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REPORT OF THE WORKSHOP ON THE DEVELOPMENT OF A REGIONAL ENVIRONMENTAL MANAGEMENT PLAN FOR THE AREA OF THE NORTHERN MID-ATLANTIC RIDGE WITH A FOCUS ON POLYMETALLIC SULPHIDE DEPOSITS

23 November - 4 December 2020; Online

INTRODUCTION

1. In accordance with the UN Convention on the Law of the Sea ("the Convention") and the 1994 Agreement relating to the implementation of Part XI of the Convention, the International Seabed Authority (ISA), on behalf of the States Parties to the Convention, is mandated to administer the mineral resources in the Area. In so doing, ISA is responsible for regulating and controlling current exploration activities, as well as future mining activities, in the Area for the benefit of humankind as a whole. At the core of ISA's mandate lies its duty to take all necessary measures to ensure effective protection of the marine environment from harmful effects which may arise from seabed activities. To that end, ISA is required to adopt appropriate rules, regulations and procedures for, *inter alia*, the prevention, reduction and control of pollution and other hazards to the marine environment, the protection and conservation of the natural resources of the Area, and the prevention of damage to the flora and fauna of the marine environment.[1]

2. In pursuance of this mandate, the Council, during its seventeenth session in 2012, on the basis of the recommendation of the Legal and Technical Commission, approved an Environmental Management Plan (EMP) for the Clarion-Clipperton Zone (CCZ).[2] This included the designation of a network of nine "Areas of Particular Environmental Interest" (APEIs).

3. At its twenty-fourth session, in March 2018, the Council took note of a preliminary strategy proposed by the Secretary-General for the development of regional environmental management plans (REMPs) for key provinces where exploration activities under contracts are carried out.[3] The Council agreed with the priority areas that had been identified on a preliminary basis as the Mid-Atlantic Ridge, the Indian Ocean triple junction ridge and nodule-bearing province, as well as the North-West pacific and South Atlantic for seamounts. The Council also noted that the preliminary strategy laid out a coherent and coordinated approach to the process and identified as essential that REMPs be developed in a transparent manner under the auspices of the Authority, in light of its jurisdiction under the Convention and the Agreement relating to the implementation of Part XI of the Convention.[4]

4. As noted by the Council, the implementation of this preliminary strategy has started with the organization of two workshops, including the one organized in Szczecin, Poland, in June 2018, which addressed the development of a framework of a REMP for polymetallic sulphide deposits (PMS) on

[1] United Nations Convention on the Law of the Sea, art.145.
[2] See ISBA/17/LTC/7; ISBA/17/C/19 and ISBA/18/C/22.
[3] See ISBA/24/C/3.
[4] ISBA/24/C/8, para 10.

Mid-Ocean Ridges[5].

5. Following the experience of the environmental management planning for the CCZ and initiatives undertaken for other regions, the development of REMPs became an essential element of the strategic plan for the period 2019–2023[6] adopted by the Assembly in 2018 and, subsequently, the high-level action plan[7] adopted by the Assembly in 2019. As reflected in the Strategic Direction 3.2, efforts are to be invested to "develop, implement and keep under review regional environmental assessments and management plans for all mineral provinces in the Area where exploration or exploitation is taking place to ensure sufficient protection of the marine environment as required by, *inter alia*, Article 145 and Part XII of the Convention".

6. At the twenty-fifth session, the Council took note of, and welcomed a report of the Secretary-General[8] on the implementation of the preliminary strategy, including a programme of work to develop REMPs through a series of workshops planned during 2019 and 2020 to undertake scientific synthesis and prepare draft elements for inclusion in the REMPs.

7. To support the organization of these workshops, the secretariat prepared a guidance to facilitate the development of REMPs, which clarified the roles and responsibilities of ISA organs, as set out in the Convention, the Agreement and the rules, regulations and procedures of the Authority. The guidance also identifies the key scientific and technical approaches for spatial planning and area-based management. As requested by the Council in its decision ISBA/26/C/10, steps are being undertaken by the Legal and Technical Commission to further develop this guidance document.

8. In parallel with this development, in 2019, two expert workshops were convened on: (i) deep sea biodiversity of the CCZ and (ii) the development of a REMP for the Area of the northern Mid-Atlantic Ridge. The results of these two workshops were discussed by the Legal and Technical Commission at its twenty-sixth session and form the basis for the ongoing review of the environmental management plan for the CCZ, as well as further development of the REMP for the Area of the northern Mid-Atlantic Ridge.

9. With the above background, ISA secretariat, in collaboration with the Atlantic REMP Project (sponsored by the European Maritime and Fisheries Fund), the Ministry of Natural Resources and Environment of the Russian Federation and the All-Russia Scientific Research Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia), convened the Workshop on the Development of a Regional Environmental Management Plan for the Area of the Northern Mid-Atlantic Ridge with A Focus on PMS Deposits, via an online platform from 23 November to 4 December 2020.

10. The workshop focused on:

a. identifying potential management approaches and measures, with a focus on polymetallic sulphide (PMS) deposits, which can be considered in the development of a REMP, including spatial and non-spatial measures as well as approaches for addressing cumulative impacts at the regional level; and

b. discussing the framework for implementation, including priority actions for addressing the knowledge gaps, monitoring and research, collaboration and capacity development.

[5] The report of this workshop is available at https://isa.org.jm/files/files/documents/ts22.pdf.
[6] ISBA/24/A/10
[7] ISBA/25/A/15, annex II
[8] IBSA/25/C/13

ITEM 1. OPENING OF THE WORKSHOP

11. Mr. Michael Lodge, the Secretary-General of ISA, delivered his opening remark through a video message. He began by welcoming everyone to the workshop and expressed thanks to the organizations that collaborated in organizing this workshop: the Ministry of Natural Resources and Environment of the Russian Federation, the All-Russia Scientific Research Institute for Geology and Mineral Resources of the Ocean, and the European Commission, through its Atlantic REMP project. Gratitude was also conveyed to Mr. Georgy Cherkashov and Mr. Gordon Paterson, members of the Legal and Technical Commission, for their contribution as the workshop's co-chairs. Appreciation was then expressed to the Atlantic REMP project, as well as the technical support teams from Duke University and the Commonwealth Scientific and Industrial Research Organization (CSIRO).

12. Mr. Lodge reiterated the ISA's mandate to ensure the effective protection of the marine environment from potential harmful effects that may arise from exploration and exploitation of mineral resources in the Area. He highlighted the importance of the development of REMPs for the implementation of this mandate and noted that the process started more than a decade ago in the Clarion-Clipperton Zone (CCZ). He recalled the adoption of the first REMP for the CCZ by the Council of the Authority in 2012 and noted that considering growing interest in exploration in the Area, it was important to develop this process in other regions. He recalled that in 2018, the Council endorsed the strategy for the development of REMPs, highlighting that all REMPs should be developed under the auspices of the Authority and in the priority areas identified. He noted that the current workshop was a continuation of the work started in the workshops held in Szczecin, Poland (2018) and Evora, Portugal (2019). He also indicated that since these meetings, much progress has been made in ensuring that the process was inclusive and supported by strong scientific evidence. He outlined the workshop's aims and acknowledged the valuable contribution of experts to post-Evora workshop activities, which have provided a strong foundation for the current workshop deliberations.

13. His Excellency Vladimir Vinokurov, Ambassador of the Russian Federation in Jamaica, and Permanent Representative of the Russian Federation in the International Seabed Authority, delivered his opening remark through a video message. He began by highlighting the historical partnership between the Russian Federation and ISA. He then noted that the Russian Federation was the first country to sign an exploration contract and has remained compliant with the established obligations, which includes engagement in environmental baseline studies to provide knowledge on the potential impacts which may arise from future exploitation activities. He highlighted the importance of the development of REMPs, which would complement and build on the efforts of contractors toward an integrated approach to studying and monitoring the environment. He expressed confidence that the workshop would stimulate international cooperation on the effective development of mineral resources in the Area. In closing, he expressed gratitude to the Secretary-General of ISA and the secretariat for making the workshop possible.

14. Mr. Valery Kaminsky, Director-General of All-Russia Scientific Research Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia) delivered his opening remark through a video message. First, he welcomed all participants and then expressed gratitude to the Secretary-General of ISA and his team for making the workshop possible. He also thanked the Ministry of Natural Resources and Environment for providing support. He highlighted the work of the Institute in research conducted by the Soviet Union and then the Russian Federation in the past 50 years, data from which was used for the selection of contract areas in the Pacific and Atlantic oceans. He underscored the importance of environmental protection; a principle advocated by the Convention and highlighted the important role that ISA has been playing for the development of REMPs for all mineral types.

