draft regulations: • Introduction of proponents and their interaction; • Identification of research questions and related sampling strategy; • (Risk) Assessment and significance framework;	The report seems fairly complete, including authors and reviewers and a technical annex with technology information, modelling results and a so-called risk-register with mitigation measures.

Requirement acc. ISBA/25/LTC/6/rev1 /Corr.1 and earlier guidance	Performance of the BGR EIS report (BGR, 2019)	Performance of the DEME-GSR EIS report (DEME-GSR, 2019)
	• Reporting (only appears as dissemination by the project, not as contractor task); • Stakeholder and reviewer comments and responses; • Project coordination with contractors.	However, an assessment and significance framework, as well as a report of stakeholder consultations, expert review and comments is missing. Reporting does not appear as a contractor task.
Accuracy	?	?
Statistical reliability**	This subject was not addressed, but should be elaborated: demonstrate comparability of control vs. impact sites.	A start was made to compare statistically PRZ and IRZ. It was not demonstrated how the BACI monitoring will provide for statistical reliability.

* at the time of drafting and submission of the two EIS, no reference for formal "completeness" existed in ISBA/19/LTC/8, and the proponents voluntarily chose to follow the draft EIS formate in Annex V of the draft exploitation regulations 2017. The structure is very useful also in view of an eventual application for exploitation. However, guidance on the qualitative and quantitative requirements on the information to be provided does not exist yet.

** (Ardron, 2020), p. 102 suggests that both contractors are "very possibly under-sampling" which if baseline surveys are continued without consideration of effect size and statistical power will be unlikely to detect even the largest impacts.

5.1.8 Issues to Discuss

5.1.8.1 Relationship between JPIO MiningImpact2 Project and the Two Contractors

Other than the BGR (2018) EIS, the GSR (2018) EIS clearly sets out that the technical project ProCat#2 and the environmental project run by JPIO MiningImpact have to be seen as separate tasks. GSR will carry out the technical trial and some monitoring, while the science project will monitor the the environmental impacts of the whole endeavour as broadly as possible. Only because the trial will take place in two contract areas, two EIS are required for similar activities by the same actors. This is justified by the slightly different environmental baseline conditions in the two areas, and the need to gain experience on environmental impacts in various settings. While in the Belgian contract area, GSR has invited the science project to supplement the technical trials, in the Germany contract area GSR has been invited by BGR to carry out identical operations. Other connections exist: BGR and the GSR science contractor from the University of Gent are partners in the JPIO MiningImpact project.

The coordination between the JPIO MiningImpact2 project and GSR has been briefly addressed in GSR (2018, chapter 7.1), however does not specify coordination among the contractors, and is missing in the BGR (2018) EIS. The relationships between BGR, the MiningImpact2 project and GSR remain unclear in both reports.

In terms of monitoring, prior to the hearings it seemed as if the JPIO MiningImpact2 project would perform all the monitoring work, while GSR would only carry out the technical tests. For the cruise and trial in 2021, GSR has substantially broadened its own monitoring programme, including with external scientific support from MIT. Also, BGR reports on its intention to carry out an extended long-term monitoring programme. However, these changes are not documented in the EIS, which effectively remain without the required long-term monitoring plans.

5.1.8.2 Sponsoring States Responsibilities

Initially, the rules, regulations and procedures of ISA, as applicable in 2018, did not foresee any stakeholder consultation in case of an EIS being submitted for a test mining exercise.[132] Nor did the relevant legislation in Germany and Belgium foresee a national evaluation or public consultation on the issue. It only refers to ISA rules, regulations and procedures. Therefore, despite being required to exercise due diligence, including best environmental practice (ITLOS, 2011; Moreira and Teixeira, 2020), and being members of the European Union where stakeholder consultation and participation is legally encoded, both Germany and Belgium originally did not intend to provide civil society with the opportunity for commenting the activities planned and reported in the EIS report of BGR and DEME-GSR in national context.

After an IASS/UBA national expert discussion (Fachgespräch) in 2017,[133] and pressure of NGOs and environmental government bodies a public consultation process was initiated in both countries, and took place well after the EIS had been submitted to ISA in April 2018. In both countries, all stakeholder submissions were made publicly accessible on the responsible governments website[134] and a broad range of potentially interested parties were invited to take part in the public hearings. In Germany, stakeholder comments and questions were answered individually by the responsible agency, however did not lead to any modifications in the EIS submitted by BGR in accordance with ISBA/19/LTC/8. After the consultation, the German government certified its acceptance of the EIS as submitted to ISA, however committing to a longer-term monitoring programme.

In Belgium, DEME-GSR was asked to make some adjustments to the EIS in response to several independent reviews and stakeholder comments and both the government and the company responded to submissions. In its letter to the ISA of 11 December 2018[135] Belgium noted that contrary to what the EIS states"*it cannot be stated with certainty that a) no serious harm will be caused*", and b) "*the scale of impact and disturbance will be limited and controlled*" due to knowledge gaps. However, it confirmed its sponsorship, appreciated the expected knowledge gains and encouraged its contractor to publish part of its annual reports to ISA.

The most recent set of recommendations, ISBA/25/LTC/6/rev.1/Corr.1, does advise contractors to conduct a stakeholder consultation, and to forward the comments received to the LTC. "*Any available information concerning such stakeholder consultation will be made available on the website of the International Seabed Authority"(Annex VI E, para.41 (d)).* The EIS and the respective responses of the national authorities, with links to the consultation documents, are available for download on the ISA website.

Sponsoring States are obliged to actively cooperate with ISA in the achievement of the ISAs mandate, but what if the ISA regime provides for lower standards of regulation than the national or regional standard to which the State is bound? Certainly, the best option would be a best-practice EIA process implemented by the ISA, which establishes a uniform set of ambitious standards for environmental protection to all contractors. Nevertheless, each Sponsoring State has the liberty to apply more strin-

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[132] The revised "Recommendations for the Guidance of Contractors" ISBA/25/LTC/6rev1 now includes a requirement for public consultation, see section 5.4.3

[133] Outcome document of IASS/UBA Fachgespräch 2017 https://www.umweltbundesamt.de/fachgespraech-am-7112017-in-potsdam

[134] https://economie.fgov.be/en/themes/enterprises/deep-sea-mining/workshops-and-public/environmental-impact-statement

https://www.lbeg.niedersachsen.de/startseite/bergbau/offshore/aktuelle_projekte/aktuelle-projekte-offshore-124111.html

[135] https://ran-s3.s3.amazonaws.com/isa.org.jm/s3fs-public/files/documents/belgium_1.pdf, https://www.isa.org.jm/environmental-impact-assessments

gent procedures and criteria than implemented by the ISA for checking the environmental acceptability of the planned activity of the contractor through an own environmental impact assessment, guided by national authorities.

An additional Environmental Impact Assessment carried out under national Sponsoring State responsibility could be of importance to ensure that the activity in question will not impede achieving the national obligations and commitments to implement the precautionary principle, the ecosystem approach, the polluter-pays principle, as well as to achieve the global biodiversity targets and sustainability goals. This will become highly relevant once decision-making on an EIA/EIS for exploitation will have to be made.

5.1.8.3 Issues with the EIS Submitted to ISA

At the time of submission of the two EIS for the collector trial in the Belgian and German contract areas, no ISA guidance existed on the structure and contents of the report and the proponents both choose to follow the draft EIS template annexed to the draft exploitation regulations 2017 (ISBA/23/LTC/CRP3/Rev)[136]. This exceeds the requirements sketched out by LTC in the latest guidance for contractors.

However, the two EIS submitted by BGR and DEME/GSR would greatly benefit of a more detailed structure and advice for which information is relevant and how it should be provided. The two very extensive reports remain mostly descriptive of existing scientific understanding of the broader environment, and fall short of evaluation. This is of course due to the current limited understanding of the environment, and the aim to develop the needed scientific tools during the scientific project, but also relates to the lack of an assessment framework provided by ISA to evaluate risks, impacts and significance of monitored environmental changes.

Nonetheless both contractors were required to state that "*no serious harm will be caused*", which cannot be substantiated without further criteria. At present, and despite the considerable sampling and survey effort in both contract areas, the sampling scheme currently is not likely to be able to detect even larger benthic community changes due to test mining activities with some statistical means (Ardron, 2020). Impacts of operational plumes on the non-sedentary, bentho-pelagic as well as the pelagic fauna have not yet been considered (Christiansen *et al.*, 2019a; Drazen *et al.*, 2020) and will likely be difficult to verify, but will get some attention in the future also in the MiningImpact2 investigations. In that context, the fate and ecological effect of the ultra-fine fraction of the operational and discharge plumes, and of the metal-loaded solution plume is of utmost importance and should be measured and modelled in context with real, high-resolution topography (Durden *et al.*, 2020; Hauton *et al.*, 2017; Simon-Lledo *et al.*, 2019).

As noted above, the EIS do not specify the temporal extent of the monitoring by both contractors, *i.e.* the overall period, and the continuity of measurement with stationary equipment. This information should be provided in the EIS, in particular as the subsequent contractor annual reports will not be available for public view.

5.1.8.4 Issues with the ISA Procedure

The main issues with the ISA LTC review of the EIS are discussed in chapter 5.4. As the two EIS from BGR and GSR have been the first of their kind, contractors and stakeholders would have benefited of a clear and transparent process for the consideration of the contents of the EIS, the review process and a link to decision-making with eventually some conditions, as usual in national context. However, there was neither transparency in advance on when the LTC would review the EIS, what information has

[136] https://www.isa.org.jm/files/documents/EN/Regs/DraftExpl/ISBA23-LTC-CRP3-Rev.pdf

contributed to LTC evaluation, (e.g. ISA commissioned reviews, submissions to the national stakeholder hearings) or how the information was addressed.

In the report of the ISA Secretariat on the "Review of environmental impact assessments for the testing of collector components in the exploration area" (ISBA/25/LTC/4) it is stated that an initial technical review was based on "paragraph 52 of the recommendations, in which key components of the plan for the testing of collector systems are outlined" (this paragraph does not exist, it is likely to be para. 38 in Section C). As a result of this review, both contractors were asked to submit additional information on their monitoring programme. The information supplied has not been published.

The evaluation reports of the two external reviewers, commissioned by the ISA Secretariat, together with the Secretariat´s review, and the contractors´ responses to the reviews were made available to the LTC, however not the public. LTC established an intersessional working group to further evaluate the EIS. The evaluation was concluded after both Sponsoring States had sent their approval of the activities, subsequent to a national stakeholder consultation, as reported in the report of the Chair of LTC to Council in July 2019. Here (Section VIII, para. 27) it says: "*The Commission took note of the review of the EIS (ISBA/25/LTC/4) and notes that the contractors had followed most of the recommendations made during peer review, and that Sponsoring States had conducted public consultations*". Owing to the long review process, the conclusion of the LTC review came later than the start of the activities.

5.2 India Equipment Test in the Indian Contract Area in the Indian Ocean Basin

5.2.1 India’s interest in Test Mining

Since 1982, India has been one of the pioneer investors and an early contractor of ISA for exploring manganese nodules in the Indian Ocean Basin (see chapter 3.1). The first exploration contract with ISA expired in 2017, but was prolonged by another 5 years until 2022.

India not only conducted a benthic impact experiment (INDEX, 1997 - with ongoing monitoring, (Rodrigues *et al.*, 2001; Sharma, 2001, 2011; Sharma *et al.*, 2001), see chapter 3.4.1.1) but also started early to develop the required technology to recover manganese nodules (Chung *et al.*, 1996; International Seabed Authority, 2001; Sharma, 2010). A "self-propelled mining machine with a flexible hose", developed and constructed by the National Institute of Ocean Technology in cooperation with the German Institut für Konstruktion of University of Siegen was tested *in-situ* in the Indian Ocean already in 2000, and a mining system was tested in 2006 (at 450 m), in national waters. A Soil-tester was tested at 5200 m depth in the Central Indian Ocean Basin, likely outside the contract area (Atamand, 2011). Also, the INDEX disturbance, which according to today’s LTC "Recommendations for the Guidance of Contractors" would require an EIS went without further assessment of the ISA. A First--Generation-Mine-Site was identified in 2007 (Atamand, 2017; Sharma, 2010). Already in 2011, Atamand (2011) presented the elements and data for a future EIS, likely in view of exploitation.

In February 2020 (acc. ISBA/26/C/12/Add.1), India submitted a EIS accompanying a planned collector trial in its contract area in the Central Indian Ocean Basin (Government of India, 2020)[137]

5.2.2 Actions and Timeline

The trials of the mining machine and nodule collector shall be conducted within the designated IRZ at 2-3 sites, up to 3 hours at each site. Neither dates nor cruise schedules are given, but the period of January-February 2021 is likely (from Table risks of planned trials), as the risk of heavy weather is limited during that period. Overall, the EIS lacks a definitive and informative time and action schedule for

[137] for download from https://moes.gov.in/content/deep-sea-mining-system-trials-moes; not available from the ISA website any longer.

the trial, but also for past activities which are displayed without considering season and elapsed time (season, the 24 years since INDEX).

5.2.2.1 Technology Test

The objective of the trial is to test the capability of one nodule collector vehicle in terms of locomotion, crushing, pumping and discharge within a limited area on the seabed at 5200 m depth. The trial will have three stages and is very-small-scale with an anticipated cumulative distance of 1000 m for the pre-prototype collector vehicle, conducted within a couple of hours during 2-3 deployments. The vehicle will mechanically comb nodules from the sediment layer down to 15-30 cm over a breadth of about 2 m (two parallel 0.8 m pick-up units). In the first instance the nodules will only be collected, in the second also crushed to 1-20 mm size and released behind the collector. One load of nodules (300 kg) will be brought up.

In a subsequent trial, the nodule slurry will be pumped up to ~80m above bottom through a hose and released there. The collector speed is expected to be 0.15 m/sec and the pumping will be carried out at a maximum rate of 80 m^3/hour. The slurry is expected to have a concentration of less than 8% and particle sizes below 20 mm.

India estimates an area of max. 4600 m^2 on the seafloor be directly impacted. The collector efficiency is assumed to be 50% and it is assumed that nodules will be flushed from sediments prior to entering the (here not existent) vertical transport unit. It is not clear whether the plume dispersal in the water column will be studied.

5.2.2.2 Environmental Monitoring

Two 30 days cruises are planned to measure physico-chemical and biological environmental parameters immediately before and after the trial, respectively, as well as one year after the trial (India EIS, p. 332) in order to detect:

- Change in geomorphology due to collector trial in the area;
- Changes in physico-chemical characteristics of seafloor sediment;
- Changes in abundance and diversity of benthic communities and recolonization;
- Thickness of redeposited sediment due to locomotion and discharge plume;
- Changes in benthic community structure due to smothering by sedimentation;
- Changes in water column physico-chemical characteristics due to discharge plume;
- Changes in metals in dominant fauna due to resettled sediments and discharge plume.

The EIS does not elaborate upon the scope, nature, extent, or schedule of post-trial monitoring. No details on the cruises are provided, and the associated Figure 4.5.3.1 displays the sampling stations in places which do not match the PRZ and IRZ.

First baseline data were acquired prior to the benthic impact experiment, INDEX, in 1995, however this experimental area is nowadays outside the contract area of India (see their Fig. 4.5.2.1). Baseline benthic conditions in the designated IRZ and PRZ are reported to have been studied (but see above) by collecting environmental data at 5 sampling stations each during two cruises during 2015 and 2019 covering

- Grain size distribution –sand, silt and clay content;
- Geotechnical properties - water content, shear strength, wet bulk density;
- Geochemistry of sediment (organic carbon), elemental concentration of key elements (ex. V, Cr, Cu, Ni, Co, Zn, Pb) and pore water (pH, nutrients);
- Benthic community structure – abundance and composition of meiofauna, macrofauna and megafauna;
- Biochemistry of sediment – protein, carbohydrates, lipids (to estimate labile organic matter), Adenosine Triphosphate;

- Microbiology of sediment - total bacterial count, microbial mass and diversity
- Bioturbation studies;
- Molecular biology: molecular taxonomy identification and diversity/ gene connectivity.

The nodule abundance information, metal grade and the bathymetry plotted to characterise the IRZ and PRZ as well as the maps in Figs. 3.2.2 and 4.1.3 (Government of India, 2020), are in fact located outside the coordinates given for the PRZ and IRZ in their Tab. 3.2.1.1. The same holds for all baseline data sampling locations listed in their Table 4.1.5.1.

