Review of the Global Sea Resources Minerals *(hereafter GSR)* **Environmental Impact Statement:** Small-scale testing of nodule collector components on the seafloor of the Clarion-Clipperton Fracture Zone and its environmental impact.

1.) Executive Summary

The GSR EIA describes the testing of a nodule collector and its environment impact. As such, this is not an extractive project but more of a disturbance experiment and the EIA has been structured accordingly. The deployment of a collector will take place over 4-5 days to remove nodules, disturbing the top 10 cm of sediment and generating a sediment plume. A modest sized area will be highly impacted with key habitat altered. It is argued by the proponents that this represents a similar sort of impact to previous research disturbance experiments in the past, with a justification being that the amount and quality of scientific information gathered outweigh the costs of the impact to deep sea habitat and associated biota. The proposed project brings in much expertise and knowledge of the deep sea system and invests significantly in a monitoring program that seeks to understand many of the impacts likely to occur with deep sea mining. The proposed GSR project is a joint program with a BGR effort under the framework of the European "Joint Programming Initiative – Oceans" project "MiningImpact 2".

For the most part, the EIA loosely follows the ISA Appendix V EIA format. There are chapters/sections missing given that there is no removal of nodules to the surface (e.g. sections pertaining to the socio-economic impacts of the operations). However, the GSR EIA also misses many sections within each of the Annex V chapters – in particular those that touch upon managing the potential impacts – such as "best practices" in creating a risk register/assessment, and a management (and mitigation) schemata for dealing with potential risk should they occur. The GSR EIA report also does not focus on clearly answering the key questions under the Annex V the report attempts to cover.

The GSR EIA contains a fairly elaborate and complete description of the nodule collector, the collector deployment and the program to monitor collection impacts. The GSR team appears to comprise a wide diversity of interests and experts. The character of the biota revealed in previous studies is detailed and useful. The GSR proposes a variety of physical, biogeochemical and biological monitoring which are useful. While the proposed monitoring plan will undoubtedly bring much interesting new information that will help assess future mining impacts, increased research planning and detail including on the experimental design would increase the relevance and usefulness of the data collected, and increase the value of the disturbance experiment.

2.) The main recommendations for the GSR EIA:

- There is little if any information or comments on how alternative nodule collection approaches might be tested to identify how to minimize the most deleterious impacts on marine biota, or lead to greatest recovery post-disturbance. There could also be coordination between the BGR and GSR efforts to test different collection methods for their impact on local biota.
- I recommend the EIA should more clearly reflect the questions in Annex V that pertain to managing risk rather than only focus on monitoring impact (as is currently in the EIA). There are specific comments under relevant sections below.
- The GSR EIA describes an impressive number of monitoring systems. It would be useful to include more specifics on the decision making by which the GSR team intends to determine sampling sufficiency in space, time, frequency, location, etc. This will be helped by listing more specific research questions they intend to test and the amount of change they are hoping to detect over time and space.

- Given that the proposed collector is ¼ the scale of the intended collector – it would be good to model and potentially test (either empirically or via modelling) the kind of impact that will occur with a larger collector. This is especially important since the proposed value of this monitoring program is to inform future mining operations.
- Given the large uncertainties in the proposed impact (due in part to relative unknown of seafloor biodiversity and responses to impacts, unknown dispersion of plume, etc.), it seems important to both extend sampling spatially, frequency and level of detection. Secondly, developing and sharing the rationale for choosing a sampling frequency (and documenting hypotheses behind that rationale) – will be important in providing guidance for future efforts (e.g. help others who seek to learn from the GSR program.) and interpreting the data.
- There is evidence of local scale variation in habitat (e.g. facies) and biota both within the reference and impact zones – as well as between the impact and reference/control zones. I recommend they use a standardized and named facies/habitat nomenclature and be more specific on how the monitoring/sampling will reflect facies diversity to efficiently and effectively sample local habitats and biota. In other words, how will they ensure each habitat/biotic system be sufficiently sampled to accurately determine level of impact and/or recovery? There is work done by Tilot et al 2018, among others that have started to develop approaches to address this.

3.) In summary, the GSR EIA sets out an extensive monitoring program to assess the performance and impact of Patania-II, a scaled down prototype of nodule collector. The EIA has much information and is mostly complete and accurate. It suffers from some deficiencies, notably in attention to the need for management of impacts (in addition to monitoring of impacts) (as required by Annex V). While the GSR EIA is rich in analyses and details on many facets of the proposed monitoring program, it is also short in terms of rationale of decision making around sampling design (e.g. intensity and sufficiency) which may limit the value of the scientific outcomes from the disturbance experiment. The GSR team has assembled a competent team of experts to support the monitoring program – and they will hopefully be engaged with sufficient resources to ensure the monitoring program is well carried out – but the current EIA makes this hard to ascertain.

4.) Detailed comments on Annex V sectors (the Annex V section descriptions are highlighted in light grey)

Executive summary…

One of the main objectives of the Executive Summary is to provide an explanation of the project and a summary of the content of the EIS for non-technical readers. Information provided in the executive summary should include:

- *description of the proposed development and its objectives;*

This section is complete, and clear

- *anticipated impacts of the activity (physico-chemical, biological, socio-economic)*

The anticipated impacts will be highly significant to a restricted portion of the seabed (where collection takes place and plume settles) but is also described by proponents as “no serious harm” due to limited scope of project

- *mitigation measures to minimize environmental impacts*

Incomplete - not really any measures described should something unforeseen happen

- *benefits to be derived from the project;*

Described clearly and accurately

- *end-use plans for the development activity, including information about decommissioning and consultation undertaken with other parties*

Incomplete - Few specifics given except will follow standard operating procedures in terms of information sharing. It would be useful to have more specifics here as to where and when data will be shared and be made available since the primary described benefit is information for future efforts.