15. Mr. Felix Leinemann, Head of Unit Blue Economy Sectors, Aquaculture and Maritime Spatial Planning, DG Maritime Affairs and Fisheries of the European Commission, delivered his opening remark through a video message. He began by commending ISA on successfully organizing the workshop, notwithstanding the hurdles imposed by the global pandemic. He then spoke on the European Green Deal and the associated task of addressing biodiversity crisis and the goal of making Europe the world's first carbon neutral economy by 2050. With this in view, he highlighted that much attention has been focused on 'critical raw material' and ensuring their supply. He however underscored that seabed mining should only start after sufficient research has been undertaken on the potential risks involved. This has driven the Commission's financial support for research projects such as MIDAS, Blue Mining, Blue Nodules and ROBUST. Similarly, the Commission currently funds the project supporting the Atlantic REMP project. Mr. Leinemann highlighted the role the project has played since 2018, in collaboration with ISA, in supporting the development of a REMP for the northern Mid-Atlantic Ridge with a focus on PMS deposits. He noted with pleasure the positive feedback received on the Regional Environmental Assessment report, which was produced by the project in preparation for the Evora workshop in 2019 and would be used to inform management approaches during this workshop.

ITEM 2. WORKSHOP BACKGROUND, SCOPE AND EXPECTED OUTPUTS

16. Georgy Cherkashov and Gordon Paterson, members of the LTC, were invited as co-chairs to moderate the workshop deliberation.

17. Under this item, participants had before them two Council documents (ISBA/24/C/3 and ISBA/25/C/13), and the "guidance to facilitate the development of regional environmental management plans".

18. Jihyun Lee (ISA secretariat) provided a presentation on the workshop background, including ISA's approach to REMP development, and Wanfei Qiu (ISA secretariat) provided a presentation on the workshop objectives, scope and expected outputs.

19. The ISA secretariat then introduced the list of background documents prepared for the workshop.

ITEM 3. KEY OUTPUTS FROM PREVIOUS WORKSHOPS ON THE DEVELOPMENT OF A REGIONAL ENVIRONMENTAL MANAGEMENT PLAN IN THIS REGION, AND THEIR IMPLICATIONS FOR DESIGNING MANAGEMENT APPROACHES AND MEASURES

20. Under this item, participants had before them:

a. Report of the workshop on the REMP for the Area of the northern Mid-Atlantic Ridge held in 2019 in Evora, Portugal ("Evora workshop");

b. Draft report on qualitative mathematical models for assessing cumulative impacts on ecosystems of the Mid-Atlantic Ridge from future exploitation of polymetallic sulphides;

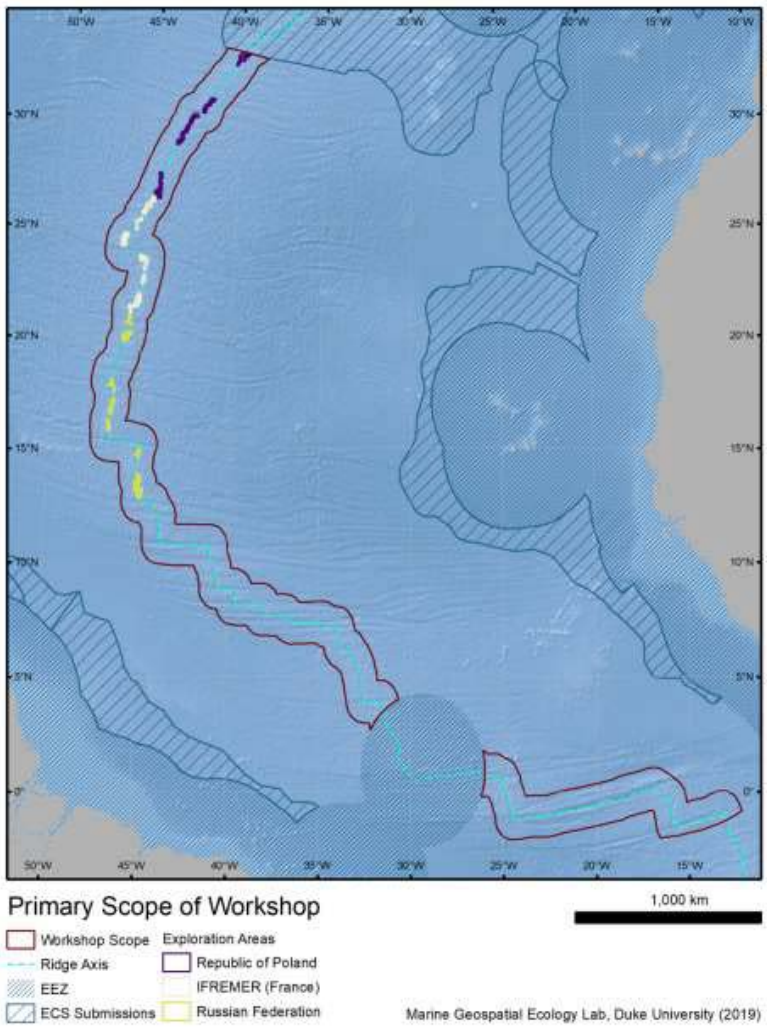
c. Regional Environmental Assessment for the northern Mid-Atlantic Ridge (revised version after the Evora workshop); and

d. Data Report (revised version after the Evora workshop).

21. To provide the context of the exploration and future exploitation of mineral resources in this region, Georgy Cherkashov and Pedro Madureira, members of the LTC, delivered a presentation on geological settings and current exploration activities, and one on prospects for relinquishment and exploitation of PMS deposits, respectively.

22. To provide the context of environmental management planning at the regional scale, Gordon Paterson (member of the LTC) and Patrick Halpin (Technical support team) delivered a presentation on environmental goals and objectives, and one on the geographic scope of the workshop and the potential scope of the environmental planning at the regional scale, respectively.

23. As this workshop's deliberation would build on the results of the Evora workshop[9], it was noted that the geographic scope of this workshop would similarly focus on the areas as considered by the Evora workshop (see Map 1).



Map 1. Geographic scope of this workshop's deliberation

24. The following presentations were then delivered on the synthesis of scientific information for management approaches, based on the outputs of the Evora workshop:

a. Philip Weaver (Seascape Consultants Ltd./Atlantic REMP Project): Scenario planning for adaptive management;

b. Patrick Halpin (Technical support team): Area-based management approaches; and

[9] See the workshop webpage: https://www.isa.org.jm/index.php/event/workshop-regional-environmental-plan-area-northern-mid-atlantic-ridge ; Workshop report is available at https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf

c. Piers Dunstan (Technical support team): Qualitative modelling to address cumulative impact assessment.

25. Building on the presentations above, participants exchanged their questions, views, insights, and suggestions, *inter alia*:

a. Participants discussed the issue of relinquishment, which has been or will be carried out in accordance with the exploration regulations. Contractors relinquish part of their exploration areas primarily based on resource or commercial considerations. The relinquished blocks will revert to the Area. Environmental data collected from the relinquished areas would have been submitted to ISA through the annual reporting process and made available in the DeepData database. The level of information available in DeepData may vary among different contract areas. The potential use of relinquished areas for environmental monitoring and management was considered an issue that requires further discussion.

b. Participants exchanged views on the qualitative modelling approach for cumulative impact assessment, in particular with respect to how ecosystem values were incorporated within the model, and how to address uncertainties in responses of ecosystem components to future exploitation activities.

c. With respect to ecosystem values, participants noted that there can be many different values attached to ecosystem components, for example, commercial, social, cultural and ecosystem function values. Clarification was provided on the ecosystem values used for the qualitative modelling work, which focused on the biophysical assets; i.e., the parts of the ecosystem that the participating experts could describe. Because the habitats considered in the ecosystem models for the northern Mid-Atlantic Ridge are physically remote, the biodiversity value was considered to represent the intrinsic value of these systems. With more information, future models may be able to assign different types of values to specific ecosystem components and build a wider range of values into the resulting models.

d. Regarding the uncertainties in ecosystem component response to pressures as determined by the modelling exercise, clarification was provided on how an uncertain (sign-indeterminate) response was calculated. The fact that ecosystem components have an uncertain response to a pressure indicates that there was a mix of negative and positive pathways of effect from the pressure to the ecosystem component, making it impossible to predict the overall response of the ecosystem component to that particular pressure or a combination of pressures. These uncertainties could be addressed through measuring ecosystem component responses to the specified pressures *in situ*, enabling the direction and magnitude of responses to be determined.

e. Discussion was held on the use of terms and concepts related to 'precaution', in particular a need for consistent use of terminology throughout the workshop deliberations. Participants were encouraged to consider a note by the ISA secretariat on implementing the precautionary approach to activities in the Area[10] when discussing the application of the precautionary approach in the context of the REMP development.

f. The importance of biological connectivity as one of the network criteria for area-based management was raised by participants. Whilst it was agreed that connectivity is an important consideration for determining suitable networks of representative areas, detailed scientific discussion on connectivity would be beyond the scope of the current workshop, where the focus is on management measures, building on the results of the Evora workshop.

ITEM 4. SPATIAL AND NON-SPATIAL MANAGEMENT MEASURES FOR

[10] ISBA/25/C/8: https://isa.org.jm/files/files/documents/25c-8-e.pdf

CONSIDERATION IN THE DEVELOPMENT OF THE REMP

26. The ISA secretariat briefed participants on suggested approaches for producing outputs under this item through break-out session discussion. Participants then split into two groups, as arranged by the secretariat considering their expertise and experience. The contribution of participants from Group 1 and 2 were facilitated by Pedro Madureira and Harald Brekke, respectively.