The environmental baseline description is insufficient and inconclusive and comes mostly without references. The lack of quality data and information will prevent the detection even of acute changes because

- Despite the period of nearly 30 years, all sampling has been treated as directly comparable without taking into acount natural variability or possible changes due to global warming and other human activities, including pollution, fishing and bycatch**.**
- It remains unclear how much information exists actually from the deep-water column, but also on e.g. bentho-pelagic fauna incl. scavengers, plankton, nekton, mammals, turtles and seabirds of the area.
- The sampling indicated does not seem to be adequate for detecting spatial and temporal trends and crucial parameters for plume development (deep current moorings, near-bottom turbidity), sediment disturbance (bioturbation channel connection, oxygen penetration depth, sediment density measurements (via x-ray), total inorganic carbon, nitrite concentrations, oxygen utilization/carbon fixation, and total organic carbon) and biological impacts (microbial fauna, carbon flux, ..);
- Information on the methodologies used for sampling, evaluation and assessment is scarce or missing - for impact assessments a demonstration of comparable before-after-control measurements is required.
- No time series or replicate sampling seem to be planned, which limits the reliability and significance of the results.
- The reference to the INDEX result is misleading, as the experimental disturbance area chosen is not only located much further to the north (10°S compared to 13.5°S, see India EIS, Fig. 4.5.3.1), but was also chosen for its low nodule density. It may therefore differ substantially from the site of the collector trial which was chosen for a high density of nodules.

5.2.3 Experimental Set-up

As detailed in the EIS (Government of India, 2020), chapter 8) India has established a Preservation Reference Zone 60 km west of the anticipated collector trial area (Impact Reference Zone, IRZ). Both areas are of similar size (7.5x7.5 nautical miles), and are presented as having similar nodule abundances, metal grade and environmental data as collected over four seasons. However, it does not become clear where the actual samples come from and the similarity or difference between PRZ and IRZ are not statistically supported.

To evaluate the seafloor disturbance due to the collector trial, high resolution bathymetric surveys in PRZ and IRZ will be carried out before and after the trial in both areas. The disturbance caused by the collector will be studied through photos and/or videos (only trial 1?). It is not stated how the different plumes of the three trials will be disentangled?

At the time of the trial, water and sediment samples will be collected from 5 locations around the area of collector test in IRZ (see India EIS, Fig. 8.2.1) and at the centre location in PRZ in all phases of the study. Water depth and sampling methodologies for the water column samples are not given, nor is the relation to the discharge experiment at 80 mab. Sediments will be sampled with short-term moorings 100 mab supplementing the planned continuous measurement of one surface-to-bottom mooring in the same place over one year. The location of these stations will be 500-1000 m on either side of the collector path based on earlier experience and modelling.

The deployment of altogether three moorings has been planned for 2020/2021, to be located at the center of the IRZ, of the PRZ and a station approx. 50 nm to the north, respectively (see Government of India, 2020, Fig. 8.1.3). Apart from measuring current velocity and direction, the moorings will measure sedimentation by means of attached sediment traps at different depths, with the lowest trap being about 100 mab. A hydrodynamic model of the plume dispersal will be developed with the new data.

However, there are several issues with this set-up, referring to Fig. 8.1.3.1 (Government of India, 2020), p.334), which are questionable, e.g.

- The location of the trial area/IRZ in the immediate vicinity of a relinquished block, which may lead to impacts on the common heritage;
- The distance of 60 nm between PRZ and IRZ, may be too large (see BGR, 2018);
- The PRZ was located 23 km from the nearest benthic sampling station (EIS, p. 37) and thus cannot be counted as biologically comparable to the IRZ. As seen in the CCZ, there may be very high small-scale spatial variability, and replicate sampling has to cover multiple stations including the immediate vicinity of the mining site.
- The height of 100 mab for measuring sedimentation above the collector path if sediment is being discharged at 80 mab is unsuitable for following the plume development and eventual impacts on plankton.

5.2.4 Expected Results and Applicability to Commercial-sized Mining

This collector trial is too small in temporal and spatial scales of impacts to be extrapolated to commercial-sized mining operations. As stated, the scale is much smaller than that of the disturbance caused by the INDEX experiment in 1997, and as such will not generate much new knowledge unless modern instrumentation and sampling methods will be used which address so far neglected ecosystem components (e.g. microbes, pelagic fauna, mobile fauna) and functions (C-flux, food web) or sensitivities (toxicity, sedimentation).

5.2.5 Performance of the Indian EIS

Table 92: How the requirements of the ISBA/25/LTC/6/rev1/Corr.1 and earlier guidance have been addressed in the EIS of India (Government of India, 2020).

Requirement acc. ISBA/25/LTC/6/rev1 /Corr.1 and earlier guidance	Performance of the Indian EIS
A plan for testing of mining components or test-mining shall include provision for monitoring of those areas impacted by the contractor’s activities which have the potential to cause serious environmental harm, even if such areas fall outside the proposed test site.	Direct and indirect effects of the collector trial will be measured and sampled. The project aims at developing the basic criteria for grading harm, including serious harm. However, it is very unlikely that based on the sampling already done, even the most severe effects could be detected as the station grid is very wide and no clustered and repetitive sampling has been carried out to ascertain the results. A comparison of investigations actually made with those recommended in ISBA/25LTC/6/rev1 or earlier recommendations should be given, including reasoning for those not carried out.

Requirement acc. ISBA/25/LTC/6/rev1 /Corr.1 and earlier guidance	Performance of the Indian EIS
The programme will include, to the maximum extent practicable, specification of those activities or events that could cause suspension or modification of the tests owing to serious harm, including if the specified activities or events cannot be adequately mitigated.	Risks of failures are indicated in 3.5, however not in much detail. Probability estimates should be added and a framework for environmental risk assessment and management for activities in the Area developed.
The programme will also authorize refinement of the test plan prior to testing and at other appropriate times, if refinement is necessary.	This is not specified but likely. No detailed information exists.
The plan will include strategies to ensure that sampling is based on sound statistical methods, that equipment and methods are scientifically acceptable, that the personnel who are planning, collecting and analysing data are well qualified and that the resultant data are submitted to the Authority in accordance with specified formats.	This remains vague, no detailed methodologies are given, making comparisons through space and time impossible. References on baseline results are lacking.
During exploration test-mining, the notification of a proposed impact reference zone and a preservation reference zone is recommended.	Both zones were designated, however they do not seem to match previous sampling locations (?). The reported sampling to date is unlikely to appropriately capture the temporal and spatial baseline situation.*
The monitoring programme proposed by the contractor must provide details of how the impacts of the testing of mining components and test-mining activities will be assessed. [Recommendation VI.D.40]	The monitoring programme remains very general, no details are given.
LTC evaluation criteria	**LTC review of performance of the India EIS (ISBA/26/C/12/Add.1)**
Completeness*	?
Accuracy	?
Statistical reliability	Improvements *to augment the statistical reliability of the environmental impact statement"* are needed, relating to the monitoring programme, the sampling plan to demonstrate an improved experimental set-up and a demonstration of statistical significance of any monitored environmental changes.

* DOSI submission to India MoES, 20 May 2020.

5.2.6 Issues to be Discussed

5.2.6.1 Issues with the Sponsoring State Responsibility

India is a State contractor and as such completely responsible and liable for the consequences arising from deep seabed mining-related activities in the Area. India seemingly was not aware of the need for an EIS when testing mining components in the contract area. In October 2020, a letter of DSCC to the President of the Council alerted to the planned testing activities and requested ISA to call India to provide an EIS. This happened in January 2020 (date on the report) and was received by the ISA Secretary General on 6 February (ISBA/26/C/12/Add.1, Section VII B).

Upon the invitation of the ISA Secretariat, the Indian Ministry of Earth Sciences, MoES, responsible for the test mining exercise, invited for public comments on 27 March 2020 through the MoES and ISA websites, with a notion that ISA had received the EIS by 15 March (modified version?). Several stakeholders sent comments, among others the DOSI group of scientists, the DSCC group of NGOs and IASS. As far as known, none of these got any response or acknowledgement of receipt of the submission[138]. The summary report of the comments received as announced in document (ISBA/26/LTC/5, para 9) is neither available on the ISA website nor at MoES.

Nevertheless, the EIS submitted and information provided by India after a preliminary review by the Secretariat was reviewed for completeness, accuracy and statistical reliability by the LTC during its session in July 2020. The review stated substantial deficits (see 5.2.6.3 below).

5.2.6.2 Issues with the EIS submitted to ISA

The EIS as submitted to the ISA and available for review by stakeholders reflected clearly the caveats left by the ISA "Recommendations for the Guidance of Contractors" in that it is overly descriptive, not fit for the purpose of assessing environmental changes caused by mining-related activities, and unspecific as to the plan of work and the environmental monitoring programme (see above). Stakeholder consultation should accompany a prior scoping exercise to avoid wasted effort in an undirected attempt to fulfil not well-defined criteria by the ISA.

5.2.6.3 Issues with the ISA Procedure

Other than the evaluation of the BGR and GSR EIS through LTC, the review of the Indian EIS resulted in some very concrete recommendations which were published as part of the report to the Council by the Chair of LTC (ISBA/26/C/12/Add.1, B).

The draft EIS submitted and information provided after a preliminary review by the ISA Secretariat was reviewed for "*completeness, accuracy and statistical reliability*" by the LTC during its session in July 2020. LTC recommended "*that the Secretary-General communicate to the contractor that, when the statement was incorporated into the programme of activities under the contract, the contractor take into account the suggestions outlined below,*" LTC recommended to augment the evaluation of the main impacts, to strengthen the monitoring programme and to enhance the sampling plan in order to demonstrate an improved experimental set-up and statistical significance of any monitored environmental changes. The contractor shall report in the context of the annual report on how the suggestions were taken into account (ISBA/26/C/12/Add.1, B).

As with the review of the BGR and GSR EIS, it remains in-transparent LTC does not provide a publicly available reasoning for its conclusions. In this case, seemingly no external reviews assisted LTC and the Secretariat in their evaluation. As the submissions of other stakeholders have not been published, it is uncertain whether these were taken into account.

[138] As of January 2021, the EIS is not available on the ISA website anymore. The consultation is still advertised on the MoES website with a deadline of 24 May, 2020, however no further comments or processes are indicated.

The request to report on modifications to the monitoring plan in the annual reporting is a new step not previously required by any contractor. Unfortunately, this reporting will not be available for scientific and public scrutiny. The EIS is not accessible on the ISA website any longer.

5.3 Conclusions on the EIS in Practice

The lack of specification the ISA recommendations (see chapter 4) has strong implications not only for the quality of the EIS delivered by the contractors - as can be assumed in best effort - but also generally on the ISA´s ability to ensure a "*uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind*" (ITLOS, 2011, para. 159). Despite the substantive obligation to carry out an environmental impact assessment, EIA, and deliver and environmental impact statement, EIS, the procedural and scientific framework for guiding contractors to deliver a fit-for-purpose EIS is insufficient in many respects (see also chapter 5).

The three contractors (see chapters 5.1 and 5.2) have coped with the task of delivering an EIS at a time when the then valid guidelines (ISBA/19/LTC/8) requested them to provide an EIA of undetermined content, and without specifying a conservation objective. In particular, the lack of guidance on a framework for monitoring and assessment results in every contractor to reinvent the wheel. In addition, a guidance is desirable to advise contractors in providing a comprehensive, ecosystem-based view on the targeted ecosystem and its components before and after being subject to pressure from exploration and testing. Ideally, the ISA would have established a coarse regional environmental baseline and quality description at the latest by the time contractors apply for exploitation and deliver a full-scale environmental impact assessment/statement. This would enable fit the contractor EIS and EMMP with the objectives of the respective Regional Environmental Management Plan.

Test mining will predate this, but *vice versa* can be expected to contribute to the delivery of a meaningful prior environmental impact study in context with decision-making on exploitation. Therefore, already at this early stage, contractors should be made aware of the hurdles to be overcome in order to be eligible for an exploitation contract. A binding precautionary and ecosystem-based framework, agreed by the ISA Council with expert advice and after public consultations, would be instrumental to succeed in the uniform implementation of the highest protection standards for the marine environment, as requested by ITLOS (2011, para. 159).

At present, the ca. 100 requirements for baseline investigations to be carried out by contractors specified in the ISA recommendations (Bräger *et al.*, 2018) come as a sort of unsorted and unprioritised wish-list, which means that contractors may select and perform a set of any selection of measurements from the list, that will act then as testimony for complying with the recommendations.

Well-designed time series of certain crucial ecosystem parameters at the potential mine sites and the respective PRZ will be of utmost importance also for the contractors to demonstrate the degree of natural variability and change as opposed to changes occurring due to mining activities. So far it is unclear, what the qualities of such a well-designed time series must be, but this can be subject to scientific advice. Time series observations also fit nicely to current endeavours to establish a global ocean deep water observation network (Danovaro *et al.*, 2020; Levin *et al.*, 2019; Sherman and Smith, 2009) and the monitoring efforts by other industries, (e.g., BSH, 2013; Kropp, 2004; Norway Climate and Pollution Agency, 2011) and regions (e.g., Lyons *et al.*, 2010; Zampoukas *et al.*, 2013).

Distinguishing harm from natural variability or e.g. climate change-related trends in a statistically significant way, means that substantial numbers of replicate samples have to be taken and analysed for the same parameters both in the PRZ and IRZ. To detect a man-made impact, the change observed has to exceed natural variation or trends. So far, none of the present contractors, and research projects have been able to sample for example megabenthos with sufficient resolution to ascertain the community composition and the natural level of variability, which makes it unlikely that even severe effects could be detected (Ardron, 2020; Ardron *et al.*, 2019a). This calls for ISA to set up at least a working group to compile the necessary elements of a monitoring and assessment programme which would enable the contractors to demonstrate impacts on seafloor and water column ecosystems rather than "background noise".

As shown in chapter 4, provisions are necessary to enhance transparency, expert involvement, stakeholder participation, but also ISA-guided scoping and other critical elements of good governance, which would enhance regulatory control and public trust However, both are missing in the current ISA rules, regulations and procedures. Importantly, there is currently no requirement for contractors or the LTC to spell out uncertainties or knowledge gaps (see also International Seabed Authority, 2017a; Jaeckel, 2017b). Deep seabed mining will be a high-risk endeavor to the ocean environment, hence regulatory mechanisms and measures should be designed to control the risk in view of the uncertainties in a precautionary way (Komaki and Fluharty, 2020; Washburn *et al.*, 2019). Expert opinion can here be an invaluable supplement here to inform appropriate policies and regulations (Kaikkonen *et al.*, 2018a; Komaki and Fluharty, 2020; Washburn *et al.*, 2019).

Mining tests can be one way to address the uncertainties, to optimise equipment and minimise the disturbance of the environment. The higher the risk and the uncertainty, the more stringent the contractors obligations must be (rather than “grandfathering” the mining practices and technologies contained in the original plan of work);[139] Good governance practice requires anticipatory(Foley *et al.*, 2015), precautionary and adaptive governance (Jaeckel, 2016, 2017b, 2018), as well as active scientific knowledge management by ISA (Ginzky *et al.*, 2020). In anticipation of upcoming challenges and opportunities, a feedback cycle of adaptive management provides for strategic planning, analysis of long-term consequences, capacity building, and management of emerging technologies while such management is still possible (Foley *et al.*, 2015).

Not only do the ISA´s recommendations for the guidance of contractors fall short of such standards, also the drafting process is currently flawed, and could certainly be improved by wider consultations (rather than consulting only the exploration contractors). In particular, the process recommended in ISBA/25/LTC/6/rev.1/Corr.1 and earlier versions for assessing environmental impacts from disturbances such as caused by test mining has several significant deficits. These include:

- the lack of formal structure, including a scoping phase;
- the lack of conservation vision, goals and objectives - or link to the respective REMP;
- the lack of transparent expert and public involvement;
- the lack of environmental indicators, thresholds and assessment methodology;
- the lack of criteria for a baseline description of acceptable quality;
- the lack of common criteria and decision-making framework for the designation of IRZs, PRZs and measuring points along the impact gradient; and
- the absence of a clear monitoring concept.

Neither is there much guidance on the expected quality of EIS contents. Apart from standardised headlines, the 2020 set of recommendations does not give any advice on the scope, extensiveness and quality (descriptive, analytic, discussion of other information) of the information to be provided. In particular, extensive descriptive text will not be helpful in establishing the before-after differences due to e.g. a collector trial. Rather, the strategic process linking baseline investigations with the later monitoring and assessment has to be made clear.

Developing a regionally meaningful deep-sea monitoring scheme with indicators that inform on changes caused by mining activities and threshold values determined to prevent harm, will be very

[139] see footnote 133; https://www.umweltbundesamt.de/fachgespraech-am-7112017-in-potsdam

costly to achieve. The process requires the provision of advice and the build-up of an ISA knowledge repository from which scientists can start to develop new investigations.

Many issues may be premature for final recommendation, however

- All contractors, and in particular non-sponsoring parties and the global public would benefit of a transparent, well structured and nested EIA procedure which aligns with the global best practice standards. This is currently not the case (see further 6.3)
- There are ample recommendations from scientific experts, for example compiled in ISA technical workshop reports, and scientific literature, which provide at least a starting point for determining a monitoring framework. Targeted workshops would certainly help the case.
- The precautionary approach requires that the standards and requirements established at the start of activities correspond with the level of risk and degree of uncertainty associated with potential environmental impacts. As knowledge increases, these standards and requirements can be adjusted accordingly. This means that test mining provides the best opportunity for establishing not only risk factors but also to reduce the risk by e.g. modifying technology and practice.
- Providing basic standards for environmental baseline and monitoring investigations will enable the ISA to develop its own knowledge base from contractor reporting and enable inter-contractor and regional comparisons, develop preliminary indicators and test threshold values. Environmental standards need to be amendable based on lessons learned.
- Addressing uncertainties: There is an extreme knowledge gap concerning seabed and water column ecosystems, environmental thresholds and the technologies necessary for both exploitation and monitoring. To address these uncertainties, institutional learning and dynamic, responsive regulation is necessary for effective implementation. It is essential that this regulation is designed to "learn" and continuously review environmental protection measures as scientific knowledge increases. That is meant by "Reflective Regulation". The future ISA Exploitation Regulations must include appropriate instruments ensuring reflective regulation (Ginzky *et al.*, 2020).

