Contact Information	
Surname	Van Dover
Given name	Cindy
Government (if applicable)	
Organization (if applicable)	Duke University
Country	USA
Email	clv3@duke.edu

COLLEAGUES,
This response to the consultation on the draft nMAR REMP is in my personal expert capacity as a scientist with forty+ years of experience working in the deep sea. It draws on my on-going work on hydrothermal-vent ecosystems, a recent element of which has been funded by the GOBI Project sponsored by the International Climate Initiative. The German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.

The draft nMAR REMP reflects much of the science put forward since the first ISA-sponsored workshop on chemosynthetic ecosystems (Tech Study 9; or even going back to the 2004 workshop on sulfide systems in Jamaica), through the multi-year-duration of the (Strategic Environmental Management Planning in the Atlantic) SEMPiA process, and finally through the formal ISA nMAR REMP process. §II(A-C) is especially well-developed, a great outcome from substantial community discussions. The area-based ISA stakeholder process (LTC-led workshop series) is a great model for further development of §III in this REMP and for development of a REMP for the Indian Ocean.

GENERAL COMMENTS
Implicit in this REMP is a list of tasks that would benefit from scientific input (among other stakeholders), to be initiated/undertaken before exploitation begins, including (but not limited to):

1) Thresholds – at least preliminary thresholds are need for implementation of the nMAR REMP, as noted in ¶32 and elsewhere. Thresholds are mentioned in multiple places in the draft REMP; it would help to collect them all in one place, along the lines of what I suggest below for ¶48. c).

2) The process for designation of AINPs, SINPs, S/A in Need of Precaution in the REMP and the implementation of management measures for AINPs, SINPs, S/A in Need of Precaution in the REMP need to be in place before exploitation begins (¶27. c) and should include scientific input. This REMP document makes considerable progress toward this process for the nMAR, but additional work is needed (e.g., buffer zones,¶36. c).

3) Establishment of a process for updating environmental baselines (¶27. j) with science-based rubrics to assess the quality of baselines and to identify gaps in baseline data and analysis.

4) Establishment of a network of representative habitats for each natural management unit (¶12. d, ¶31) in consultation with scientists and other stakeholders.

5) Determination of pelagic and benthic indicator species (¶50*. I.* d) in consultation with scientists and other stakeholders.

In addition, this REMP may be the best opportunity to acknowledge UNCLOS Article 149 and cultural heritage, including the trans-Atlantic slave trade routes in the region, in consultation with cultural heritage experts. Turner et al. are submitting a response to this consultation that offers the rationale for including cultural heritage in REMPs and suggested text additions for relevant sections of the REMP document.

Definitions

The adjectives “key” and “important”, are used perhaps interchangeably in this document, and need to be defined, especially relative to criteria for AINPs, SINPs.

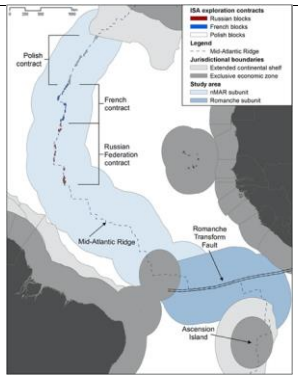
PLEASE REFER TO RED TEXT BELOW FOR DETAILED EDIT SUGGESTIONS. NB: for simplicity, footnotes were deleted from pasted and revised texts and would need to be reentered where suggestions are adopted.

For ease of reference, consider including an outline number for all headers, not just some. The document as it is includes multiple sections labeled as *I., II., III.*
Here’s how I understand this document to be organized, recognizing that the outline numbering here is perhaps not “UN” style:

I. Introduction and background
II. Guiding principles
III. Overarching goals
IV. Purpose of the REMP
V. Geographic scope of the REMP
VI. Environmental and geological setting and the exploration areas for PMS deposits
VII. Region-specific goals and objectives
VII.1. Region-specific goals
VII.2. Operational objectives
VII.2a. Operational objectives for the area covered under this REMP
VII.2b. Operational objectives for contract areas
VIII. Management measures
VIII.1. Overall consideration
VIII.2. Area-based management measures
VIII.2a. Areas in Need of Protection (AINPs)
VIII.2b. Sites in need of protection (SINPs)
VIII.2c. Site/Areas in Need of Precaution (S/A Precaution)
VIII.3. Other management measures
VIII.3a. At the scale of the area covered under this REMP
VIII.3b. At the scale of contract areas
IX. Implementation strategy
IX.1 Monitoring at the regional scale and research to enhance a comprehensive understanding of regional environmental baseline, and spatial and temporal variations
IX.2Monitoring and research to support area-based management
IX.3Monitoring and research to support non-spatial management
X. Review of the progress in the implementation of the REMP

Specific Comments

Page	Line	Comment
7	126	COMMENT. It is important to recognize the presence of multiple biogeographic provinces in the section on *Environmental and geological setting and the exploration areas for PMS deposits*. The need to pay attention to natural management units was highlighted at an ISA-sponsored workshop (Van Dover et al. 2011 and 2012)**.** This was also discussed in Dunn et al. (2018). Indeed, the SEMPiA team purposefully chose an area containing two latitudinal natural management units (north and south of the Romanche) to serve as an example of how to manage a politically or arbitrarily defined “region”. See figure below copied from Dunn et al. (2018), noting the two blue ”sub-units” corresponding to the two management units.