27. These two groups were invited to contribute to the following thematic segments to undertake focused discussions:

a. Thematic segment A: Area-based management measures (moderated by Pat Halpin, with three rapporteurs – Thomas Kuhn (BGR), Elisabetta Menini (Technical support team/Duke University) and Wanfei Qiu (ISA secretariat))

b. Thematic segment B: Non-spatial management measures (moderated by Phil Weaver, with two rapporteurs - Rachel E. Boschen-Rose (Atlantic REMP Project) and Luciana Genio (ISA secretariat))

28. Break-out session discussions were assisted by moderators and rapporteurs invited by the ISA secretariat, in consultation with the workshop co-chairs, considering their expertise and experience.

29. Further information on the break-out groups and key questions to be addressed in each group were provided in the "Note for Participants on Break-out Session Discussion", circulated by the ISA secretariat before the workshop.

30. After the breakout session, participants gathered in a plenary session, and each moderator of the break-out groups reported on the progress made in their respective group discussion. Participants then exchanged their observations and insights and sought guidance from the plenary.

31. After the plenary, participants were given an opportunity to review and provide comments on a preliminary summary of the results of the break-out session discussion on Thematic Segments A & B, as compiled by the co-chairs, based on the inputs from respective moderators and rapporteurs and with assistance from the secretariat.

ITEM 5. KEY ELEMENTS OF THE IMPLEMENTATION OF A REMP, INCLUDING TECHNOLOGICAL CONSIDERATIONS, MONITORING AND RESEARCH, COLLABORATION AMONG STAKEHOLDERS, AND CAPACITY DEVELOPMENT

32. Under this item, a series of presentations were provided on three topics related to the implementation of a REMP.

33. On the topic of technological considerations, the following presentations were delivered:

a. Ulrich Schampera (ISA secretariat): Technology considerations relating to the future exploitation of PMS deposits;

b. Arne Myhrvold (Equinor): Technology development as an integrated part of environmental management; and

c. Naohisa Kanda (Japan NUS Co., Ltd.): Japan's experience in PMS testing and implications for monitoring.

34. On the topic of experience of regional bodies, the following presenters shared their experiences and lessons learned in the application of area-based management tools and adaptive management at the regional scale:

a. Fred Kingston (Northwest Atlantic Fisheries Organization); and

b. Darius Campbell (North-East Atlantic Fisheries Commission).

35. On the topic of addressing knowledge gaps through research, monitoring, collaboration, and capacity development, the following presentations were delivered:

a. Knowledge gaps and priorities for monitoring and research identified by the Evora workshop, including through the compilation of data and information for the Regional Environmental Assessment and Data Report:

- Philip Weaver (Atlantic REMP Project), Rachel Boschen-Rose (Atlantic REMP Project), and Patrick Halpin (Duke University)

b. Monitoring and collaboration from various perspectives:

- Livia A. Ermakova (VNIIOkeangeologia);
- Jozée Sarrazin (French Research Institute for Exploitation of the Sea-IFREMER);
- Teresa Radziejewska (University of Szczecin); and
- Sang-Mook Lee (InterRidge).

36. A Q&A session followed after each topic for participants to exchange views, insights, and suggestions.

37. Then, Piers Dunstan (Commonwealth Scientific and Industrial Research Organisation) delivered a presentation on how the framework of assessing cumulative impacts can help prioritize future monitoring and research activities and strategize future collaboration among stakeholders. This was followed by a Q&A session for participants to exchange views, insights, and suggestions.

38. Next, the ISA secretariat briefed participants on suggested approaches to producing outputs under this item through break-out session discussion. Participants then split into the following breakout groups to undertake focused discussions:

a. Thematic segment C: Monitoring, research and technological priorities at the regional scale to support effective implementation of a REMP and address knowledge gaps (moderated by John Jamieson, with two rapporteurs - Anna Metaxas and Rachel E. Boschen-Rose)

b. Thematic segment D: Collaboration among stakeholders and capacity development of various actors to support effective implementation of a REMP and address knowledge gaps (moderated by Gordon Paterson and Michelle Walker, with three rapporteurs - Elisabetta Menini, Thomas Kuhn, and Wanfei Qiu)

39. Further information on the break-out groups and key questions to be addressed in each group were provided in the “Note for Participants on Break-out Session Discussion”, circulated by the ISA secretariat before the workshop.

40. Break-out session discussions were assisted by moderators and rapporteurs invited by the ISA secretariat, in consultation with the workshop co-chairs, considering their expertise and experience.

41. After the breakout session, participants gathered in a plenary session, and each facilitator of the breakout groups reported on the progress made in their respective group discussion. Participants then exchanged their observations and insights.

ITEM 6. SUMMARY AND CONCLUSION

42. Participants were invited to review and provide comments to the draft report prepared and presented by the workshop co-chairs, with the support of the secretariat.

ITEM 7. CLOSURE OF THE WORKSHOP

43. The workshop closed at 11 a.m. (Jamaica; GMT-5) on Friday, 4 December 2020.

Annex I

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Annex II

Summary of Theme Presentations

Presentations delivered under agenda item 2

Workshop background

By Jihyun Lee

Ms. Jihyun Lee (ISA secretariat) introduced the context for the workshop, by explaining the process of developing REMPs, which the Council had decided to undertake under the auspices of the Authority. The development of REMPs is at the core of the ISA's commitment to the protection of marine environment, and the application of a precautionary approach within the context of its mandate under the UN Convention on the Law of the Sea as well as the ISA Strategic Plan (2019-2023) and its high-level action plans (HLAPs). REMPs are established by decisions of the Council, based on recommendations of the Legal and Technical Commission, and each Contractor is to comply with these decisions. In its 25th session, the Council encouraged the secretariat and the Commission to make progress on the development of REMPs, in particular where there are currently exploration contracts, including the northern Mid-Atlantic Ridge. Ms. Lee also presented the progress so far in organizing a series of workshops on the development of REMPs. She also informed the participants that in its 26th session, the Council highlighted standardized approaches for the development, approval and review of REMPs. Pursuant to this decision, LTC is currently working on further development of "Guidance to facilitate the development of regional environmental management plans". She also informed the participants that scientific preparation has been undertaken in collaboration with various partner organizations and scientific groups as inputs to support the workshop deliberation. She then thanked the experts, who provided inputs, after the Evora workshop, for the finalization of the Regional Environmental Assessment Report and the Data Report, as well as their contributions in the preparation of the draft report on qualitative mathematical models for assessing cumulative impacts on ecosystems of the mid-Atlantic ridge from future exploitation of polymetallic sulphides.

Workshop scope, objectives and outputs

By Wanfei Qiu

Ms. Wanfei Qiu (ISA secretariat) began by highlighting that this workshop built on previous ISA workshops held in Szczecin, Poland in 2018, and in Evora, Portugal in 2019. The workshop focuses on the management and implementation aspects of the draft REMP, based on the scientific outcomes from the Evora workshop. The workshop objectives are to: i) describe the scope for the draft REMP; ii) identify possible elements to be included in the draft REMP; iii) identify potential management approaches and measures, with a focus on PMS deposits, that can be considered in the development of a REMP, including spatial and non-spatial measures; and iv) discuss the framework for implementation, including priority actions and monitoring and research. The expected outputs of the workshop include the formulation of key elements for the draft REMP, which can be considered by the Legal and Technical Commission in developing the REMP for the Area of the northern Mid-Atlantic Ridge.

Presentations delivered under agenda item 3

Geological setting, distribution and potential resources of SMS deposits

By Georgy Cherkashov

The key geological parameters for the setting of SMS deposits include:

- Bathymetry/geomorphology, including rift valley and slope characteristics as well as other lineaments of the rift zone;

- Type of host rocks/substrate: sediments/basalts/ultramafic rocks; and
- Intensity of tectonic, volcanic, and hydrothermal processes.

One of the main characteristics of the Mid-Atlantic Ridge is segmentation. 22 segments between 13° and 21°N have been identified based on morphostructural analyses. The average length of the individual segment varies from several tens to 100 km.

There are two distinguished types of ridge segments – tectonic and magmatic. Their nature is determined by the regime of volcanic accretion and magmatic budget. The first type with symmetrical seafloor spreading is characterized by a high magmatic budget. Hydrothermal sites are associated mainly with the axial volcanic ridge basalt lavas. The second type of segmentation with asymmetrical mode of accretion has low (or zero) magmatic budget. SMS deposits are related to oceanic core complexes, presented by deep-seated gabbro-peridotites rocks structurally exhumed on the seafloor. Hydrothermal SMS deposits from these two settings differ by tonnage and by metal grades. Currently ultramafic-hosted deposits are believed to have a higher economic value due to their higher grades of metals like copper and gold. Statistically, the number of SMS deposits discovered within tectonic and magmatic segments are equal.

The geomorphology of the MAR rift zone is very complicated and characterized by a highly variable configuration of the rift valley floor and other lineaments. Such variability in the geological setting impedes the task to find areas of protection with geological and biological characteristics close to the sites of potential exploitation.

The distribution of 22 currently detected SMS deposits is rather heterogeneous and distances between separate sites vary considerably (from 10 to 100 km and more). It should be noted that all known sites represent ~20-30% from predicted sites which remain to be discovered (Beaulieu et al., 2015).