By contrast, the recent version of the recommendations, ISBA/25/LTC/6/Rev.1, like the draft exploitation regulations (2017, 2019) abandon the idea of a regulatory EIA process and instead only require contractors to submit an Environmental Impact Statement, EIS, in line with a given contents outline (Annex III of the recommendations). This will make it impossible for ISA to develop a common assessment framework for activities of all contractors in one region exploring for one resource, as is required for developing meaningful regional environmental management plans, REMPs (Christiansen and Singh, 2021). It is questionable how the EIS of contractors could be guided by the respective REMPs at all, if no formal links are established also in the ISA recommendations. In addition, the lack of own data and experience, and lack of independent scientific advice will make it extremely challenging for the ISA to evaluate the justifications raised by the proponent, in particular regarding the accuracy and statistical reliability of before-after-control measurements.

Even more worrying in terms of the ISA´s ability to ensure a "*uniform application of the highest standards of protection of the marine environment*" is the fact that presently, the EIS delivered by contractors is a formality with no practical effect. The ISA can only recommend contractors to adjust their operations or improve an EIS, however does not have the means to deny for example test mining operations because no consent/decision-making is needed. This is why BGR and DEME/GSR were able to start the field trial prior to the LTC finalised the review of the EIS. Also, India, while asked to improve the monitoring plan and to report on any changes made, can in principle go forward without addressing the LTC requests.

5.4 Recommendations

Environmental impact assessment and related statement prior to an activity taking place is the core process for exercising regulatory control over the environmental impacts likely to be caused by an operation. Therefore, it is of utmost importance that its submission is not just a formality, and the contents are not beyond the expertise and capacities of the ISA. The testing of mining equipment or systems *in situ* during exploration, accompanied by a prior environmental impact assessment, monitoring of the trial events and reporting of the results could, if done properly, not only ensure the formal control, but also the control on the severity of effects caused by various gears in various environments. Learning from experiences made by the operators of such activities, the assessment and decision-making over tolerable and intolerable environmental changes caused by such activities could be informed. If such information was available to all contractors, this might save time and effort and avoid insufficient operations and reporting.

Ideally a controlled, staged approach to testing of collection equipment and systems *in situ* would be required. The contractors could then use *in situ* tests of equipment for refining the environmental baseline information, for knowledge acquisition on ecological functions and sensitivities, for developing all required procedures and its environmental management system (Durden *et al.*, 2017), and for moving towards a least invasive operational process and technology (Gerber and Grogan, 2018). The experience would inform standards to be developed for Best Environmental Practices, BEP, and Best Available Techniques, BAT.

Testing is also needed to reduce the uncertainty of the regulator and stakeholders about the severity and longevity of environmental effects resulting from test mining, and later from commercial mining. Based on current knowledge, the effects of one or more commercial-scale mines cannot yet be anticipated (Boetius and Haeckel, 2018).[140] Nonetheless, the legal framework for enabling the exploitation of mineral resources in the Area is under negotiation, with provisions for a prior EIS (ISBA/25/C/WP.1, Part VI, section 2) at the application stage of exploitation. At this point, the uncertainty about the impacts of a commercial-scale mining operation will be maximal, unless the mining system has been demonstrated in advance to not cause harmful effects on the environment. If the information for the full commercial-size mining system is not available, then the proponent should be required to at least deliver meaningful data from testing of a prototype mining system *in situ* for an appropriate time. Once the contractor starts with exploitation, the predicted environmental effects will have to be verified in a staged approach to monitoring starting with an intensive validation phase upon the start of the activity (Gerber and Grogan, 2018).

For the reasons given above, and the public interest in this new type of activities which will be impacting on a common good, it is paramount to establish a fully transparent EIA process, such as proposed by and discussed in (Durden *et al.*, 2018), with a binding effect of the outcome of the EIA/EIS review on applications for exploitation. Such a multi-staged process will not only include public consultation in line with the Aarhus Convention, but also feedback loops to Sponsoring States and the ISA in order to gain full control over the activities and related impacts.

A long list of recommendations for making the EIS (during exploration and when applying for exploitation) more fit-for-purpose is given in (Christiansen *et al.*, 2019b, p. 193ff) and chapters 5 and 6. Important solutions for being effective with regards to ensuring a more sustainable use of the environment, include the no-net-loss of biodiversity goal to be a binding objective of the EIA process and decision-making (Jay et al., 2007), and should also enable integrated and sustainability assessment to direct planning and decision-making also towards sustainable development (Hacking and Guthrie,

[140] Boetius and Haeckel, 2018, p. 35:" On the basis of current scientific knowledge, the long-term risks of industrial-scale deep-sea mining to the marine environment seem unmanageable from both the economical and the ecological perspective".

2008). In addition, clear technical standards are required, to prevent inconsistencies in decision-making over the significance of impacts (Maclean et al., 2014; Wood, 2008).

Recommendations

ISA has to ensure a "uniform application of the highest standards of protection of the marine environment, the safe development of activities in the Area and protection of the common heritage of mankind" (ITLOS, 2011, para. 159). To reach this goal,

- ISA should become a proactive regulator of activities in the Area. Member States will need to provide for sufficient funding and capacity to do so.
- ISA must spell out that the context for the approval of activities in the Area is the application of precautionary decision-making in an ecosystem approach to management of activities in the common heritage of mankind, where higher uncertainty and higher risk leads to more precaution.
- ISA must set out binding conservation goals and objectives globally and regionally, which inform the assessment of the severity of mining-related and cumulative effects.
- One incremental, multi-staged EIA process should cover all activities from the first components testing and test mining during exploration to the prior exploitation EIA and verification of predicted impacts during exploitation. All information would accumulate in one comprehensive EIA report over the exploration period. The essential procedural elements include
    - Meaningful public participation in line with requirements of the Aarhus Convention;
    - Feedback loops to Sponsoring States and the ISA;
    - Independent expert advice;
    - A scoping phase, where the proponent and ISA develop the formate and elements of the prior EIA and EIS appropriate to the particular case. This could then also ensure the link to the respective REMP and that there are higher stakes for higher risks. A public and expert consultation is needed;
    - The joint (with experts and eventually stakeholders) elaboration and testing of
        - best-practice BACI design including rules for designating PRZ and IRZ,
        - best-practice monitoring schemes,
        - identification of environmental indicators and thresholds,
        - ecological risk assessment and management,
        - meaningful reporting;
        - arguments on the benefits and cost of deep seabed mining in the Area to inform stakeholders and the public.
    - Identification of uncertainties and risks, publication of justifications of advice or decisions;
    - Publication of the EIA report (draft EIS) and monitoring and assessment results as timely as possible to enable experts and other stakeholders to keep track of the activities environmental impacts;
    - A public annual monitoring and impact assessment report post-activity, and a final report at the end of the contract, instead of delivery of data only.
    - The option to not approve an EIS.

6 Scientific View on Test Mining

This chapter supplements the previous considerations from an environmental governance perspective with a practical scientific view on the test mining concept in relation to the knowledge needs for making well-informed assessments of environmental impacts. It starts with featuring the gains from test mining, to consider then the need for adequate baseline information as a starting point, and the needed robust design of monitoring programmes to enable capturing environmental change. It closes with considering elements of a framework for EIS prior to the start of exploitation.

6.1 What Can Ideally be Gained from Test Mining?

Disturbance experiments conducted in polymetallic-nodule provinces, on seamounts and at hydrothermal vents have, given their relatively small scales and low-intensities, provided valuable but limited insights into the impacts of deep-seabed mining e.g., (Gollner *et al.*, 2017a; Jones *et al.*, 2017b). It is widely anticipated that habitat removal, sediment plumes, as well as increased chemical, noise and light pollution, will result in effects at species, community and ecosystem levels (Kaikkonen *et al.*, 2018b). Therefore, without insights gained from test mining, both component and full-scale, predictions of the types, scales and intensities of potential commercial-scale mining impacts will remain unclear, making management mechanisms to ensure the effective protection of the marine environment less likely to be successful (Ginzky *et al.*, 2020). As such, test mining should be seen as an essential tool.

Scientific understanding about the impacts of commercial mining will need to improve, and test mining can play a key role in this. Impacts at a species level include extinction, significant decline in abundance and/or foundation species, reduction below critical reproductive density, loss of source populations, and/or loss of critical stepping-stone populations (Levin *et al.*, 2016). Community-level impacts include the alteration of key trophic linkages among species in a community, reduction in species diversity beyond natural levels of variability, and/or regional declines in habitat heterogeneity, such as loss of entire habitats or community types (Levin *et al.*, 2016). Impacts at the ecosystem scale include impairment of important ecosystem functions such as biomass production, nutrient recycling or carbon burial can lead to loss of major ecosystem services upon which society depends (e.g., carbon sequestration capacity, genetic resources, or fisheries production) (Levin *et al.*, 2016). For these, indicator species/ecosystems or surrogate species (e.g., of functional importance, that are fragile, vulnerable or have a high extinction risk) that can be measured and monitored will need to be determined (Levin *et al.*, 2016).

Avoiding harm altogether is unlikely to be achievable given the destructive nature of deep-seabed mining (Niner *et al.*, 2018; Van Dover *et al.*, 2017a), thus the likelihood of resilience to mining impacts by deep-ocean biodiversity and ecosystems, and/or the potential for recolonization or recovery, are critical gaps (Cuvelier *et al.*, 2018; Da Ros *et al.*, 2019) that can begin to be informed by test mining. A key question related to resilience and recovery, as well as management, is that of cumulative impacts, which can also be informed by the information gleaned from test mining (Levin *et al.*, 2016). Test mining will also play an important role in validating the findings of predictive models on the sphere of impact of, for example, the plume, as well as for upscaling *ex situ* or laboratory experiments. Test mining could also aid the assessment of best available technology and best environmental practice (Ginzky *et al.*, 2020).

Furthermore, test mining could provide data that would directly lead to more effective management of this nascent industry. This includes by providing data that would assist in defining appropriate strategic environmental goals and objectives (SEGOs), as well as survey and monitoring criteria such as sensitivity indicators, metrics and thresholds to measure impacts. SEGOs are a starting point for assessing environmental responsibilities and should articulate what the end result is that needs to be achieved both scientifically and from a management perspective (Tunnicliffe *et al.*, 2020). SEGOs should guide all decision-making, including the identification of scientific knowledge gaps and the approaches to resolving them (Tunnicliffe *et al.*, 2020). Additionally, SEGOs are necessary to operationalize serious harm (Levin *et al.*, 2016; Tunnicliffe *et al.*, 2020). SEGOs have not yet been identified for any of the resources or regions where deep-seabed mining may occur, so test mining provides an opportunity to inform which environmental goals and objectives are the most essential.

Survey and monitoring criteria, such as sensitivity indicators, as well as metrics and thresholds to measure impacts, are key to ensuring that SEGOs are met, and that a program is in place that is capable of measuring an adverse impact to allow intervention before it becomes a significant adverse impact or serious harm. Existing ISA regulations for exploration of polymetallic nodules, SMS and cobalt-rich crusts provide only a vague definition for serious harm: "*any effect from activities in the Area on the marine environment which represents a significant adverse change in the marine environment determined according to the rules, regulations and procedures adopted by the Authority on the basis of internationally recognized standards and practices*" (ISBA, 2000, 2010, 2012). However, beyond this, the definition of serious harm and associated adverse change, as well as specific criteria to operationalize, measure and monitor it, in the context of the marine environment continues to remain elusive given that a lack of knowledge is the rule rather than the exception (Levin *et al.*, 2016). Regulators can set rules designed to minimize environmental impacts however, without knowledge on, for example, species-specific responses to impacts, consequences for ecosystem-level functioning, and natural variability, it is difficult to determine survey and monitoring criteria to assess mining impacts in space and time to aid effective management (Levin *et al.*, 2016).

Delimiting metrics and thresholds to measure monitoring efforts as currently, available data come from shallow-water ecosystems where background levels of sedimentation, turbidity and pollutants are orders of magnitude higher (Smith *et al.*, 2020) and may have different physiological effects (Hauton *et al.*, 2017), can also be aided by test mining. A threshold is a point at which changes in an important ecosystem property or phenomenon have exceeded normal ranges of variability (Groffman *et al.*, 2006; Levin *et al.*, 2016). A trigger point indicates that the quantified threshold for significant adverse impact is being approached so preventative and precautionary action should be taken as soon as possible to minimize such harm as well as prevent non-compliance (and ensure that serious harm is avoided), and as such will fall within natural variability (Levin *et al.*, 2016). Key biotic metrics that may be used to indicate when a threshold is being approached include measures of biodiversity, abundance, habitat quality, population connectivity, heterogeneity levels, and community productivity (Levin *et al.*, 2016). Potential examples of abiotic metrics include toxicity and oxygen levels in the sediment and water column, particulate levels in the water column and levels of sedimentation on the benthos (Levin *et al.*, 2016).

Given the limited state of knowledge for the deep ocean, and the great deal of uncertainty and risk regarding deep-seabed mining, a stepwise cautious process, that incorporates adaptive management, is required (Craik, 2020). There will likely be legal, institutional and environmental challenges associated however, but an approach that allows multiple levels of test mining would be useful in decision making related to the protection of the marine environment. This could begin by gathering and analyzing scientific data associated with component test mining, then with full-scale test mining, and finally with industrial-scale mining, while allowing for periods between each for review and the incorporation of learning and adaptation into the management process.

6.2 What Constitutes a Good EIS Prior to Test Mining of Polymetallic Nodules?

The Environmental Impact Assessment (EIA) is one of the main tools to warrant the protection and conservation of natural resources, however the EIA process globally has been largely seen to legalize environmental harm rather than to prevent it, and with the deep ocean mostly out of sight and unlikely to recover on human timescales, the robustness of this process is critical (Niner *et al.*, 2018). Component testing will be undertaken by individual contractors during exploration, requiring an EIA reported in a condensed form in an Environmental Impact Statement (EIS) that includes equipment specifics and details of a monitoring plan (see Section 5.4). Clark *et al.* (2020) and Section 5.5.3 outlines key research issues relating to core principles and criteria of an EIA. In addition to the above, a high-quality EIA is underpinned by adequate baseline information, a robust monitoring plan, adequate risk assessment and thorough reporting (Durden *et al.*, 2018). However, this management mechanism is also dependent on the comprehensive assessment of the accuracy (the degree to which the result of a measurement or calculation conforms to the correct value or a standard), completeness (regarding the contents and documentation), and statistical significance (reliant on ample sampling) of the EIA, as well as a review process that allows for stakeholder review and ensures the feedback from experts and public consultation is taken into account (Durden *et al.*, 2018; Lallier and Maes, 2016). This assessment should be undertaken by independent (*i.e.*, who are not benefiting from the contractor) deep-ocean and marine-management experts.

6.2.1 Adequate Baseline Information

The remoteness, inaccessibility and expense of studying polymetallic-nodule ecosystems has resulted in major biological baseline knowledge gaps (Christiansen *et al.*, 2019a; Christiansen *et al.*, 2019b; Drazen *et al.*, 2020; Webb *et al.*, 2010). This varies considerably by environment and region, with many areas still entirely unexplored, or if studied, lacking a complete characterization, including in areas such as the CCZ where research has been ongoing for decades (Table 10). Assessing any potential changes to deep-sea ecosystems as a result of test mining is challenging at best, but without a robust baseline, a full understanding of how nodule ecosystems and the pelagics associated will respond to disturbance under the plan of work will not be possible, and therefore will hinder informed decision-making. As such, environmental baseline data constitutes one of the main tools to warrant the protection and conservation of natural resources through the EIA process (Bräger *et al.*, 2020). It is also important to remember that the combined environmental baseline data of the contractors in the CCZ should also serve as the basis for region-wide Strategic Environmental Assessments (International Seabed Authority, 2011; Lodge *et al.*, 2014), which will account for cumulative impacts not only of all mining activities in the region, but also of additional anthropogenic impacts such as from pollution or climate change (Brito-Morales *et al.*, 2020; Levin *et al.*, 2020; Ramirez-Llodra *et al.*, 2011).