The GSR proposal makes a key assumption that JPI-0II MiningImpact2 program using a downscaled collector can evaluate environmental impacts that a future (larger scale) nodule collection activity may generate. Understanding the limitations of this assumption are important in that for example, the nature of the sediment plume of a larger collector (head) may behave quite different from one that is roughly a quarter its size.

1. Introduction

1.1 Background *This section should briefly summarize the project being proposed, including all main activities and locations*.
1.2 Project Viability *This section should provide information on the viability of the proposed development and provide economic context, why the project is needed, and include a description of benefits to the sponsoring State*
1.3 Project history
This section should briefly summarize the work undertaken up to the date the Environmental Impact Statement was finalized and ready to be submitted to the ISA. This should include a brief description of the deposit discovery, the Exploration undertaken and any mining system component testing conducted to date. For the component testing, provide a brief description of activities here. If applicable, include any report(s) related to component testing in the Appendix.
1.4 Project proponent
This section should summarize the credentials of the Contractor or entity proposing the development including major shareholders, other tenements owned including in other jurisdictions, etc. The proponent's technological and environmental expertise, capacity and resources should be outlined.

Incomplete. Much of the project history including about the mine valuation is not well described. There is not much about the project proponent (Annex V section 1.4) nor on project viability (section 1.2) in the Introduction.

1.5 This report
1.5.1 *Scope*
This sub-section should detail what is and what is not included based on earlier assessments or work. Link to other supporting information.
1.5.2 Report structure
This section is required if the Environmental Impact Statement spans multiple volumes. This section can provide additional details not listed in the main report's Table of Contents.

The report scope and structure is well described. (P. 20-21) Clear description of structure and rationale of proposed program. The organization of work groups and cross cutting themes is clear and useful. (p 21) – the listing of three goals is useful.

2. Policy, Legal and Administrative Context ***This section should provide information on the relevant legislation, agreements or policies that are applicable to the proposed mining operation.***

2.1 Applicable mining and environmental legislation, policy and agreements *The applicant should note any legislation, regulation or guidelines that apply to the management or regulation of seabed mining in the Area, including how the proposed operation will comply with these.*

2.2 Other applicable legislation, policy and regulations *This sub-section should include a description of any other legislation, policy or regulations that do not necessarily apply specifically to seabed mining or the environment, but may be relevant to the proposal (e.g. shipping regulations, etc.).*

2.3 Relevant international and regional agreements *This sub-section should list the international agreements applicable to the operation, such as the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on Biological Diversity (CBD), the International Maritime Organization (IMO) suite of environmental and safety conventions including the Safety of Life at Sea (SOLAS) Convention, the International Convention for the Prevention of Pollution from Ships (MARPOL), the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention), etc.*

2.4 Other standards, principles and guidelines *This sub-section should discuss any other non-legally-binding standards or guidelines that will be adhered to, or aligned with, throughout the operation, e.g. Equator Principles, International Organization for Standardization (ISO) standards for Environmental Management, the International Marine Minerals Society (IMMS) Code for Environmental Management, International Seabed Authority guidelines, International Finance Corporation (IFC) Performance Standards, etc.*

This section (p.23) only refers to the Law of the Sea – and makes no reference to any other conventions, treaties or guidelines. This may be because they consider the activities to be of small impact. Nevertheless, in the spirit of developing information to be of benefit to future monitoring and management – it would be beneficial to identify greater alignment and concordance with other policies, treaties and guidelines that touch upon resource extraction as proposed in the EIA – including many of those listed in Annex V. At the very least, the EIA could name those that are more or less relevant and how the principles embodied in each relate to the proposed activities either in the two projects currently proposed in the EIA.

3. Description of the Proposed Development ***This section should provide details of the proposed development activity including relevant diagrams and drawings. It is understood that most projects will likely involve the extraction of minerals from the Area with the concentrating process(es) occurring on land within a national jurisdiction and outside the jurisdiction of the ISA. Whilst it is expected that this section would provide a brief description of the entire project including offshore and land-based components, the EIS should focus on those activities occurring within the ISA's jurisdiction (e.g., activities related to the extraction of the minerals from the Area up to the point of transshipment). Details to be provided under this section may include the headings listed below.***

3.1 Project area definition

3.1.1 Location *This sub-section should include coordinates of project area, detailed location maps (drawn to scale), site layout, any closed/ exclusion areas.*

3.1.2 Associated activities *This sub-section should include a description of any supporting activities and infrastructure required (e.g. transportation corridors) that are outside the direct mining site.*

3.2 Mineral resource *This sub-section should detail the type of resource proposed for extraction (e.g. seafloor massive sulfides, polymetallic nodules, manganese crusts, etc.), the type of commodity, the grade and volume. Estimates of inferred and indicated resource should be provided, along with visual models of the resource.*

3.3 Project Components *This section should provide background information to the proposal, technologies to be employed, etc., and include the following sub-sections:*

3.3.1 Mining *This section should include technologies to be employed with relevant diagrams and drawings, and should cover: mine plan, general mining sequence, technologies to be employed to separate the resource from the seabed, depth of penetration into the seabed etc.*

