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CC:
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May 20, 2020

Re: Stakeholder Consultation for Deep-Sea Mining System Trials by MoES (India) in the Central Indian Ocean Basin

Dear Sirs,

Below, please find our Commentary on the Environmental Impact Statement for a Polymetallic-nodule Collector Pre-prototype for Deep-sea Mining issued in March this year by the Government of India's Ministry of Earth Sciences.

As Group Leads, we submit on behalf of the Deep-Sea Minerals Working Group of the Deep-Ocean Stewardship Initiative (DOSI). The list of contributors is presented at the beginning of the document. Express Consent for sharing is granted.

Sincerely,

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COMMENTARY ON THE ENVIRONMENTAL IMPACT STATEMENT FOR A POLYMETALLIC-NODULE COLLECTOR PRE-PROTOTYPE DEEP-SEA MINING MACHINE IN THE INDIAN CONTRACT AREA OF CENTRAL INDIAN OCEAN BASIN

Issued by the Government of India's Ministry of Earth Sciences (MoES)

PREFACE

The Deep-Ocean Stewardship Initiative ("DOSI") integrates science, technology, policy, law, and economics to advise on ecosystem-based management of resource use in the deep ocean and strategies to maintain the integrity of deep-ocean ecosystems within and beyond national jurisdictions. DOSI gathers expertise across disciplines, jurisdictions, and industrial sectors to foster discussion, provide guidance, and facilitate communication. As a distributed network, DOSI has over 700 members from 40 countries and was granted Observer Status at the 22nd Session of the International Seabed Authority in Jamaica in 2016.

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SECTION A. GENERAL COMMENTS

1. When compared with the '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 Environmental Impact Statement (EIS) is incomplete, inaccurate, and not statistically robust.
2. While there have been significant efforts and resources dedicated to collecting environmental and biological data, the baseline is incomplete and not fit for purpose. In some cases, it is missing entire components e.g., microbial activity, water-column biology, ecosystem function. As a result, it will not enable monitoring results to establish that there is no serious harm from activities being conducted on the seabed, in midwater, and in the upper water column. A better understanding of all components, especially biological, are required, and should be gathered using best available science.
3. There is a lack of definition and identification of impacts associated with the collector trial that will allow assessment of the impact and that will inform future impact studies. Key questions arising from environmental sciences include the 3-D extent of the plume, water-column disturbances caused by the plume, loss and recovery of benthic taxa and microbial functions, and effects of scaling up. The metrics and methods needed to assess these impacts are not summarized in the introduction, nor is the sampling effort required to provide scope for robust statistical analysis for most metrics.
4. The plan for the environmental impact assessment and monitoring of proposed activity is not described in sufficient enough detail to understand whether it will effectively assess impacts. A robust monitoring plan is of critical importance and should be included in the future.
5. The EIS often states that there will be no impact from deep-seabed mining to various aspects of the environment, despite incomplete baseline data and therefore understanding to confirm these assumptions. Instead, the EIS should state that there is a high level of uncertainty.
6. There are several instances within the EIS where the language insinuates that the findings from this collector trial can be extrapolated to commercial mining. This is inaccurate.
7. While it is quite likely that the impacts from this collector trial will be small, as this EIS is one of the first to be assessed for the deep-seabed mining industry, it should set the precedent and establish a high standard.
8. Parts of this EIS include information that seems irrelevant and unnecessary. At times, it was difficult to distinguish between baseline data for the Impact Reference Zone (IRZ) and Preservation Reference Zone (PRZ), the entire contract area, and the Central Indian Ocean Basin (CIOB), as well as the relevance of the latter to the collector trials.
9. Many of the figures and tables throughout the EIS document are missing legends, units, scales, and/or appropriate detail in the caption, which are key to effectively assessing them. There are also many typographic errors throughout the EIS.
10. DOSI is concerned that the level of detail provided by the ISA for EIS guidance is not sufficient. and would like to reiterate the importance of standardized minimum requirements, both for exploration and exploitation phases. Standardized minimum requirements for EISs shall ensure that potential effects on the environment can be addressed and should include standards for (1) collection of baseline data from the IRZ and

PRZ, and (2) a local monitoring plan that allows the detection of any impact arising from a collector trial/test-mining/full-scale mining. Such an approach, using best available science, would allow for transparency, an equal level playing field, and focused (and thus cost-efficient) sampling strategy, which is key given the typically scarce baseline knowledge on deep-sea biodiversity and ecosystem function.

11. We would like to offer our sincere thanks to the Government of India for extending the deadline for stakeholder review. For future EISs, the period of stakeholder review should be increased to a minimum of 60 days, stakeholders should be consulted during the scoping phase, and advance notice of the publication of the EIS should be communicated via the ISA and other platforms.

SECTION B. ITEMIZED COMMENTS

Executive Summary

The Executive Summary has little information about the intended locations relevant to this collector trial e.g., the IRZ and PRZ. Additionally, a summary of the environment and biology that will be impacted should be included.

Pg. 6-7: "Based on extensive baseline environmental data collected during several expeditions, the existing physico-chemical environment comprising of bathymetry, sediment properties, water column and meteorological data, as well as biological environment comprising of water-column biology, benthic faunal communities, nodule associated fauna and community structure are described for their spatial, temporal and seasonal variability on a regional scale over several years as well as local conditions within the Impact Reference Zone (IRZ) and Preserved Reference Zone (PRZ) in the Central Indian Basin." This statement is inaccurate as the environmental baseline data collected are not as comprehensive as reported. Several components are near wholly lacking e.g., the water column biology (see Section 5).

Pg. 7: The following statement is problematic: "Due to such small-scale activity, it is expected that no serious harm is expected to be caused to the seafloor environment or in the near bottom water column." There is, as yet, no operational definition of serious harm. Furthermore, there will be harm to the direct area including biodiversity loss, loss of function, etc. but to what extent is undefined. Instead the high level of uncertainty should be communicated.

Pg. 7: "Small scale impacts due to compaction during locomotion of the collector, or due to nodule removal, sediment redeposition and bio-geochemical alteration are expected that would get restored within a short span of time in view of the weak currents and recolonisation by biological communities from adjacent areas." There is little biological information related to the recovery of deep-sea nodule areas and as such, assumptions should be limited. Furthermore, this conclusion is not warranted from the data contained within this EIS, including results from INDEX or the analyses of nodule-associated fauna. While generalisations between regions should be treated with caution, studies from the Clarion-Clipperton Zone (CCZ) should be drawn on. It has been shown that recovery will not occur in a short space of time for any components of the biological community (megafauna, macrofauna, meiofauna, microbes, and ecosystem function), as well as sediment redeposition and biogeochemistry e.g., Vanreusel et al., 2016; Simon-Lledo et al., 2019a; Volz et al., 2020; Vonnahme et al., 2020.

1. Introduction

The introduction provides an overview of physico-chemical and biological data that have been collected over the past decades. Little information is provided as to the actual methodology used (e.g., use the best available science, standardisation, etc.). Without this, an assessment of the baseline data collected is not possible.

The authors present data from the CIOB, the exploration license area, the sites relevant to the collector trial, and the INDEX experiment sites. Throughout the EIS, it is difficult to follow what region/zone/site is considered and how the results of these compare through space and time. A map, as shown on Pg.136 (Fig. 4.5.3.1) should be clearly presented in the Introduction. A clear definition of the sites (size, exact location, depth) and underlying reason why those were chosen for the EIS should be given in the Introduction.

Explanations why specific ISA recommendations as per ISBA/25/LTC/6/Rev.1 were followed or not should also be given.

Pg. 9: There appears to be a typographical error - 1,50,000 sq.km.

Pg.11-13: The sampling effort detailed, including in Table 1.2.1.2, appears to be impressive, however little information is provided as to the actual methodology used e.g., use of best available science, standardisation, etc. Without this, an assessment of the baseline data collected is not possible.

Pg. 13: The number of scientific publications (>350) that originated from MoES's program is impressive. It would be an excellent addition to the EIS if a reference list could be provided as an Appendix.

Pg. 16: Fig. 1.2.1.1 is the first of many examples throughout the EIS, including within this section, where the figure is incomplete. The legend, scale, and/or caption are not comprehensive enough to allow the figure to be easily understood. Additionally, Figure 1.2.1.3. metrics are missing and color code is not clear.

Pg. 17: In Table 1.2.1.3., what is the metric used?

Pg. 17: The EIS makes reference to the recommendations within ISBA/19/LTC/8 issued by the Legal and Technical Commission (LTC) in 2013. However, in Section 2, ISBA/25/LTC/6 is listed as the document used as a guideline for the development of the study. It is not clear which document was used.

Pg. 18: Table 1.2.2.2 gives only key-parameters analyzed. It should be noted that several parameters recommended by the LTC (ISBA/25/LTC/6/Rev.1) are not included as part of the baseline studies e.g., microbial community, ecosystem function.

Pg. 19: Table 1.2.2.3 points to undersampling for some baseline components from a spatial and temporal perspective e.g., in the IRZ and PRZ, there was only one CTD station each, and five sediment samples.

Pg. 20: Table 1.2.2.4 summarizes non-confidential environmental data submitted to the ISA. A direct link to DeepData could be provided and the data added as an Appendix to the EIS.

Pg. 23: Again, a number of parameters required and recommended by the LTC (ISBA/25/LTC/6/Rev.1) have not been included, particularly for Sections 4 and 5. These are detailed in the relevant sections below.

Pg. 23: The following statement is misleading: "Section 6 - describes the types of impacts that could occur due to different activities related to deep-sea mining." Section 6 instead describes the impacts for this small nodule collection trial and cannot be directly extrapolated to commercial deep-seabed mining. Please amend this sentence.