		 Add a new paragraph: ¶xx. Within the REMP area, there are both **bathyal** and **abyssal** regions (Watling 2013), as well as two recognized bathyal provinces **BY4** and **BY13** (Watling 2013) with a biogeographic transition in the vicinity of the Romanche Fracture Zone. Multiple biogeographic regions also apply to the mesopelagic environment in the nMAR REMP area (Sutton et al. 2017). REFERENCES Dunn et al. 2018 "A strategy for the conservation of biodiversity on mid-ocean ridges from deep-sea mining." *Science advances* 4.7: eaar4313. Sutton, T. T., Clark, M. R., Dunn, D. C., Halpin, P. N., Rogers, A. D., Guinotte, J., ... & Heino, M. (2017). A global biogeographic classification of the mesopelagic zone. *Deep Sea Research Part I: Oceanographic Research Papers*, *126*, 85-102. Van Dover et al. 2011 "Environmental management of deep-sea chemosynthetic ecosystems: Justification of and considerations for a spatially based approach" International Seabed Authority, Kingston, Jamaica Tech Study 9 Van Dover et al. 2012 Designating networks of chemosynthetic ecosystem reserves in the deep sea." *Marine Policy* 36.2: 378-381. Watling et al. 2013 "A proposed biogeography of the deep ocean floor." *Progress in Oceanography* 111: 91-112)
ENVIRONMENTAL AND GEOLOGICAL SETTING AND THE EXPLORATION AREAS FOR PMS DEPOSITS		
8	166	Existing text: "¶21. The benthic environment of the northern MAR is a complex patchwork of habitats spanning thousands of metres depth range and encompassing varied seabed geomorphological types. The MAR exhibits a high heterogeneity of habitats. The diverse range of benthic habitats can be broadly grouped into four types: (i) hydrothermal hard substrata habitat (subdivided into hydrothermally active and inactive sulphide habitat); (ii) exposed non-sulphide hard substrate (such as basalt); (iii) soft sediment (including pelagic sediment and hydrothermally active sediment); and (iv) the water column 50m above the seafloor (benthopelagic). These deep-sea benthic habitats are dynamically connected over a range of spatial scales through dispersal processes and interactions with the pelagic ecosystem. Distinguishing between active and inactive

		sulphide habitat can be challenging, but is essential, because active and inactive habitats support very different biological communities, with potentially different resilience and recovery potential." COMMENT. I suggest reorganizing this paragraph to keep like with like and to clarify further that most benthic species have a larval phase. It may be useful to break ¶21 into two paragraphs, one on the habitats, one on the dual habitat nature of the benthic and larval phases. "¶21. The benthic environment of the northern MAR is a complex patchwork of habitats spanning thousands of metres depth range and encompassing varied seabed geomorphological types. The MAR exhibits a high heterogeneity of habitats. The diverse range of benthic habitats can be broadly grouped into four types: (i) hydrothermal hard substrata habitat (subdivided into hydrothermally active and inactive sulphide habitat); (ii) exposed non-sulphide hard substrate (such as basalt); (iii) soft sediment (including pelagic sediment and hydrothermally active sediment); and (iv) the water column 50m above the seafloor (benthopelagic). Distinguishing between hydrothermally active and inactive sulphide habitat can be challenging, but is essential, because active and inactive habitats support very different biological communities, with different resilience and recovery potential. Juvenile and adult invertebrates reside in the benthic environment, but for most benthic species, a portion of their life history is spent as larvae in the water column. Deep-sea benthic habitats are dynamically connected by the larval phases over a range of spatial scales through dispersal processes and interactions with the pelagic ecosystem."
8	177	COMMENT. I have understood from my geology colleagues that the term "occurrence" is preferred instead of "deposits", since "deposit" implies an ore of sufficient size and quantity to be of commercial value. Proposed edit: "¶22. Along the northern MAR, distribution of the twenty-two known occurrences of PMS is heterogeneous and distances between sites vary considerably…."
8	183	Existing text: "¶23. The environmental setting of the MAR influences the development of this REMP in a number of ways. The complex geomorphology and high heterogeneity of habitats make it challenging to identify a representative network of sites or areas that can capture the full range of biodiversity and environmental gradients across the region. Distinct habitats and communities, such as active hydrothermal vent systems, occur at a much finer spatial scale, compared to abyssal plain and other deep-sea environments. Several active vent systems are present within existing contract areas for exploration. As such, the goals, objectives and management measures developed under this REMP were developed to reflect these regional characteristics." COMMENTs. Regarding the text in blue above: Dunn et al. 2018 (op cit.) proposed a model for design of representative networks of areas – yes, it *was* challenging and took a lot of people, time, and thought, but a model concept has been developed and should be acknowledged here. Also, it makes sense to me in the context of this paragraph to compare the scale of the vents to the scale of the general features of the ridge axis (axial valley, bathyal slopes), not to abyssal plains. Further: yes, individual vent sites occur at a finer scale in terms of local populations, but species and communities at hydrothermally active vents should be viewed as part of metapopulations and metacommunities, which requires us to consider how we refer to spatial scale very carefully. This proposed edit and the one highlighted for ¶25 (p9, 198) will need to be consistent. Proposed text:

		"¶23. The environmental setting of the MAR influences the development of this REMP in a number of ways. The Mid-Atlantic Ridge has complex cross-axis and along-axis geomorphologies and a high heterogeneity of habitats. This suggests that a network of cross-axis areas distributed latitudinally could capture most of the biodiversity and environmental gradients within each natural management unit (Dunn et al. 2018). Distinct habitats and communities such as active hydrothermal vent systems also occur at a much finer spatial scale compared to the axial valley and bathyal slopes of this mid-ocean ridge and several active vent systems are present within existing contract areas for exploration. In the case of hydrothermally active vent ecosystems, however, each species population and community at a site is one part of a metapopulation (spatially separated populations; Vrijenhoek 2010) or metacommunity (spatially separated communities; Mullineaux et al. 2018). Because of this "meta" condition, the spatial scale of the metapopulations and metacommunities is much greater than the spatial scale of an individual sulfide occurrence. As such, the goals, objectives, and management measures developed under this REMP were developed to reflect these regional and specific characteristics." REFERENCES Mullineaux, L. S., Metaxas, A., Beaulieu, S. E., Bright, M., Gollner, S., Grupe, B. M., ... & Won, Y. J. (2018). Exploring the ecology of deep-sea hydrothermal vents in a metacommunity framework. *Frontiers in Marine Science*, *5*, 49. Vrijenhoek, R. C. (2010). Genetic diversity and connectivity of deep-sea hydrothermal vent metapopulations. *Molecular ecology*, *19*(20), 4391-4411.
9	198	Existing text: "¶25. It should be noted that PMS deposits differ from PMN and CMC deposits. This applies to the more complex geological and geomorphological setting, the presence of specific physicochemical conditions and biocenoses associated with hydrothermal vents, as well as to the limited surface extent of PMS deposits on the ocean floor. The surface area of known PMS deposits is measured at a scale of a few hundreds of meters. In comparison, the surface area is dozens of times larger for CMC deposits, and hundreds and thousands of times larger for PMN deposits. The large difference in the surface extent of different mineral deposits likely result in different scales of the potential environmental impacts from exploitation activities in different mineral provinces, and should be taken into consideration in regional environmental planning and management." COMMENT. PMS biota differ from PMN and CMC biota in that PMS biota are understood to be distributed as highly localized metapopulations and metacommunities, separated by as much as hundreds of kilometers, with all that implies in terms of population connectivity. Because of this "meta" condition, mining impacts will extend beyond the local population to affect "adjacent" and more distant vents through poorly understood source-sink dynamics. Thus, while "the surface area of known PMS deposits is measured at a scale of a few hundreds of meters", the indirect impact may extend many hundreds of kilometers, depending on the geographical extent of the metapopulation/metacommunity. Proposed text addition: Add to ¶25 at the end (or in a separate paragraph): "In addition, species that colonize hydrothermally active sulfide ecosystems comprise metapopulations and metacommunities. Because these ecosystems are relatively transient features (generally considered to be decades or centuries on the nMAR, local populations/communities have finite lifespans. But the metapopulation (metacommunity) is stable because one population/community may provide colonists to another one. This highlights the importance of source-sink dynamics for the persistence of benthic populations/communities

		at hydrothermal vents. It also underscores the much greater geographical extent of indirect impacts of exploiting mineral deposits hosting hydrothermally active ecosystems."
9	204	Proposed text addition: new paragraph, to follow ¶25 "¶xx. Biological characterizations of hydrothermally inactive sulfide occurrences and metal-rich sediments in the region are in early stages. It is not known to what extent these hard and soft substrata might support endemic taxa" COMMENT. This is an important point to make in the section on *Environmental and geological setting and the exploration areas for PMS deposits,* since the resource and habitat are one and the same, yet we know extremely little about inactive sulfides or metal-rich sediments as habitat. See, for example, Van Dover et al. (2020). REFERENCE Van Dover, C. L., Colaço, A., Collins, P. C., Croot, P., Metaxas, A., Murton, B. J., ... & Vermilye, J. (2020). Research is needed to inform environmental management of hydrothermally inactive and extinct polymetallic sulfide (PMS) deposits. *Marine Policy*, *121*, 104183.
REGION-SPECIFIC GOALS		
9	205	COMMENT. Hydrothermally inactive sulfides and metal-rich sediments are habitats on the Mid-Atlantic Ridge; some portion of these habitats needs to be left undisturbed if we are to protect representative habitats in the region. Proposed new sub-paragraph "¶xx. Protect a representative percentage (TBD) of unimpacted habitat that will be removed by mining (i.e., hydrothermally inactive sulfides, metal-rich sediments) within each natural management unit"
9	209	Existing text: "¶26. b) "Prevent habitat loss to maintain ecosystem viability" COMMENT. The pelagic habitat, for example, arguably won't be "lost", but it might be degraded. Proposed text change: "¶26. b) Prevent habitat loss or degradation to maintain ecosystem viability"
9	211	Existing text: "¶26. c) Maintain representativity of habitats at the regional scale"; COMMENT. See p7, line 126 comment/suggested addition above. This needs a corresponding Operational Objective (¶27. X); added below). There should be a network of representative habitats in the region (see Dunn et al. 2018 op. cit.). Proposed text change: "¶26. c) Maintain representativity of habitats within each natural management unit";
9	215	Existing text: "¶26. g) Ensure exploitation does not exceed cumulative impacts thresholds." COMMENT. I think this needs clarification. Is this in reference to cumulative impacts from, for example, climate change and/or bottom fishing together with mining impacts? Are mining impacts (direct or indirect) allowed outside a contract area? I had thought they were