3.3.2 Transport/materials handling *Description of all methods to be used to transport the mineralized material, including from the seafloor to the surface, and any methods related to the transshipment of the mineralized material, including at-sea transfers.*
3.3.3 On-site processing *Description of any processing of the mineralized material to occur within or above the Area. This includes a description of any methods to be used on the seafloor to separate the mineralized material from surrounding sediment and/or rock, as well as any dewatering of the mineralized material and this section should also cover any*
disposal of seawater/fines, etc. This should also include a description of the disposal of waste, including handling and disposal of hazardous materials.
3.3.4 Project Scale *Overview of the spatial and temporal scales of the operation including volumes of material to be extracted, processed, and deposited.*
3.3.5 Support equipment *This sub-section describes any equipment expected for mining and support operations (e.g., mining vessels/ platforms, supply vessels, barges). Describe anticipated frequency of vessel movements for support, supply, barge removal, etc.*
3.4 Commissioning
3.5 Decommissioning *Including offshore infrastructure.*
3.6 Construction and operating standards *This section should outline the design codes to which the equipment will be or has been built, as well as the health and safety standards that will be applied. This section should include sub-sections such as:*
3.6.1 Design codes
3.6.2 Health and safety
3.7 Other alternatives considered *This section should provide an overview of the other locations, methods, etc, that were considered, and rejected, in favor of what is being proposed.*
3.8 Development timetable (Detailed schedule) *Description of the overall timetable, from implementation of the mining programme through to decommissioning and closure of operations. This should include the major phases of the operation, as well as the milestone dates on which relevant tasks are expected to be completed. Information on the development timetable provided under this section should clearly communicate the different phases in the development proposal. For reasons of clarity, a Flow chart, Gantt or PERT chart should be used where appropriate. Information provided in this section should include, but not be limited to, the following:*

- *The funding arrangement for proposed activity or if availability of funds is subject to this or other approvals being granted;*
- *Pre-construction activities;*
- *Construction schedule, staging, etc.;*
- *Infrastructure development schedule; and*
- *Closure schedule.*

Overall, this is a well detailed section with a clear indication of proposed development.

Some questions remain:

(P 23) – Procat#2 collector vehicle used in 2019 is to be significantly smaller than the envisioned commercial vehicle – notably – the collector head not scaled (it would be important to understand how the Procat#2 is different than projected scaled up collector to be used in mining operation).

(p.25) – biological, geological and oceanographic samples are available for this area. This section includes description of benthic (reference) impact zones/areas (IRZ) vs plume impact reference zone (PIRZ) vs control reference zone (RZ). It would be good to have consistent naming between Fig 4 and P 25 – e.g. Fig notes it as Control Reference Area whereas p 25 notes it as Control Reference Zone

(p 26 & 33) – Why are maps using different spatial coordinate systems (UTM in Fig 4 and Lat/long in Fig 5)- it makes overlaying of maps more difficult for reviewer. How were the locations for mining impact, plume assessment and control chosen – wrt nodule density?

(p. 52) Vessel. Should standards be identified more precisely for contracting the vessel?
For any of the equipment operating at depth – Procat2, AUV and ROV – what procedures are set up in case there is a failure when at depth? What is the likelihood of failure? How is this recorded, reported and lessons learned shared?

Incomplete: the following sections little of any information in the EIA:
3.6 Operating standards *(stated vaguely especially with respect to health and safety standards))*
This section should outline the design codes to which the equipment will be or has been built, as well as the health and safety standards that will be applied. This section should include sub-sections such as:
3.6.2 Health and safety
3.7 Other alternatives considered
This section should provide an overview of the other locations, methods, etc, that were considered, and rejected, in favor of what is being proposed.

4. Description of the Existing Physico-Chemical Environment *This section should give a detailed account of knowledge of the environmental conditions at the site. It should include information from a thorough literature review as well as on-site studies. It provides the baseline description of the geological and oceanographic conditions against which impacts will be measured and assessed.*

4.1 Key messages *Overview of key content (this information can be provided as a box with up to 6 bullet points of the main aspects covered, or the main findings).*
4.2 Regional overview *Description of the general environmental conditions of the site, including geological and oceanographic setting within a broader regional context. This is a brief section that should include a map. A more detailed site-specific description will be provided as per the sections below.*
4.3 Studies completed *Description of any prior research/Exploration Activities that could provide relevant information for this EIS and future activities. These should be detailed in the appendices, and submission of the environmental reference baseline data collected for the Authority, as outlined in exploration contract conditions, should accompany the EIS.*
4.4 Meteorology and air quality *General overview of climatology, e.g. wind directions and speeds, seasonal patterns. This section may be most relevant to surface operations.*
4.5 Geological setting *Description of the nature and extent of the mineral deposit and bedrock within a broader geological context. Description of the general geological landscape and topographic features of the site, including bathymetric maps.*
4.6 Physical oceanographic setting. *Description of oceanographic aspects such as currents, sedimentation rates, and waves. Detail is required on the regional setting, as well as the specific site, and include changes with depth and horizontal distance (near-field, far-field).*
4.7 Chemical oceanographic setting. *Description of water mass characteristics at the site and at various depths of the water column in particular near the seafloor, including nutrients, particle loads, temperature and dissolved gas profiles, vent fluid characteristics if applicable, turbidity and geochemistry etc.*
4.8 Seabed substrate characteristics *Description of substrate composition, including physical and chemical properties (e.g., sediment composition, pore-water profiles, grain size, sediment mechanics).*
4.9 Natural hazards. *Description of applicable potential natural hazards for the site, including volcanism, seismic activity, cyclone/hurricane trends, tsunamis etc.*
4.10 Noise and Light. *Description of ambient noise and light, and the influence of existing Exploration and maritime activity*.
4.11 Greenhouse gas emissions and climate change. *Description of the greenhouse gas emissions from existing activities as well as any activity that may affect seafloor acidity.*
4.12 Summary of the existing physico-chemical environment. *Bring together key findings, and include any sensitive environments or highly valued areas. It is anticipated that this summary will be up to one page, and more extensive than the key messages section.*

(p. 52) “The spatial variability within the GSR contract area and the area of interest B4S03 for the experiment itself is considered limited.” – Why is this so? This should be substantiated.
(p 53). Description of surface meteorology – I do not see missing any reference to frequency, intensity, seasonality of storms/cyclones which may disrupt any sea surface activities.
(P55-60) – It would be useful to overlay the sampling plots areas overtop these maps to get a sense of how similar control and disturbed sites are.