2. Policy, legal, and administrative context

Pg. 24: To avoid unnecessary confusion with the 1994 Implementation Agreement, we suggest that the term "agreement" in the sentence "An agreement for exploration for polymetallic nodules was signed between the ISA and the Ministry of Earth Sciences (..)" be replaced by "contract".

Pg. 24: In order to improve the understandings of the many stakeholders that may assess this document, a more comprehensive presentation of the legal background prescribed by UNCLOS and the ISA, through its regulations and recommendations, and how the Government of India perceives this pursuant to its obligations under the exploration contract, would be very much appreciated. This will give stakeholders a better context and aid their understanding of how this EIS is embedded in the exploration process.

Pg. 25: It would be useful for this section to include an analysis of domestic legislation in India that would apply to its conduct of activities in the Area, if there are any (whether in the form of enacted law or draft bills). Further, inclusion of an overview of any other domestic legislations in India on the EIS process would be helpful.

3. Areas of operation and description of the proposed collector test

This chapter should incorporate combined mapping of the CIOB, the contract area, the collector-trial area, the IRZ and PRZ, and the sampling points. This is needed to set the context for the rest of the EIS and is currently difficult to understand.

<u>3.1 General description of area, geological setting and polymetallic nodules</u>
Information on sediment distribution, sediment components, sedimentation rate, and nodule densities and shapes, is given for several points in the CIOB. However, it is not clear how these values relate to values for the contract area, PRZ, and IRZ. The relevance of contents of some sections (e.g. Sections 3.1.2 and 3.1.3) are not clear and could be explained.

Pg. 30: It is unclear what the circles with numbers represent, and where the contract area, PRZ, and IRZ are on Fig. 3.1.4.1.
Pg. 35: It is unclear where the contract area, PRZ, and IRZ are located on Fig. 3.1.5.2.

<u>3.2. Impact Reference Zone (IRZ) and Preservation Reference Zone (PRZ)</u>
High-resolution bathymetry is needed for both the IRZ and PRZ in order to understand baseline conditions and impacts more clearly (e.g., Figs. 3.2.2.1, 3.2.2.2, 3.2.2.3, 3.2.2.4). The resolution of the bathymetry should be clearly stated.

The IRZ and PRZ were selected based on bathymetry, nodule abundance, and grade. The IRZ has a bathymetric relief range of ~1000 m due to a knoll in the northwest, but is mostly between 5200 and 5300 m. The PRZ has three knolls of slightly lower height (to 4600 m) but otherwise is between 5000 and 5200 m. While these may arguably be "similar", the proponents should be explicit about their assumptions and rationale regarding biological similarities. In addition to the selection criteria used, there are other important criteria for IRZ and PRZ (ISA 2018), which are not addressed in the EIS. These criteria include but are not limited to:

- Each PRZ should serve as a reference area containing a stable biota (within the natural range of variation) with representative habitats, biodiversity, and ecological function potentially impacted by mining in the IRZ.
- The (total) PRZ area(s) should be large enough to include representative biota, habitats, biodiversity, and ecological function potentially impacted by mining, and take into account the geographical ranges of the biota present.
- The PRZ should be an appropriate distance away from any seafloor mining activity to ensure that the PRZ is not impacted by mining.

Pg. 36: There appears to be a typographical error - 1,50,000 sq.km.

Pg. 36: Fig. 3.2.1.1 would benefit from a bathymetric underlay and associated descriptors, as well as a scale.

Pg. 37: It is unclear what the relation of Fig. 3.2.1.2 to the contract area is. Additionally, clarity is needed on what the red stars represent, what the scale is, what type of sampling occurred where the black dots are, and the PRZ and IRZ boxes should be transparent so the nodules abundances for these areas can be easily understood.

Pg. 38-39: In addition to the abundances of nodules (kg/m2) in Tables 3.2.2.1 and 3.2.2.2, nodule densities would be helpful to understand the correlations between nodules and fauna, which would greatly aid in future impact mitigation and other management efforts.

<u>3.3 Technical information of nodule collector system</u>

The depth of sediment penetration of the nodule collector was initially listed as 150-300 mm, but later in the EIS 150 mm is used for calculations of impact. Additionally, the width of the collector is not given. Instead, the total contact area (4.5 m^2) and the width of the two nodule-pickups (each 0.8 m) are given. Without the width of the collecting machine, the total direct impact (area of compressed sediment plus area of removed nodules) cannot be calculated.

<u>3.4 Plan of work for sea trials of collector system</u>

The presented plan does not represent much detail. It is unclear e.g., how operations will be monitored using an underwater camera system. As is stated in the EIS, visual monitoring would only be applied for Trial 1, but not for Trial 2 and 3.

The sediment plume created will be different between the trials (Trial 3 includes pumping the slurry to 80 meter). If plumes from trials overlap, it may be difficult to disentangle their impacts. How is this accounted for? Is there sufficient distance between the trials? Clear statements of impact assessment objectives and rationale should be included.

The impacts assumed in the EIS are based on ~1000 m accumulated trial-tract length and 2 x 0.8-m width for the two nodule-pickups on the collector. The plan to have three trials of 500 m would yield ~ a total of 1500 m. Similarly, the impact would not be 2 x 0.8 m along these 1500 m, but the total width of the collecting machine (see 3.3) along these 1500 m.

3.5 Risks Associated with the Planned Trials

Risks associated with the trials and the corresponding management strategies should be more detailed, especially for the column "Emergency-Failure". Other terms referred require more clarification, for example: what does the acronym "DP" mean? There is no reference to it before. The means of "Ser" for the first column is unclear. On what studies or practices are the "Management Strategies" based on? References for that are required in the text as well. Finally, the likelihoods of risks should be included together with references used for its establishment.

4. Baseline physico-chemical environment

As per LTC requirements and recommendations (ISBA/25/LTC/6/Rev.1), it is important to obtain sufficient physico-chemical information from the exploration area to document the natural conditions that exist prior to test-mining, and to gather other data that will make it possible to make accurate environmental impact predictions related to e.g., the seabed disturbance plume, discharge plume, potential toxicity, noise, and intensity of light. The best available technology and methodology for sampling should be used in establishing baseline data for the EIS. It is unclear whether the baselines of the IRZ and PRZ have been sampled extensively and effectively, partly because the methodologies and analyses undertaken are not clearly or completely described. There is also a general lack of clarity on where sampling was undertaken and the relevance e.g., many water-column profiles appear to have been taken several degrees latitude away from the study area, so it is not clear if the current data are reflected in the mining trial area.

The following sampling and analyses required and/or recommended by the LTC (ISBA/25/LTC/6/Rev.1) have not been undertaken as part of the baseline surveys thus far and should be included in future efforts. These include:

- Requirement 15a.i and Recommendation Annex I 25: There is little indication that high-resolution bathymetry revealing the geomorphology of the seabed has been collected and is informing the measurement programme. Bathymetric resolution in the IRZ and PRZ is not at the meter-scale that could be obtained with AUV mapping, as recommended. The same applies to regional hydrodynamic processes at the sea surface, in the water column, and at the seafloor.
- Requirement 15c.i: It is unclear whether Geographic Information System regional maps with high-resolution bathymetry and seafloor bottom type showing major geological and geomorphological features that reflect the heterogeneity of the environment have been produced. These maps would greatly inform efforts as well as independent assessment.
- Requirement 15b.iv: There was little additional water column information provided, with no information provided for pH and other components of the carbonate system (e.g. carbon dioxide, alkalinity), as well as water-column optical properties (light intensity, backscatter, attenuation).
- Recommendation 43 Annex I: Baseline surveys to determine background noise levels in vertical profiles through the water column from the sea surface to the seabed, including temporal variability in ambient noise levels, were not included in the EIS.
- Sediment oxygen profiles, sediment community oxygen consumption, depth of oxic-suboxic transition, assessment of bioturbation, total inorganic carbon and the redox system (Eh and pH), including down to the depth of the mining trial disturbance (30 cm) were not included. Importantly, Vonnahme et al. (2020) has shown that the most sensitive indicators of sediment disturbance are 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. Thus, the most important parameters for assessing a baseline and potential impacts are not reported.

The inclusion of a combined map representing all types of sampling undertaken in the IRZ and PRZ, as well as high-resolution bathymetry would be helpful. As with other sections within the EIS, a number of figures and tables could be made more complete and improved to enhance understanding. A final concern is that not all data and samples included in the EIS appear to be in the public domain for transparent evaluation or stored in a suitable repository.

4.1 Onboard and laboratory methods for collection of baseline data

This section describes the equipment used on one of the research cruises but this may not be exhaustive. Providing details of all pieces of equipment used to collect baseline data across all research cruises would assist with assessing their quality. Furthermore, an indication of whether these pieces of equipment will also be used for the monitoring of the proposed collector trial would also be useful, even if only included in Section 8.

Pg. 47: Five sediment samples were collected for assessing "benthic conditions" from each site. It is not clear what this term means.

Pg. 48: Fig. 4.1.1.2 would benefit from bathymetry, a regional context, and labels for the IRZ and PRZ.

Pg. 50-51: The locations of the CTDs, given the large boxes compared to the map, are unclear on Figs. 4.1.3.2a and 4.1.3.2b.

Pg. 52-53: Section 4.1.5 describes subcoring, but no information has been provided for the number of samples used for different studies.

Pg. 54: Only one rosette cast in PRZ and two in IRZ with two depths fired below 1000m does not constitute a comprehensive baseline. There should be multiple CTDS per area and an additional temporal component.

4.2 Bathymetry of the area

It is not clear what resolution of bathymetry was collected for the relevant areas, especially as the maps are of low resolution. As stated previously, high-resolution bathymetry is needed to inform all aspects of this EIS.

Pg. 60: There is a high abundance of abyssal hills and seamounts but the text does not address the influence of these bathymetric features on currents and turbulence as well as on biota. For Fig. 4.2.2.1, please indicate the locations of the PRZ and IRZ.