Resource evaluation of the sulfide areas is rather uncertain. Application of different approaches could result in increasing resources. Resource estimation depends on morphology and the inner structure of deposits, the amount of non-sulphide minerals within the individual orebody and its zonality.

Current resource estimation of SMS deposits in the North Atlantic (first hundreds Mio. t) could increase dramatically (2-3 times higher) as a result of extension of the exploration area (with increasing exploration corridor up to 20 km) or could decrease as a result of drilling SMS deposits outcropping on the seafloor.

Due to the absence of an economic model for SMS mining, it is not possible to determine the level of resources which could be commercially interesting for future exploitation. Suggested profitable level of annual nodules production (2-3 Mio. t/year) is not applicable for SMS deposits.

Prospects for relinquishment and exploitation of PMS deposits

By Pedro Madureira

In contrast to polymetallic nodules, polymetallic sulphides constitute three dimensional deposits, which are typically characterized by a relatively high heterogeneity and zonation. At the beginning of the exploration activities, the discovery of prospective areas for sulphide mineralization can be facilitated by the presence of active vents and associated hydrothermal plumes that change the physico-chemical properties of the ambient seawater. The search for inactive and extinct sites is more demanding and is usually performed by electromagnetic surveys. Notwithstanding the crucial role of drilling for the polymetallic sulphides resource assessments, the search for potential targets plays a crucial role in the strategy followed by contractors in the early stages of their contracts for exploration. In fact, according to Regulation 27 of ISA regulations on prospecting and exploration for polymetallic sulphides in the Area, by the end of the eighth year from the date of the contract, the contractor shall have relinquished at least

50 per cent of the original allocated area. Also, by the end of the tenth year from the date of the contract, the contractor shall have relinquished at least 75 per cent of the original allocated area. Therefore, after this time period, the area available for advanced exploration and resource assessment under the contract does not exceed 2,500 km^2. According to paragraph 1 of the same regulation, areas to be relinquished shall be defined by the contractor in the form of sub-blocks comprising one or more cells of a grid as provided by the Authority. In the 25th Session of ISA, the Legal and Technical Commission (LTC) was assisted by the Secretariat to issue the recommendations for the guidance of contractors on the relinquishment process. In order to provide certainty and efficiency in managing areas under contract, the subdivision of the initial exploration blocks into cells of 1 km x 1 km was proposed and decided. Therefore, the final area of exploration allocated to a contractor after this relinquishment process may be characterized by a patchy pattern that should be considered in the scientific approach aimed to develop a feasible and effective REMP for the Northern Atlantic.

Environmental goals and objectives that an REMP is aiming to achieve

By Gordon L J Paterson

To enable a clear understanding of what a Regional Environmental Management Plan is trying to achieve, it is necessary to have well-defined goals and objectives. This presentation provided a brief summary of discussions at the Evora Workshop in 2019 and aimed to provide some context for the discussion at the current workshop. Mr. Paterson highlighted that goals and objectives must be set within the legal context and the overarching principles that are derived from this context. The legal context for the REMP is based within United Nations Convention on the Law of the Sea (UNCLOS). He also explained that REMPs are a mechanism that facilitates the actions of the regulator and contractors to ensure that the principles enshrined in UNCLOS are fulfilled. He elaborated that from UNCLOS it is possible to derive a set of guiding principles which should underpin any management plan. The ones discussed in the presentation were derived from the REMP for the Clarion-Clipperton Zone, which emphasized that the Area is the common heritage of humankind, activities should be guided by the precautionary approach, and that the protection and preservation of the marine environment were paramount. Goals reflect high-level outcomes that the plan is aiming to achieve. A key goal should be preserving the distinct and unique ecosystems found along the Mid-Atlantic Ridge, and the services they provide. Objectives are how the goals are going to be met, guide the actions to ensure the attainment of the REMP's goals, and up-hold established principles. Mr. Paterson then presented a set of high-level objectives as points to guide the workshop discussions. He emphasized that many of the objectives can be derived from UNCLOS, such as minimizing pollution that arise from activities in the Area, as well as objectives which are specific to the Mid-Atlantic Ridge. In addition to goals and objectives are the principles which underpin its management, particularly at the scale of operations, for example, use of ecosystem-based management approaches.

Geographic Scope of the Workshop

By Patrick N. Halpin

Mr. Halpin started by explaining the key considerations made for defining the geographic scope of the Northern Mid-Atlantic Ridge (nMAR) REMP workshop conducted in Evora, Portugal in November 2019. The lower bathyal biogeographic province was used as an initial description of the general area of focus. However, this area was considered to contain significant area (up to ~400km) of sedimented features along the side slopes of the ridge, so a more specific description was developed. He noted that the effective width of seabed area actively considered for ABMTs and adaptive management measures was narrowly restricted to an approximately ~50km area representing primarily non-sedimented habitat on either side of the ridge axis. For purposes of the REMP planning, this area was extended to ~100km on either side of the ridge axis to ensure complete coverage and uncertainty. This provided a ~200km-wide area covering the ridge axis in the Area from north of the Azores as well as south of the Azores. The workshop further refined the focus area to include only the region south of the Azores (~33^{o} north) to include the Romanche Fracture

Zone (~0º). This south of the Azores region was described to contain deep ridge features, multiple active vent fields, five transverse sections and three primary fracture zones.

Scenario Planning for Adaptive Management
By Phil Weaver

The mid Atlantic ridge is a linear feature running down the centre of the Atlantic Ocean and represented by elongate valleys and ridges, occasionally offset by fracture zones that may create deep trenches. Hydrothermal vents are created when fluids, flowing through the rocks, are emitting at the seabed where they may precipitate metals in varying quantities. Active venting occurs within a few kilometres of the ridge axis, though inactive and extinct vents can be found further away. The ridge axis is rocky but as the crust ages away from the axis sediment builds up quickly eventually covering the vents. Potential mine sites, and contract blocks, are located in the rocky areas in a narrow band along the ridge axis. Although mine sites will be in the order of one km^2, plumes of particulate laden water and potentially toxic substances will spread away from the mine sites. A number of ecosystems exist along the ridge axis that could be affected by the mines or plumes. These include hydrothermal vent faunas and areas of structural species, such as coral and sponge gardens, that may live on the rocky outcrops. The process of defining SINPs, as described by the Evora workshop, will need to be flexible to accommodate newly discovered areas during the exploration period. Buffer zones should be considered around each SINP to protect from plume impacts, and the dimensions of these require discussions involving knowledge of the mining technique, local conditions and variations in currents over time. The development of good equipment design may reduce or eliminate plumes, which could eventually allow smaller buffer zones and thus potentially more mining opportunities. Attention should however be paid to the possible effects of cumulative impacts, and thresholds could be considered for the maximum impact on ecosystems for any given area. The ore will be transferred to the support ship in a wet state, with the water removed and returned to the ocean as a plume, again with particulates and potentially toxic substances. If this water is released in midwater its impact is unclear as little is known of midwater faunas. The Evora workshop suggested this water should be released as close to the seabed as possible. The generation of noise at the seabed, from riser pipe pumps (particularly in the SOFAR layer) and from the surface ship, should also be considered, as should impacts of light at the seabed and from the support vessel.

Approaches for spatial planning: Area-Based Management Tools (ABMTs)

By Patrick N. Halpin

Mr. Halpin presented an overview of the spatial planning approaches discussed and the proposed outcomes from the Northern Mid-Atlantic Ridge (nMAR) REMP workshop in Evora, Portugal in November 2019. He introduced the potential interaction between broader scale cumulative impacts analysis, area-based management and finer scale adaptive management approaches. He noted the fundamental differences between the previous planning processes in the Clarion-Clipperton Zone region versus the nMAR region and the need to apply a broader range of area-based management tools (ABMTs) in the nMAR REMP. He then described the three general area-based management approaches discussed: (1) observation of vulnerable species or ecosystem occurrences (using the VME criteria); (2) description of specific important sites or areas (using the EBSA important area criteria); and (3) selection of representative ecosystem features and gradients (using the EBSA network criteria). Mr. Halpin noted that the Evora workshop discussed but did not attempt to apply the representative ecosystem approach using the network criteria, since this approach requires a regional analysis that was beyond the scope of the in-person workshop and would need to be conducted in the future (ref. pg.79 Evora report). He also presented two levels of information and specificity: (1) sites or areas in need of protection, where sufficient information exists to describe those sites/areas; and (2) sites/areas in need of precaution, where the sites are inferred or predicted. A matrix describing the three approaches by two levels was presented to summarize these relationships. Mr. Halpin summarized the four specific ABMT outcomes of the Evora workshop, including their respective approaches for description: (1) 11 active hydrothermal vents proposed as Sites in the Need of Protection; (2) 3 transverse fracture zones proposed as Areas in Need of Protection; (3) 12 inferred

hydrothermal vent sites proposed as Sites in Need of Precaution; and (4) modeled areas of octocoral habitat suitability proposed as Areas in Need of Precaution.