The components required and recommended for a robust baseline for the exploration area to document the natural conditions that exist prior to test-mining, as well as that should make it possible to acquire the capability necessary to make accurate environmental impact predictions are outlined in ISBA-LTC (2020), Bräger *et al.* (2020) as well as in Table 13 below. Although it is a non-binding document, contractors are expected to comply with the Recommendations to the best of their abilities. However, there is no indication of what levels of environmental baseline data are deemed as adequate, and there appears to be no consequence if submissions from contractors fall short of that which is desired (Ginzky *et al.*, 2020)(ISBA/26/C/12/Add.1, B). It is hoped that the further ISA-issued Guidelines that are expected on the acquisition of baseline data as well as for EIS in the exploration area will be more prescriptive (see further chapter 5.4).

Baseline studies to support EIAs have to be tailored to ensure they are fit for purpose. However, according to Clark *et al.* (2020), there should be a level of consistency so that core deep-sea ecological information demands are met, and these are comparable and can be combined between contractors to form a regional picture. The key aspects include:

- What parameters should be measured and the spatial and temporal interval at which they should be measured
- The necessary accuracy and precision of measurements (what is measured to acceptable standards)
- What key ecological indicators need to be assessed in transitioning from baseline data to measuring/monitoring future changes under the environmental management plan

- What level of change might be acceptable in terms of mitigation against generic ecological limits and thresholds (not management targets) (Clark *et al.*, 2020).

Key abiotic gaps still include, depending on the region, the physical and chemical oceanographic setting (e.g., currents, oxygen minimum zones, temperature, turbulence levels, sound, suspended particles, pH, oxygen concentrations), high-resolution bathymetry and seabed properties (e.g., sediment characteristics, oxygen penetration, redox zonation, metal reactivity), and prevailing natural disturbance regimes (e.g., natural tectonic disturbance, benthic storms) (ISBA-LTC, 2020) (Table 10). Biological gaps also still abound for the benthos and pelagic, again depending by region (Table 10): species taxonomy and distributions, trophic relationships, life histories (e.g., age of maturity, longevity, reproduction, fecundity, settlement cues, recruitment, dispersal mechanisms), community dynamics (e.g., abundance, biomass, diversity, rarity, endemicity, size structure, colonization patterns, successional timescales), productivity, biogeographic patterns, as well as species and ecological connectivity (ISBA-LTC, 2020). The spatial and temporal variability of these abiotic and biotic parameters is also an essential part of a baseline study (Table 10). The impact of naturally occurring periodic processes on the biological environment should be well quantified, requiring as long a history as possible of the natural responses of the sea-surface, midwater, near-bottom and seabed communities to natural environmental variability before the mining-related activities begin. The final component of a baseline understanding is how the structure of marine habitats (including biodiversity) is translated into their basic functions, as well as the ecosystem services we rely on (Le *et al.*, 2017; Thurber *et al.*, 2014). Without further knowledge of these relationships, it remains difficult to incorporate them into deep-ocean management.

Table 10: Current level of baseline knowledge in nodule ecosystems where exploration contracts have been granted by the ISA. (adapted from Amon (In prep.).

Baseline Knowledge		Nodule Ecosystems*		
Topic	**Sub-Topic**	**CCZ**	**CIOB**	**West Pacific**
Abiotic	High-resolution bathymetry	++	-	-
	Oceanographic setting (e.g., currents, oxygen minimum zones, temperature, turbulence levels, sound, suspended particles)	++	+	-
	Seabed properties (e.g., sediment characteristics, oxygen penetration, redox zonation and metal reactivity)	++	+	-
	Natural disturbance regimes	+	-	-
Biotic	Species taxonomy	+	-	-
	Pelagic	-	-	-
	Trophic relationships	+	-	-
	Life histories (e.g., age of maturity, longevity, reproduction, fecundity)	-	-	-
	Spatial variability	++	+	-
	Temporal variability	+	-	-

	Connectivity (e.g., dispersal mechanisms, species ranges, source/sink populations)	+	-	-
	Ecosystem functions and services	+	+	+
Impacts	Removal of resources	+++	+	+
	Plumes	++	-	-
	Contaminant release and toxicity	-	-	-
	Noise, vibration and light	-	-	-
	Cumulative impacts	-	-	-
	Resilience	+	-	-
Manage-ment	Survey and monitoring criteria	-	-	-
	Effectiveness of mitigation strate-gies	+	-	-

* This has been compiled from the peer-reviewed literature and includes both target and non-target areas within each region. The scale is as follows: '-' - No or next to no knowledge; '+' - There is little knowledge; '++' - Moderate knowledge and as such further sampling is needed; '+++' - Comprehensive knowledge and as such, informed management decisions can be made. CCZ – Clarion-Clipperton Zone; CIOB – Central Indian Ocean Basin.

In order to close these scientific gaps, more comprehensive environmental baseline data needs to be collected. However, collecting baseline information is no small task in the abyssal regions of the deep ocean; it is time and resource intensive. Nodule ecosystems exhibit high patchiness on a variety of scales (tens of meters to thousands of kilometers) influenced by variation in topography, depth, nodule abundance, and food flux from the sea surface to the seafloor (ISBA, 2020; Simon-Lledó *et al.*, 2019; Simon-Lledó *et al.*, 2020). Additionally, given the variable geographic ranges (including many with very narrow ranges), of fauna in the CCZ and the deep ocean (Higgs and Attrill, 2015; ISBA, 2020), sampling needs to occur systematically. It also needs to be of sufficient density to overcome the perceived high levels of rarity and diversity of fauna; Glover *et al.* (2002) analysed polychaetes in 94 box-cores from eight sites in the central Pacific abyss but still did not reach species asymptote at any site or accurately ascertain the turnover of rare species. See further discussion of this in Section 7.2.2.

As such, an entire contract area (of approximately 75,000 km^2) should be sampled comprehensively, taking an ecosystem approach, to allow for the proper positioning of the specific site of the mining test (Impact Reference Zone - IRZ), as well as from an unimpacted control area (Preservation Reference Zone – PRZ) as per the BACI (before - after- control - impact) design, and be clearly distinguishable (Bräger *et al.*, 2020; ISBA, 2018). This should theoretically begin by collecting high-resolution bathymetry to create a geoform map that shows the different habitat types. From the geoform map, sampling should be allocated to encompass all ecosystem components and be gathered using the best available technology and methodology (Bräger *et al.*, 2020). If a geoform map is not yet in hand, a sampling grid across the contract area will assist in allocating sampling equally but randomly.

Ideally, during the collection and analysis of general environmental baseline data, the IRZ and PRZ locations should become clear as their designation depends on these areas being as ecologically similar as possible, as well as the IRZ being representative of the mining site (Bräger *et al.*, 2020). However, further sampling targeting those areas may be necessary to amply characterize all size classes and sub-habitats from the sea surface to the seafloor, including microbes, meiofauna, macrofauna, and megafauna (which should be clearly defined), in the IRZ and PRZ prior to test mining (Bräger *et al.*, 2020). There need to be multiple samples for each that cover spatial and temporal variation, with a minimum of annual sampling over at least three years) (Bräger *et al.*, 2020). However, this would also depend on the natural mortality, which is thought to be high in some deep-sea species (Roark *et al.*, 2009). Additionally, in order to accurately assess the baseline information that underpins the entire

EIA, unless published in the scientific literature, a detailed methodology of how all of the data was collected and analyzed, including equipment used, is necessary. And although the level of baseline information needed to inform an EIA will depend on the specific mining test at hand and should be tailored to suit, the greater the understanding of the broader environment, the better.

The following example demonstrates a near-complete general biological baseline survey plan, and the extent of resources needed to undertake this. This is the level of knowledge that would be needed to inform the choice of IRZ and PRZ location and assess and EIS. The ABYSSal baseLINE (ABYSSLINE) project undertook benthic biological baseline studies in accordance with ISA environmental guidelines, using state-of-the-art approaches in deep-sea ecological, taxonomic, and connectivity studies, mostly in the UKSRL exploration contract area (UK-1), but also the Ocean Minerals Singapore exploration contract area (OMS-1) and APEI-6. This project addressed the following key questions: 1) What are the baseline conditions of community structure and biodiversity for the key benthic biotic components of this ecosystem (megafauna, macrofauna, meiofauna and microbes)? 2) How do community structure, sediment community respiration, and biodiversity vary as a function of environmental parameters (especially nodule cover) within and across three study areas (or “strata”) within UK-1, and between years within one of these study areas? 3) What is the connectivity at species and population levels between strata and across the CCZ for representative components of the biota?

The ABYSSLINE benthic baseline study was scheduled to take place over five years and utilize a stratified random design of three 30 x 30 km strata distributed across UK-1 with studies conducted at 10-12 random locations within each stratum, however the project ceased after three years. Cruises (~35 days long each) were planned to occur in years 1-4 (but only two took place before cessation of funding for fieldwork (Smith *et al.*, 2013; Smith *et al.*, 2015), accounting for three different strata plus a repeat visit to one stratum, and with the fifth year scheduled for joint analysis. In addition to benthic biological sampling, this included geological studies via side-scan sonar, multibeam bathymetry, and nodule sampling, which facilitated analyses of the covariance between biological and physical parameters. Benthic sampling, data collection and analyses undertaken is summarized in Table 11.

Table 11: Benthic sampling, data collection and analyses undertaken during two ABYSSLINE research cruises totalling ~70 days.

Sampling Equipment	Successful Deployments Undertaken	Environmental Component	Analyses Following Fieldwork
Ship-based multibeam	-	High-resolution bathymetry	-
Remotely Operated Vehicle (ROV) & Autonomous Underwater Vehicle (AUV)	15	Megafauna and benthic environmental parameters	Qualitative and quantitative community analyses, integrated with geological and geochemical surveys by other investigators
Remotely Operated Vehicle (ROV)	5	Megafauna collections and targeted core sampling of seafloor	Morphological and molecular analyses for taxonomy and connectivity studies
Megacorer	34	Foraminifera, meiofauna, sediment/nodule microbes and benthic environmental parameters	Morphological and molecular analyses for taxonomy, connectivity and quantitative community studies

Sampling Equipment	Successful Deployments Undertaken	Environmental Component	Analyses Following Fieldwork
Boxcorer	28	Megafauna, macrofauna, foraminifera, nodule fauna and environmental parameters	Morphological and molecular analyses for taxonomy, connectivity and quantitative community studies
Moored near-bottom sediment traps	1	Bentho-pelagic larvae and vertical particle flux	Morphological and molecular analyses for taxonomy, connectivity and quantitative community studies
ROV-mounted plankton nets and plankton-pump landers	1	Bentho-pelagic larvae and meroplankton	Morphological and molecular analyses for taxonomy, connectivity and quantitative community studies
Brenke epibenthic sled	18	Macrofauna and megafauna	Morphological and molecular analyses for taxonomy, connectivity and quantitative community studies
Baited cameras and traps	33	Ichthyofauna and invertebrate scavengers	Qualitative and quantitative community analyses, plus morphological and molecular analyses for taxonomy, connectivity and quantitative community studies
Autonomous respirometer lander	10	Sediment community respiration, sediment ecosystem function, sediment microbes	Quantitative biological and geochemical benthic processes
CTD-Niskin Rosette	13	Water-column environmental parameters, water-column microbes and plankton	Morphological and molecular analyses for taxonomy, connectivity and quantitative community studies

* There were a number of issues associated with ROV and AUV megafaunal surveys and sample collections that are described in the cruise reports (Smith et al., 2013; Smith et al., 2015).

This project required a team of ~25 scientists, >2 months of ship time, a significant injection of funds (>8 million USD), as well as >3 years to undertake the fieldwork plus processing and analyses of samples and data in shore-based laboratories. Despite this, the ABYSSLINE project was not projected to include broader regional sampling in non-targeted areas of the CCZ to facilitate evaluation of regional patterns of population connectivity and species ranges, specialized data collection at the sea surface or in the water column above the benthopelagic zone, isotopic analysis to study trophic dynamics, analysis of Pb-210 activity for bioturbation, etc. Given the curtailing of the project, the assessment of collected data in relation to a larger spatial and temporal context was also limited. Taking into account both the unexecuted ambitions, as well as the three years of research, it was clear that attaining a robust baseline, even if only for the benthos, is a significant but necessary undertaking, because without this knowledge, assessment of the potential environmental impacts of deep seabed mining will not be adequate.

Of the EISs for deep-seabed mining activities that have been submitted for the Area (BGR, 2018; DOSI, 2020; Government of India, 2020; GSR, 2018), all have been largely deemed to be deficient with regard to baseline data during review by experts and wider stakeholders, e.g. (DOSI, 2020). For example, the EIS for a polymetallic-nodule collector pre-prototype issued in 2020 by the Government of India's Ministry of Earth Sciences demonstrated significant efforts to collect environmental and biological baseline data, but the baseline was incomplete and not fit for purpose (DOSI, 2020; Government of India, 2020). It was missing entire baseline components (e.g., high-resolution bathymetry, water-column physical, chemical and biological parameters, and information on noise, sediment profiles, microbial activity, protozoa, scavengers, near-bottom communities, surface communities, nodule communities, trophic relationships, ecosystem function), and as a result, would not have enabled monitoring results to establish that no serious harm occurred on the seabed, in midwater, and in the upper water column from the activities planned, as well as how likely recovery would be (DOSI, 2020; Government of India, 2020). Spatial variation in the composition of the community and levels of connectivity were not comprehensively evaluated making it impossible to know the degree of isolation of populations and whether a given population serves as a critical brood stock for other populations (DOSI, 2020; Government of India, 2020). A direct comparative description of the PRZ and IRZ faunal communities was also needed as these two locations will be compared after the trials take place to measure the impacts, as well as potential recovery (DOSI, 2020). Temporal scales (seasonal, inter-annual, episodic and extreme events) were not established for most components e.g., data from only one CTD rosette cast in the PRZ and two in the IRZ whereas instead, there should have been multiple CTDs per area and a minimum of annual sampling over at least three years) (DOSI, 2020; Government of India, 2020). Furthermore, little information was provided on the methodology used (e.g., the equipment used, duration of sampling, resolution of sampling) to collect the data presented, which prevented an analysis of the accurateness of the baseline (DOSI, 2020; Government of India, 2020).

6.2.2 A Robust Environmental Monitoring Program

Without robust environmental monitoring programs in place, the ISA will not be able to verify the effective protection of the marine environment. A robust environmental monitoring program should incorporate the following:

6.2.2.1 Clear Objectives and Critical Parameters for Monitoring

Key elements of a successful program to monitor the environmental impacts of test mining are the rationale and objectives, as well as the indicators of, and metrics for measuring and monitoring stepwise or continuously, change before it becomes serious harm (Danovaro *et al.*, 2020; Ingels *et al.*, 2021). This will include ecological thresholds that are reliant on knowledge of long-term (years to decades) baseline conditions and natural ecological variability, which again demonstrates the importance of a comprehensive baseline being established prior to the EIS being conceptualized (Levin *et al.*, 2016). For instance, Ardron *et al.* (2019b) showed that, for Pacific nodule regions, the numerical density of megafaunal individuals and Pielou's evenness of communities appear to be the most sensitive of metrics to simulated disturbances and may provide suitable "early warning" metrics for monitoring. Studies such as Ingels *et al.* (2021) have also highlighted that metrics cannot be limited to megafauna but should include among others the smaller fauna such as meiofauna and microbes. The metrics for the direct and indirect impacts on the benthopelagic and pelagic communities are so far mostly unresearched (Christiansen *et al.*, 2019a).

6.2.2.2 A Detailed Description of the Test Technology and Methodology

Detail of the test mining technology and operational practice is needed although it is difficult to provide whilst equipment and technologies are still under development (Clark *et al.*, 2020). A clear definition of the sites including the respective water column (size, exact location, depth), the underlying reasons why those were chosen for the EIS (e.g., bathymetry, nodule density), as well as how they fulfil the ISA criteria for IRZs and PRZs should be a requirement (ISBA, 2018). These should be underpinned by the baseline information, including an explanation of the value of the fauna in the predicted impacted area in regional context, and inclusive of the test mining technology and methodology. The information provided has to be detailed and accurate: For example, the EIS for a polymetallic-nodule collector pre-prototype by the Government of India's Ministry of Earth Sciences initially described the depth of sediment penetration of the nodule collector as 150-300 mm, but later in the EIS, 150 mm was used for calculations of impact (Ministry of Earth Sciences and India, 2020). Additionally, the width of the collector was not given, without which the total direct impact (area of compressed sediment plus area of removed nodules) could not be calculated (Ministry of Earth Sciences and India, 2020). While the trial may in fact operate on one linear track, for the exploitation phase, detailed information on which types of seafloor will be mined vs. which will not, is required to estimate the total area impacted and to inform best environmental practice. Clarity is needed in both these cases in order to assess whether the monitoring program is fit for purpose.

6.2.2.3 Identification of the Anticipated Impacts of the Test

This should be for both direct and indirect impacts. Thus far, EIAs for deep-seabed mining lack in their treatment of indirect/secondary impacts, such as ecotoxicology, or noise, and impacts of plumes (both particulate and dissolved components) to both the benthic and pelagic fauna (BGR, 2018; Clark *et al.*, 2020; GSR, 2018; Ministry of Earth Sciences and India, 2020).