The information including images for physical features of benthos seem quite complete and give a good sense of the terrain. It appears that the level of detail allows for reliable estimates of (surface) nodule abundance

(p67) - Megafauna trails and Tumuli. Can these be mapped or interpreted to better understand siting for sampling or ability to manage monitoring the impact of nodule dumping or plumes?

p. 79-80 – current model well described in EIA – It would be important to include substantial mooring data to develop reliable models into the future. Leave some out for longer? Leave mooring close to seabed to capture near benthos currents 9rleevant to biota and deposition of plume.

P 80. It is clear that the current direction is quite variable. Therefore, current direction observations from the 8-17 days mooring deployments might not be long enough to determine the long-term directional current climate.

Figures 40-42. The assessed current diagrams (roses) for 2017 do not seem to be captured in the presented 21-day model averages. This is an area that needs to be investigated to model plume dispersion (temporal and spatial)

p.86. I think the overall model results for speed are close – but with some deviations that may be biologically significant. These seems to be consistently greater current using mooring data than model – especially at 40 m – 60 m above seafloor – but also greater max velocity at seafloor at Mor002. Gaining greater confidence in current speed and velocity clearly an important area for monitoring.

(p.89-). Sediment analysis. They should use the following facies nomenclature to facilitate comparison with others. Hoffert, M., and Saget, P. (2004). Manuel D’ identification des “Facies-Nodules” Pour la Zone de Plongées NIXO45. Rapport Interne IFREMER, Plouzané.

(p.112) Noise not monitored specifically to date. These sections have little specific baseline information to document potential impact.

5. Description of the Existing Biological Environment ***This section should be divided by depth regime for the site into a description of the various biological components and communities that are present or utilize the area.***

5.1 Key messages *This section should provide an overview of the key content (this could entail a box with up to 6 bullet points of the main aspects covered, or the main findings).*
5.2 Regional overview *This section should provide general regional context and include site-specific issues and characteristics, particularly sensitive environments. Existing conservation areas and protected species, etc., should be covered and there should be a reference to relevant technical data and previous studies. This is a brief section, but provides the broader scale context for the more detailed site-specific description below.*
5.3 Studies completed. *Description of any prior research/Exploration activities that could provide relevant information for this EIS and future activities. These should be detailed in the appendices, and submission of the environmental reference baseline data collected for the Authority, as outlined in exploration contract conditions, should accompany the EIS.*
5.4 Biological environment. *Diversity, abundance, biomass, community-level analyses, connectivity, trophic relationships, resilience, ecosystem function and temporal variability should be addressed. Any work on ecosystem models and appropriate ecosystem indicators, etc., should also be presented here. This section should span the size*

ranges from megafauna through to microfauna. The description of the fauna is structured by depth range as this enables a direct linkage to the source and location of an impact. For each depth zone, there should be a description of the main taxon/ecological groups (e.g., plankton, fish, marine mammals, benthic invertebrates, demersal scavengers), using Recommendations from the ISA.

5.4.1 Surface. *This section describes the biological environment from the surface down to 200 m water depth. This includes plankton (phytoplankton and zooplankton), surface/near surface fish such as tuna, as well as seabirds and marine mammals.*

5.4.2 Midwater. *This section describes the biological environment in the open water from a depth of 200 m down to 50 m above the seafloor and includes zooplankton, mesopelagic and bathypelagic fishes, and deep diving mammals.*

5.4.3 Benthic

This section describes the benthic invertebrate and fish communities, including infauna and demersal fish up to an altitude of 50 m above the seafloor. This should include considerations of species richness, biodiversity, faunal densities, community structures, etc. Bioturbation should also be covered in this section.

5.4.4 Ecosystem/community level description. *This should summarize existing community or ecosystem studies, where elements of the above sections are integrated.*

5.5 Summary of the existing biological environment. *This section should bring together the key findings with respect to the biological environment including regional distributions, any sensitive environments identified and fauna or highly valued areas. It is envisaged this summary will be up to a page in length.*

(p. 113-). Biological environment. Accurate and complete – but with limited ability to project biological environment given limited sampling done. There is a good description of the available data – noting that there is limited sampling done which restricts any ability to determine the true extent of biological diversity across sites or time.

(p. 123)- This is a useful comparison of nodule rich vs poor sites.

Fig 75 – tempting to declare that there is no difference between nodule rich and poor sites – but for Shannon wiener and ET plots, there is a difference that might become significant with more plots. Need to do a power analysis to determine whether the sampling frequency is sufficient to determine a difference. Note that diversity indices are of limited value (in my opinion because it is the distribution of actual species one is interested in here, and not simply the occurrence of sites with similar diversity indices).

(p. 128-129) The findings point to some degree of connectivity between contract areas that are separated by 100s of kilometers. I think that the description given here is likely accurate based on available information – but I am unclear on the degree the inferences drawn about likely similarities of fauna across space and time are truly merited given the limited quantity of sampling done, and limited degree to which taxa were identified to species level. Their findings are not consistent with the findings of others done in similar areas (e.g. Tilot et al 2018).

This suggests increasing sampling frequency and scope.