		not allowed. If not, then this might better be listed under operational objectives for contract areas? Given region-specific goals *a* through *f* in this paragraph, it would help to clarify what (*g*) as written adds to the over-arching goals of the REMP. Proposed text change; move to ¶28, operational objectives for contract areas: "¶28. x) Ensure exploitation impacts within and beyond contract areas do not exceed cumulative impact thresholds [(¶48. c)]." COMMENT. Thresholds need to be determined for this goal to be operationalized.
OPERATIONAL OBJECTIVES FOR THE AREA COVERED UNDER THIS REMP		
9	222	Existing text: "¶27. b) Determine patterns of connectivity between populations of species important for maintaining ecosystem function and processes"; COMMENT. Oceanographic circulation patterns are important for understanding larval dispersal potential and should be characterized for the region at an ecologically relevant degree of resolution. Proposed text addition along the lines of: "¶27. b) Describe oceanographic circulation for water masses in the region and determine patterns of connectivity between populations of species that are important for maintaining ecosystem function and processes within each natural management unit"
		Existing text: "¶27. c) Identify and designate, where appropriate, Areas and Sites in Need of Protection and establish processes for the identification and designation of such sites;" COMMENT. Conceptually, it is important to establish the process first (included "appropriateness") and then identify and designate AINPs, SINPs. N.B., this needs to be in place before mining begins. Proposed text: "¶27. c) Establish and implement a process for the identification and designation of AINPs, SINPs within the REMP."
10	227	Existing text: "¶27. e) Develop scientific methodologies for understanding and assessing cumulative environmental impacts in the Area, through collaboration with other competent regional and international organizations and scientific communities, where feasible;" COMMENT. A LOT of work went into "Quantitative modeling for addressing cumulative impact assessment" at the Evora REMP meeting and in subsequent zoom meetings (throughout the summer of 2020) with the modeling team and scientific experts and zoom meetings among the scientific experts. It would be good to cite the final report by this post-workshop effort sponsored by the ISA, with a link to it. I cannot locate a copy of the final report out of CSIRO on the ISA website, though I imagine it is there somewhere. It is not clear what "where feasible" refers to – collaborations? Methodologies? Suggest deleting (or clarification). Proposed text addition:

		"¶27. e) Develop scientific methodologies for understanding and assessing cumulative environmental impacts in the Area through collaboration with other competent regional and international organizations and scientific communities~~, where feasible~~ (see, for example [ADD CITATION to CSIRO-led Working Group Report])." FURTHER COMMENT ¶27. e) should follow ¶27. h) , i.e., after data has been compiled.
10	237	Existing text: "¶27. i) Assess the distribution of habitats and model potential responses impact from climate change and human activities that would require assessment or reassessment of any future area-based management tools (ABMTs) to be established under this REMP" COMMENT. A key contribution of Dunn et al. (op. cit.) was the call for assessment of network design options against conservation objectives, including climate change. Proposed replacement text: "¶27. i) Assess network design options for Area-Based Management Tools against region-specific goals, including, but not limited to, protection of representative areas, including those that are potentially less impacted by climate change. See Dunn et al. (op. cit.)."
10	240-243	Existing text: "¶27. j) Establish a process for periodically updating environmental baseline data for the region"; and "¶27. k. Update regional environmental assessments, as outlined in the Strategic Plan of the International Seabed Authority for the period 2019–2023, when appropriate as new scientific data and information are made available" COMMENT. Updated baseline data should be analyzed and shared with stakeholders, and changes should be assessed relative to mining activities. Updated baseline data without analysis of what the data tells us in terms of natural variability and impacts (potential and realized) of mining is not of itself a useful tool for environmental management. Proposed text changes: "¶27. j) Establish a process for periodically updating, analyzing, and disseminating environmental baseline data for the region; "¶27. k) Update regional environmental assessments, as outlined in the Strategic Plan of the International Seabed Authority for the period 2019–2023, when appropriate as new scientific data and information are made available. These assessments should highlight changes in the baseline data that may have arisen from direct or indirect impacts from human activities, including mining and climate change, among others;
		And add a new paragraph: "¶27. x) A protected network of representative habitats should be established within each natural management unit in the region (see Dunn et al. 2018 op. cit.).
OPERATIONAL OBJECTIVES FOR CONTRACT AREAS Summary of suggested revised text for this paragraph (rationale and details below): ¶28. The following operational objectives are related to contract areas as well as the region:		