6.2.2.4 A Detailed Description of the Monitoring Technologies and Methodologies

The plan for the environmental impact assessment and monitoring of the proposed activity needs to be described in sufficient enough detail to understand whether it will effectively assess direct and indirect impacts. A description of how the data will be used to assess impact is also needed. All methodologies should be supported with peer-reviewed publications and be in line with best scientific standards.

The standardization of monitoring before, during and after the project within the Mining Code will allow this assessment to be simpler (Ginzky *et al.*, 2020). Such an approach, using the best available science, would allow for transparency, a level playing field, a focused (and thus cost-efficient) sampling strategy and comparison of results across provinces. Standardization should include methodologies *i.e.*, instruments and equipment; quality assurance in general; sample collection; treatment and preservation techniques; determination methods and quality control on board vessels; analytical methods and quality control in laboratories; and data processing and reporting (Bräger *et al.*, 2020).

Additionally, the monitoring methodology not only needs to be properly described and standardized but also needs to be thorough. Beyond the BACI reference zones, all (potentially) impacted areas should be monitored consistently (with sufficiently high sampling station density) throughout the lifetime of the mine(s) or until the impact is no longer significant, but what is 'sufficiently high' and who deems when the impact is no longer significant (Bräger *et al.*, 2020; Durden *et al.*, 2018; ISBA, 2018)? Specific requirements for the scale, frequency (in space along a sampling gradient, and in time), and duration of the monitoring techniques is needed to ensure that the entire ecosystem affected by mining will be observed. Data should include samples from the immediate test area before and after test mining, from selected distances away from the mined area to determine the effect of the benthic plume, and at repeated intervals after test mining (Bräger *et al.*, 2020). The contractor is also requested to provide an examination of ecosystem recovery from natural and anthropogenic disturbances, even if such recovery may take decades to centuries (Bräger *et al.*, 2020; Jones *et al.*, 2017b).

Given the low densities and prevalence of singletons, doubletons and tripletons in the communities, ensuring there is not only enough taxonomic resolution, but also enough statistical power, should also be a standard component of DSM planning, monitoring and reporting, as without this, a "no effect" result is misleading and gives false sense of assurance (Bräger *et al.*, 2020; ISBA, 2020). Ardron *et al.* (2019b) found that in order to reliably detect a simulated degradation (mortality) caused by e.g. mining polymetallic nodules, impact monitoring samples should each have at least 500–750 individual megafauna; and at least five such samples, with control samples also being assessed. In the eastern CCZ, that equates to approximately 1500–2300 m^2 seabed per impact monitoring sample, or 7500–11,500 m^2 in total for a given location and/or habitat (Ardron *et al.*, 2019b). However, detecting less severe disturbances will require more sampling. All three EIAs submitted to the ISA to date have lacked the statical power to detect the sorts of impacts (harm) that they were supposed to be monitoring. The BGR EIS (BGR, 2018) stated that "*the amount of analysed samples is too small to obtain an accurate picture of the community*" when comparing the overlap between communities of the PRZ and IRZ. The GSR EIS suggested sample sizes were too small, with too few replicates to attain a sufficient overview of the sample sites, and the India EIS also contained too little sampling (GSR, 2018; Ministry of Earth Sciences and India, 2020).

This points to more guidance being needed from the ISA on what statically robust means *i.e.*, how large should a sample be in order to get a representative sample, how many samples is enough in order to capture spatial variation, and what effect size do we need to detect the tipping point prior to serious harm? Sample size, replication and the metric used will together affect the results (measured effect size) and hence regulatory threshold, and as such need to be considered in the Standards and Guidelines. Monitoring details, data, and results including power analyses should be made fully available, to facilitate independent review and informed policy discussions (Ardron *et al.*, 2019b).

Finally, it is prudent to also develop independent monitoring programs, in particular outside the contractor areas, in order to supplement the local view of contractors and increase the transparency on the effects of activities given these environments are so remote from human interaction (Ginzky *et al.*, 2020). For example, the JPI-Oceans MiningImpact project (August 2018 to February 2022), which is studying and comprehensively monitoring in real time the environmental impact of a component mining test in the Belgian and German license areas in the CCZ, has provided some of the most unique and reputable information surrounding the impacts of seabed mining thus far. The ISA could further expand its efforts in this area by requiring contractors to engage the services of independent agencies to verify monitoring activities and verify the actual impacts that arise, in addition to validating the environmental reports that contractors are required to submit (Ginzky *et al.*, 2020). Additionally, most of the monitoring by contractors (as it stands currently) will focus on tests within their contract areas, which leaves vast areas of the CCZ unaccounted for. Independent monitoring programs will be instrumental to delivering a regional perspective on human-induced changes caused by mining against the natural and climate change-induced variabilities and trends of the benthic and pelagic ecosystems. This would enable the ISA to feed information obtained through monitoring programs into regional environmental management plans to foster the development of appropriate risk thresholds and indicators, boost management measures and assess the compliance of contractors with the provisions of the Mining Code and their individual contractual terms, and, where necessary, to take enforcement measures (Ginzky *et al.*, 2020). However, once again, this will be reliant on clear instruction from the ISA on what data needs to be collected, as well as why and how.

6.2.3 Standard Risk and Impact Assessment Framework

The understanding of the environment gathered during the baseline study should be used in combination with up-to-date plans for the test mining activity (including detailed information on the specific technologies, logistics and practical implementation) to complete a risk assessment (Durden et al., 2018). The risk assessment and management process aims to identify, evaluate and rank risks associated with the activity, and to identify ways to mitigate these as best as possible according to the mitigation hierarchy: first to avoid/prevent, second to minimize, third to restore when possible, or finally to offset any impacts (Cormier, 2019; Durden *et al.*, 2018; Van Dover *et al.*, 2017a). This requires focus on the main sources of impact, as recommended by Clark et al. (2020). An Environmental Risk Assessment (ERA) facilitates this prioritization by providing for the application of a systematic problem formulation risk-based decision making framework to ensure an objective consideration of the acceptability of certain risks, and thus should be an integral part of the EIA process (Clark et al., 2020; O et al., 2015). Although the method used for an ERA may vary, any assessment should be transparent, and rank or quantify activities in such a way as to highlight those that have a high risk of causing an impact (Clark et al., 2020).

6.2.4 Reporting

The processes for reporting the results from test mining activities should be clearly conveyed within the EIA and follow a high level of structural standardization to allow for increased consistency, verifiability and transparency (Bräger et al., 2020). The reporting should include interpretations of the findings through comparisons with peer-reviewed studies, and details of sample and data management as well as dissemination plans, with a timeframe given for each step. The results of mining tests, including all data and samples, should be placed in the public domain or stored in a suitable and accessible repositories for transparent independent evaluation by experts and other stakeholders and, if possible, results should be published in peer-reviewed scientific journals (Bräger et al., 2020). The format and content of the EIA reporting is forthcoming as they are currently under consideration by an ISA expert working group.

6.3 What Constitutes a Good EIS Prior to Exploitation of Polymetallic Nodules?

Commercial mining will result in environmental impacts that are large on both spatial and temporal scales. It would be difficult to mitigate these impacts and avoid serious harm using only the information gleaned from component testing and small-scale disturbance experiments, given the stark differences in scale. Commercial mining plans, and the associated EIAs, can be improved by upscaling from small-scale tests to those that are full-scale, to gain insights that are closer to the environmental impacts of commercial extraction, and as such, both levels of testing should be strived for. The more testing of equipment on a sufficiently large scale, using technology as close to what may actually be used in commercial mining, the more accurate predictions will be about the impacts of commercial mining, especially related to the longevity and extent of impacts (Clark et al., 2020; Ginzky et al., 2020). The data gathered can also assist with further delimiting metrics, trigger points and thresholds, so that confidence is gained to guide future management, including whether the same thresholds and indicators be used across nodule regions such as the CCZ. The capacities needed for monitoring commercial mining will also differ in scale, with full-scale mining tests also providing an avenue to gain insights into how to successfully achieve this.

Given the profound injection of resources that would be needed to undertake a full-scale test, a coordinated joint full-scale mining test could be useful. This could begin with a series of workshops to plan a joint test, including the location (in an area where a REMP was in place), time and method. This could be a Member-State driven process, coordinated by the ISA and encouraged by civil society organizations. However, this can also be undertaken by an individual contractor or consortia of contractors. Like during component testing (see Section 7.2), an EIA, including equipment specifics and details of an independent assessment, would also be required. This test could be scaled up over time, with monitoring ideally taking place for at least a decade and the data generated from the test should be made openly accessible and transparent (Jones *et al.*, 2017b; Vonnahme *et al.*, 2020b).

An adequate EIA prior to exploitation would also depend on modelling capabilities, especially regarding the impacts on the biodiversity and ecosystem function, moving beyond where they currently are.

These models will depend on large amounts of high-resolution data, some of which can be gleaned during the collection of baseline data and monitoring of a component test, but a lot of which will still be unavailable. Full-scale mining tests can begin to alleviate this issue and assist predictions and mitigation of impacts from commercial mining (Cuvelier *et al.*, 2018). Error analyses of all models used, including tools or statistical studies, as part of a complete description of the model, should be provided in the EIA to assess accuracy, especially when such information is not in the public domain (DOSI, 2020). This should include 3D dimensional hydrodynamic numerical models to predict the dispersion of any plume through time and space, as well as models to assist with understanding cumulative impacts from multiple machines within one contract area (Bräger *et al.*, 2020; Levin *et al.*, 2020). Information gleaned from a full-scale mining test is crucial for understanding the resilience of the system during commercial-scale mining, including through cumulative impacts both within the scope of the proposed mining operation and beyond. Modelling that has incorporated data from component and full-scale test mining, as well as the use of Strategic Environmental Assessments, cumulative impacts from multiple machines operating within one contract area and multiple contract areas over time, is essential to fully understand the resilience of the ecosystem. Yet to date, there are no ecosystem models for the deep ocean, least so predicting ecosystem functions and dynamics of the whole. However, some process studies already indicate the probable outcome of the failure of functional recovery in perpetuity (Gollner *et al.*, 2017b; Volz *et al.*, 2020; Vonnahme *et al.*, 2020a).

Modelling should also extend to other cumulative impacts, such as via interactions with other anthropogenic activities (e.g., fishing activities, pollution) and climate change stressors (warming, ocean acidification and deoxygenation) also occurring within the ecosystem (Levin *et al.*, 2020; Ramirez-Llodra *et al.*, 2011). Climate change is already manifesting through warming, oxygen loss, increasing acidification, and changing particulate organic carbon flux (Brito-Morales *et al.*, 2020; Levin *et al.*, 2020). This could lead to range shifts, habitat loss, decreasing food supply, reduced growth and reproduction, and loss of biodiversity and associated ecosystem services, and may interact synergistically or additively with disturbance from mining activities (Levin *et al.*, 2020). These added factors will make predictions of impacts even more challenging.

As such, impact assessment and monitoring of extraction activities should not just embrace climate consciousness via coupled climate and biological modeling approaches, but include it as a core design criterium for impact assessment (Levin *et al.*, 2020). However, the accuracy of this approach given the lack of data and understanding, especially related to natural variation over space and time, is uncertain highlighting the need for robust baseline and pre-impact measurements, and the application of the precautionary approach in all management of mining activities. However, even if, through efforts dedicated to baseline data collection as well as component and full-scale test mining, a satisfactory knowledge base on the impacts of nodule operations can be gained, there will still be large unknowns related to the type and scale of cumulative impacts, including on ecosystem functions and services.

The current EIS template in Annex IV of the Draft Exploitation Regulations, while comprehensive, is not yet adequate (ISBA, 2019). The following expert comments from the Deep-Ocean Stewardship Initiative demonstrate some of the ways this document can become more fit for purpose encompass many of the recommendations already included in Section 7 (DOSI, 2019).

- The EIS template should begin with a clear definition of what constitutes an impact and the conditions under which mitigation, specifying what form, would be required.
- Specific goals and objectives, as well as the targets for meeting them, should be provided as the Contractor and the ISA can use during the creation and evaluation of the EIS.
- The template is currently a guide to format and populate the content of EIS, rather than being prescriptive or legally binding. The template should instead set standards that are implemented by Contractors.
- There were also suggestions that the Environmental Management and Monitoring Plan (EMMP) is listed as a separate document, but that it can be used as an opportunity to highlight

some of the key issues from the EIS to be addressed in the EMMP. The EIS and EMMP need to be tightly linked. The EIS should identify the parameters and activities that must be monitored and provide the metrics for both impact and mitigation; the EMMP needs to outline the implementation of a plan that will allow the obtaining of these metrics. The EMMP should directly refer to the EIS rather than to only key issues arising from it.

- Several sections list the need for defining mitigation measures, but there is no mention of testing mitigation measures or initial studies showing that certain measures are appropriate or effective, or who or what will determine the need for mitigation measures. It should be specified that justifications be given for all decisions when completing the template, including those grounded in peer-reviewed literature where possible.
- Maps showing the long-term spatial planning in the contract area, including the proposed project area, and related IRZ and PRZ, as well as zones of anticipated impacts, should be a requirement. Also the notation of special-interest areas identified by other regulatory or international bodies (including EBSAs, VMEs, PSSAs, MPAs, migration routes of endangered species, etc.) should be required.
- A section should be required on how the biological environment compares to regional biodiversity and meet the standards set by the respective REMP.
- Microbes are not currently taken into account but should be.
- The EIS template should incorporate climate change as: quantification of projected changes, inclusion in risk assessment, inclusion in mitigation planning, and quantification of mine project contributions to climate change.
- The EIS should include the characterization of the global-scale regulating and supporting ecosystem services (carbon burial and sequestration, nutrient cycling). Independent assessment in the monitoring process itself is currently overlooked.

6.4 Conclusions

The precautionary approach requires that exploitation contracts be granted only when the environmental impacts of commercial mining operations can be predicted with some certainty and are deemed societally acceptable. This is not the case in the foreseeable future, however learning from stepwise testing, in conjunction with a robust EIS process, could provide a better basis for decision-making on the acceptability of the mining activity. Crucially, the success of stepwise testing depends on the comprehensive assessment of the scientific accuracy, completeness and statistical significance of the EIS by experts, as well as a mechanism that ensures the feedback is taken into account and rectified (Durden *et al.*, 2018). Unfortunately, this final requirement has not yet been realized, as was demonstrated by the LTC's recommendation following their review of the draft EIS from India (Ministry of Earth Sciences and India, 2020). The LTC only recommended that improvements be made regarding the statistical reliability of the environmental impact statement in order to augment the evaluation of the main impacts, to strengthen the monitoring program and to enhance the sampling plan, despite there being many more fundamental flaws (ISBA/26/C/12/Add.1, B). This scarcity of feedback, as well as the insufficient quality control and weak enforcement, has highlighted major shortcomings in the effectiveness of the ISA EIS process and may lead to poorly informed decision making (compare chapter 6). It is of the utmost importance that a robust EIA process surrounding deep-seabed mining activities in the Area be implemented before further steps are taken toward commercial extraction.

Recommendations

- Both component and full-scale test mining should be seen as essential tools for predictions of the types, scales and intensities of potential commercial-scale mining impacts, information which needs to be available for decision-making on exploitation contracts.

- A high-quality EIA is underpinned by adequate baseline information; clarification of what levels of environmental baseline data are deemed as adequate is needed and appropriate and should take due account of the effects of climate change.
- A robust monitoring plan, adequate risk assessment and thorough reporting are also needed for an EIA, as well as its comprehensive assessment by independent (*i.e.*, who are not benefiting from the contractor) deep-ocean and marine-management experts.
- Strategic Environmental Goals and Objectives are needed as the essential starting point for assessing environmental responsibilities and to guide all decision-making.

7 Re-envisioning Test Mining during Exploration and Exploitation

Chapter 7 provides a re-envisioning of the existing functions and regulatory options pertaining to test mining at the exploration and exploitation stage, namely, through a compulsory two-phased approach to test mining that is based on a proposal submitted by Germany to the ISA in October 2019.[141] The chapter assesses the said proposal and discusses its potential implications.

7.1 The Proposed Compulsory Two-Phased Approach to Test Mining

In the comments submitted by Germany in October 2019 with respect to the current version of the Draft Exploitation Regulations, Germany proposed a number of new insertions that would, if adopted, make test mining (the conditions, requirements and procedures to be defined) a compulsory element of the applications for exploitation contracts and require contractors to not only make evident their technical ability to carry out activities in the Area, but also to demonstrate their ability to manage the ensuing environmental impacts that arise therefrom effectively. The main insertion made by Germany in relation to test mining can be found in proposed Draft Regulation 48bis, although numerous other insertions elsewhere also make references to test mining and give effect to Draft Regulation 48bis.

Excerpts from the Comments to ISBA/25/C/WP.1 Submitted by Germany in relation to Test Mining

Draft Regulation 7(3)

"An application [for a Plan of Work for exploitation] shall be prepared in accordance with these regulations and Standards and accompanied by the following: […]

[(a)bis] A **test mining study** prepared in accordance with Regulation [48bis] Paragraph 2 or 3, as applicable, and Annex [IVter]."