Pg. 64: Fig. 4.2.4.1could be improved with a legend indicating the depths as well as a scale.

Pg. 69-70: The baseline nodule coverage for the IRZ and PRZ have not been outlined in Subsection 4.2.9 but are crucial to understanding the impacts from the trial and the potential recovery.

4.3 Atmospheric and meteorological conditions

The data used to establish a baseline for sea surface temperatures, wind speed, and rainfall were obtained from 1988-1998. More recent data would assist with building an accurate baseline, especially given the increasing influence of climate change. Furthermore, it is not explained why the intervals of data utilised for sea-surface temperature, wind speed and rainfall are different to that of the data used for cyclones and waves.

Pg. 86-92: Regional and local observations were conducted from 9 September to 6 October 2009, and from 3 to 19 August 2015, respectively. It remains unclear how the baseline, regional, and local observations relate to each other and if they can be compared, as the year of collection and periods of measurement vary significantly.

4.4 Water column conditions

The types and amounts of water-column data that are essential to assess the environmental impact of this trial will depend on what metrics will be used. It is unclear what impacts are considered important to assess, and therefore what data is needed. It would be helpful to see some prioritization and rationale for what should be assessed for this kind of trial. Throughout this section, historical data is presented that likely has little bearing on how the environmental impact of the mining trial will be assessed, however it is valuable for context and to understand the general properties of the area. Robust measures that allow the assessment of changes in dO_2, nutrients, and chemistry at depth from the collector trial are important to generate a better understanding of plume impacts and aid in parameterizing future models. Most of the data included is at an inappropriate scale for impact assessment. CTDs may not be sensitive enough to accurately measure a signal above background variability, so the use of O_2 probes at multiple heights above bottom on moorings at plume level in the IRZ and PRZ during the trial may be more appropriate. Also, there are few water-column data points from near bottom or from the depths where plume dispersal would be expected. While the profiles provided indicate limited natural variability, the dataset is likely not sufficient to adequately characterize variability.

Pg. 99: Providing regional context, as well as the locations of the PRZ and IRZ, would allow for better assessment and understanding of the placement of the three moorings in Fig. 4.4.1.4.1.

Pg. 99-103: There were not enough moorings deployed to capture spatial or temporal trends for the contract area, IRZ, or PRZ, especially given the presence of hills and seamounts in these areas and their effects on currents and therefore plumes. This is further compounded by 23% of current meters failing, as well as no observations above 450-m depth (thereby covering surface spills).

Pg. 101-102: The presentation of "mean currents" suggests a very quiescent ocean. These numbers result from rotating currents on tidal and seasonal scales that give little indication of the energy in the system. Murty et al. (2001) illustrate active bottom conditions (daily averages to 20 cm s^{-1}) that vary over the year. However, without long-term monitoring to capture natural variability, it is very difficult to assess current behaviour that would affect plumes.

Pg. 109-110: While methods indicate that 28 CTD stations were sampled over the entire contract area, De Sousa et al. (2001) report that only three casts went below 3500 m. Thus, there is no baseline available against which to assess effects of mining on deepwater oxygen, nutrients or any chemical fluxes, nor any assessment of spatial variability. The EIS does show one WOCE section but that is ~200 km north of the northern boundary of the contract area. Furthermore, this appears to be for only one time point which does not allow for the assessment of temporal variation.

Pg. 112-113: Single profiles are presented for 1997 and 2015 showing great differences in pH. Please account for these.

Pg. 114-120: The replicate CTD casts at the IRZ are useful for understanding local variability so that the resolution of a sensor to detect changes in, for example, dO2 can be assessed, as well as the number of replicate sensors and sensor depths that would be appropriate for impact assessment. If relying on CTD data, there were not enough deployments (one in PRZ and two in IRZ) to capture spatial or temporal baseline trends. If the impact assessment does not rely on CTD data but uses logging sensors on moorings in rational locales and depths, two CTDs may be considered adequate.

Pg. 120: The Suspended Particulate Matter at bottom is one of the most important parameters to understand prior, during, and after the proposed trials. There is one data point each in the PRZ and IRZ showing high bottom values which have been described as "probably due to resuspension". These findings contradict other parts of the EIS e.g., Pg. 103 - "that the bed stress is usually low to cause local re-suspension of sediments." These records and the reasons for them should be clarified.

4.5 Physical properties of seabed sediments

A substantial portion of the document concerns the sediment properties and composition of the region. While there are many useful analyses, the redox profiles along with pH and porewater O_2 concentrations requested by the Guidelines (ISBA/25/LTC/6/Rev.1) are not presented. Porewater chemistry data (e.g., profiles of nitrate, silica, phosphate) have been provided but none of the profiles have data from close (0.5cm to 1cm) to the sediment surface. Future sampling should include this as this data can be used to calculate nutrient fluxes in the absence of in-situ chamber experiments.

Pg. 121: As Boxcore 18 is located close to but not within the PRZ, this data should be treated with caution.

Pg. 135: While five boxcores each in the PRZ and IRZ may be adequate in a homogenous environment, parameters essential to understanding biological community drivers, such as nodule density, do not appear to have been quantified. To understand if the sediment properties are similar between the PRZ and IRZ, statistical tests for significant differences between means would be useful.

Pg. 152-154: The TOC plots included are informative but measurements of biopolymeric organic carbon sensu have not been undertaken (Danovaro and Snelgrove, 2014).

5. Baseline biological environment

As per LTC requirements and recommendations (ISBA/25/LTC/6/Rev.1), it is important to obtain sufficient information from the exploration area to document the natural biological conditions that exist prior to the collector trial and to gather other data that should make it possible to acquire the capability necessary to make accurate environmental impact predictions. The impact of naturally occurring periodic processes on the biological environment may be significant but is not well quantified. It is therefore important to acquire as long a history as possible of the natural responses of sea-surface, midwater, near-bottom and seabed communities to natural environmental variability before the mining-related activities begin. The best available technology and methodology for sampling should be used in establishing baseline data for environmental impact assessments. However, the presented biological baseline, especially of the IRZ and PRZ, shows that it is not adequate for the majority of components within this EIS. The following sampling and analyses required and/or recommended by the LTC (ISBA/25/LTC/6/Rev.1) have not been undertaken as part of the baseline surveys.

- Requirement 15d.i and Recommendation Annex I 25: High-resolution bathymetric maps do not appear to be used to plan the biological sampling strategy.
- Requirement 15d.iii and Recommendations Annex I 41g, 42g: There does not appear to have been any data collected on the near-bottom communities specifically relating to demersal fishes and scavengers and other biota (e.g. meroplankton) both in the exploration area and in areas that may be impacted by operations. Additionally, the seafloor protozoan communities have also not been studied in sufficient detail.
- Requirement 15d.iv and Recommendations Annex 42a, b, c, d, e, f, 44, 45: There has been little assessment of the pelagic communities in the water column including, but not limited to, the phytoplankton composition, biomass, and production, and bacterial plankton biomass and productivity, as well as temporal variation on seasonal and inter-annual scales. Also, the zooplankton (both holo- and meroplankton and gelatinous), nekton (including epipelagic fishes, deep-diving surface fishes, mesopelagic fishes, shrimps and squids), non-migrating nekton, benthopelagic fishes, mesopelagic micronekton, and larger mesopelagic taxa. The vertical migration dynamics of mesopelagic zooplankton and nekton should also be characterised.
- Requirement 15d.v and Recommendation Annex I 51: There has been no systematic sampling program that records sightings of marine mammals, other near-surface large animals (such as turtles and fish schools) and bird aggregations, identifying the relevant species where possible. This should also include data on whether sensitive, protected, or migratory species pass through the area, and whether the trial timing will impact on migration of these species. These direct observations should be coupled with previously known information regarding the behaviour and seasonal migrations of these animals.
- Requirement 15d.vi: It is questionable whether temporal variations in water-column and seabed communities have been established.
- Requirement 15d.vii: The regional distribution of species and communities/assemblages as well as genetic connectivity of key and representative species has not been comprehensively undertaken.
- Requirement 15d.viii: The photo or video documentation in situ appears to be of very poor quality.
- Requirement 15g: Sediment community oxygen consumption as a metric of whole community (largely microbial) function has not been measured.
- Requirement 15h and Recommendation Annex I 35: The food-web structure of the pelagic and benthic habitats, via molecular and isotopic analyses, has not been evaluated.
- Recommendation Annex I 32a, b, c, d and 47: No molecular studies appear to have been undertaken for megafauna, macrofauna, meiofauna, and microeukaryotes.
- Recommendation Annex I 32d and 41e: Few samples dedicated to microbiology (including microorganisms, bacteria, archaea, fungi, viruses, microeukaryotes) were collected. Thus, no diversity assessment and in-situ microbial activity measurements will be possible to identify potential mining impacts. Additionally, no molecular analyses were undertaken on this biological component. Vonnahme et al. (2020) recently reported that sediment microbial cell counts are an important metric for assessing impacts thus, this EIS does not provide sufficient baseline information for assessing impacts to the microbial community from this collector trial.