Developing Cumulative Impact Assessments

By Piers Dunstan

The basis for adaptive management has three key components: (1) A clear understanding of objectives and desired outcomes; (2) An assessment process that includes all potential positive and negative effects of development; and (3) A monitoring program that can test this assessment and ensure that the desired outcomes are being achieved. This presentation described the process used to assess cumulative impacts in the Northern Mid-Atlantic Ridge. Understanding the effects of cumulative impacts in a region is multitiered process, which requires the description of the distribution of key ecosystems, key effects on the ecosystems and then understanding how these components interact. Qualitative models represent a working hypothesis about how an ecosystem works. They should: a) identify the important components and processes in the system; b) document assumptions about how these components and processes are related; c) identify the linkages between these components/processes and anthropogenic pressures; and d) identify knowledge gaps or other sources of uncertainty. Qualitative models were developed to assess the potential risks from mining operations in the Northern Mid Atlantic Ridge. Information on the Values (ecosystem components), Pressures (potential mining activities) and Zones of influence were used to develop qualitative models for the Northern Mid Atlantic Ridge. These models were then used to explore the potential impacts of single and multiple pressures acting simultaneously on vent and non-vent ecosystems. The outputs of the models can be used to develop monitoring questions (What will be impacted, by what pressures and over what time scale) and identify the best indicator species/groups.

Presentations delivered under agenda item 5

Technology considerations relating to the future exploitation of PMS deposits

By Ulrich Schwarz-Schampera

Technology considerations for seafloor mining has existed since the late 1970s and is still evolving. The traditional concepts for ocean floor mining all involve driving vehicles on the seafloor independent of the type of mineralization, ores and their mode of occurrence. The concepts also suggest vertical riser technology with the use of seawater slurry pumps for the transportation onto the production vessel and the release of the transport medium at depth. Mining PMS from seafloor subsurface necessarily will involve mining activities towards depth. Similar to land-based deposits, an open pit mining concept was adopted and followed by Nautilus for its SOLWARA deposit in Papua New Guinea. However, an alternative concept of a vertical recovery system was developed already in the late 70s for the recovery of sulfide muds from the Red Sea. Both concepts included the discharge of transport and process water to the ocean. The company Nautilus followed an open pit mining strategy and the design of appropriate mining machines including continuous miner, bulk cutter, collecting machine and lift pumps. The discharge of process water may result in limited visibility during the mining process. JOGMEC performed the world's first ore-lifting pilot test for polymetallic sulfides in August/September 2017 within the Okinawa Trough and followed a similar concept but as a multi-ship operation.

Different mining concepts adopted a vertical approach. Available techniques can possibly accommodate a particular shape of narrow three-dimensional and conical geological bodies better than the traditional open pit mining technique developed for land-based deposits. SMS deposits are considered three-dimensional, of conical funnel shape and they are usually narrowing towards the base. The deeper portions of the deposit are considered high-temperature and therefore Cu-(Au)-rich. Potential advantages of vertical mining are its selectivity diminishing the recovery of barren rock or uneconomic pyrite ore. Trench cutting allows very selective and low-impact drilling. The concept includes separation of process water during the mining and the mining process could be continuous or discontinuous. This may all lead to a lower environmental

footprint.

Technology development as an integrated part of environmental management

By Arne Myhrvold

Mr. Myhrvold described how Equinor considers technological advancement as an integral part of the development and maturation of projects and their environmental management. The presentation was based on experiences related to the offshore oil & gas (O&G) industry, but he noted that examples presented are relevant for both O&G and deep-sea mining activities. He explained that a project typically matures through the following phases: 1) exploration activities; 2) feasibility studies; 3) selection of concept; 4) final investment decision, execution and building; and finally, 5) operations. To further develop the project in accordance with good environmental practice, there are important "to do elements" in these different phases. He focused on elements demonstrating the need to understand the project's environmental challenges early in the exploration phase, or even earlier when assessing the business opportunity. He described the need to conduct a risk and impact assessment during an early phase, to understand significant sources and causes of risks, and to assess potential mitigation actions, since it is much easier and less expensive to mitigate them earlier than later in the process. Based on this, we can assess the need to develop enabling and enhancing environmental technologies and understand where technology is needed, whether for physical materials, such as tools and machines, or others, such as computer software, models, methods, and documentation of knowledge and competence. He also presented examples of technological development that could improve our understanding of environmental risks associated with particle rich plumes and advance biological knowledge to inform the assessment of threshold values and further development of an environmental risk framework for PMS mining, as described in the application for a RCN funded research project named *Eco-Safe ridge mining*. He also showed examples that can be relevant to both near-field and far-field environmental monitoring, including the LoVe ocean observatory (love.equinor.com) and the underwater intervention drone Eelume (https://eelume.com/). Lastly, he described examples of technological development that could improve our general knowledge of deep-sea ecosystems and enhance research capacity on benthic taxonomy. Through these examples, he explained how the advancement of environmental technology is an important integral part of project development and that knowledge and capabilities derived from such technologies will improve both our understanding of environmental risks as well as our ability to mitigate them.

Japan's experience in PMS testing: impact prediction by numerical model

By Naohisa Kanda, Tomomi Eriguchi, Shogo Kato

In 2017, the Ministry of Economy, Trade and Industry of Japan and Japan Oil, Gas and Metals National Corporation successfully conducted the world's first pilot test of excavating and ore lifting for seafloor polymetallic sulfides (PMS) lying approximately 1,600m below sea level near Okinawa, Japan. One of the several objectives of the pilot study was to examine, through the disturbance experiment at the site, whether or not mathematical prediction models can predict diffusion process and re-sedimentation level of plumes generated from the mining operation, in order to assess the impact of the mining on the surrounding environment. This project is significant because the model, which was developed to predict the extent/degree of impact on the environment from the mining operation, was evaluated by comparing the predicted results from the model with the actual data observed from the monitoring surveys. The monitoring surveys were conducted near the seafloor on ecosystems before, during, and after the disturbance experiments to collect the environmental data for evaluating the prediction model. The prediction model was verified after the disturbance experiment due to slight changes in the initial test plan. Re-sedimentation from the experiment was examined at nine different sites scattered around the disturbance starting point in the inactive vent field by the re-sedimentation marker that detected increased thickness of the sediment. Among the nine sites, re-sedimentation at five sites along the east side of the disturbance point from north to south was observed with the maximum amount (5mm thickness) at the

southeast site. The monitoring survey found that the abundance of meiobenthic copepods (Harpacticoida) decreased at the re-sedimentation sites. Comparison of the results of the simulation and the monitoring survey showed that the distribution pattern and re-sedimentation thickness were in good agreement between both results, confirming that the model enabled a high-quality prediction of the behavior of plumes. It was thus demonstrated that the model exercise would be very useful and accurate to predict the dynamics of the plume generated from the deep-sea mining operation and their impact on the surrounding environment. Contrary to that, however, the comparison of the two simulation results conducted before and after the disturbance experiment showed quite different pattens of the plume diffusion. This is probably because some of the simulation (environmental) conditions, such as flow speed and direction, differed from each other as associated with the changes of the disturbance starting point and the starting time. This also indicates the importance of the mining location, with respect to currents and topography as well as drilling conditions, for predicting the plume dispersal as discussed during the Evora workshop.

Northwest Atlantic Fisheries Organization (NAFO) – Use of Area-based Management Tools in Fisheries Management

By Fred Kingston

NAFO is a Regional Fisheries Management Organization (RFMO) managing the international fishery in the northwest Atlantic. Its objective is "to ensure the long-term conservation and sustainable use of the fishery resources in the Convention Area and, in doing so, to safeguard the marine ecosystems in which these resources are found". Its constituent bodies are a Scientific Council and a fisheries management body – the Commission, which adopts binding measures. Area-based management measures are in common use in international fishery management in general, and NAFO in particular, including the delineation of NAFO's "fishing footprint" (i.e., area in which bottom fishing activities have taken place in 2 years over a prescribed 10-year period), fish stock boundaries and so-called "move-on" rules when certain by-catch thresholds are reached. Since 2005, NAFO has been developing its ecosystem approach framework in the management of its fishery, of which one aspect has been the protection of seamount areas and vulnerable marine ecosystems (VMEs) in the NAFO Regulatory Area (outside the 200-mile limits of coastal States). The basis for the identification and protection of VMEs by NAFO include the 2008 FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO Deep-Sea Fisheries Guidelines). NAFO has identified concentrations of VME indicator species mainly through trawl surveys. The VME areas are then determined through 'kernel density analysis' and further refined through species distribution modelling. NAFO has relied heavily on area-based management measures to protect VMEs, including closed areas, a ban on bottom fishing outside the fishing footprint, except with approval of NAFO's Scientific Council and Commission (Exploratory fishing provisions) and "move-on" rules in the remaining open fishing areas if a certain amount of VME indicator species have been caught. Currently over 275 thousand km^2 of the NAFO Regulatory Area is closed to bottom fishing, representing over 10.34% of the Area. Moreover, with fishing currently only allowed within NAFO's "fishing footprint", only 4.25% of the Area is subject to bottom fishing. Because NAFO only has competency in managing the fishery resources in its region, these closures and other area-based management measures are not binding on other deep-sea activities. Nevertheless, these closures should be taken into account by other ocean actors in the region.