Draft Regulation 11

"1. The Secretary-General shall, within seven days after determining that an application for the approval of a Plan of Work is complete under regulation 10:

(a) Place the Environmental Plans and any information necessary for their assessment as well as the non-confidential parts of the **test mining study** on the Authority's website for a period of 60Days, and invite members of the Authority and Stakeholders to submit comments in writing, taking account of the relevant Guidelines; and

(b) Request the Commission to provide its comments on the Environmental Plans and the **test mining study**, prepared in accordance with Regulation [48bis] Paragraph 2 or 3, as applicable, and Annex [IVter], within the comment period.

Confidential information pursuant to Regulation 89 contained in the **test mining study** shall not be made publicly available.

2. The Secretary-General shall within 7 Days following the close of the comment period, provide the comments submitted by members of the Authority, Stakeholders, the Commission and any comments by the Secretary-General to the applicant for its consideration. The applicant shall consider the comments and may revise the Environmental Plans and the **test mining study** or provide responses in reply to the comments and shall submit any revised plans or responses within a period of 30 Days following the close of the comment period. All comments shall be published on the ISA-Website.

[141] Comments on the Draft Regulations on Exploitation of Mineral Resources in the Area (ISBA/25/C/WP.1), Submitted by the Federal Republic of Germany, 15 October 2019, at https://isa.org.jm/files/files/documents/191015_ISA%20draft%20exploitation%20regulations_comments%20Germany.pdf.

3. The Commission shall, as part of its examination of an application under regulation 12 and assessment of applicants under regulation 13, examine the Environmental Plans or revised plans and the test mining study in the light of the comments made under paragraph 2 above, together with any responses by the applicant, and any additional information provided by the Secretary-General.

4. Notwithstanding the provisions of regulation 12 (2), the Commission shall not consider an application for approval of a Plan of Work until the Environmental Plans and the test mining study have been published and reviewed in accordance with this regulation.

5. The Commission shall prepare a report on the Environmental Plans and the test mining study. The report shall include details of the Commission's determination under regulation 13 (4) (e) as well as a summary of the comments or responses made under regulation 11 (2). The report shall also include any amendments or modifications to the Environmental Plans recommended by the Commission under regulation 14. Such report on the Environmental Plans or revised plans shall be published on the Authority's website and shall be included as part of the reports and recommendations to the Council pursuant to regulation 15. [...]."

Draft Regulation 25(1)

"At least 12 months prior to the proposed commencement of production in a Mining Area, the Contractor shall provide to the Secretary-General a Feasibility Study prepared in accordance with Good Industry Practice, taking into account the Guidelines as well as the results of the **test mining study** pursuant to Regulation [48bis] Paragraph 2 or 3, as applicable, and in accordance with Annex [IVter]. In the light of the Feasibility Study and the **test mining study**, the Secretary-General shall consider whether any Material Change needs to be made to the Plan of Work in accordance with regulation 57 (2). If he or she determines that any such Material Change needs to be made, the Contractor shall prepare and submit to the Secretary-General a revised Plan of Work accordingly.[...]."

Draft Regulation 47(1)

"The purpose of the Environmental Impact Statement (EIS) is to document and report the results of the environmental impact assessment process (EIA process). The EIA process: [...](b) Includes at the outset a screening and scoping process, which identifies and prioritises the main activities and impacts associated with the potential mining operation in order to focus the EIS on the key environmental issues. This should be based on the prior **testing of equipment and operations** in the mining area under application and include an environmental risk assessment; [...]."

Draft Regulation 48*bis*

"1. The purpose of **test mining** is to ensure that no significant harm is caused by Exploitation activities. **Test mining** projects shall as a general rule provide evidence that appropriate equipment is available to ensure the effective protection of the Marine Environment in accordance with Article 145. To this end, a Contractor shall conduct **test mining**, in at least two critical stages, unless Paragraph 5 applies; firstly, when applying for an approval of a Plan of Work in accordance with Part II, and secondly, before Commercial Production shall commence in accordance with Regulation 25.

2. Before applying for an approval of a Plan of Work, a Contractor has to provide evidence to substantiate the required information in accordance with Regulation 7. A **test mining study** in accordance with Annex [IVter] shall be submitted with the application for the approval of a Plan of Work.

3. Before Commercial Production may commence in accordance with Regulation 25, a Contractor shall provide evidence demonstrating its ability to ensure effective protection of the Marine Environment, in particular, to show that no significant harm to the Marine Environment is likely to occur during the phase of Commercial Production. A **test mining study** in accordance with Annex [IVter] must be submitted to substantiate this.

4. Contractors should apply for the approval for **test mining** projects from the Authority in accordance with all relevant Standards and Guidelines. The potential effects of **test mining** projects shall be assessed in the form of an Environmental Impact Assessment. Potentially affected States, international organisations and relevant Stakeholders shall be consulted in accordance with the relevant Standards and Guidelines.

5. A **test mining study** pursuant to Paragraph 3 does not have to be submitted if the evidence required pursuant to Paragraph 3 has been demonstrated in the **test mining study** pursuant to Paragraph 2 or in a **test mining study** in the context of another approved Plan of Work. The Contractor has to submit relevant information to the LTC. The Commission shall decide whether the submission of a **test mining study** pursuant to Paragraph 2 is required."

Draft Regulation 92(1)

"The Secretary-General shall establish, maintain and publish a Seabed Mining Register [which] shall contain: […]

(b) The applications made by the various Contractors and the accompanying documents submitted in accordance with regulation 7 including any revisions, as well as any non-confidential parts of annual reports and the results of monitoring and **test mining** projects; […]"

A close perusal of the proposal put forward by Germany reveals a mandatory two-phased approach for test mining: first, prior to the application for an exploitation contract and second, prior to the commencement of commercial production at the exploitation stage. Put differently, pursuant to the German proposal, the results of test mining projects (*in situ* experiments) performed by contractors should be among the factors that would inform the decision-making process at the ISA with respect to the decision to grant an exploitation contract in the first step, and to the decision on whether or not to allow a contractor with an ongoing exploitation contract to proceed with commercial production in the second step.

With respect to the first phase, pursuant to the German proposal, a contractor holding an exploration contract who wishes to proceed with an application for an exploitation contract would be required to conduct test mining activities during the exploration stage. The results therefrom would be used to support its application for an exploitation contract. In applying for an exploitation contract, the contractor would have to submit, inter alia, a 'test mining study' to support its application. Note that the test mining study is one of between 10 to 12 requirements that must accompany an application for an exploitation contract. Furthermore, the submitted test mining study, alongside the Environmental Plans submitted by the contractor, shall be made open to public review (with confidential information redacted), followed by a review by the LTC. The application by the contractor shall not be considered until this review process is completed. Accordingly, it is important to note here that the results of the test mining projects by the contractor (as reflected in the said test mining study) will be one of several key factors for consideration by the LTC in determining whether or not to recommend the approval of the application. In this regard, the test mining study submitted by the contractor would serve as a form of evidence to inform the LTC of the contractor's technical ability and capacity to meet environmental requirements, which is already a pre-existing requirement that appear even in earlier versions of the Draft Exploitation Regulations.

The second phase recognizes that the procurement of an exploitation contract is only the starting point of the activity, because actual exploitation will only take place when the contractor moves on to commercial production (*i.e.* large-scale mining). In most cases, it will take up to 10 years and even more after the granting of the contract to procure investments, develop and assemble the necessary technology, as well as make to ensure all other related and ancillary matters are in order (e.g. transportation, logistics, processing, market conditions, etc.). Thus, the second phase of test mining is introduced to ensure that technologies and knowhow acquired by the contractor after receiving the exploitation contract would meet the technical and environmental expectations of the ISA as set out in the prior EIS and EMMP, and helps to subsequently verify the contents of those documents. This is even supported in an ISA Brochure, which, in referring to testing of mining systems at this phase (pre-commercial exploitation) and after observing that the "mining systems for these tests are assumed to be similar to commercial systems, but would operate for much shorter periods", goes on to state that "these test operations would provide the first opportunity for the accurate assessment of environmental impacts from long-term, commercial mining".

7.2 Understanding the Compulsory Two-Phased Approach to Test Mining

The two-phased approach to test mining proposed by Germany will support informed decision-making at the ISA, particularly from the environmental perspective, and therefore deserves serious attention. Several additional points are necessary for further contemplation here.

One, the two-phased approach recognizes that test mining projects conducted at the exploration stage and the exploitation stage are subject to distinct treatment, and accordingly, different expectations. In this regard, test mining experiments at the former stage are expected to be between small- and mid-scale levels, e.g. testing of one or several equipment or components of equipment, whereas experiments at the latter stage will be between mid- and full-scale levels.

Two, the results of such test mining experiments is intended to provide the decision-makers with reliable information and a more realistic picture of the activities that will take place and its actual impacts on the marine environment. This is essential for the ISA, especially at the very beginning of this nascent activity, to be able to carry out its environmental obligation under Article 145 of UNCLOS, as well as to exercise control over activities in the Area pursuant to Article 153 of UNCLOS. Especially at the early stages of such a novel activity, results from test mining activities would allow the ISA to better understand, and therefore better regulate, activities in the Area. Hence, the two-phased approach introduced by Germany could be interpreted as a 'necessary measure' pursuant to Article 145 to ensure the effective protection of the marine environment from harmful effects arising from activities in the Area. Apart from facilitating informed decision-making, the two-phased approach also allows for the incorporation of adaptive management strategies. In this respect, Germany's proposal makes room for an appropriate degree of regulatory intervention at critical phases. The proposal is also in line with the precautionary approach, which requires the ISA to be prudent and to exercise caution and take necessary preventive measures in the face of uncertainty. Moreover, test mining activities will also lend significant weight towards understanding 'best environmental practices', 'best available techniques' 'good industry practice' and other concepts that feature in the current version of the Draft Exploitation Regulations. The adoption of Standards and Guidelines, especially necessary ones that pertain to the environment, also interrelate with test mining.

Three, the said proposal gives effect to the common heritage of mankind nature of the Area and provides a more truthful evaluation of whether activities in the Area will benefit mankind as a whole. By requiring contractors to first demonstrate the impacts of their activities and their ability to manage these impacts, a greater degree of transparency is added to the process. In the long run, this lends legitimacy to the work of the ISA and the conduct of activities in the Area.

Four, the proposal serves the best interests of sponsoring States, whom would also be in a more advantageous position to supervise and exercise due diligence over the activities of the contractors under their sponsorship. Requiring contractors to first demonstrate their ability to manage environmental harm arising from their activities would give sponsoring States a greater assurance about the potential liability they might incur under international law if something eventually goes wrong. Without prior test mining and the contractor having demonstrated its ability to manage environmental impacts, sponsoring States are left in the dark and may yet be responsible under international law for the harm that is caused (unless it is able to show that it has met its due diligence and direct obligations).[142]

Five, the proposal by Germany also serves in the best interests of contractors. Firstly, it allows for a level-playing field across contractors, seeing that all contractors would be treated equally, and secondly, expenses incurred from test mining projects may be subject to deduction as expenditure costs. Six, the proposal considers test mining activities as mining, which by itself could cause significant harm, and therefore requires environmental impact assessments prior to testing. As seen with respect to the LTC Recommendations (ISBA/25/LTC/6/Rev.1) that applies to the exploration stage, this insertion is nothing new. Indeed, for the contractor, the assessment of environmental impacts should be seen as a continuous process that requires revision from time to time.

Lastly, the German proposal also entails the possibility of an exemption for the submission of a test mining study for the second phase under certain circumstances, *i.e.* if the test mining study during exploration or the test mining study of another contractor fully provides the necessary information. By this exemption unnecessary costs and delays should be avoided. Moreover, it also encourages contractors to collaborate and conduct joint test mining projects. However, it should be emphasized that the decision on whether or not to approve an exemption is to be made by the LTC, upon the contractor submitting all relevant information to support its request for an exemption. Potentially, the LTC would have to ascertain, among others, if the contractor will actually employ the same methods, equipment and systems as was used in the earlier test mining project, that the contractor has acquired the necessary technical capability and expertise to operate the said methods, equipment and systems, and that the environmental and physical conditions of the contract area is identical or comparable with the area that was test mined. A set of criteria for that purpose should be adopted by the Council.

What is the Compulsory Two-Phased Approach to Test Mining?

1. **Is it necessary to have compulsory test mining, or could it be optional?**

   Compulsory test mining prior to starting the exploitation phase and prior to commercial production is necessary for several reasons. First, it ensures a level-playing field across all contractors. Second and more importantly, the ISA will only be able to discharge its environmental obligation to ensure the effective protection of the marine environment by first requiring contractors to demonstrate their abilities to satisfactorily avoid, minimize and mitigate the harmful effects that arise therefrom. This will be imperative for getting a social license to operate in the Area.

   It is understood that test mining will result in expenses for the contractor. However, as explained earlier, contractors may be able to deduct this later as expenditure costs. It is also possible to foresee that some contractors may face unplanned delays if they are required to conduct mandatory test mining, seeing that they will only be allowed to proceed if they can show their ability to manage their activities. Nevertheless, compulsory test mining should serve to encourage contractors to invest in research and development in order to grow confidence in their capabilities. Finally, seeing that the Area belongs to mankind as a whole, including future generations, compulsory test mining is indispensable.

   The exact scope and contents of both test mining studies will need to be developed and agreed. Germany’s proposal includes a template for this purpose via Annex [IVter] of the Draft Exploitation Regulations, which has been left open for the moment in order for further deliberation.

[142] See Chapter 2.5 and the discussions on the 2011 Advisory Opinion (on the responsibilities and obligations of sponsoring States).

2. Is a two-phased approach to test mining necessary? Can it not be sufficiently dealt with only during the exploration stage?

A two-phased approach is indeed necessary, and covering test mining only at the exploration stage will be grossly inadequate. As is well known, the environmental impacts arising from commercial production is anticipated to be the greatest of all impacts related to the conduct of activities in the Area. Moreover, test mining projects at the exploration stage are only anticipated to be between small- and mid-scale levels, involving the mere testing of one or some equipment or the components thereof. A realistic account of the likely environmental impacts from full-scale mining activities at the exploitation stage and how these can be effectively managed is only possible through a two-phased approach. In addition, a two-phased approach will also benefit contractors as well as sponsoring States. Contractors would have a good indication of their abilities to meet the environmental requirements of the ISA, while sponsoring States will be able to justify having met some of the responsibilities attached to them.

In order to satisfy the contractor´s need for security of tenure and the ISA´s interests in ensuring the technical capabilities of the applicant and the environmental consequences of the operation, as well as to exercise and maintain control over the activities of the contractor, it was suggested that the ISA roll out a relatively slow, stepwise process towards commercial production. The proposal put forward by Germany when considered in this light is a good compromise that protects the interests of both sides.

3. What should be done with the information acquired through test mining?

Environmental information and data obtained through test mining should be shared with the public via the test mining study submitted through the ISA. Confidential data and information, particularly about equipment design, may be withheld through prior agreement with the ISA. One aspect that needs to be greatly improved is what the ISA does with incoming data. This should not only be uploaded onto a database, but it should be processed, evaluated and synthesized, in order to be transformed into useful knowledge to develop environmental criteria and thresholds.

Ideally, the ISA would not only store the information contained in the reports from test mining, but use it to gain experience with the type and scale of impacts in different habitats, and related to different types of activities and different gear tested. This could not only inform an assessment framework but also help inform Best Available Techniques and Best Environmental Practice, both of which are among the principles for developing the resources of the Area.

For the ISA as a regulator, the results derived from test mining activities, including the compilation and evaluation of incoming environmental monitoring results from post-testing are highly relevant for developing an environmental assessment framework, appropriate indicators and thresholds to enable informed decision-making. Moreover, as proposed by Germany, the test mining study would be one of numerous documents to be considered by decision-makers. It is a form of information to make evident the technical ability of the contractor as well as the capability to avoid, minimize and mitigate the environmental impacts that arise. This would serve to improve the process and build confidence in the system.

4. Should there be a distinction between contractors that have conducted test mining at the exploration stage and contractors that have not?

Contractors that have conducted test mining at the exploration stage would have submitted a test mining study with their application for an exploitation contract. The test mining study will serve as information and evidence to facilitate informed decision-making at the ISA. If test mining is made compulsory, as explained above, a contractor would not be permitted to submit an application for exploitation. Indeed, this is advantageous to a contractor, because it adds more credence to the procurement of an exploitation contract. It is anticipated that if equipment and techniques have been previously tested and certified with respect to the same resource type and in a comparable environment, and the contractor is able to prove that such equipment and techniques will indeed be used and that it has the expertise and knowhow to apply it, an exemption in the form of a reduced scope of testing may be considered.

5. **Are test mining projects subject to environmental impact assessments processes? If yes, is an EIA process always required for all test mining project?**

Test mining activities are mining activities, capable of causing negative environmental impacts. Accordingly, environmental impact assessments are both necessary and essential for the contractor as well as the ISA as a regulator. This is the existing position for test mining at the exploration stage, as seen in the applicable LTC Recommendations (ISBA/25/LTC/6/Rev.1). However, in contrast with previous versions, the latest version of the said Recommendations for contractors only require an Environmental Impact Statement, EIS, from the contractor. This report is expected to include the EIA, prepared exclusively by the applicant/contractor. In some jurisdictions, e.g. the US, an EIS merely identify and disclose eventual harm, however do not influence the decision on a given project.