6. Description of the Existing Socio-Economic Environment

6.1 Key messages *Overview of key content (can be a box with up to 6 bullet points of the main aspects covered, or the main findings).*

6.2 Existing uses

6.2.1 Fisheries. *If the project area occurs within an area used by fisheries, then this needs to be described here.*

6.2.2 Marine Traffic. *This section describes the non-project related marine traffic occurring within the project area.*

6.2.3 Tourism *This section describes areas used by cruise-liners, game fishing, sightseeing, marine mammal watching and other relevant tourism activities.*

6.2.4 Marine Scientific Research. *An outline of the current scientific research programs taking place in the area should be provided here.*
6.2.5 Conservation Areas. Describe any nearby and/or relevant Marine Protected Areas or Marine Reserves, Areas of Particular Environmental Interest, Marine Mammal Sanctuaries, etc.
6.2.6 Other. *List other uses of the project area that are not related to the above (e.g. telecommunications cables, other mineral Exploration or Exploitation projects, bioprospecting, etc.).*
6.3 Cultural environment. *As applicable, list places of cultural/historical significance that occur within the zone of influence of the project area (e.g. shipwrecks, traditional fishing grounds, World Heritage Sites, etc.).*
6.4 Summary of existing socio-cultural environment *Bring together key findings of socio-cultural environment. It is envisaged that this section will be up to a page in length, and more extensive than the key messages.*

NA

7. Assessment of Impacts on the Physico-Chemical Environment and Proposed Mitigation ***Provide a detailed description and evaluation of potential impacts of the operation to the physical environment components identified in section 4. This may need to consider effects that could happen during construction/development (pre-commissioning), operational, and decommissioning phases, as well as the potential for accidental events. The preferred approach in this template is that for each component there is a description***
of:

(i) the nature and extent of any actual or potential impact, including cumulative impacts;
(ii) measures that will be taken to avoid, remedy or mitigate such impacts; and
(iii) the unavoidable (residual) impacts that will remain.

It is important for these sections to make clear the expected longevity of residual effects.
7.1 Key messages *This section should provide an overview of the key content covered in Section 7.*
7.2 Description of potential impact categories. *This section is an overview and description of general impact categories caused by the mining operation. This is not expected to be detailed, but introduce the major types of effect, such as habitat removal, creation of sediment plumes, noise, light etc. A description should be included of any lessons learned from activities during the exploratory phase of the programme (e.g. mining system component tests). The results of any environmental risk assessments should be described, and included as separate reports or appendices where appropriate.*
7.3 Meteorology and air quality
Description of potential effects on the air quality from the surface or subsurface operations.
7.4 Geological setting
Description of impacts the mining operation may have on the topography of the site or geological / geophysical composition.
7.5 Physical oceanographic setting *Description of effects on current speed/direction, sedimentation rates, etc. A regional oceanographic model will be relevant for this section.*
7.6 Chemical oceanographic setting *Description of effects such as sediment plume generation (composition and concentration) and clarity of water, particulate loading, water temperature, dissolved gas and nutrient levels etc., in all relevant levels of the water column. A regional oceanographic model will be relevant for this section. For a seafloor massive sulfide project, modification of vent fluid discharges should be addressed.*
7.7 Seabed substrate characteristics. *For example: changes in the sediment composition, grain size, density, pore water profiles.*

GSR EIA section 5

These sections are in general well described
(p.131). from GSR EIA "At the moment, the amount of sediment deposition from a mining-induced plume that could either be tolerable or lethal for any of the faunal groups of the deep sea is unknown."
While not inaccurate, this is a misleading statement in that the amounts of deposition caused by a plume at its discharge site will exceed by several orders of magnitude the natural rates of sediment deposition and thus exceed

anything these organisms experience except under the most extraordinary circumstances – and are thus likely to be highly deleterious close to where the plume is generated. There is evidence that benthic biota do not recover from disturbance and plume generation for many years post disturbance event. More accurately, it is unknown how close to natural sediment deposition rates the local biodiversity can tolerate- conditions that will only be found at great distance from where the plume will be generated.

(p.132). the section on historical data infers that little quality studies exist on the temporal longevity, vertical height and spatial extent of sediment plumes – this seems to differ from other studies (e.g. Tilot et al 2018) which infer much greater spatial extent and temporal longevity of sediment plumes.

(p.137-139) – useful description of "experimental" disturbance trials (4 of them) – these seem a good mix that represents a variety of scenarios.
But why not model at 0.1 or 0.2m/s to understand the impact of a reduced speed on sediment dispersal. This may be useful in general or areas with highly sensitive or rare species.

(p.145).The selected Reference Area is located roughly 11 km southwest of the MiningImpact 2 Program area. Sediment deposition (≥0.1 mm) from the disturbance is not expected to occur at the reference/control area under any flow direction condition, given that the maximum size of the deposition zone was 6 km for the performed simulations. (Note this assumes models are correct).
Both the moderate (scenario 1) and high impact yield modeled sediment dispersion areas that are significant (many kms) from source. It seems important to test for collection with lower plume dispersal impacts.

There is not much is discussed in terms of being able to mitigate the impacts of the plume.

(p.145) – section 5.1.3.3 Impact on biogeochemical setting – impact of collector tracks and in immediate vicinity of disturbance will be significant – not sure how best to mitigate it – no suggestions given.

Sections on natural hazards and impacts to operations (equipment failure are well described and appear complete and accurate.