- Recommendation Annex I 32e: No environmental DNA (eDNA) samples were collected from water and sediment.
- Recommendation Annex I 38: Spatial variation in the composition of the biological community and levels of connectivity were not comprehensively evaluated making it currently impossible to know the degree of isolation of populations occupying the nodules and whether a given population serves as a critical brood stock for other populations.
- Recommendation Annex I 41a: Megafauna data that do not appear to have been collected include biomass, species structure, and diversity. Photographs did not appear to have sufficient resolution to identify organisms greater than 2 cm in their smallest dimension. A time-lapse camera has not been installed at the study area for at least one year to examine the physical dynamics of surface sediment and document the activity level of surface megafauna and the frequency of resuspension events. Species identification was not confirmed by collection of specimens at the site.
- Recommendation Annex I 41b: Macrofauna data not collected in sufficient detail or at all includes species structure, biomass, and diversity of sediment fauna. The fauna on the surface and crevices of polymetallic nodules should be studied also.
- Recommendation Annex I 41c, d: Meiofaunal biomass was not collected at all and species structure does not appear to have been analysed in sufficient detail.
- Recommendation Annex I 41f: The nodule fauna has not been comprehensively analysed.
- Requirement 46: Temporal variation including seasonal and inter-annual variation and other relevant potentially episodic and extreme events. Temporal variation should be evaluated for at least one trial site and the PRZ following the terminology agreed prior to the trial (ideally, with a minimum of annual sampling over at least three years).
- Requirement 52: The natural spatial and temporal variability of bioturbation, including rates and depths of bioturbation from profiles of excess Pb-210 activity from cores, has not been undertaken.
- The description of ecosystem function is completely lacking. Disruption of the ecosystem functioning is likely to be the greatest impact from disturbance of the sea floor, but this is not described or assessed. Monitoring measures should be developed to start addressing this gap.

An extremely high level of biodiversity is known to exist in the CCZ nodule plains, with thousands of species of bacteria and invertebrates typically found within one abyssal contract area (e.g. Amon et al 2016; Gooday et al 2017; Shulse et al 2017; Simon-Lledo et al., 2019b). New species make up more than 80% of the thousands of species sampled within one contract area (Smith et al., 2008), highlighting our poor understanding of abyssal fauna. There is also known to be heterogeneity on a variety of scales (tens of metres to thousands of kilometres) for abyssal communities, which are driven by environmental parameters (Simon-Lledó et al., 2019b). None of this is evident from the data presented in this EIS. Additionally, there are no comprehensive species list for any size classes included and the analyses undertaken are not clearly or completely described. Also, there is a need to quantify any statements such as "high", "low", "sharply declined/increased", "dominant", and so on throughout the EIS.

The majority of citations used are from the 1950s, 60s, and 70s. While we can recognize that there is a lack of data from the CIOB, it would be appropriate to incorporate more recent studies when applicable e.g., Matondkar et al. (2005), Pavithran et al. (2009). At the very least, a statement should be made acknowledging the state of the art on current knowledge gaps in the region and any plans to follow up on these.

5.1 Marine birds and mammals

While not necessarily needed for this small-scale collector trial, an adequate baseline requiring dedicated surveys is needed for surface fauna especially marine mammals and birds. As such, much of the anecdotal evidence provided in this subsection should be disregarded until surveys have been undertaken; in particular, statements including "It is understood that these birds could be the predators for surface plankton, nekton and fish, but their rare appearance probably indicates the lack of sufficient quantities of preys on the surface in this area" and "mostly whales and dolphins were sighted while the vessel was cruising, whereas sharks, turtles and flying fish were seen close to the vessel during operations probably in search of food." Additionally, the mention of sharks, turtles, and flying fish is not appropriate for a section on marine birds and mammals, but when mentioned, should be quantified and identified where possible.

5.2 Water column biology

From the information provided, it is difficult to ascertain whether there were differences between the IRZ and PRZ, and whether the data presented can be even compared. Most of the data appears to come from a single time-point assessment of water-column productivity from 1997(Sagar Kanya cruise 120 in 1997), which highlights the need for more explicit guidance from the ISA regarding what is acceptable. A comprehensive species list for neither phytoplankton nor zooplankton for water-column biology has been included.

There is a distinct absence of any explanation of the methodology used in sampling and data collection. No sources are cited in this section, so it is very difficult to establish the basis for this dataset. Planktonic organisms in particular can be impacted by a variety of environmental and anthropogenic effects, including warmer sea surface temperatures (SST) and decreased ocean circulation (Houde 1989). Indian Ocean SST has been linked to speed and intensity of ENSO transitional phases (Kug & Kang, 2006), so considerations of cyclical population booms and busts should be considered in establishing a baseline data set. Additionally, many water-column species exhibit frequent vertical migration (Moteki et al., 2017). For these reasons, having sample site data on record for sea surface temperature, sea surface salinity, and chlorophyll-a concentrations is important. Additionally, standardizing the sampling procedure to account for diel and/or lunar migrations will be required. Further methodology that would provide useful context includes: the type of sampling apparatus used, the duration of sampling, resolution of sampling nets, whether species identification is morphological, genetic, or both, whether subsamples or exhaustive counts were conducted to determine the proportion of groups, and whether there is any sort of baseline data in the region to which numbers can be compared. If not, it is worth stating that this study is the first of its kind in the area.

Pg. 183: The EIS incorrectly cites De Sousa et al. (2001) "have shown the presence of three water masses viz,. (a) having sub-surface salinity maximum in the depth range of 125 – 200m, (b) with deep oxygen minimum at depth of 250-750m…". De' Sousa et al. (2001) states water mass (a) is characterised by high salinity and an oxygen minimum (due to a weak maxima in nutrients) and that (b) is the Deep Oxygen Maximum (234 – 245 μM) at 250-750 m, partly due to its high pH. In addition, Antarctic Intermediate Water is given the wrong abbreviation, it should be AAIW, not AIW and the depth of this water mass is 800-1200m, not 800-1100m (De Sousa et al. 2001). The EIS should also have included that the AAIW water mass has the Salinity Minimum Water and the measurements for each should be included as in De Sousa et al. (2001).

Pg. 183: "indicating that chlorophyll-a the phytoplankton community in the deep sea occurs on the typical physico-chemical environment where nutrients are very low." This sentence is not clear.

Pg. 183-184: This level of sampling is likely sufficient for a short-duration mining trial, but likely not adequate for a baseline prior to exploitation. From Fig. 5.2.1.1, it is not clear which samples are within the PRZ or IRZ.

Pg. 184-185: The surface water PAR is discussed in terms of °E and °S but in the corresponding Figure 5.2.1.1.1 a vertical axis is labelled Latitude (N).

Pg. 184, 189: Figure 5.2.1.1 and 5.2.1.2.1 were taken directly from Matondkar et al. (2005) as well as many of the figures relating to phytoplankton counts – this paper should be clearly cited throughout.

Pg. 186-190: No dates of sampling were provided. Please clarify as it appears to be pre-2000.

Pg. 186-189: "…below the mixed layer, chlorophyll-a increased to a maximum between 50-80m, where the concentration was 4 to 5 times higher than the surface concentration" gives the impression this was the case across all stations. When comparing chlorophyll-a levels at the surface to the peak at 50-80m, levels were not 4-5 times higher at the following stations: Station 8, 11, 13, 14, 15, 16, 18, 20, 22, and 24 (Figure 5.2.1.2.1). The levels often doubled or tripled but were only 4-5 times higher at 4 of 14 stations. This could be improved by stating 'up to 4 to 5 times higher' but it would be more useful to explain in more detail the trends across all stations.

Pg. 186: Discussing specific coordinates makes it difficult to see any patterns. It would be better to discuss differences in surface chlorophyll or changes in depth maxima in terms of east-west or north-south trends.

Pg. 191-192: The EIS states "high phytoplankton counts were seen in the areas east of 75° E longitude" but in Figure 5.2.2.1, surface phytoplankton counts seem to be higher west of 75° E longitude, and the same in Figure 5.2.2.2 (25 m), but lower in Figure 5.2.2.3 (75 m). Depth should be specified to give proper context to this statement.

Pg. 191: It would be useful to quantify statements regarding species "dominating the population".

Pg. 191: For Fig. 5.2.2.1, please justify the use of quantifying biomass measurements through cell counts rather than the more common methods of either biovolume or biomass in carbon units.

Pg. 193-197: No dates of sampling were provided. Please clarify as it appears to be pre-2000.

Pg. 193: A volumetric unit (ml/100m^3) for zooplankton biomass is used, taken from Matondkar et al. (2005). The standard units for zooplankton biomass tend to be mg C m^{-3} (Irigoien et al. 2004; Lucas et al. 2014) if conversion is at all possible.

Pg. 193: Thirty-two "groups" of zooplankton are mentioned. Please clarify what taxonomic level this refers to.

Pg. 197: "iron is generally required for the growth if phytoplankton" with no reference and then goes on to state "recently it is seen that externally added iron to the surface waters, stimulates the growth of phytoplankton in Southern Ocean indicating the role of iron as a phytoplankton growth-limiting factor" again with no reference. Citing a study such as Martin & Fitzwater (1988) would support the first statement. Gall et al. (2001a, 2001b) iron infusion experiment should be referenced here if this is what the second statement refers to.

Pg. 183, 196-197: The in-text citation “Matondkar et al. (2000)” should be Matondkar et al. (2005), unless the incorrect citation was used in the reference list.

5.3 Midwater fauna

It is unclear what was considered ‘midwater fauna’ vs. ‘benthic fauna’ during these baseline surveys. This should be clearly defined. For instance, meroplankton inhabit the water column just above the seafloor and are mostly larvae. This community is essential to recolonisation and connectivity so should be surveyed. Without a clear definition of “midwater fauna” the statement given on pg. 197 cannot be assessed: “As no major impacts in the midwater sections of the water column are expected due to the activity in the area, midwater fauna (zooplankton, mesopelagic, bathypelagic fish etc.) have not been specifically studied in the area.” This section seems to be inadequate in terms of a general baseline sampling as well as assessing the impacts of the planned collector trials, which will generate a low-level plume and a plume started at 80 metres, as well as noise and light pollution (Drazen et al., 2019). There are many unknowns about the depth of the plumes that will form from mining (Washburn et al., 2019), including the possibility of travel upwards from the seafloor due to vertical migrations.