Regulatory control over the EIS to be produced by the contractor would be improved, if environmental impact assessment would be pursued as a participated process, driven by the ISA as regulator. An EIA process would not only include a (public) scoping phase but also ensure that wider considerations e.g. arising from possible transboundary issues or Regional Environmental Management Plans, as well as appropriate public participation are taken account of. It is useful to see environmental impact assessments as an incremental process, which the operator conducts under guidance of the regulator, leading to the final endorsement for commercial operation. Since the current framework remains to be unclear, particular attention is needed to clarify the EIA/EIS process in the context of activities in the Area.

Finally, it would be necessary to consider if an EIA/EIS is required for all test mining projects. It is important to acknowledge that test mining is one of the only ways that the work of the contractor and its potential environmental impacts can be publicly scrutinized and for such knowledge to be made available in the public domain. Hence, the conduct of EIA/EIS will also serve as much needed information for all stakeholders – *i.e.* not only the regulator – and therefore this is an important procedural requirement as a matter of good governance and transparency.

Whether a not separate EIA/EIS will be required for each test mining project would depend on the circumstances. If the nature of the test mining project is different from earlier projects, e.g. testing of different equipment or components of equipment, or is to be conducted in a different contract area where the physical and environmental conditions are not identical or comparable to the area of the previous test mining projects, a new EIA/EIS will be necessary. If the nature of the test mining project is similar to earlier projects or if it is merely a follow-up to an earlier test mining project, the requirement to carry out an entirely new EIA/EIS process may be dispensed with and reduced accordingly (e.g. limited to the reporting of the planned activity, a description of the equipment or system in question and a periodic report on the related long term monitoring programme).

The environmental monitoring of all testing activities should be cumulatively reported on in order to enable an appropriate evaluation of the environmental effects. It is suggested that more clarity is provided for this through ISA regulations or via Standards and Guidelines, and that the LTC be entrusted with the responsibility to determine whether the requirement for the contractor to conduct a new EIA/EIS can be dispensed with and reduced (based on prior EIA/EIS for test mining projects that have been submitted and accepted).

6. **When is an exemption for the submission of a test mining study possible?**

As provided for in DR48bis at paragraph (5), an exemption may be granted for the requirement to submit a test mining study at the second phase (*i.e.* before commercial production). An exemption may be granted if the test mining study submitted at the first phase is determined to have satisfied the requirement to provide the ISA with all the necessary information and evidence needed in order to allow the contractor to progress with commercial production. An exemption may also be granted if a test mining study from another approved plan of work has provided the necessary information, including potential site-specific impacts, and evidence to the ISA. It should be emphasized here that an exemption is not automatic; rather, a contractor would have to provide the LTC with all necessary information to support a request for an exemption. The LTC will determine, on a case by case basis (e.g. through a scoping process), whether an exemption is appropriate. Potentially, the LTC would have to ascertain, among others, if the contractor will actually employ the same methods, equipment and systems as was used in the earlier test mining project, that the contractor has in fact since acquired the necessary technical capability and expertise to operate the said methods, equipment and systems, and that the environmental and physical conditions of the contract area is identical or comparable with the area that was previously test mined. A set of criteria for that purpose should be adopted by the Council.

Finally, it should be noted that DR48bis paragraph (5) does not envisage the granting of an exemption for the first phase of test mining (*i.e.* before the application for a plan of work for exploitation). This distinction is primarily because contractors who wish to proceed to the exploitation stage are expected to already conduct some form of test mining during the exploration stage. Making this an absolute mandatory requirement, *i.e.* under which the granting of an exemption is not appropriate, will help to ensure that exploitation contracts are only awarded to deserving contractors, who have demonstrated their ability to manage the harmful environmental effects of their activities. Of course, this presupposes that the ISA will evaluate and synthesize the test mining information provided by contractors, in order to ascertain the capabilities of the contractors. This will also allow the ISA to verify best available techniques and best environmental practices.

It may also be worthwhile, however to consider the granting of exemptions during the exploration phase in future, for example, once experience, expertise and good industry practices have sufficiently developed, especially for applicants that have held previous contracts and successfully demonstrated their ability to manage environmental impacts. It is foreseeable that at some point in future, once technological developments have matured, that the exploration stage will be used more for the search of minerals and determining extraction feasibility, as opposed to testing technologies or techniques. In such an event, and provided that the effective protection of the marine environment is ensured, the ISA might consider developing a 'fast-track' approach and allow for test mining exemptions.

7. How does the compulsory two-phased approach to test mining differ from the 'provisional exploitation contract' approach?

The 'provisional exploitation contract' essentially refers to the phase between the end of exploration and the start of commercial production. It envisions an additional contract, of a provisional nature, for which the provisional contract holder will have some time (approximately three years) to prepare and carry out a pilot commercial operation. The provisional contract holder will then use the data and results from this pilot commercial operation to prepare

In many respects, the 'provisional exploitation contract' approach corresponds to the compulsory two-phased approach to test mining. In particular, the second phase of the latter also targets the phase between the end of exploration and the start of commercial production. The compulsory two-phased approach also requires full testing of mining systems and operations before a contractor with an exploitation contract is able to proceed with commercial production. Crucially, both approaches also involves the opportunity for regulatory intervention, *i.e.* the possibility for the ISA as regulator to not allow the contractor to enter into commercial production.

That said, it also has several differences. First, under the two-phased approach, testing activities during the exploration phase is already a requirement. Second, once a contractor obtains a contract pursuant to the two-phased approach, the contractor would be able to use it as an instrument of security (e.g. mortgage or lien) in order to leverage funds to finance its operations. Third, prior EIAs are required before test mining activities take place under the two-phased approach, and contractors must submit test mining studies to the ISA, which will be considered in the context of the applicable decision-making processes. Finally, if a contractor does not meet the required threshold to proceed with commercial production, the said contractor still remains in possession of the exploitation contract and the value that comes with it. Thus, the contractor in question may decide to keep trying on its own, partner with another entity, or entirely transfer the rights and obligations under the contract to a third party (with the consent of the ISA).

In short, the compulsory two-phased approach also targets the exploration stage, and provides the contractor with a little more certainty, security and value.

8. What about security of tenure?

The security of tenure provisions under UNCLOS and standard clauses in the contract provide assurance to the contractor that the conditions of the contract and the exclusive rights of the contractor would not be terminated or suspended except in accordance with the terms of the contract itself. Section 4.1 of Annex X (Standard clauses for exploitation contract) of the Draft Exploitation Regulations stipulate that: "The Contractor shall have security of tenure and this Contract shall not be suspended, terminated or revised except in accordance with the terms set out herein". Moreover, Annex X also includes an undertaking clause, whereby contractors undertake to comply with the regulations and decisions of the relevant ISA organs. Assuming the compulsory two-staged approach is adopted in the forthcoming Exploitation Regulations, it may be necessary to also insert a contractual term in each exploitation contract that is awarded stating that the contractor would not be able to proceed with commercial production without the prior approval of the ISA, the decision of which is to be premised on the final test mining study of the full test mining operation submitted by the contractor (unless an exemption applies).

9. What about the commercial interests of contractors?

It is obvious that while the introduction of a compulsory two-phased approach to test mining could be viewed favourably by some contractors, it might not appeal to others. In particular, the possibility of regulatory intervention, particularly at the second phase (prior to commercial production) may cause anxieties and difficulties to contractors. However, in one sense, it might actually be interpreted as fair and facilitative of a level playing field, since all contractors would be required to demonstrate their abilities to minimize and control the harmful effects from their activities. It would also make sense for contractors to dedicate more effort and attention towards aggressive testing at the exploration stage, in order to ensure that it would have smooth passage to commercial production once it obtains the exploitation contract.

That said, it is acknowledged that some contractors may choose to wait until it comes into possession of the exploitation contract before procuring or constructing complete mining systems. Hence, contractors that are unable to do most testing during the exploration stage could still be permitted to proceed to the exploitation stage, as long as they are able to provide a feasible plan for testing activities and willing to run the risk that they would not be permitted to enter into the commercial production phase until they are able to demonstrate their ability to minimize and control the environmental impacts of their activities to the satisfaction of the ISA.

As an alternative to the compulsory two-phased approach to test mining, the possibility of creating a 'provisional exploitation contract' can also be considered; however, this does not really alleviate the concern that regulatory intervention may prevent the contractor from eventually proceeding with commercial production unless the contractor can first demonstrate its ability to minimize and control the environmental impacts of its activities.

In this respect, it is essential to prioritize the value of the Area and its mineral resources as the common heritage of mankind, the need to ensure that mining activities are conducted for the benefit of all of mankind and the importance of safeguarding the effective protection of the marine environment over the individual commercial interests of some contractors. Given the presumed high-risk of the activity and the prevailing uncertainties on the scale of its potential harmful effects, it is logical to err on the side of caution and impose stricter requirements, as well as to reverse the burden of proof onto the proponent, at least until more knowledge and experience is accumulated.

10. What could be a reasonable regional approach to test mining?

In theory, a regional approach to test mining would be possible, although it is uncertain if there is enough widespread interest and political will for this. Contractors are permitted, and in fact encouraged, to collaborate on test mining projects (see ISBA/25/LTC/6/Rev.1). If this is the case and two or more contractors choose to collaborate and conduct joint test mining projects over one contract area for the same resource type in the same region, the contractors involved may under certain circumstances be exempted from further test mining requirements – provided they can convincingly demonstrate that their contract area is of an identical and comparable environment, and that they will in fact deploy the same equipment and mining system as well as acquire the necessary knowhow and expertise.

Another relevant consideration is whether the ISA could, as regulator, authorize and/or lead a test mining project for a particular region, especially in the light of developing Regional Environmental Management Plans (REMPs) for the said region. It should be noted that as the regulator, the ISA may authorize contractors to collaborate with each other in conducting joint test mining projects, but should however refrain from taking charge of such a project. However, this would be an interesting point for consideration if the Enterprise is duly operationalized and is tasked to take charge of this endeavour. Since it is the entrepreneurial arm of the ISA and is effectively a contractor on its own right (albeit representing mankind as a whole), the Enterprise would be well-poised for this purpose. In fact, this would serve the additional benefit of empowering the Enterprise with the relevant expertise and knowhow, which is an obligation under UNCLOS read in light with the 1994 Implementation Agreement on Part XI. As such, the operationalization of the Enterprise and charging it with a regional test mining endeavour with the collaboration of other existing contractors in the region might be an effective way to move forward.

7.3 Assessing the Compulsory Two-Phased Approach to Test Mining

While the German proposal certainly is very useful, there appears to be some shortcomings that are worthy of a discussion. The following points might be taken into account as the proposal is considered and debated at the Council of the ISA.

First, it is arguable that test mining should be fully regulated and required at the exploration phase. In other words, alongside the gathering of environmental baseline data, all test mining activities should also be required to be conducted during the exploration phase. All the results obtained from test mining projects, i.e. information and data, should then feed into the EIA process and feature in the EIS that is expected to be submitted alongside an application for the approval of a plan of work for exploitation. In other words, as examined in previous chapters, the use of models is not sufficient and *in situ* test mining is essential to generate the knowledge that is necessary to comprehend the nature and extent of the environmental impacts that are to be expected from commercial mining. Therefore, the testing of mining equipment and systems (including riser) should be required during the exploration phase as a pre-requisite to preparing the EIS required under the Draft Exploitation Regulations. While it is understandable that the scale can be reduced, but a full operation test would be necessary so that the results can be up-scaled using models. It is important to note that while the Exploration Regulations could be amended to reflect this, it is still possible to require this via the forthcoming Exploitation Regulations. In this respect, the future Exploitation Regulations could provide that the results from test mining projects conducted during the exploration phase should be collated into one final study, submitted alongside the application for an exploitation contract, and be incorporated into the EIS that is also submitted thereto. In this sense, collating all the test mining reports into one ultimate study or report and preparing the final EIS would not be a duplicity of efforts, since they would both feature hand-in-hand. Moreover, making test mining compulsory for all exploration contracts under the Exploration Regulations would not be rational, given that there would be no need for exploration contractors that do not wish to submit an exploitation application to conduct test mining projects. As such, this requirement for all necessary testing to be conduct already at the exploration phase could easily fit within the future Exploitation Regulations. In any case, most of the documents currently required by the Draft Exploitation Regulations would have to be prepared during the exploration phase anyway, as the regime does not currently anticipate a transition phase (e.g. provisional exploitation phase).

Second, which is related to the above, is that the second phase of the German proposal is not entirely clear. It is assumed that an EIA/EIS is not needed for test mining at the exploitation phase since this would presumably be covered in the earlier EIS that was submitted at the application stage, which would cover commercial-scale mining activities. That said, if there is a change in the technologies or methods that will be employed from the ones that were initially documented, a subsequent EIA/EIS should be required prior to the testing. Apart from that, there is a slight ambiguity with respect to what testing is required at the second phase, assuming that the argument made earlier that all necessary testing should be conducted at the exploration phase is accepted. It seems like the German proposal does consider that considerations may differ between contractors and their various business models, which although would be appealing especially to commercial contractors, may not be in the best interests of the marine environment. In this respect, it should be acknowledged that the German proposal does envisage an exemption process at the second phase for contractors that have already demonstrated all necessary testing during the exploration phase. In any case, the German proposal does not make explicit that all contractors should be required to conduct a full scale test operation prior to commercial production in order to verify if the environmental harm that would occur from commercial mining is along the lines as predicted under the accepted EIS and will be managed and controlled according to the contractor's Environmental Management and Monitoring Plan.

Third, again also related to the above, there is no clarity in the distinction between the second phase of the German proposal and the current requirement under the Draft Exploitation Regulations for the submission of a 'feasibility study' prior to commercial production and the determination on whether or not there is a 'material change' to the approved plan of work. This lack of clarity is possibly also due to the fact that there are uncertainties with respect to what this feasibility study entails, which appears to be more concerned with technical and economic feasibility to accomplish the approved plan of work rather than environmental feasibility (although the definition accorded to feasibility study in the current Draft is as follows: "comprehensive study of a mineral deposit in which all geological, engineering, legal, operating, economic, social, environmental and other relevant factors are considered"). The second phase of the German proposal would be useful here, i.e. to require a full-scale test for a certain duration, now that the contractor should be expected to have all equipment and technologies ready to conduct commercial scale extraction at this stage. The results from the full scale test could then feed into the feasibility study, which would help the ISA determine whether or not a 'material change' to the plan of work is needed. In this respect, it is preferable that this determination is left to the LTC (and not to the Secretary-General of the ISA, as the Draft Exploitation Regulations currently envisage) since this is highly technical matter requiring expertise and not an administrative one.

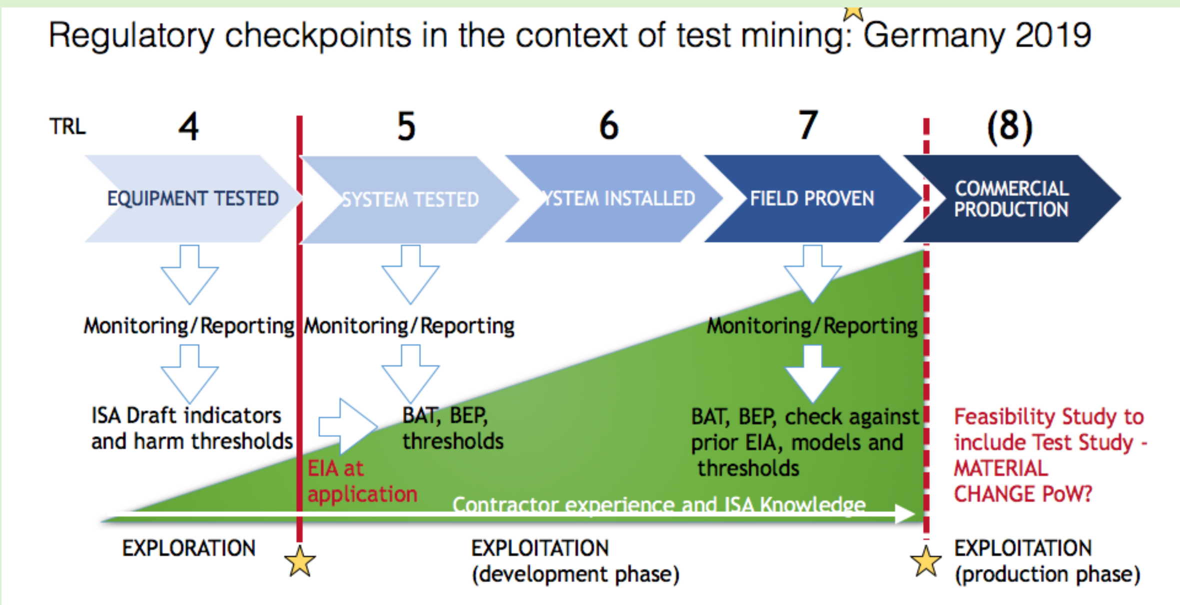
Fourth, the German proposal does not fully engage with or reflect upon an earlier proposal to introduce a transitional phase between exploration and exploitation, where a successful applicant would first be granted a provisional exploitation contract in order to use this time to conduct proper testing of equipment and systems that would be used at the exploitation stage. It might be worth reconsidering if this approach is more desirable, since the award of an exploitation contract would add pressure on the ISA to allow a contractor to proceed with commercial production (given the contractor's security of tenure), whereas the ISA could still disapprove to convert a provisional exploitation contract into a tenured one in the case of a transitional phase. Finally, there is a need for more clarity in the German proposal on reporting requirements and the types of data collected from test mining projects, in particular with respect to the confidentiality.