a. Ensure that all nMAR REMP "area-based" (§II) and "other management measures" (§III) are adopted and applied within the contract area. These measures should also be applied to areas adjacent to a mine site as necessary; b. Minimize harmful environmental impacts on important species for the maintenance of ecosystem functioning and integrity; c. Minimize harmful environmental impacts to ecologically important sediment, hard substrata, and pelagic systems.		
10	249	New addition, at the top of the list: ¶28. x) Ensure that all nMAR REMP "area-based" (§ II) and "other management measures" (§ III) are adopted and applied within the contract area. These measures should also be applied to areas adjacent to a mine site, as necessary; COMMENT. With this new paragraph, the existing (¶28. a) and (¶28. b) should not be necessary, I think; delete. (¶28. c) and (¶28. d) may not be necessary either, if they are covered by (§II, §III). It would help to define "important", "key" species – both terms are used in the draft. Is (¶28. c) meant to apply to marine mammals, mesopelagic fish and jellies, etc?
10	256	Existing text: "¶28. c) Minimize harmful environmental impacts on important species for the maintenance of ecosystem functioning and integrity;" COMMENT. Define "important species" – or at least the process through which "important species" will be determined/identified before exploitation activities begin.
10	258	Existing text: "¶28. d) Manage harmful environmental impacts to ecologically important sediment systems." COMMENT. I don't understand why sediments were singled out here. Is "ecologically important…system" something different from an AINP or SINP? If they are one and the same, then perhaps this bullet is not be necessary? Proposed text change: "¶28. d) Manage harmful environmental impacts to ecologically important sediment, hard substrata, and pelagic systems"
MANAGEMENT MEASURES – Overall considerations		
11	270	Edit/add to existing text: "¶30. Contractors are encouraged to conduct environmental surveys outside their contract areas, in cooperation with the scientific community and in particular ~~those~~ scientists from developing countries. If a mine site is near the boundary of a contract area (within some initially prescribed threshold distance), then it is imperative that all AINPs and SINPs in the adjacency (to some initially prescribed threshold distance) should be mapped."
11	272	Existing text: "¶31. This REMP does not include ABMTs identified through the application of network criteria such as representativity and connectivity, based on a regional analysis. It is noted that additional expert discussion led by the LTC will be needed in the future on the application of the network criteria." COMMENT. Natural management units are important to consider in thinking about other ABMTs, as noted above (p. 11, line 272, ¶31). Networks will need to be developed for *each* natural management unit, not on a "regional" basis, if the "region" is the geographic area defined in Figure 1. Also, a key contribution of Dunn et al. (op. cit.) was a call for assessment of network design against conservation objectives.

		Proposed text changes: "¶31. This REMP does not include ABMTs identified through the application of network criteria such as representativity and connectivity within natural management units ~~based on a regional analysis~~. ~~It is noted that~~ Additional expert discussion on the application of the network criteria and assessment of network design options (Dunn et al. 2018), led by the LTC, is needed.
11	276	Add to existing text: "¶32. It is noted that thresholds are needed for describing the occurrence of vulnerable ecosystem features in the application of the criteria for ABMTs, and for evaluating and controlling the impacts of mining activities. As such thresholds would be useful for consistent implementation of both area-based and non-spatial management measures. These thresholds may need to be adaptive, and likely change as new data and information are collected on the impacts of mining activities and new knowledge of habitat and species responses becomes available. Additional expert discussion led by the LTC will be needed to determine initial threshold values; these values must be in place before mining may commence. Periodic updates on appropriate parameters and thresholds will be also needed."
		New paragraph on adaptive management: ¶xx. Where the duration of a mining activity is relatively brief (e.g., months to a year or two), adaptive measures need to be considered on relevant timescales. COMMENT. For a given mining event, it will in general do no good to adapt critical area or other management measures on a time-frame longer than the duration of the activity.
II. AREA-BASED MANAGEMENT MEASURES A. AREAS IN NEED OF PROTECTION AINPs		
11	288	Existing text with a simple suggested edit: "¶34. AINPs aim to protect regional-scale ecosystem features, which are important in terms of basin-scale water mass exchange, biogeographical zonation and transitions, connectivity and ecosystem function. Because of their large areal extent and up to abyssal depths, they may cover multiple biogeographical provinces, habitats and ecological gradients." COMMENT. AINPs will likely not cover multiple provinces; for example, a specific type of coral garden is unlikely to cross a natural management unit (though what happens in the transition zone between two units isn't well understood at present). Of course, another type of coral AINP may be found in the adjacent unit.
B. SITES IN NEED OF PROTECTION		
13	368	Existing text: "¶45. In the case of inferred active vents, contractors are encouraged to apply increased survey efforts to validate the existence of active vents. It is noted that habitat suitability models can be useful for showing areas where new sites are potentially more likely to be discovered. However, suitable habitat areas predicted by models must be validated through surveys, and encounters and quantitative measurements (e.g. abundance, diversity, biomass) of indicator species need to be reported. COMMENT. "Encouraged" seems wholly inadequate, if vent ecosystems and other SINPs or AINPs are to be protected from mining impacts. Mapping these must be part of the environmental baseline given the goals and objectives of this REMP. Systematic ROV imaging transects are best science practice for validating vent locations and other vulnerable ecosystems. This is a fundamental contractor responsibility. Best practices are well known for locating hydrothermal plumes (e.g., Baker et al. 2016; German et al. 2021) and should be required. Further, refer to §III. B. b, line 405, p14: to achieve this monitoring management