5.4 Benthic communities

Pg. 197: The first half of this statement is inaccurate: “The benthic ecosystem of the abyssal depth is like a desert deprived of local primary production and is considered as food limited environment.” While the deep abyssal seafloor may be food limited, it is certainly not a desert regarding marine life. Studies from other abyssal areas show high biodiversity e.g. Amon et al 2016; Gooday et al 2017; Shulse et al 2017; Simon-Lledo et al., 2019b. Evidence also indicates primary productivity by microbes through chemosynthesis (Sweetman et al., 2019). This suggests there are inadequacies in the data being sampled.

Pg. 198-208: In order for an accurate assessment of the data presented to be made for the megafauna, a detailed methodology must be included here. This includes information on the camera system used (e.g. resolution) as well as the protocol followed (e.g. altitude, lighting, and speed of the vehicle) during surveys to ensure the collection of a fully comparable (e.g. homogenous fauna detectability rates) and statistically robust (e.g. with sample replication across predefined environmental strata) image dataset. It is concerning that out of 50,000 images, megafauna was apparently only detected in 300. What area of seafloor was surveyed? What was the smallest size of fauna resolved? ISBA/25/LTC/6/Rev.1 defines megafauna as organisms >2 cm, but literature can state otherwise, for example >1 cm (Beazley et al. 2013). Many megafauna in abyssal regions are very small, as specimens <5 cm can account for more than 60% of the total megafauna (>1 cm) detectable in an image survey (Simon-Lledo et al 2019b). Thus, high-resolution, well-lit, low-altitude imagery is needed, otherwise the majority of megafauna > 2cm cannot be detected and data will be inaccurate. This is emphasized by the fact that holothurians, being generally the larger (>5cm) benthic specimens in abyssal areas, were the dominant fauna as it is likely that they were the easiest to resolve. Lastly, assuming that each of the 300 images containing megafauna potentially encompassed a maximum of 1-2 specimens, a total of 600-1200 m^2 of seabed would have had to be sampled for these numbers to fit with the overall mean megafauna density reported (~ 0.5 individuals / m^2, calculated from Figure 5.4.1). This could have only been achieved if the mean seabed surface mapped in each of the 50,000 images collected ranged between 0.012 - 0.024 m^2 (e.g. quadrat shaped images of approximately 10 x 10 cm or 15 x 15 cm). These numbers make very little sense. Please clarify.

Pg. 207-208: The images shown are of extremely poor quality. This highlights the difficulty of distinguishing different taxa, which may be why only 21 species appear to be recorded, none of which have been identified to species level. In comparison, one contract area in the CCZ typically has hundreds of species of megafauna, showing the massive undersampling and underreporting related to community parameters like richness, diversity, and evenness (Amon et al., 2016; Simon Lledo et al., 2019b). The use of any sort of sampling effort validation (lacking not only in megafauna but also in other size groups), such as species accumulation curves would help determine whether the rate of sampling is appropriate to characterise baseline conditions. Taxa accumulation curves would show that almost no new taxa are discovered once sampling is sufficiently saturated. A full list of megafauna in this contract area, as well as each of their abundances should be included. This should be corroborated with potential environmental data in the target areas, such as nodule densities or variations in terrain, as that will be fundamental to the effective monitoring and management across the area. Furthermore, related to the megafauna, it is unclear how many samples were from within the IRZ, PRZ, or nearby. Unfortunately, it is also impossible to assess the variation in the megafauna community in space and time from 300 photos, especially in a statistically robust way. It does not appear that there were replicate surveys or a time series. The methodology related to megafauna needs to be substantially improved in order for this baseline to be supplemented during upcoming research cruises.

Pg. 199: In Fig 5.4.1.1, it is unclear where line 8.1 ends and 8.2 begins and the same for several other transects. Use of different colours would help delineate.

Pg. 200: The EIS lists "genus such as…" and includes Ascidiacea (Class), Decapoda (Order) and Actinaria (Order), so should be changed to 'taxa such as…'.

Pg. 201: The vertical axis on Fig 5.4.1.4 shows units as "(n0.10m^{-2})". Please clarify whether this should be 'no. 100m^{-2}.

Pg. 206: *Malpodonia* is not an existing genus name highlighting that there may be taxonomic errors. What reference guides were used to identify the fauna?

Pg. 209-213: The macrofauna are grossly undersampled. A species list, number of species observed, and the abundances of each species should be provided, especially as it was not clear what taxonomic level identifications were done to. Describing the community present in the relevant area is of utmost importance for assessing impacts. Rarefaction curves that show no new species once sampling is sufficiently saturated should be utilised to see the extent of sampling and how well it is capturing the community. Community parameters should be corroborated with environmental parameters such as nodule densities from boxcores as that will be fundamental to the effective monitoring and management of the area. The pictures on Pg. 210 are of extremely poor-quality preventing comparison with fauna from other areas. There are also no scales included on the images. Little information is provided on the collection methodology, which makes it difficult to assess the accuracy. Sieve size and sediment depth need to be explicitly stated at the beginning of this section. It also appears that the boxcores were sub-sectioned (Pg. 52). While this type of sampling is okay for shallow sediments, it is not the standard method for the deep-sea samples because of the much lower abundances. This likely led to the low abundances of <50 animals m^{-2} recorded (Fig. 5.4.2.2.1). Unfortunately, it is also impossible to assess the variation in the macrofauna community in space and time from the level of information provided, especially in a statistically robust way.

Pg. 210: Figure 5.4.2.1.3 should include scales in all images.

Pg. 211. Fig. 5.4.2.2.1 shows some boxcores with zero macrofauna. This is unlikely. Did these fail? Another example of the importance of providing details about the sampling methodologies.

Pg. 212: Fig. 5.4.2.2.2. is likely inaccurate as macrofauna communities are known to be heterogenous on much smaller scales (Glover et al., 2002; Wilson, 2017). The method used to estimate macrofauna abundances is not explained.

Pg. 212: The top 0-5 cm contained only 26% of total macrofauna, which is very unusual as generally the top few centimetres contain the majority of macrofauna. This interesting observation calls for an analysis of the underlying reasons (e.g., nutrients, sediment chemistry, sampling method).

Pg. 213: Fig 5.4.2.3.1 includes data from BCs from different years. To figure out what year "EVD"s were undertaken, one has to return to Table 1.2.2.3 (from 2003 2005, 2007?). In two sampling efforts (EVDI green, EVDII red), BC14 had 0 macrofauna at any depth. Boxcore data on macrofaunal abundance shows some considerable variability across sampling efforts e.g., BC15 and BC18 had 0 abundances throughout the core in EVDII, but up to 800 individuals per m^2 for some depth intervals in EVD III. This suggests there may be some combination of sampling and analysis error and/or considerable dynamics in infaunal population dynamics. Either will be important to clarify.

Pg. 214-216: Similar to the other size classes of fauna, there is no information on how the meiofauna were collected, which makes it difficult to assess the accuracy. There is no list of species recorded included, as well as data on how these species varied with environmental parameters like nodule densities. Polychaetes are generally a dominant taxon in the meiofauna. Were these animals that passed through a 300-um sieve but were retained on a 45-um sieve? Nematodes found to 35 cm depths? Please clarify.

Pg. 215: Fig. 5.4.3.2.1 is likely inaccurate as meiofauna communities are known to be heterogenous on much smaller scales (Hauquier et al., 2019; Uhlenkott et al., 2020; Macheriotou et al., 2020). This generalises this community given the scales of this image. The method used to estimate meiofauna abundances is not explained.

<u>5.5 Biological communities in IRZ and PRZ</u>

A direct comparative description of the PRZ and IRZ faunal communities would be more beneficial as these two locations will be compared after the trials take place to measure the impacts, as well as potential recovery.

It is not clear whether there is sufficient statistical power in the macrofauna and meiofauna samples to test if the mean abundance of individuals undergoes changes after the disturbance. Multivariate statistics with environmental data from the same cores would be useful.

Pg. 217-220: Chlorophyll a, phytoplankton, and zooplankton appear to be measured at one station located in the PRZ. The single time-point assessment of water-column biology over 20 years ago prevents temporal or spatial assessments. No species list has been included.

Pg. 217: "the present report is based on the biological sampling conducted…(Matodkar et al. 2001)". There is no such reference in the citation list; this may be an incorrect citation of Matondkar et al. (2005).

Pg. 221-223: Nematodes and forams are usually considered as part of meiofauna rather than macrofauna. No species list has been provided, and no comparison with environmental parameters like nodule density has been provided.

Pg. 223: The abundance of macrofauna between Fig. 5.4.2.2.1 is an order of magnitude lower than in Fig. 5.5.1.4.2.1. This is a very large variation and should be clarified.

Pg. 223: Macrofauna decreased sharply down to 10 cm in the PRZ, but a third of animals were observed below this in IRZ. Abundances were higher in the top 5cm in PRZ but higher in 5-10 cm in IRZ? Please suggest possible explanations for these discrepancies.

Pg. 224: In Fig. 5.5.1.4.3., Boxcore 3 had macrofauna found in only the top 5cm and 25-30cm section. The likelihood that abundances in the deepest section are the same as surface sediments is highly unlikely. Please suggest possible explanations, including potential sampling errors.

Pg. 225-226: Ophiuroids and bivalves tend to be considered as part of macrofauna rather than meiofauna. No species list has been provided. The use of species accumulation curves would help determine whether the rate of sampling is appropriate. Biodiversity data should be corroborated with environmental parameters such as nodule density.

Pg. 225: In Fig. 5.5.1.5.1, nematodes were reported at 46% of the community in the IRZ but 73% in PRZ. These are significant differences (please see Section 3.2. on guidelines for selection of IRZ and PRZ).

Pg. 225: In Fig. 5.5.1.5.2, average meiofaunal abundances in the PRZ are five times that of the IRZ. This is a significant difference.