North East Atlantic Fisheries Commission (NEAFC)- Balancing Economic Activity and Conservation In Areas Beyond National Jurisdiction:

By Darius Campbell

Mr. Campbell provided a brief summary of the objectives and scope of NEAFC. The legally binding measures under the NEAFC Convention manage fisheries to maximize the sustainable harvesting of fisheries resources. The objectives of the Convention also include conservation of biodiversity. The adaptive management process follows a cycle of independent scientific advice leading to management

measures, monitoring control and enforcement of these measures. This is followed by new scientific advice in the subsequent years, taking into effects of such measures. The key illustration of this of relevance to ISA is the closure of bottom fisheries where Vulnerable Marine Ecosystems (VMEs) are present. A combination of full closed areas and restricted areas that require exploratory fisheries before fisheries are considered 'established' means approximately 98% of the NEAFC Regulatory Area is closed in practice to bottom contact fisheries. The presentation provided further details on the process, including on the indicators and thresholds used to manage activities under the regulations. Independent scientific advice from the International Council for Exploration of the Seas (ICES) is provided every year, which enables NEAFC to adopt new, or amend, closed areas. Every five years all closed areas are renewed according to ICES advice. Additionally, the effectiveness of the binding regulation on VMEs is reviewed every five years. The majority of the NEAFC Regulatory Area outside the closed and existing fishing areas is restricted to bottom fisheries. This means a strict protocol of exploratory fishing is applied to any proposed activity. This then generates 2 years of closely monitored fishing to determine whether the proposed area should be opened to fisheries or include further restrictions. The presentation also provided a brief explanation of cross-sectoral coordination mechanisms.

Knowledge gaps and priorities for monitoring and research as identified by the Evora workshop

By Phil Weaver, Rachel Boschen-Rose & Patrick N. Halpin

Mr. Weaver explained that our knowledge of habitats along the North Atlantic ridge axis is very patchy and in many areas is limited to knowledge of active hydrothermal vents, with locations of some inactive vent sites being known but poorly studied. As more information becomes available, we expect a number of other habitats such as coral gardens and sponge beds to be located, though many areas may remain sparsely populated. A major research priority is to identify and map habitats along the North Atlantic ridge axis as a prerequisite to protecting any vulnerable habitats. Plumes associated with mining may have a major impact away from the mine site through smothering and toxic effects. Major gaps in knowledge relate to the composition of these plumes in terms of particulates and toxins, how far they will have an impact, and the tolerance thresholds of different animals both at the seabed and in midwater. Other knowledge gaps relate to the potential impact of light at the seabed and on the surface vessel and the potential impact of sound at the seabed, from riser pipe pumps and from the vessel. A number of engineering solutions may be possible to limit the spread and content of plumes and to limit the effects of light and noise.

Ms. Boschen-Rose provided a brief overview of the knowledge gaps and priorities for monitoring and research, specific to the biological environment of the Mid-Atlantic Ridge. Based on the Regional Environmental Assessment report for the northern Mid-Atlantic Ridge, the biological aspects where we are missing the most information for both the pelagic and benthic environments are resilience and recovery. Discussions during the Evora Workshop identified multiple research priorities for both the pelagic and benthic environment, with potentially the biggest knowledge gap being the response of biological communities to pressures associated with mineral exploitation activities. Based on the Evora Workshop discussions and the post-workshop cumulative impact modelling exercise, potential monitoring priorities could focus on biological components that are considered to have a key role in ecosystem structure or function, alongside biological components that were considered to have a particularly negative response to exploitation activities. These potentially sensitive biological components could serve as potential indicators for developing impact thresholds.

Mr. Halpin presented on the need to consider knowledge gaps in Area-Based Management Tools (ABMTs) from the perspective of the three types of ABMTs discussed for the region. The three types of tools were (1) Sites in Need of Protection using, in the context of ISA, FAO's criteria for vulnerable marine ecosystem (VME), (2) Areas in Need of Protection using important area criteria, and (3) Representative Areas using network criteria. It was suggested that using these three sets of criteria as a guide could help more efficiently fill necessary data gaps into the future. Also, focusing efforts on data that will help answer

specific ABMT site and area criteria will help identify or confirm both sites/areas in need of protection as well as sites/areas in need of precaution. Priorities for sites in need of protection include: (1) identification of additional vulnerable or sensitive species occurrences; (2) identification of specific vulnerabilities & responses to mining impacts and stresses; (3) identification of vulnerable life history traits; and (4) additional species occurrence mapping and additional species distribution modelling. Priorities for areas in need of protection include: (1) increased surveys of a variety of ecosystems; (2) additional species distribution models; (3) identification of which species are endemic versus under sampled in current surveys; (4) additional characterization of community structure on active and inactive sulphide; (5) an increased understanding of regional patterns of habitat, species distribution, and productivity to better understand regional uniqueness. The future identification of representative areas will require regional analysis of representativity, connectivity, replication, and adequacy. Analysis of representativity will require more comprehensive benthic habitat mapping, high resolution bathymetric data benthic position analysis, topographic analysis, bottom and water column temperature stratification, substrata-dependent biodiversity assessments as well as better information on depth zonation. Analysis of connectivity will require consistent ocean bottom and near-bottom currents data, potential larval dispersal distances, Beta biodiversity at different scales, genetic connectivity, source-sink dynamics between population, and latitudinal distribution of species. Replication analysis will require sensitivity analyses of habitat replication needs locally, regionally and globally as well as comparative studies of community structure related with topography. Finally, adequacy analysis will require analyses of habitat representation within ABMT areas, mining exploration areas, and the larger REMP region, as well as assessments of locally, regionally and globally rare or unique species representation. The provided list of ABMT knowledge gaps and data and analysis needs is intended to provide suggestions of the types of data needs and is not intended to represent all possible research priorities that will be required to update and maintain REMP planning into the future.

Monitoring and collaboration in contractor's and scientific perspectives

By Livia Ermakova

The obligations of contractors to monitor effects of their activities on the marine environment and to develop monitoring programs as well as to gather baseline environmental studies are established by the Regulations on Prospecting and Exploration for Polymetallic Sulphides in the Area (ISBA/16/A/12/Rev.1) and retreated in the exploration contracts. According to the Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area (ISBA/25/LTC/6/Rev.1, ISBA/25/LTC/6/Rev.1/Corr.1), monitoring can be divided into two types: (1) during prospecting and exploration activities; and (2) during and after mining test. Results of baseline environmental studies are the base for monitoring. By default, all the ISA documents mean monitoring and baseline studies inside contract areas. Although the holistic nature of the ocean caused by a single circulation system, propagation of water masses, population connectivity and other reasons, filling knowledge and data gaps requires monitoring and baseline environmental studies in areas outside contract areas as well. Comparable data require standardization of methods and equipment, taxonomy and DNA barcoding, as well as intercalibration between different methods. For fast sharing of scientific data and information, alignment of data format is crucial. The ocean is a changing system, thus, simultaneity of measurements and observations in different parts of the region through a pre-agreed/coordinated program is very important. For successful addressing of all issues pointed above, enhanced collaboration between contractors involving both officials and experts is necessary. An important part of such collaboration is development of joint research programs and organization of collaborative cruises (especially, for research outside contract areas). For this, a creation of a forum among representatives of contractors can be very helpful. The role of ISA in this regard would be to develop a framework for studies outside contract areas, including Area of Particular Environmental Interests (APEIs), in order to provide recommendations on narrowing the knowledge gaps through sufficient studies and to coordinate contractors efforts.

Management of Ifremer's 15 year exploration contract on SMS from the Mid-Atlantic Ridge (2014-2029)

By Jozée Sarrazin, Ifremer

Ms. Sarrazin delivered a presentation on the management of L'Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer)'s 15-year exploration contract for Seafloor Massive Sulphides (SMS) in the Mid-Atlantic Ridge. In October 2014, on behalf of the French government, Ifremer signed a contract to start a detailed exploration program for SMS deposits located between 21-28°N on the Mid-Atlantic Ridge. Ms. Sarrazin highlighted that the exploration program linked to this 15-year exploration contract must include the description of SMS deposits and a resource assessment, as well as detailed environmental baseline studies in the contract area. She then presented Ifremer's 10-year work plan and noted that three major cruises were organized so far, together with an opportunity cruise in 2016. This temporal planning was used as an opportunity to deploy moorings/colonization substrata that were recovered during the following cruises. She also noted that the focus of Ifremer's future cruises will shift from more descriptive studies to research focusing on the functioning of ecosystems and also from a baseline approach to the elaboration of potential preservation and restoration strategies. Next, scientific objectives and results of the Bicose (2014 & 2018) and Hermine (2017) cruises were presented. She underlined that, in addition to high-resolution mapping of 98% of Ifremer's exploration area, major results include the discovery of very old and oxidized sulfide deposits off-axis and of mineralized quartz veins. Regional exploration in the water column led to the detection of at least 7 new active hydrothermal fields. One of the highest local densities of hydrothermal mineralization currently known in the oceans was found. This mineralized district might represent a potential for several tens of millions tons of ore. Biological and microbiological studies were also conducted to understand and describe biodiversity and ecosystems functioning on both active and inactive sites and habitats. A thorough research program has been developed on the natural plume of the active Trans-Atlantic Geotraverse (TAG) mound, integrating multidisciplinary data to understand natural plume dynamics, quantify natural chemical input in the water column, describe the diversity and functions of microbial communities, and evaluate trace metal dispersion of the plume and its impact on faunal communities. Lastly, Ms. Sarrazin informed participants that the next cruise planned is Hermine 2 (2022) followed closely by Bicose 3 (2023) and that a third Hermine cruise focusing on the 3D evaluation of the resources is planned in 2025-2029.