		measure, the contractor has to know where SINPs, AINPs are in their contract area and beyond. Proposed text: ¶45. A comprehensive/systematic hydrothermal plume survey over an exploitation contract area is required to ensure that ALL active hydrothermal vents (within a certain threshold of detection and threshold distance from a proposed mine site) are located relative to commercial deposits to be extracted. Other types of SINPs and AINPs need to be located relative to commercial deposits as well. Habitat suitability models may provide preliminary indications of where to focus surveys, but locations of all SINPs and AINPs must be validated through visual surveys. Encounters and quantitative measurements (e.g. abundance, diversity, biomass) of indicator species need to be reported. REFERENCES German, C. R., Baumberger, T., Lilley, M. D., Lupton, J. E., Noble, A. E., Saito, M., ... & Blackman, D. K. (2022). Hydrothermal Exploration of the southern Chile Rise: Sediment-hosted venting at the Chile Triple Junction. *Geochemistry, Geophysics, Geosystems*, e2021GC010317. Baker, E. T., Resing, J. A., Haymon, R. M., Tunnicliffe, V., Lavelle, J. W., Martinez, F., ... & Nakamura, K. (2016). How many vent fields? New estimates of vent field populations on ocean ridges from precise mapping of hydrothermal discharge locations. *Earth and Planetary Science Letters*, *449*, 186-196.
C. SITES/AREAs IN NEED OF PRECAUTION		
III. OTHER MANAGEMENT MEASURES		
A. AT THE SCALE OF THE AREA COVERED UNDER THIS REMP		
13	386	Existing text: "¶48c. Develop multiple thresholds, which can enable timely detection of where impacts are approaching serious harm. Determining the thresholds for what would be considered "serious harm" can draw on existing frameworks and strategies and benefit from engaging with appropriate experts. The following thresholds together with their indicators and methodology for measuring these thresholds will be developed" Suggested revision: "¶48 c) Develop multiple thresholds, and methodology for measuring these thresholds, to enable timely detection of where and which impacts are approaching serious harm. Determining the thresholds for impacts that cause "serious harm" can draw on existing frameworks and strategies. Impacts, thresholds, and monitoring protocols need to be developed in consultation with LTC-led experts prior to commencement of mining. Thresholds include (but are not limited to): -plumes (extraction and dewatering): particles and toxic contaminants (included in ¶48. c plus see ¶49. g) -light (surface vessels, seabed vehicles especially near SINPs with light-sensitive taxa) (¶48. c plus see ¶49. k) -noise (seabed, riser pipes, surface) (included in ¶48. c) -plume/sediment deposition (see ¶49. d) -deviation from biological baselines and selection of indicator species (see ¶48. c and ¶50. I. d) -thresholds for vulnerable ecosystems (see ¶32) -faunal thresholds establishment of AINPs, SINPs -minimum distance from mine sites for locating and characterizing SINPs, AINPs (may be within or beyond contract area (¶45; see also REMP p.13, line 400 discussed below)

Commented [DCVDP1]: Insert references here, at least as examples. It is not clear to me what is intended here by "existing frameworks and strategies".

		-cumulative impact thresholds (see¶26. g) -ecological tipping points -significant faunal communities (see ¶49. q) …..but how are these different from AINPs, SINPs? Is this a separate category? -threshold for detecting hydrothermal sites (see ¶45 revision above; p. 13, line 368) -others (I may have missed some, plus an LTC-led group of experts can add to/ refine this list)
13	391	¶48.c.bullet1: ”acceptable levels of potentially toxic contaminants and particulates impacting on biota in the SINPs and AINPs listed in Annex I and II” COMMENT: See ¶36. A): “They (AINPs) will be protected from direct or indirect impacts from exploitation of mineral resources in the Area” and ¶40. a: “The SINPs will be protected from direct and indirect impacts of exploitation of mineral resources”. ¶36. a and ¶40. a call for no direct or indirect impacts. Given these protections, by my understanding there should be no acceptable level of potentially toxic contaminants and particulates impacting the biota. Proposed revision: Delete ¶48.c.bullet1.
AT THE SCALE OF THE CONTRACT AREA		
13	400	Proposed new paragraph: ¶xx.) Active vents and other SINPs, AINPs must be fully mapped within some reasonable distance of the mine site, of PRZs, and, where necessary, outside the exploitation contract area (within a threshold distance from a proposed mine site). COMMENT. See also ¶45 revision above that requires all active vents in contract area to be located.
13	400	Proposed new paragraph: ¶xx.) As part of their environmental baseline requirements, contractors must characterize the biota of hydrothermally inactive sulfide occurrences or metal-rich sediments that are target for exploitation, including characterizing any endemic taxa and identifying representative inactive sulfide occurrences and metal-rich sediments that will be protected from mining impacts.
14	408	Existing text: “¶49. C) On key vulnerable/sensitive species, contractors will monitor significant communities of fauna within contract areas and in surrounding areas likely to be impacted by mining activities.” COMMENT. See comment for line 410: what is meant by “key”, “significant”? Should one assume here SINPs, AINPs? Is something else intended here in addition? Possible edits: “¶49. d) For key vulnerable/sensitive ecosystems (SINPs, AINPs), ….”?
14	410	Existing text: “¶49. d) To manage harmful environmental impacts to key sediment systems, contractors will need to identify key sediment communities both within and in the areas surrounding a contract area and actively manage the return-water plumes and the impact of the removal of any sediment overlying the mineral resources (over burden) and its deposition to avoid serious harm to the marine environment.“