Pg. 227-229: Chlorophyll a, phytoplankton and zooplankton appear to be measured at one station located in the IRZ. The single time-point assessment of water-column biology over 20 years ago prevents temporal or spatial assessments. Zooplankton biomass is discussed, but there is nothing reported about zooplankton abundance or diversity. No species list has been included. Reporting results in different units between the PRZ and IRZ makes it very difficult to compare.

Pg. 229-235: For the macrofauna in the IRZ, it is unclear how many stations were sampled, and what the methodologies were. No species list has been included and no measurement of temporal or spatial variability. Nematodes are usually considered as part of meiofauna rather than macrofauna. There is no comparison with environmental parameters like nodule density. The pictures on Pg. 232-235 are of extremely poor quality preventing comparison with fauna from other areas. There are also no scales included on the images. Furthermore, there should not be a category of ‘unknown fauna’.

Pg. 229-230: It is unclear what “crustacean were dominant in area” means when they were only 14% of macrofauna. Additionally, the lack of polychaetes is problematic as they are usually the most dominant phylum in the abyss (Glover et al., 2002). Please suggest possible explanations, including potential sampling errors.

Pg. 230: 94% of macrofauna were in the top 10 cm in the IRZ unlike at other studies sites. Please clarify why.

Pg. 236-238: For the meiofauna in the IRZ, it is unclear how many stations were sampled and what methodologies were used. No species list has been included and no measurement of temporal or spatial variability. Ophiuroids, and bivalves are usually considered as part of macrofauna rather than meiofauna. No species list and comparison with environmental parameters such as nodule density has been provided. The pictures on pg. 238 are of extremely poor quality preventing comparison with fauna from other areas. There are also no scales included on the images.

<u>5.6 Nodule fauna</u>

Nodule fauna should be well characterized as, given the nature of deep-seabed mining, they likely have one of the highest extinction risks (Taboada et al., 2018). Unfortunately, it is unclear where and when these samples were collected. Furthermore, 109 nodules are an insufficient number from which to assess the full range of fauna inhabiting nodules, much less the potential for their endemicity. Were only meiofauna associated with nodules analysed? Megafauna and macrofauna also inhabit nodules and should have been included in this analysis. It would also be helpful if a species list was provided as well as the average abundance of fauna per nodule. The data provided in Table 5.6.2 is useful but does not appear to be analysed anywhere. The pictures on Pg. 245 are of extremely poor quality preventing comparison with fauna from other areas. There are also no scales included on the images.

Pg. 244: There are no units provided for 'mean faunal abundance' in Table 5.6.3. Additionally, what is percent faunal diversity?

Pg. 248: This imagery is of very low quality.

<u>5.7 Ecosystem functioning</u>

Ecosystem function is an important aspect of the EIS that has implications for an impact assessment of a mining operation, and yet no sampling has been undertaken (Stratmann et al. 2018.). Studies specifically targeting ecosystem function are necessary in order to determine the baseline function and any changes resulting from the collector trial. While there is Pb concentration data, there does not appear to be Pb210 data or any estimates of bioturbation rates. Additionally, no respirometry data has been provided, and sediment samples for porewater nutrients are too coarse (vertically) to be able to calculate nutrient fluxes.

Pg. 249: References supporting "low productivity, growth, colonization, and delicate habitat structure" should be given.

Pg. 249: As stated previously on Pg. 197, the first half of this statement is inaccurate: "The benthic ecosystem of the abyssal depth is like a desert deprived of local primary production and is considered as food limited environment."

Pg. 249-250: "However, as depth increases, food becomes limited for the deep-sea organisms, therefore microbes are the most important in recycling the organic matter." This statement could be validated by citation of the papers that have shown this using in situ sampling (e.g., Sweetman et al. 2019).

6. Potential impacts of nodule collector trial on physico-chemical environment

This section contains a large quantity of information, not all of which appears to be relevant. There is also some confusion with some potential biological impacts included in this section rather than Section 7. Another overarching issue is the difference between restoration and recovery. These two processes have clear definitions and are distinct from one another. No evidence is presented on restoration, but there is data on recovery to pre-disturbance levels. However, great care should be taken to ensure that the results are presented within the context of natural variability and at the appropriate timescales (defined based on biological and ecological knowledge). Finally, the calculations of impact assume 15-cm depth of sediment impact, whereas the Executive Summary states sediment penetration to 30 cm will occur thus, the EIS provides a skewed assessment of potential impact.

<u>6.1 Types of likely impacts</u>

Pg. 251: This statement is incorrect "This section describes the potential impacts that could occur during a full-scale mining operation for polymetallic nodules on the physico-chemical

environment." This section should only describe the impacts from this nodule collector trial but instead attempts to encompass all impacts from a full-scale mining operation, which it does not achieve.

Pg. 251: The collector trial will result in the release of CO_2, the major greenhouse gas contributing to climate change. The estimated emissions should be stated, even if only from the research vessel, and the risk assessed.

Pg. 251: Not all potential impacts from ship surface activities have been included e.g., pollution of the ocean from the vessel has not been mentioned. The collector trial will involve sound and light produced by the ship.

Pg. 251: Water-column impacts should still be included given the production of a plume from 80 m above the seafloor, with the potential to spread shallower. This also should be discussed in terms of potential changes in suspended sediment concentration and particle sizes, particulate organic content, contaminants, oxygen consumption, light attenuation, and any other properties that might be modified when water comes in contact with the nodule slurry. Also discuss the interaction of direct physical disruption and plume deposition on the seafloor properties. The smaller particles are likely to be those discharged and to travel longer distances, eventually affecting the midwater column. The collector trial will also involve sound and light produced by the instruments on the seafloor. Even if there is no impact in the midwater, an experimental design to sample this area should be proposed. Please be quantitative and cite appropriate literature when claims of no harm are made.

Pg. 251: Given that nodule removal will potentially occur down to 30 cm of sediment, the first sentence in this subsection should be changed to "Collection of nodules from the associated sediments that are mainly clay sized particles will disturb the benthic habitat in the mining area causing changes in the seabed habitat" as it is currently inaccurate. The following sentence, which is also inaccurate, should also be changed to "This will lead to alterations in seafloor micro-topography as well as physico-chemical conditions of the sediments" as per the observations from the peer-reviewed literature in other abyssal areas (Vonnahme et al., 2020). The physical and chemical effects of nodule removal over 1600 m^2 should be discussed in more detail. These impacts include changes in the ratio of hard/soft substrate, possible changes in the vertical distributions of sediment texture, biogeochemical properties (e.g., O_2, Fe, Mn, redox, nutrients), water content, organic carbon content, permeability, shear strength, sediment resuspension, and water clarity. The effects of discharging nodules behind the collector should also be discussed in terms of the effects mentioned here on substrate availability, texture, and biogeochemistry. The concluding sentence "not likely to have a significant effect on the physico-chemical environment" may be true for this nodule collector trial but is misleading given the introduction to this section which says that it is going to describe the impacts for full-scale mining.

Pg. 252: More detail is required for the proposed monitoring program than "The above effects can be measured through collection of environmental data in the near bottom waters as a reference before the collector operation as well as analysing water and sediment samples at regular intervals through time series observations using sensors mounted on moorings or physical sampling. It is proposed to deploy moorings around the trial area with sediment traps and current meters to collect real time data on movement of sediment particles during the collector trials", although it should be included in Section 8.

Pg. 252: There should be a detailed discussion of light attenuation, particle concentrations, possible effects on oxygen consumption, release of contaminants associated with the plume, and a more detailed discussion of the total area affected, gradients, and expected sedimentation patterns. Also, discuss the interaction of direct physical disruption and plume deposition on the seafloor properties. Please be quantitative and cite appropriate literature when claims of no harm are made. Although it is mentioned that measurements of environmental data will be done through time series observations and moorings will be deployed, more detail should be provided, including the type of data to be collected and how widely spaced the sampling gradient should be. For example, the concentration of chemicals of concern should be measured and their bioavailability assessed.

Pg. 252: "However during the trials, the activity is restricted to collection of nodules on the seafloor and discharging them immediately behind the collector, which is not likely to create a sediment plume except for a minor disturbance about 0.5-1 m above the seafloor that would settle within the tracks." While this plume will be small compared to that from commercial mining, the plume still needs to be rigorously monitored. There is also no evidence to suggest that the dispersion of sediments at depth will be limited to 0.5-1 m above seabed. Please provide references for this statement, as well as this statement, "it is not expected to cause any harm to the biota or changes on the sediment deposition patterns on the seafloor". Furthermore, there is a second trial being undertaken, which discharges crushed nodules and sediment from 80 m above the seabed, which will certainly create a plume and cause impacts that should be described here.

Pg. 253: There will be potential impacts of light and noise from the ships at the surface through the water column to the benthos. As this is a stated impact, a baseline needs to be established in the future.

6.2 Results of benthic impact experiment

A lot of information is given about the effects of the previous INDEX disturbance experiment. However, the relationship between INDEX and this proposal is not clear. We cannot find the exact locations of EDS and PDS relative to the PRZ and the IRZ and the criteria for selection are not stated. Secondly, the habitats are different since EDS was selected as an area of low nodule density to match the disturber capabilities. The two sites were sampled for "salient features" (Table 6.2.7.1 vs. 6.2.7.2) but only qualitative comparisons were drawn. It appears that the experiment was designed to address pre- with post-disturbance levels, but effects were not compared quantitatively, which is a missed opportunity. Quantitative comparisons could be done between samples within a site versus between sites. For example, the authors discuss "Likely impacts with respect to natural variability" but provide no evidence of the natural variance and how the impacts will be characterized based on the measurement. The purpose of this analysis and how it relates to the current sites is unclear. Please explain how the INDEX disturbance instrument and its sediment disruption compare to that of the proposed collector trial. It would be more appropriate to include raw data from this test as an Appendix and to make predictions regarding the impact of the proposed collector trial on the basis of the 1997 results.