The following are less well described or not described at all:
7.10 Greenhouse gas emissions and climate change *Estimated greenhouse gas emissions released by activities and any activity that may affect water acidity. Sub-sections should include estimated greenhouse gas emissions and greenhouse gas emissions assessment.*
7.11 Maritime safety and interactions with shipping. *Include project safety, interaction with other vessels.*
7.12 Waste management. *Vessel waste management, with reference to compliance with relevant conventions, legislation or principles, methods of cleaner production and energy balance.*
7.13.1 Proposed operations impacts. *Cumulative within the scope of the mining proposed herein.*
7.13.2 Regional operation impacts. *Cumulative between activities where known in the region.*
7.15 Summary of residual effects. *A table may be a useful summary format.*

8. Assessment of Impacts on the Biological Environment and Proposed Mitigation

Provide a detailed description and evaluation of potential impacts of the operation to the biological environment components identified in section 5. This may need to consider effects that may happen during construction/development (pre-commissioning), operational, and decommissioning phases, as well as the potential for accidental events. The preferred approach in this template is that for each component there is a description of:
(i) the nature and extent of any actual or potential impact, including cumulative impacts;
(ii) measures that will be taken to avoid, remedy or mitigate such impacts; and
(iii) the unavoidable (residual) impacts that will remain.

It is important for these sections to make clear the expected longevity of residual effects and whether or not the biological environment is expected to recover, and in what timeframe, following disturbance.
8.1 Key messages *This section should provide an overview of the key content covered in Section 8.*
8.2 Description of potential impact categories *This section is an overview and description of general impact categories caused by the mining operation. This is not expected to be detailed, but introduce the major types of effect, such as habitat removal, crushing of animals, creation of sediment plumes, noise, light, etc. A description should be included of any lessons learned from activities during the exploratory phase of the program (e.g. mining system component tests).*
8.3 Surface *Description of potential effects on the biological environment from the surface down to 200 m water depth. This includes any impacts to plankton (phytoplankton and zooplankton), surface/near surface fish such as tuna, as well as seabirds and marine mammals.*
8.4 Midwater *Description of potential effects on the biological environment from a depth of 200 m down to 50 m above the seafloor and includes zooplankton, mesopelagic and bathypelagic fishes, and deep-diving mammals.*
8.5 Benthic *Description of potential effect on benthic invertebrate and fish communities, including infauna and demersal fish up to an altitude of 50 m above the seafloor.*
8.6 Ecosystem/community level *Describe estimated effects on the ecosystem or where linkages between the various components above are known.*
8.7 Cumulative impacts *The nature and extent of any interactions between various impacts, where they may have cumulative effects must be considered.*
8.7.1 Proposed operations impacts. *Cumulative within the scope of the mining proposed herein.*
8.7.2 Regional operation impacts. *Cumulative between activities where known in the region.*
8.8 Other issues *Outline where there are other more general issues, i.e. aspects of existing conservation areas and management plans, biosecurity, etc.*
8.9 Summary of residual effects *A table may be a useful summary format.*

Section 5.2 On the biological environment (p.147)
5.2.1 Description of potential impact categories The major types of impacts that will or potentially might affect biological communities during the GSR collection trial are (1) habitat/nodule removal, (2) sediment disturbance and plume deposition, (3) increased concentrations of plume particles in the water column directly above the seafloor, (4) biogeochemical alterations of the sediment (i.e. change of habitat integrity), (5) potential release of toxic sediments and/or substances into the lower water column, and (6) noise and light pollution.

(p.149) Would it be possible to leave rows of undisturbed nodules in between the tracks to see if they can serve as recolonizing habitats rather than disturbing a whole section (but the nodules forming the habitat would be gone…).

(p.157) Good description of impacts and history of impacts and how this means further study would be beneficial, not much on trialing ways to prevent it. Instead focuses on limited area of impact.

9. Assessment of Impacts on the Socio-Economic Environment and Proposed Mitigation ***As per preceding sections, provide a detailed description and evaluation of potential impacts of the operation to the socio-economic components identified in section 6. This may need to consider effects that may happen during construction/development (precommissioning), operational (including maintenance), and decommissioning phases, as well as potential for accidental events. The preferred approach in this template is that for each component there is a description of:***
(i) the nature and extent of any actual or potential impact, including cumulative impacts;
(ii) measures that will be taken to avoid, remedy or mitigate such impact; and
(iii) *the unavoidable (residual) impacts that will remain.*

9.1 Key messages *This section should provide an overview of the key content covered in Section 9.*
9.2 Impact Identification

9.2.1 Existing uses
9.2.1.1 Fisheries *A description of potential impacts and issues to be addressed, along with proposed management measures and a description of residual impacts.*
9.2.1.2 Marine Traffic *A description of potential impacts to non-project related marine traffic occurring within the project area, along with proposed management measures and a description of residual impacts.*
9.2.1.3 Tourism *A description of potential impacts and issues to be addressed, along with proposed management measures and a description of residual impacts.*
9.2.1.4 Marine Scientific Research *A description of potential impacts and issues to be addressed, along with proposed management measures and a description of residual impacts.*
9.2.1.5 Conservation Areas *A description of potential impacts and issues to be addressed, along with proposed management measures and a description of residual impacts.*
9.2.1.6 Other *List other potential impacts that are not related to the above (e.g. telecommunications cables, other mineral Exploration or Exploitation projects, bioprospecting, etc.).*
9.3 Cultural environment *As applicable, describe potential impacts to places of cultural/historical significance that occur within the zone of influence of the project area (e.g. shipwrecks, traditional fishing grounds, World Heritage Sites, etc.), along with proposed management measures and a description of residual impacts.*
9.4 Socio-economic and socio-cultural issues *This section will provide a description of economic benefit or impact, including any applicable social initiatives.*
9.5 Summary of existing socio-cultural environment *A table may be a useful summary format. Potential cumulative effects should also be included.*
10. Accidental Events and Natural Hazards *Environmentally hazardous discharges resulting from accidental and extreme natural events are fundamentally different from normal operational discharges of wastes and wastewaters. This section should outline the possibility/probability of accidental events occurring, the impact they may have, the measures taken to prevent or respond to such an event, and the residual impact should an event occur. For each component include:*
(i) The nature and extent of any impact;
(ii) Measures that will be taken to avoid, mitigate or minimize such impact; and
(iii) Residual impacts.
10.1 Extreme weather. *For example: hurricanes/cyclones.*
10.2 Natural hazards *For example: volcanic eruption, seismic events.*
10.3 Accidental events. *For example, hazardous material leakage or spillage, fire and explosion, collisions, including potential loss of equipment.*