		COMMENT: Would "representative" be better than "key"? Or "important"? What is meant by "key"? Presumably not meeting any of the SINP or AINP criteria*? Need to use a consistent and defined terms throughout the REMP for non-SINPs, non-AINPs.*
14	415	Existing text: "¶49. e) To control exploitation activity to remain within impact thresholds, contractors should apply the established thresholds and where relevant identify relevant environmental thresholds, e.g., for impact of particulates in plumes"; COMMENT. This is difficult to understand. Further, thresholds should be defined by experts (including contractors, but not just contractors, as suggested here) and should apply to the REMP area, as well as in contract areas, as appropriate. Delete "¶49. e) SEE ALSO: proposal below for Page 14, Line 424 (§49.g.)
14	418	Existing text: "¶49. f) To ensure no increase in ambient particulate flux in the pelagic environment, contractors should control the generation of plumes arising from extraction and redeposition of waste material from surface processes such that they remain at or below ambient levels. The release of returned water plume (particles, contaminants, and altered water chemistry) should be returned as close to the sea floor as practical, noting that release in midwater can disrupt larval dispersal and gene flow at all ocean depths leading to loss of connectivity or ecosystem function" COMMENT. Difficult to understand. Does my rewrite below capture the intent? Proposed text: "¶49. f) Contractors should control the generation of plumes arising from extraction at the seabed and from dewatering on the surface vessel such that particulate flux remains at ambient levels in surface and mid-water environments. The dewatering plume (particles, contaminants, and altered water chemistry) should be returned as close to the sea floor as practical, noting that release in midwater can disrupt larval dispersal and gene flow at all ocean depths leading to loss of connectivity or ecosystem function"
14	424	Existing text: "¶49. g) "Apply thresholds for the impacts of mining plume (particles and toxic contaminants) on SINPs;" COMMENT. This should include AINPs as well – best to refer to regional requirements, though there may be some reorganization of text required. Proposed replacement text: "¶49 g) Apply all relevant thresholds established for the region (see¶48.c)"
14	426	Existing text: "¶49. h) Prevent the impact of overburden removal and placement on hydrothermal vent faunas and fauna of other SINPs;" COMMENT. Shouldn't these apply to AINPs and SINPs? Proposed text: "¶49. h) Prevent the impact of overburden removal and placement on hydrothermal vent faunas and fauna of other SINPs and AINPs;"

14	432	Existing text: "¶49. k) Control light on the seabed and from vessels that can attract birds and disrupt their behavior" COMMENT. Delete; capture this as a regional threshold to which Contract Areas/Contractors must abide – see¶48. c above. [Proposed text, if this sub-paragraph must be kept: "¶49. k) Control light from vessels that can attract birds and disrupt their behavior and avoid extended exposure of light-sensitive species (e.g., alvinocarid shrimp at hydrothermally active vents) are known to occur."
15	447	Existing text "¶49. q) Develop thresholds for categorization of significant faunal communities." COMMENT. DELETE. Developing thresholds should not be solely a contractor responsibility. See thresholds p 3, line 389 (¶48. c; above).
IMPLEMENTATION STRATEGY		
I. Monitoring at the regional scale and research to enhance a comprehensive understanding of regional environmental baseline, and spatial and temporal variations		
15	461	Existing text: "¶50. *I.* c) Regional patterns of biodiversity: A practical first step may be to focus on basic matrices, such as species abundance and composition of different taxa and the diversity, richness, evenness of assemblages." COMMENT. Best science practices have moved from univariate statistics (div, eve, rich) to multivariate statistics (e.g., non-metric multidimensional analyses, PCA, and a suite of other analyses now easy to perform on species-abundance matrices using, for example, vegan in R) together with environmental parameters and functional traits. I thus disagree with this text: A panel of experts might quickly come to agreement on what is a reasonable and more meaningful approach to assessing regional patterns of pelagic and benthic biodiversity in the context of establishing a baseline and managing the REMP area. Perhaps as a start: "¶50. *I.* c) Patterns of biodiversity within natural management units should be mapped for "key" assemblages (e.g., mesopelagic fishes, mesopelagic jellies; benthic megafauna; marine vertebrates) using multivariate diversity measures together with spatially and ecologically relevant environmental variables." REMINDER. Be sure to define "key" somewhere, or otherwise use a consistent, defined term.
15	464	Add to existing text: "¶50. *I.* d) A standardized approach can be established using suitable indicator species for regional analyses of connectivity to provide regional baselines against which changes can be monitored. A panel of experts led by the LTC will be needed to come to consensus on which pelagic and benthic species may serve as indicators."