Pg. 255: Fig. 6.2.3.1 would be much more informative if bathymetry was provided as well as a legend that describes where the test site was compared to the reference areas.

Pg. 257: Fig. 6.2.5.1.1. should have a scale including for relief. Does grey equal the test track and black dots the sampling sites?

Pg. 259-260: A lot of information is given about the effects of the previous INDEX disturbance experiment. Is this because the effects are expected to be similar to the proposed experiment or because you are illustrating the study approach and methods? Please explain how the INDEX disturbance instrument and its sediment disruption compare to that of the proposed collector trail for the current study. INDEX was carried out in an area with low nodule density. How will the higher nodule density affect the relevance? What will the effects be of the added nodule crusher?

Pg. 260: From the quality of seafloor images included previously, conclusions on the impacts of this experiment on megafauna should be treated with caution. Images taken at 4-5 m off the seafloor at poor resolution are likely not of sufficient detail to make accurate predictions.

Pg. 261: From images, it is unlikely that one could accurately state that the areas were devoid of biological activity. Please revise this statement to say that this observation was only for megafauna above a certain size and indicate what that was.

Pg. 262: Moorings placed at 7-m height above the seafloor may not accurately assess the plume as most sediment may have been constrained close to the seafloor. Treat these results with caution.

Pg. 264: Both Figs. 6.2.6.1.3 and 6.2.6.2.1 would benefit from a scale and more information in the caption, as well as an update of the display.

Pg. 268-270: The main message given is that natural variability supersedes or masks the longer-term impacts of the test disturbance over 8 years. However, Tables 6.2.7.1 and 6.2.7.2 give only single values and do not show variability. These results raise questions about the sampling resolution required to capture impact (more than three cores?) and the validity of these findings. Furthermore, there are many parameters that show impact to biological communities beyond abundance e.g., community diversity, evenness. Please provide more information.

<u>6.3 Development of sediment plume dispersion model</u>

The presentation of modeled and observed currents, including updated HYCOM runs, raises questions about the ability of models to accurately simulate the bottom currents at 5100 m or below. "Further, the observed currents at 5155 m depth, i.e., 30 m above seabed, did not match with the HYCOM model currents at 5000 m depth, but also exhibited out of phase with these model currents. This mismatch was more prominent in 2012. This mismatch suggests that there exists a Bottom Ekman Layer (BEL) in the CIOB study area as the currents experience friction in the bottom Ekman layer." The presentation then in a subsequent section says "The Hydrodyn-SEDPLUM model predicted currents are well compared with observed currents even at abyssal depths." This is a different model and it is unclear the purpose of the previous exposition.

Nevertheless, some observations can be formulated. A significant disparity between observed computed currents was observed in July 2011 and the variation of observed currents is more stable than the computed currents. An explanation of these observations would be needed to confirm the validity of the model. An error analysis of the model, including tools or statistical studies, as part of a complete description of the model, should be provided in the EIS to assess the accuracy of the model (e.g., Luick 2012), especially when such information is not in the public domain. To ensure the best use of this model, there also needs to be more recent data integrated. It is also worth noting that other sediment dispersion models have been developed by other contractors, sponsoring States, industries, and academics (e.g. Kulkarni et al. 2018), so it would be valuable to compare these two models.

Pg. 292: A more detailed description of Fig. 6.3.5.1 would be welcomed.

6.4 Estimations of area, volume and weight of sediment and nodules to be disturbed during nodule collection trials

This section should include predictions for the area over which a sediment plume may occur in order to understand potential impacts but is absent. In addition, it is not clear if or how the hydrodynamic model has informed any estimates in this section. As such, it appears that predictions regarding volume of sediment to be mobilised have been made on a purely geographical basis, and that no prediction regarding the extent to which those sediments will be mobilised in the water column, and resettled, has been made. Additionally, information on recovery from the above-referenced 1997 test is presented in detail, but without analysis of its relevance to the current proposed collector trial or monitoring regime.

Pg. 294: Previously in this EIS, 300-mm depth disturbance was estimated but this calculation is down to 150 mm. Please clarify.

6.5 Likely impacts of nodule collector trial

Subsection 6.5 describes the likely impacts of the nodule collector trial superficially, often with only one reference. Each should instead include a discussion of the magnitude and resulting risk (e.g., change in sediment relief, shear strength, lebensspuren, POC, trace metal reactions, oxygen consumption, sediment geochemistry, nutrients). This section could be made more succinct and reordered. Many aspects of this section should be treated with extreme caution.

Pg. 298: "As it would take less than one day (higher estimate) to settle, the particles are not likely to be involved in the scavenging (thus not affecting the dissolved constituents) and plankton growth (see Rolinski et al., 2001 for the possibilities of sediment discharge and the long-term propagation of tailings from deep-sea mining)." How was the estimate of a "less than one day" determined, and how does this relate to the very low rate of movement in the water column? Would this not cause the sediments (fines) to remain suspended for longer? The explanation on why scavenging and dissolution are not affected needs to be clearer.

Pg. 299: "The increased organic carbon values were probably due to the organic matter from dead biota and the migration and redeposition of fine-grained, organic-rich particles. A positive relationship was observed between total and labile organic carbon and macrobenthos density and total bacterial numbers prior to disturbance, whereas a negative relationship was seen after disturbance owing to drastic reduction in the density of macrofauna and bacteria." How will this influence the nodule genesis and biogeochemical characteristics and function? How this change in organic carbon will impact the composition and structure of the benthic communities should be considered in Section 7. Further research is needed to close these gaps.

Pg. 318: The concluding paragraph of the section should be treated with extreme caution given results from other abyssal areas where tests and associated long term monitoring have been undertaken e.g. Jones et al., 2017, Simon Lledo et al 2019a. The INDEX results presented are interpreted to reflect seafloor recovery of natural conditions in 44 months. This is hard to accept given results from DISCOL and other areas. The conclusion that impacts will be insignificant cannot be made on any other factor than the small scale of the impacts relative to full-scale mining. This collector trial and the associated impacts need to be framed in how they can inform future design and operation of potential exploitation, exposing the risks and impacts. It should highlight the potential issues and gaps in knowledge rather than making assumptions where data or information and understanding is lacking. It should not diminish the impacts and discard potential risks.

7. Potential impacts of nodule collector on biological environment

A number of major components of the biological environment are not considered in this section, mostly corresponding with the parameters that are listed above as missing from Section 5. They include the impacts to microbes, fauna associated with nodules, biogeochemical processes associated with the formation of nodules, as well as impacts to biology from the mobilisation of trace metals, climate change, noise and light, and cumulative impacts, etc.

7.1 Types of likely impacts

Pg. 319: "The likely impacts at surface, mid-water and seafloor are described below in the context of knowledge gained from the impact experiments carried out earlier (1)." Please clarify exactly what the referred "earlier" impact experiments are.

7.2 Impacts at surface

This EIS dismisses any effects on the surface waters but instead should state that they "do not expect" discharges and will take steps to minimise the risk but cannot guarantee no pollutants will be discharged. There should therefore be a discussion of ship effects whether purposeful or accidental (movement, oil leakage, ballast, noise, and light), including information on management methods e.g., presence of spill kits, ship-strike avoidance.

Pg. 319: "no pollutants will be discharged as per the international laws". Please cite the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL) (IMO, 2020).

7.3 Impacts in midwater

The EIS also dismisses impacts in the water column, even below 80 m above seafloor. Depending on the plume movement, some biology shallower than 80 m above the seabed may be impacted. There is no mention of meroplankton (Kersten et al., 2017). Noise and light from the ship and the collector itself should be addressed. A range of species known from the water column in the CIOB area, including at least 23 species of cetaceans some of which are deep-diving species, may be impacted, thus more detail is needed (Skov et al., 2008; Schorr et al 2014; Marsh et al., 2018; Purser et al., 2019; Carwardine, 2020; Large Pelagics Research Centre, 2020).

Pg. 319: There is discussion of dense zooplankton at the base of the OMZ in midwater but the link given goes to a defunct website.

Pg. 319: North Atlantic zooplankton data are given to make the claim that release of crushed nodules at 80 m above the seafloor will not have much impact. But it should be stated that no zooplankton data appear to be available for 5000 m in the CIOB.

7.4 Impacts at the seafloor

Section 7.4 should be informed by outputs of the hydrodynamic model in relation to determining the extent of impacts and baseline data regarding benthic fauna that is specific to this mine site. The EIS should also explain the value of the fauna in the impact area in a regional context as it will inform the assessment of impacts to fauna. This section describes the outcomes of the 1997 test but should take the further step of predicting impacts of the upcoming trial. While INDEX results are given, some relevant studies are not mentioned. For example, Mevenkamp et al. 2019 studied effects on the meiobenthos of crushed nodules at 4200 m in the Pacific and found migration of animals into the crushed material and changes in the vertical distribution and feeding types of meiobenthos. Throughout this section, it is repeatedly suggested that natural variability is causing most of the differences pre- and post-experiment, but this is not supported by the data. Please clarify. Finally, there is very little attention given to impacts on the nodule-associated fauna covered in Section 5.6 (Vanreusel et al. 2016).

Pg. 320: The first paragraph implies that because abundances are moderate, impacts will not be large. The papers cited do not say that impact magnitude is positively correlated with abundance, and this concept is extremely dangerous to set as a precedent for various impacts and habitats.

Pg. 320: "The meiofaunal abundance in nodule-free areas in general are higher than that in nodule-bearing areas (e.g., Renaud-Mornant and Gourbault, 1990; Miljutina et al. 2010). In the nodule-bearing areas, meiofaunal abundance may be influenced by geological features such as sediment type, clay content, water content, porosity and other environmental parameters." What about other components of benthic biology? It is also unclear what scales are being discussed; the scale of beneath vs. next to individual nodules? Tens of metres or many kilometres? Higher abundances do not equal healthier systems. In fact, for benthic communities especially, the highest abundances are often found in polluted areas (Pearson and Rosenburg, 1979). Thus, it should not be assumed that since meiofaunal abundances are higher in nodule-free areas, mining will have little impact.