NA

11. Environmental Management, Monitoring and Reporting. ***Sufficient information should be provided to enable the ISA to anticipate possible environmental management, monitoring and reporting requirements for an environmental approval. Information listed should reflect the proponent's environmental policy and the translation of that policy to meet the requirements under this section and previous sections during different stages in the project life, i.e. from construction to decommissioning and closure. Information detailed in this section should include, but not be limited to, the headings below:***

There is much useful accurate information included in this section.

11.1 Organizational structure and responsibilities. *This section should show how the Contractor's environmental team fits into its overall organizational structure. Responsibilities of key personnel should be outlined.*

(p. 164) The organizational structure is clear and well described.

11.2 Environmental management system (EMS) *Although a full EMS may not exist at the time the EIS is submitted, this section should outline the standards that will be considered and/or aligned with in developing the EMS for the project.*

Incomplete - no EMS is described in GSR EIA.

(p.167) While it is admirable (from a conceptual perspective) having the 5 different work packages (WP) and 3 cross-cutting themes (CCT) – this could become a bureaucratic structure that slows down nimble monitoring and management on site (on ship) as the deployment happens. It is unclear how this structure will lead to a research design that tests all the ideas presented by each working group. (The workings of these groups under BGR is better described in their EIA).

11.3 Environmental Management and Monitoring Plan (EMMP) *An EMMP will be submitted as a separate document for the ISA's approval prior to mining operations commencing. This section should provide an overview of what an EMMP would entail. This section shall include, as a minimum, the following headings:*
11.3.1 Mitigation and Management
This section should summarize the actions and commitments that have arisen from the impact minimization and mitigation strategies.
11.3.2 Monitoring plan *This section should summarize the monitoring plan approach and program.*
11.3.2.1 Approach
11.3.2.2 Program. *This section should provide an overview of the envisaged monitoring program (it is noted further detail will be provided in the EMMP).*
11.3.3 Closure plan
It is expected that a Closure Plan will be submitted as a separate document for the Authority's approval. However, this section should provide an overview of what the Closure Plan will entail, including decommissioning, continued monitoring and rehabilitation measures, if applicable.

(p.167) Environmental Management and Monitoring Plan (EMMP) – unclear whether it is complete. The report starts as an Environmental Management and Monitoring Plan on p 167 but becomes an Environmental Monitoring Plan starting on p 168 (and on subsequent pages) – without an explanation. This seems confused and/or sloppy. It is unclear whether the managing of impact is truly no longer a goal or they mistakenly omitted it as part of their plan.

The underlying assumption by the GSR team appears to be that the proposed MiningImpact disturbance trials are so small in nature (or/and comply with international standards) that managing their impact is essentially not important and instead the focus should be on monitoring the impact to learn for future studies.

(p. 169.). Need to clarify why the disturbance trial (and associated sediment plume) which they have modeled to reach 5-12 km from disturbance will not reach control/reference area which is located ~ 11 km from disturbance. The text claims that the reference/control site will not be affected – but it is unclear why the authors are so certain about this. (I think they assume that currents are taking plume in another direction – but this needs to be demonstrated rather than implicitly assumed).

(p.170) - Choice of caterpillar tracks. The cost/benefit for choosing caterpillars tracks versus alternatives is too brief– this could be expanded

(p. 171) – *"Finally, all the equipment will remain well maintained during the entire expedition: this is best practice and facilitates anticipation and prevention of a potential break down and its consequences."* While this is a nice statement – giving more specifics (detailed maintenance schemes) would lead to greater assurances and plan that the equipment truly is "well" maintained.

The review of similarities and differences between reference and control sites is quite extensive and appears complete. They sampled only 3 sites in each zone – resulting in low power to discriminate differences. At a high

level, their conclusions that the control and impact zones are sufficiently similar to be used is justified. However, I think there are important details and differences which should be taken into account in subsequent monitoring that are not fully taken into account.

Why was information from MUC021 not included in the analyses for the meiofaunal assessment? (Fig 104). (p. 176).

In terms of differences between the control and impact zones, these points are noted: (p.173). The control reference site has more sand at most depths than impact sites. Reference site has higher organic matter.

(p.176) – Fig 103 illustrates that most sites of control reference are similar to impact zone – BUT there is large variation among sites within the control reference zone itself– the GSR team should look to differentiate sites within control reference zone and be cautious about lumping them together- otherwise the total variance within the control reference site will be so large as to reduce the likelihood of assessing real differences between impact and control zones after disturbance.

Looking at the PCA - Seven sites (out of roughly 28 sites ~ 25%) within control reference site load negatively on PC2. Factors which differentiate are those along PC2 including phosphate and silicate, ratio of sand to silt/clay, among other factors.

Two of reference site abundances are lower than impact sites – one site (MUC14??) is much different than other sites in abundance and perhaps biotic composition (fig 104b). The average meiofaunal abundance for the impact zone (~ 125 inds/cm3) was close to 40 % more than the control site (~ 80 inds//cm3). Given how few samples/sites were examined, it is not surprising that, significant differences were not found.