Mid-Atlantic Ridge exploration from a scientist's and educator's perspective

by Teresa Radziejewska

Activities associated with the deep sea can be assigned to different categories of value. For the present workshop, most relevant is the Direct Use category, which can be broken down into the Market and Non-Market value. The Market value includes seabed mining and is of prime importance for an ISA contractor. The Non-Market value includes marine science and education. Activities associated with the Non-Market category provide an added value in the form of new data, which will help to fill some knowledge gaps, but will also allow to identify others. From a researcher's perspective, studies that will ultimately lead to a better understanding of the Mid-Atlantic Ridge (MAR) system and its REMP have an added value in that they allow those involved in the research to still make discoveries, and thus to provide excitement for themselves and possibly for the general public. In this sense, the MAR is an epicentre of knowledge generation. From a scientist's perspective, another added value is a possibility of interacting with a contractor, and thus of working out a platform for science-based exploration and science-based measures and tools for ecosystem protection from harmful effects of possible future mining interventions. From an educator's perspective, MAR exploration is a great opportunity for capacity-building – for training students and early career researchers in sea-going work, sampling, data collection and processing (also post-cruise). It is therefore necessary to think about possible mechanisms for capacity-building. Very instructive in this regard is the InterRidge example of offering student fellowships and cruise bursaries, which make it possible for young researchers to take part in cruises whenever berths are available. From an educator's perspective, a possibility of allowing numerous young people to have the first-hand experience in deep-

sea exploration, including that on mid-ocean ridges, will constitute an extremely important added value of ISA contracts.

InterRidge update

By Sang-Mook Lee

Mr. Lee introduced InterRidge as an international organization established to promote and coordinate scientific studies of global mid-ocean ridge system by different countries. In May 2020, the Republic of Korea became the host of InterRidge Office for the next three years. As the new chair of InterRidge, Mr. Lee was determined to build a new vision and empowering young scientists. To cope with the impacts the coronavirus pandemic, InterRidge is focused on developing a series of high-quality webinars involving deep-sea research in various disciplines, including geosciences and biosciences, as well as online talks for public outreach. On the issue of addressing knowledge gaps in mid-ocean ridge studies, Mr. Lee noted that scientists tend to focus on their area of interest. However, for contractors and regulators, it is important to get a broader view, so that potential environmental impacts due to seabed mining can be adequately assessed. In this regard, he suggested to build a fleet of underwater vehicles such as AUV so that the Area can be mapped at a larger scale. He added that many countries have already begun to develop a fleet of robotic observational platforms because the cost of using the research vessel is usually the most expensive part of a research budget. Mr. Lee emphasized the importance of effective ways in which data are shared and analyzed, given this new era of artificial intelligence and Big Data. InterRidge will strengthen its effort to maintain the Vent Database which is important for assessing environmental effects. He also highlighted the need to train future scientists and conduct data analyses using techniques, such as machine learning to attract young people. Mr. Lee stressed that capacity-building has been one of the important missions of InterRidge. InterRidge supports graduate students and postdocs to join research vessels of various countries, and fellowships and student awards were granted at international meetings. Together with ISA, he hoped to build on this tradition to assist more young scientists, especially those from developing countries. He stated that InterRidge is eager to work closely with ISA and various deep-sea stakeholders, particularly on activities related to data sharing and capacity-building.

The framework of assessing cumulative impacts as a way for prioritizing future monitoring and research

By Piers Dustan, Jeff Dambacher and Keith Hayes

Mr. Dunstan began his presentation by introducing the basis for adaptive management, which has three key components: (1) a clear understanding of objectives and desired outcomes; (2) an assessment process that includes all potential positive and negative effects of development; and (3) a monitoring program that can test this assessment and ensure that the desired outcomes are being achieved. He then described the processes for evidence-based environmental assessment and management, and discussed case studies in Australia where ecosystem conceptual models have been used to prioritize monitoring efforts. He explained that in complex systems such as hydrothermal vents, it can be very difficult to identify what is causing impacts, and qualitative models can be used to identify which impact scenario is occurring, select indicators that will always show if an impact is occurring, and identify the “correct” ecosystem model. He highlighted the work undertaken on developing a framework for assessing cumulative impacts in hydrothermally active vents ecosystems and pelagic and non-hydrothermal sediment ecosystems. The results from this work can inform priorities for monitoring, including i) the identification of what will be impacted and by what pressures under different scenarios, ii) the identification of unambiguous indicators of change, and iii) the identification of the “correct” ecosystem model.

Annex III

Summary of workshop discussion on area-based management measures

1. Area-based management measures are an essential element in preparing a draft REMP. This break-out session built on the outputs from the Evora workshop, during which the following three approaches for the application of area-based management approaches (ABMTs) were identified.

- **Sites in need of protection (SINPs)** are fine-scale sites, where there is observation or evidence of vulnerable or sensitive species/ecosystems. They are described on an individual basis, using, within the context of ISA[11], the Food and Agriculture Organization's criteria for vulnerable marine ecosystems (VMEs). Identification of such sites is intended to conserve specific ecosystems, habitats of species, and specific ecosystem features that are known or highly likely to be vulnerable to human activities (e.g., exploitation of mineral resources in the context of ISA). Evora workshop participants described 11 active vent ecosystems whose existence has been confirmed by direct observation as SINPs.[12] All 11 SINPs identified at the Evora workshop are located within the existing contract areas for exploration (see map 1). It was noted that additional SINPs could be described in the future, which could include additional active hydrothermal vent ecosystems, cold-water corals or other vulnerable or sensitive species/ecosystems. The boundaries of each SINP will need to be delineated to a sufficient resolution and precision to allow for prescribed management measures to be applied to protect intact habitats, species and ecosystem function of each site.
- **Areas in need of protection (AINPs)** are large-scale areas of ecological importance due to their uniqueness and/or biodiversity. At the Evora workshop, candidate areas were described using, in the context of ISA, the scientific criteria of the CBD for Ecologically or Biologically Significant Marine Areas (EBSAs). Three fracture zones were described as areas meeting the EBSA criteria and were put forward as AINPs.
- **Sites/Areas in need of increased precaution (S/A-Precaution)** are either fine-scale sites or large-scale areas that have been predicted to have features that may give the site/area conservation value. The predictions could be based on various methods, including indirect observation of natural hydrothermal plumes (e.g., inferred hydrothermal vents) or habitat modelling (e.g., cold-water octocorals). When scientific information from further research and direct observation becomes available, ISA, through its relevant process (e.g., LTC supported by expert workshops), can assess if the sites/areas can be described as sites/areas in need of protection and inform future review of an REMP. At the Evora workshop, twelve inferred active hydrothermal vent systems were proposed as potential sites in need of precaution, and areas of potential cold-water octocoral habitat, drawn from habitat suitability models, were proposed as areas of increased precaution.[13]

2. The sites/areas described (with location coordinates and polygons) by the Evora Workshop (see Map2) through the above scientific approaches represent the scientific information describing ecosystem features/habitats in need of protection or precaution, as compiled by participants during the workshop, but this description does not carry any legal or management implications, until relevant management measures are considered by LTC and decided by the Council. On the same basis, the EBSA and VME criteria were only used at the Evora Workshop from a scientific perspective in the context of ISA to compile scientific information to describe sites/areas with a need for protection. It was also noted that these sites/areas described by Evora workshop could be captured in designing a network of APEIs, noting that the REMP itself would list the operational objectives of such a network and the management consequences of

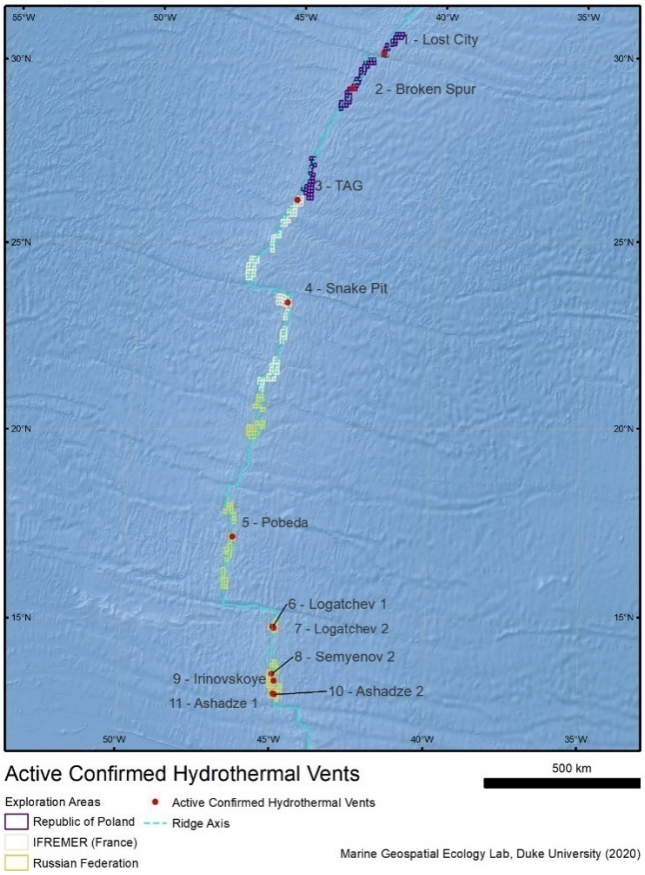
[11] It must be recalled that the FAO's identification of vulnerable marine ecosystems (VMEs) in the context fisheries carries management effects in accordance with resolution 61/105 of the General Assembly of the United Nations. Evora workshop, however, used the FAO's VME criteria in the context of addressing the potential impacts of exploitation of mineral resources within the context of ISA.