Pg. 321: It is unclear what this means in reference to the macrobenthos of the INDEX experiment, "Significant reduction in the vertical distribution was also recorded".

Pg. 321: There are heavy direct quotations relating to the INDEX study e.g., "similarly the abundance of meiofauna, in particular, nematodes and copepods showed reduction up to 40% in the disturbed track." is from Ingole et al. (1999) and should be in quotation marks. Also "nematoda was the most abundant metazoan group, on an average representing >55% of the meiofaunal population. The abundance of nematodes and harpacticoid copepods as well as total meiofauna showed marked decreases during post-disturbance sampling" and "vertical distribution of meiofauna in the sediment cores revealed that 75% to 90% of the metazoan population was confined to the top 2-cm layer of the sediment" are direct quotations from Ingole et al. (2000) and should be stated as such.

Pg. 322: The conclusion "increase and reduction in meiofaunal density…can only be due to natural changes occurring in the area, implying that the effects of artificial disturbance had waned off by then." is not clearly explained. Additionally, the study cited (Ingole et al. 2005) concludes that restoration of physically disturbed deep-sea habitats might take longer than the stated consensus, so this is an incorrect citation.

Pg. 323: This statement is likely untrue, "The population of nematodes and oligochaetes was restored after 44 months, in fact, more than what was seen before, but the crustaceans did not reach the baseline populations measured in June 1997 (Fig. 7.4.2)." It is important to know what the composition, structure, and function of these communities are and whether this is dominated by pioneer and succession species, and whether this has implications for the ecological function of the benthos. The relevance of the "recovered populations" to ecologically relevant "restoration" (as defined in the context of the mitigation hierarchy) is important. Just because there has been recruitment of species to the area does not imply the area is restored nor ecologically healthy and functional. The EIS should explicitly mention that, though abundance and diversity of benthic taxa can recover or even exceed pre-disturbance levels, it is community composition that remains impacted for decades after disturbance (Jones et al. 2017; Vanreusel et al. 2016).

Pg. 323: "Thus, the sediment analysis suggests an improvement in the biochemical parameters and likely enhanced food conditions for the benthos." What data was used to come to this conclusion? The statement points to a misunderstanding of ecosystem function and community dynamics.

7.5 Faunal abundance changes related to plume deposition (blanketing)

The interpretation of faunal change needs caution e.g., this sentence states there were no effects of re-sedimentation in the first part and then describes a change in the second part "However, the re-sedimentation effects were not noticed on larger fauna, as increased macrofaunal abundance was observed in the south of the test site after the disturbance (Ingole et al., 2005a)." All impacts should be characterized, not only declines in density, diversity, etc.

While the current understanding of the impacts of sediment plumes is based on before-after impact experiments with direct observations and data lacking in this area. However, this section could also have included natural analogue studies (e.g., Haeckel et al. 2001) and more examples from the CCZ, in relation to the CIOB region and how biological communities in this region might be impacted (Jones et al. 2017). Information regarding the associated impacts on nutrient cycling and organic-matter remineralisation and the impacts on micro-, meio-, and megafauna should also be included.

Pg. 330: "In most of the benthic impact experiments, a general reversal, mainly in density of meiofauna, towards control levels over a period of time has been observed (see Jones et al., 2017 for a review)." The reference to Jones et al., 2017 is misquoted. Impacts are often severe immediately after mining, with major negative changes in density and diversity of most groups occurring. However, in some cases, the mobile fauna and small-sized fauna experienced less negative impacts over the longer term. At seven sites in the Pacific, multiple surveys assessed recovery in fauna over periods of up to 26 years (Jones et al., 2017). Almost all studies showed some recovery in faunal density and diversity for meiofauna and mobile megafauna, often within one year. However, very few faunal groups return to baseline or control conditions after two decades, and some groups (i.e., sessile suspension feeders) remain virtually absent from directly impacted areas showing little to no sign of any recovery (Vanreusel et al., 2016; Simon-Lledo et al., 2019a). The effects of polymetallic-nodule mining are likely to be long term (Vonnahme et al., 2020).

7.6 Effects of plume on demersal scavengers and fish

The potential impacts of the plume on scavengers and fish are mentioned but as these components were not surveyed, there is no baseline to compare against. Additionally, this section refers to plumes resulting from the discharge of nodules at 50-80 m above bottom, but the collection and replacement of nodules behind the collector in the other trials will also create a small near-bottom suspended sediment plume that could affect epibenthic megafauna and fish. This should be discussed. Finally, more peer-reviewed literature should be cited.

7.7 Effects of toxic discharges on faunal organisms

A discussion of the metal concentration in the nodule-bearing sediment, the potential for release of Cu or any other potentially toxic element into the water, or exposure via sediment is needed. In addition to metals, other chemical contaminants may be present in the sediments, and the remobilization of sediments may make these bioavailable to local fauna. It should also be discussed that other chemicals of concern may be present and produce negative impacts to local fauna, including to the species with little to no mobility.

Pg. 330: Inclusions of avoidance behaviour to metals in the specific species e.g., *Holothuriaforskali* and abyssal holothurian *Amperima* sp., should be treated with caution given species-specific sensitivity to metal exposure and the sublethal and lethal impacts.

Pg. 331: "Moreover, endemic species of faunal communities associated with nodules have not been observed in the CIOB as most of the faunal groups/species are found in the sediments associated with nodules as well as those without nodules." This is an unsubstantiated claim as more research is required to ascertain the relationship between nodule and faunal presence. It is highly unlikely that the findings of the CCZ are not applicable to the CIOB.

Pg. 331: Again, restoration would not have occurred after 1395 days. It is important to know what the composition, structure, and function of these communities are, whether this is dominated by pioneer and succession species, and if this has implications for the ecological function of the benthos. The relevance of the "recovered populations" to ecologically relevant "restoration" (as defined in the context of the mitigation hierarchy) is important. Just because there has been recruitment of species into the area does not imply the area is restored nor ecological healthy and functional.

8. Plan for environmental impact assessment and monitoring of proposed activity

This section needs to be much more detailed, including a standardized design of sampling in space and time, and how the data will be used to assess impact. What monitoring actions will be conducted and type of data collected? What equipment and other resources will be required? What are the assessment procedures and reporting processes? What is the timeframe for monitoring, assessment and reporting? What is the allocation of responsibilities? What risks are there?

There is no mention of monitoring for several necessary components of the CIOB environment including water-column impacts, surface impacts, many ecosystem functions e.g., carbon sequestration/burial, respiration, remineralization, productivity, food-web structure. An additional important activity that should be included is the assessment of the bioavailability, bioaccumulation, and ecotoxicity of contaminants in key local species along an impact gradient as these will determine the species resilience to impact.

There is little mention of procedures to be followed to ensure effective protection and mitigate impacts as requested by the ISA (ISBA/25/LTC/6/Rev.1).

<u>8.1 Environmental data collection</u>

Pg. 332: Two cruises is not enough for a baseline of temporal variability.

Pg. 333: It is not apparent from this EIS that the baseline composition of communities was studied at the level of detail needed to inform the understanding of impacts and recovery.

Pg. 333: There is no evidence within this EIS that the microbial-community baseline or molecular biology and genetic connectivity has been studied. It is also not clear from this EIS whether baseline bioturbation studies were carried out at an adequate level of detail.

Pg. 333: Section 8.1.2 should elaborate when, where, and how frequently water-quality sampling will be undertaken.

Pg. 333-335: The locations for moorings provided in Fig. 8.1.3.1 (the 'regional' monitoring locations) are too far apart for a test mine activity. Using the PRZ, at a distance of 116 km from the trial location (IRZ), is not appropriate for the size of the plume expected to be generated and will not provide relevant data relating to the extent of far-field impacts.

Pg. 333-335: Monitoring equipment for the purposes of validating the plume, including sediment traps, will be mounted 90 m above the seafloor (although Fig. 9.1.3.2 indicates the lowest sediment trap will be located 107 m from the seafloor). However, Section 6.3 indicates that "solids discharged at 80 m above seafloor tend to be directed towards the seafloor". Consequently, the traps are unlikely to catch sediment and provide valid data. Ideally, vertical zonation and duration of plume detectability should be addressed.

Pg. 336: Section 8.1.5 needs specifics on survey plan and equipment to be used. No information has been provided on how long monitoring will occur for or at how many sites, etc.

<u>8.2 Impact assessment and monitoring plan</u>

Pg. 336-339: Section 8.2 refers to the longer-term monitoring plan, (covering 1 year) but does not elaborate upon the scope, nature, extent, or schedule of post-trial monitoring. Given the need to monitor recovery of benthic organisms in particular, and to gather data which may also inform the nature of recovery of the ecosystem as a whole in the context of a proposed full-scale mine, these are critical details that must be included in the final EIS. The extent to which this list is comprehensive needs to reflect a uniform series of environmental goals and objectives and an agreed-upon definition of adverse impacts and significant harm.

Pg. 336-339: The post-impact monitoring will take place 'right after disturbance' and after 1 year. This timeframe is not appropriate as impacts will extremely likely last longer than a year (e.g., Jones et al., 2017, Vonnahme et al., 2020).

Pg. 338: How were the locations of the five moorings (Fig. 8.2.1) chosen?

<u>8.3 Reporting, data management and dissemination</u>

Pg. 339: The data reporting plan appears strong. Review by a high-level committee appointed by the Ministry of Earth Science is a particularly good idea if they are independent of the scientists conducting the research. Please consider opening the data compilations for review by other stakeholders (scientists and others). It will be important to take advantage of trials such as these to learn as much as possible.

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