15	473	"¶50. *I.* f) Trophic connectivity/relationships: Monitoring and research may focus on measurements at different trophic levels, such as surface primary productivity, the location of the deep-scattering layer and diel vertical migrations in the mid-water column, and abundance of top predators." This seems focused on the upper/meso pelagic. What about bathypelagic/benthic trophic connectivity and relationships? POC flux to the seabed is modelled but not measured. Teasing out effects of mining from changes in POC flux due to climate change may be important?
II MONITORING AND RESEARCH TO SUPPORT AREA-BASED MANAGEMENT		
16	492	Existing text: "§*II*. a) Habitat mapping and modelling: Habitats will first need to be comprehensively defined and mapped within the region to establish environmental baselines and assess habitat quality, quantity and regional distribution. Habitat models may be developed for the identification of representative habitats." Proposed revision: "§*II*. a) Habitat mapping and modelling: Pelagic and benthic habitats will first need to be comprehensively defined and mapped within the region to establish environmental baselines and assess habitat quality, quantity and regional distribution. Habitat models may be developed for the identification of representative habitats."
III. MONITORING AND RESEARCH TO SUPPORT NON-SPATIAL MANAGEMENT		
16	522	Existing text: "§*III*. d) Development of other thresholds: Thresholds should be identified through a phased approach, in collaboration with contractors, scientific communities and other relevant international bodies." COMMENT 1. A phased approach is wise, but some critical/indicative threshold levels should be in place before mining begins. They can be modified (adaptively managed) as new knowledge develops under mining conditions. We will want to know the process – who will review and approve thresholds – or at least indicate that a review process will be established before mining beings. COMMENT 2. Also, given that a given PMS mine site may only be active for a relatively short period of time (months to a year or so?), the time frame for adaptive management will need to match the pace of the mining activity. Move-on to a new PMS deposit should not be permitted until environmental data has been analyzed and adaptive thresholds/protocols are put in place. COMMENT 2 needs to be addressed in the REMP; a 5-yr review could mean that all PMS deposits in an area are removed before the impact on the environment can be assessed.
REVIEW OF THE PROGRESS IN THE IMPLEMENTATION OF THE REMP		
17	567	Existing text: "57. The progress of the implementation of this REMP is to be reviewed by the LTC at least every five years, as required, focusing on the key elements of the plan, including the environmental setting, the management measures, and the implementation strategy. The review will be undertaken to determine their suitability or need for amendment, on the

		basis of the best available data and information and in alignment with the rules, regulations, and procedures of ISA. " COMMENT 1. To avoid conflict of interest, there should be a process through which an independent body of experts has meaningful input into the decision-making process. COMMENT 2. Because PMS mining activity will be of relatively short duration for a given mine site, it would be useful to have a process where amendments to the REMP may be considered during interim periods to allow for new knowledge to address specific REMP management requirements. Existing text and proposed addition: ¶57. The progress of the implementation of this REMP is to be reviewed by the LTC at least every five years, with a focus on key elements of the REMP, including the environmental setting, the management measures, and the implementation strategy. The REMP review will be undertaken to determine its suitability or need for amendment, on the basis of the best available data and information and in alignment with the rules, regulations, and procedures of ISA. In addition to regular periodic review, a process for REMP amendment between regular reviews and in response to critical new knowledge relating to one or more specific management measures will be established by the LTC, in consultation with stakeholders. REMP reviews and interim amendment proposals should include a review report by independent experts, to which the LTC is held accountable.
18	figure	This needs a caption, clarification regarding the filled areas, labels for fracture zones, and clarification regarding the rule for boundaries. The Romanche red hatch area looks right. But for Kane and Vema, the boundaries are not clear. Are there buffer zones associated with these AINPs?

Some additional thoughts about the challenges of regional-scale environmental management on the nMAR

The challenge of scaling up of environmental impacts in a region requires integration of different aspects of complexity (Snelgrove et al., 2014; Thrush et al., 1997) and detection and avoidance of critical **tipping points** (ecological thresholds) beyond which biodiversity and ecosystem function change suddenly and dramatically (Hewitt and Thrush, 2019; Kelly et al., 2015).

At the regional level, we also need to be aware of the potential for cross-scale, non-linear, and emergent interactions. Even a simple metric like species richness scales **non-linearly** with geographic area (Snelgrove et al., 2014). There may also be scale-dependent effects on predator densities, food availability, and mortality (Thrush et al., 1997) and other ecosystem metrics such as biogeochemical processes and their rates (Snelgrove et al., 2014). Loss of ecological connectivity will affect local communities and large-scale patterns and dynamics of interacting populations and communities. Significant **lag effects** (delayed mortality, indirect or second or effects such as reduced reproductive output) may further compromise our ability to predict system behavior across scales (Falk et al., 2019; Hewitt and Thrush, 2019).

The effect of increasing disturbance regimes in a region will be nonlinear, and abrupt changes in community structure and functioning can be expected once a disturbance threshold affecting the equilibrium abundances of smaller species is reached. The minimum duration for time-series studies needed to detect tipping points has been recommended in the scientific literature to be at least 15 years and preferably 20 years, to ensure that any change is not part of a natural cycle (from Kelly et al. 2015).

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