(p.177). *GSR text* "In conclusion, the minor differences in abiotic variables are not reflected in the biological communities. Therefore, both sites offer similar biotic and abiotic conditions and may be used as Impact and Control Reference Zone. Furthermore, biotic and abiotic baseline data of both sites were presented and the selected areas were approved by the scientific community of the JPI-O consortium."

The implicit assumption behind the arguments of the GSR team is that there is little or no variation across sites within their reference/control or "impact" sites – I do not believe this is justified. There is clearly significant variation among sites within each of the zones – most notably in the control/reference zone (as pointed out above).

The GSR team propose a BACI test to assess impact – which seems appropriate given the local level differences among sites in biota to look at how each site (both impact and control) changes over time. Given the potential for sites within zones to be different, they should be ready to adjust their interpretations based on the extent to which sites within and across zones are truly similar.

I recommend resampling a greater number of sites within each zone for biology and sediment analysis sites to create a more accurate baseline to test for impact.

(p. 168) I recommend using the Tilot et al 2018 paper which identifies approaches and taxa to be used .

I recommend using a nested sampling design, with sampling at different scales along cardinal directions to create a scalable sampling design. This would include some finer scale sampling at set distances from the impact. The goal would be to yield an improved understanding of habitat and biotic heterogeneity (and impact) at small, medium and larger scales.

The rest of the sections in the GSR EIA report contain much detailed approach which if carried out correctly and transparently will provide much useful information for future programming. The key is a well-documented

methodology and transparent reporting of outcomes, to be made available to the broader community for review and use.

(p. 185) *from GSR text: "The WOE model will be applied to different sampling times, i.e. before impact, shortly after impact, and if additional ship-time is available, also 1-2 years after the impact, to provide insight into the temporal evolution of plume impact hazards. "*
It would be useful to know likelihood of availability of ship time in the future – to know if this is wishful dreaming or likely to happen.

(p. 192). I recommend using more monitoring buoys of plume dispersal – and ensure sufficient biotic sampling – for all reasons given by the GSR team in their report about need to develop a more harmonized and consistent approach to developing monitoring and management plans for whole CCFZ.

(p.193). Much of the GSR report is high on language which refers to "best practices" and vague in specifics in how research experiments on what will be done and when it will be done. In practice, quick decisions will need to be taken when resources (including time) is tight. I recommend the proposed framework have more specifics and less reliance on the assumption that people will follow best practices when these are not specifically spelt out.

(p. 194). There is a great need for this kind of "research" proposed in these sections under the different work groups and it will be very useful for it to be done. However, these sections are incomplete in that no protocols/methodologies or experimental design are presented as to how they will be carried out.

Without more details, it is not possible to evaluate whether the outcomes will be valid or interesting. What are the principle alternative strategies/scenarios/procedures that could be tested? Importantly, are there working hypotheses that seek the lowest possible impact strategies for extracting nodules while minimizing long term impact to the environment including its biota? Without such a clear set of objectives, the outcomes from the research are likely to not yield the kinds of results the proponents claim.

11.3.3 Closure plan
It is expected that a Closure Plan will be submitted as a separate document for the Authority's approval. However, this section should provide an overview of what the Closure Plan will entail, including decommissioning, continued monitoring and rehabilitation measures, if applicable.

There was no closure plan

11.4 Reporting
11.4.1 Monitoring. *This section should outline how results of monitoring studies will be reported to the Regulatory Authority.*
11.4.2 Incident Reporting. *This section should outline how Incidents will be reported.*

GSR section 7.4 Reporting

This section is accurate and mostly complete. It would be good to see timelines for making data available (e.g. 1 or 2 years post expedition…), and the nature of the sharing – i.e. all data will be made openly available to the scientific community (with XX restrictions?) within X timeframe.

GSR section 7.3.1.2 Sample management
Complete and accurate.

GSR 7.3.1.3 Data image analysis and archiving
Complete and accurate.

GSR 7.3.1.4 Dissemination
Complete and accurate.

GSR 7.3.3 Incident reporting
The workflow for reporting incidents is incomplete as there is no timetable or format to follow if and when incidents happen.

12. Product Stewardship.

This section should include a brief description of what is intended for the mined material once it leaves the Area. The intention is not for a full and highly detailed account, but where information is known about environmental impacts these should be described briefly here.

Not applicable as no mined material will leave area.

13. Consultation

This section describes the nature and extent of consultation(s) that have taken place with parties identified to have existing interests in the proposed project area and other relevant stakeholders.

13.1 Consultation methods

The applicant should describe how they have consulted with different groups and how this aligns with any relevant consultation obligations.

13.2 Stakeholders

This section lists any relevant stakeholders or other interested parties that have been consulted and explains the process by which stakeholders were identified.

13.3 Public consultation and disclosure

The applicant should provide a description of the goals and consultation workshops/meetings that occurred prior to the preparation of the report. Include a description of key concerns and comments identified by stakeholders and how the applicant intends to address these concerns, or why not.

13.4 Continuing consultation and disclosure

This section outlines any further consultation with stakeholders that has been deemed as needed and which is being planned.

The sections (GSR 9&10) have a list of who has been engaged, but it is incomplete - there is no information that provides a description of the goals and consultation workshops/meetings that occurred prior to the preparation of the report. Include a description of key concerns and comments identified by stakeholders and how the applicant intends to address these concerns, or why not.

There is no information about any stakeholder engagement beyond the research/science community (applicants or experts per sections 9.2 or 10 in the EIA.

GSR Section 9.2 JPI-O MiningImpact 2 applicants

Incomplete: I am unclear what the meaning of term applicants means – are they consultants, did they apply to be consultants or on board scientists?

GSR Section 10 – Expert Review

Incomplete. There is no information about how and when the experts were engaged, what their review consisted of, or any feedback, comments or concerns raised by experts.