An Overview on Re-envisioning Test Mining

The primary concern coming from private industry relates to the decision-making step[143] ahead of the commercial production phase. It may well be the case that some contractors would aim at technology development only after the contract on exploitation is concluded. With this model, the contract is likely to be awarded based on insufficient knowledge on the environmental impacts of the technology, while the current "material change" evaluation in conjunction with a feasibility study will either necessarily lead to an EIA right before commercial production, or not be appropriate for assessing the environmental consequences of the commercial operation. The German proposal seeks a compromise, requesting a test mining study to presumably supplement the "feasibility study" (see

Figure 5).

Figure 5: Permitting procedure as proposed by Germany 2019. Prior EIA/EIS during application for exploitation (red vertical line), and consideration of "material change" compared to prior EIS (dashed vertical red line) ahead of commercial exploitation. The Technical Readiness Level, TRL, is linked to the progressing development of the commercial mining system. Contractor experience and ISA knowledge increase over time.



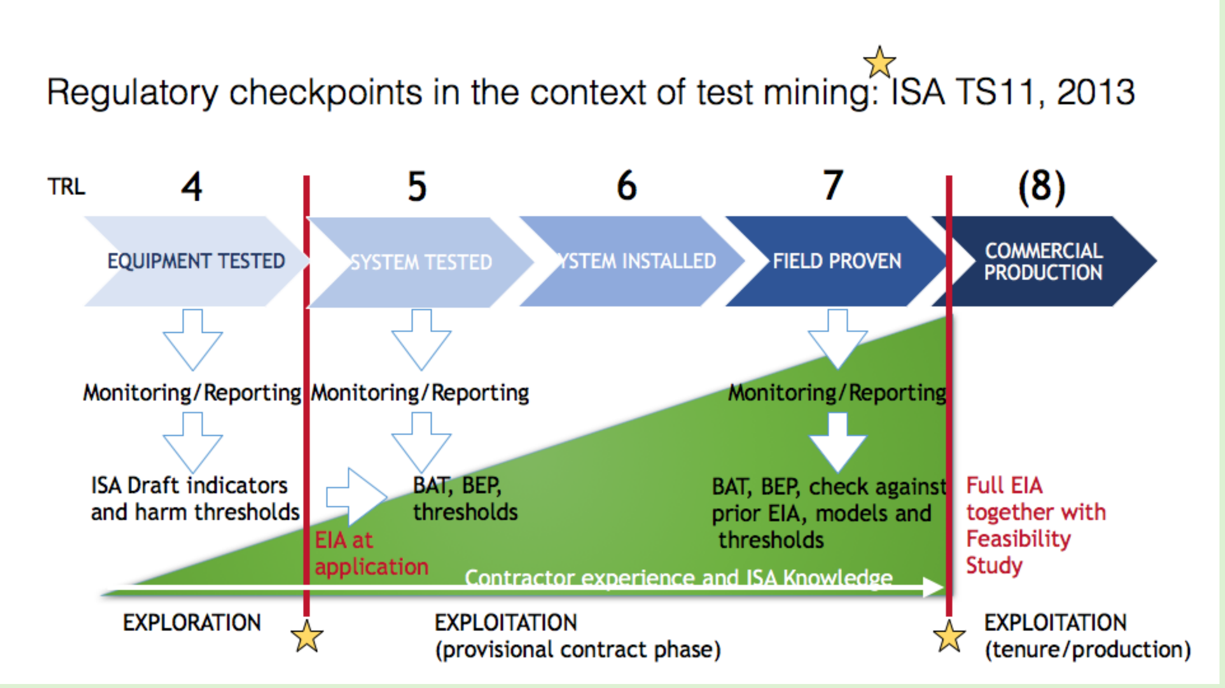
Source: own illustration, IASS

Another alternative to the German proposal would be the introduction of a 'provisional exploitation contract' approach, whereby at the end of an exploration contract, the contractor would apply for a provisional exploitation contract (lasting for a duration of at least three years), in which the contractor would be given the opportunity to plan and execute a large-scale test mining project (International Seabed Authority, 2013). The outcomes from this exercise can be used to feed into a

143 Also known as regulatory intervention.

proper and comprehensive EIA, which will then be used to support an application for a tenure exploitation contract (see Fig. 6). However, the one downside of this approach, as compared to the German proposal, is that it is unlikely that the contractor would be able to use the provisional mining contract as an instrument of security in order to obtain financial support for its operations (as opposed to a full exploitation contract).

Figure 6: Permitting procedure as proposed by ISA Technical Study No. 11, 2013. A provisional contract for exploitation is concluded after the approval of a prior EIA/EIS during application (red vertical line). A full EIA of impacts caused by the commercial system has to be passed prior to commercial production. Technical Readiness Level, TRL, is linked to the progressing development of the commercial mining system. Contractor experience and ISA knowledge increase over time.



Source: own illustration, IASS

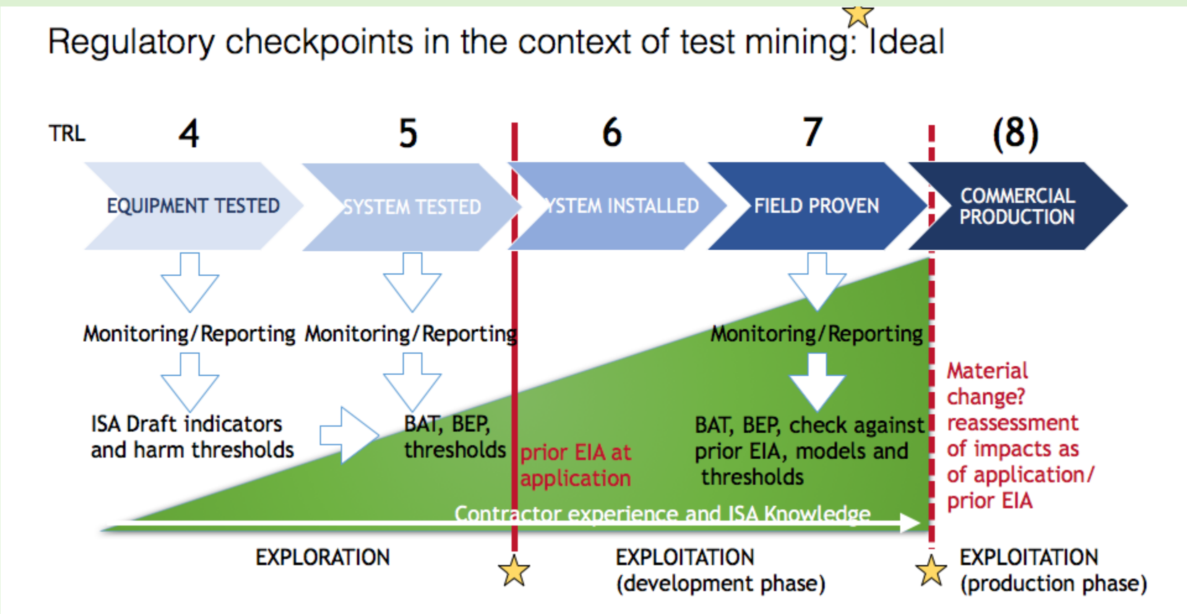
It is also necessary, on the other hand, to put more thought into considering if it would be better to require applicants for exploitation activities to conduct all test mining activities[144] during the exploration phase so that a reliable and comprehensive EIA/EIS can be prepared and produced with the application for an exploration contract (see Figure 7). This approach might be supported by some (usually State) contractors, who would prefer to conduct entire systems tests already at the exploration stage, although it may not be as favourable for private commercial companies that would perhaps prefer to have the contract in hand before being in a position to procure additional funds and acquire the necessary technologies. From the perspective of a State contractor or a sponsoring State, it is obviously in their best interest to be fully aware of the likelihood and extent of environmental harm that can be expected to occur during commercial mining already before applying for or agreeing to sponsor an application for the approval of a plan of work, since States are accountable and can

[144] This would imply the need to conduct the testing of the equipment and systems until TRL (Technological Readiness Level) 5 or 6, see Figures. On the one hand, TRLs are a hot issue because normally used internally to characterize the progress of a technical development. In other words, it is not typically coupled with regulation. On the other hand, it is very illustrative of what is meant and required.

be held liable under international law for environmental harm arising from the mining activities they conduct or sponsor.

With this model, contractors would achieve the contract based on best-available knowledge and measured against existing, stringent quantitative protection thresholds. During the exploitation phase they are of course free to continue technology development and build the commercial systems. However, prior to commercial production, it will have to be reassessed whether there has been a 'material change' in the plan of work (e.g. substantial change in technology, equipment, process, or environment). Further testing of the system may be conducted to help to demonstrate that the existing Plan of Work is still valid or requires revisions. If there is a "material change", such as a change in the technology or method that was proposed to be used earlier, then ideally the ISA should require a second EIA/EIS with public consultation to be conducted. In this respect, clarity pertaining to the roles and responsibilities, procedures and criteria for determining "material change", as well as who determines this (which preferably should not be left to the Secretary-General, as the current version of the Draft Exploitation Regulations envisages, and perhaps entrusted to the LTC instead) is required.

Figure 7 : Permitting procedure needed to ensure full understanding of environmental impacts at the application stage: all major testing and reporting information is available in the prior EIA/EIS during application for exploitation (red vertical line). The development phase is used to build and test full-scale mining system. Prior to commercial production, the assumptions on which the prior EIS and EMMP were adopted are examined in a post (dashed vertical red line) Technical Readiness Level, TRL, is linked to the progressing development of the commercial mining system. Contractor experience and ISA knowledge increase over time.



Source: own illustration, IASS

If the model in Fig. 7 is to be preferred, it remains to be determined what will constitute a sufficient information basis for the assessment of the likely risks and effects of the future commercial operation. Prior to be able to do this, it has to be clear what amounts a satisfactory environmental baseline description, in order to be able to determine any effects from testing/mining from uncertainties arising from sampling and analysis as well as natural variability.

7.4 Conclusions

From the above, it can be gleaned that the mandatory two-phased approach to test mining as proposed by Germany is not just useful, but also necessary, to facilitate informed decision-making, to meet the environmental obligation of the ISA (effective protection, adaptive management and the precautionary approach), to respect the nature of the Area as the common heritage mankind and for activities in the Area to benefit to mankind as a whole, to ensure a level-playing field, as well as to adhere to established principles of good governance (transparency, legitimacy and accountability). Premised on this, it is the responsibility of contractors to conduct their activities transparently and to diligently report all relevant results to the ISA, and it is the responsibility of the ISA to assess, evaluate and synthesize all incoming data and information and to exert control over the environmental performance of contractors. Finally, it is of paramount importance to resolve the requirements of test mining ensure a level playing field through a standardised procedure that applies to all contractors seeking to move from prospecting to exploration, from exploration to exploitation, from exploitation to commercial production, and from commercial production to closure of mine sites.

8 Conclusion

At present, there is no formal regulatory requirement for test mining in the rules, regulations and procedures of the ISA. Thus, unless a pre-condition is set in the Draft Exploitation Regulations, in theory, contractors are able to obtain an exploitation contract and proceed with commercial production without first demonstrating their ability to actually conduct mining activities and provide for effective protection of the marine environment from arising impacts. That said, the argument is put forward that the requirement to conduct test mining, even though no explicitly required under ISA regulations, is implicitly required from contractors, premised on which, it can also be seen as a due diligence obligation for the sponsoring State to ensure that test mining activities are satisfactorily conducted by the sponsored entity.

Results from the environmental monitoring of various test mining exercises, particularly at the current state of affairs where the regime is still under development and the development of environmental standards, objectives and thresholds are under consideration, will be extremely useful to enable the ISA to carry out its function as the regulator of mining activities. The information attained through test mining will build a knowledge- or evidence-base on the type and scale of harm to be expected, and the development of quantitative environmental standards, reliable models of impacts, best environmental practices and eventually best available techniques. These steps will eventually be the foundation for decision-making at the ISA on the need to adopt necessary measures for the effective protection of the marine environment from mining activities.

Due to the potentially large size of the mining areas concerned and the difficulties of sampling, models will still play a crucial role in the forecasting of the potential impacts of commercial mining activities. Physical models are in the very early stages with many limitations, and ecosystem modelling is as yet not possible; therefore, *in situ* data are of crucial importance for any progress. Test mining in conjunction with a comprehensive monitoring programme would be able to generate reliable data, which will feed into the modelling process, and thereby contribute to ensure more accuracy in predicting the potential impacts arising from mining activities. Of course, this presupposes that contractors would have already established a reliable environmental baseline – which seemingly does not exist in any one contract area to date.

From a scientific and environmental governance point of view, mining tests of various scales are indispensable for gaining knowledge and experience with the degree of resilience of the deep-sea ecosystems to disturbances of various types and spatial and temporal scales. For society, such knowledge is essential to be able to evaluate the benefits and costs of deep seabed mining in the common heritage of mankind. Likewise, for the ISA, which is mandated to ensure the marine environment from harmful effects of mining-related activities and act on behalf of mankind as a whole, testing is an important opportunity to learn about the technical development of deep seabed mining equipment and systems, as well as to

- Check the suitability of process standards and guidelines;
- Identify the biological parameters that record the impact of mining most reliably;
- Indicate preliminary thresholds of pressures and impacts;
- Identify patterns in natural variations in environmental conditions against which impacts of the mining tests will be assessed (control area);
- Assess the total impact area affected by the plume of resuspended sediment from mining equipment and discharge of return process water over longer time scales;
- Help define the appropriate location of control sites in relation to commercial mine sites;
- Inform the appropriate size and location of mine sites (how many, how close, extent of buffer zones required to prevent transboundary impact etc.).

Therefore, when considered strictly from a scientific and environmental governance point of view, the need to have large-scale test mining and a comprehensive EIA based on the outcomes of such testing is fundamental; anything else would be a compromise. Nevertheless, it is an open question as to whether there is a political will at the ISA to give effect to this approach. Tests of technical equipment *in situ* are challenging in technical terms but also in terms of time required for such tests in remote, inaccessible locations, and particularly the involved cost for large scale testing. Therefore, it is possible that some contractors would prefer to delay substantial mining tests to the "exploitation phase", *i.e.* after having concluded a contract for exploitation with ISA. Nonetheless, for environmental governance, it is of utmost importance to get a near-to full picture of the environmental impacts to be expected from the commercial operations prior to entering into contractual obligations for decades to come.

This implies that contractors should already be required to conduct near-to-full scale mining system tests during the exploration phase. As it currently seems, the machinery of *e.g.* nodules of contractors will not substantially differ in their environmental impacts, which could support consideration of a joint test mining operation, jointly funded and to take place in one of the exploration areas with the system of one or more of the contractors. Indeed, collaboration between contractor and scientists with respect to joint testing should also be promoted as this would be mutually beneficial to everyone. As long as this test can be considered representative of the range of mining systems to be applied in say the Clarion-Clipperton Zone, and it is of long-enough duration, then such a joint test could provide for the most important information on the environmental effects, required for decision-making on environmental governance of the activity. A supplementary set of requirements for contractors to inform on local conditions and predicted effects from their own technology would then have to be developed to inform the prior EIAs submitted with their individual applications for exploitation. This joint test mining operation should be given due consideration at the ISA as it would encourage contractors to work in collaboration with each other, as opposed to in competition with each other, and allows for the exchange of expertise and experience. In this respect, the immediate operationalization of the Enterprise should also be considered, so that contractors and scientists could work together with the Enterprise to conduct joint test mining projects. Not only would this allow the Enterprise to come into existence as the one contractor that truly acts on behalf of mankind, it would also enable the Enterprise to gain experience and develop necessary expertise to conduct mining activities in future.

Unless conducted as a long-term and near to full-scale mining test, it will remain extremely difficult to conclude from trial mining on the effects to be expected from commercial-sized mining on the marine environment. In this respect, test mining will provide some much needed knowledge to facilitate informed decision-making – without which, the ISA would almost be evaluating mining applications with a blindfold on. Consequently, it becomes a critical policy decision whether and how much of the common heritage of mankind will be sacrificed directly and indirectly, and which added loss of ecosystem functions and services will be considered acceptable - knowing that no projections are possible to predict the full ecosystem effects of one or more deep seabed mines.

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