[12] See the 11 site descriptions in the Appendix 1-2 of Evora workshop report, pp. 95-115, https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf

[13] See the site description in the Appendix 1-1 of Evora workshop report, pp. 156-168, https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf

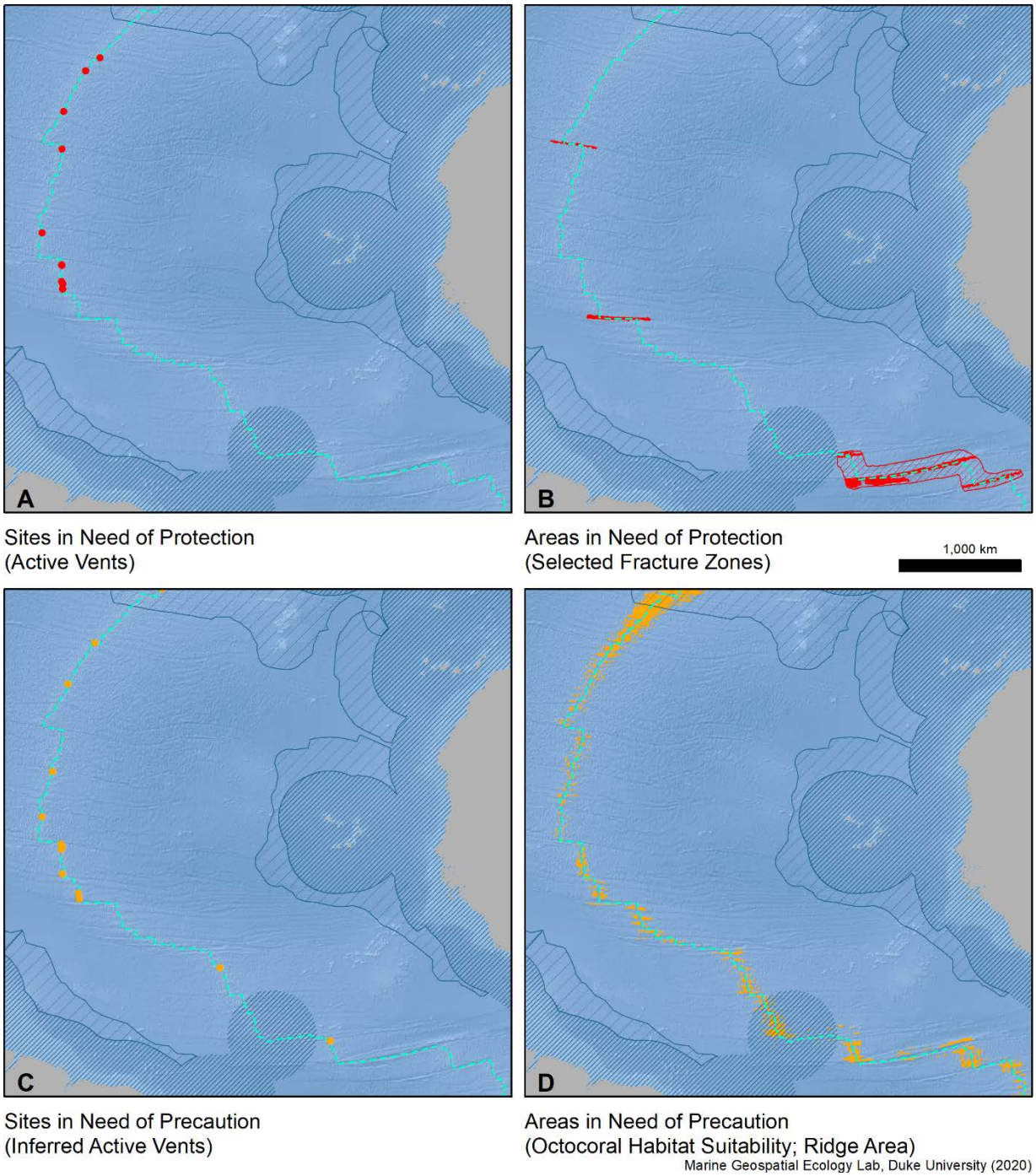
designation as an APEI, as was the case for the Environmental Management Plan of Clarion-Clipperton Zone (CCZ-EMP).

3. It was also clarified that contractors have security of tenure over contract areas, and any management measures prescribed in the context of a REMP will need to take this into account, notwithstanding the identification of sites and areas within contract areas under the scientific approaches of the Evora Workshop. It will be particularly important to ensure that the implementation of spatial management measures does not interfere with the implementation of environmental baseline studies and monitoring programmes by contractors, which are important obligations under their contracts. Other exploration activities, including large-scale sampling, testing of mining components and test mining require a prior Environmental Impact Assessment (EIA) to be conducted, in accordance with the Recommendations of the LTC[14]. Management measures contained in REMPs, particularly during the exploration phase, should rather complement the implementation of those activities relating to environmental baseline studies and monitoring.



Map 1. Sites in need of protection, as described by the Evora workshop

[14] ISBA/25/LTC/6/Rev.1 and Corr.1



Map 2. Sites/Areas in need of protection or precaution as described by the Evora Workshop

4. During this break-out session, participants focused on possible management measures for implementing each of the three approaches of ABMTs, as identified by the Evora workshop.

Sites in need of protection (SINPs)

5. The management of SINPs should aim to maintain ecosystem functions and associated features from the direct and indirect impacts of future exploitation of mineral resources. The presence of species and habitats vulnerable to such activities would require a high level of protection in the SINPs.

6. The following management measures were suggested for the 11 SINPs, as described by the Evora workshop:

- The SINPs would be protected from direct and indirect impacts of future exploitation of mineral resources. Contractors operating in the vicinity of a SINP would be required to provide sufficient evidence that there would be no direct or indirect impacts on the SINP, before the proposed exploitation activities can be approved;
- A SINP could include within its boundary: (i) a core zone of full protection, (ii) a buffer zone of sufficient size to provide protection from external effects, (iii) and possibly other zones where activities compatible to the management objectives of SINPs can be allowed, as identified by ISA and compatible with the legal framework of ISA;
- Noting that the rights and obligations of contractors in the current contracts for exploration would be fully respected, current exploration activities by the contractors, including environmental baseline studies and monitoring, would allow new data to be collected to better understand and map ecosystem features and habitats, and to ensure that they are not affected by direct and indirect impacts from future exploitation activities;
- A clear description, through detailed mapping (including physical and biological features), of the different zones (core and buffer) in terms of their areal extent as well as the identification of allowed and/or prohibited activities needs to be undertaken; and
- Contractors would be required to demonstrate that future exploitation activities would not have negative impacts on any subsurface fluid flow to the active vent features. This requirement needs to be based on the establishment of environmental baselines and environmental risks/impacts assessment, through which the negative effects can be defined.

7. Regarding the boundaries of the SINPs, participants took a flexible and practical approach, by suggesting that the SINPs should be:

- site-specific and based on the results from the Evora workshop, which focused on the description of ecosystem features; and
- sufficiently viable for the maintenance of ecosystem features and function.

8. While this workshop focused on the results of the Evora workshop (11 confirmed active hydrothermal vents), it was noted that there could be additional SINPs in the future, which might include newly discovered active hydrothermal vents and other vulnerable and sensitive ecosystems, such as cold-water corals and sponges. Spatial configuration of such ecosystem occurrences would then need to be described.

9. Concerning the purpose and size of buffer zones, it was recalled that in the context of CCZ-EMP, such zones mainly serve the purpose of protecting the core zones from the impacts of plume. Participants agreed that the buffer zones should be of sufficient size to provide protection from external effects.

10. It was noted that buffer zones are needed to address the following concerns:

(i) buffers to allow for uncertainty about the full scale of the ecological “footprint” of the features of the sites that are described by the Evora workshop as in need of protection;
(ii) buffers to allow for uncertainty about the effectiveness of measures intended to prevent or

mitigate the immediate effects of the mining operations and associated activities. This could include uncertainty about, for example, the range of dispersal of a plume, deposition of plume particles, and accumulation over the duration of the exploitation activity; and that
iii) buffers reflect the degree of acceptable risks.

11. Depending on the nature of the ecosystem features in the core of the SINP and the mining operations, the buffer zone may not need to be symmetric in all directions, if the potential mining impacts always come from one direction, or if the ecological footprint of the features receiving protection in the SINP is itself unlikely to be symmetric around the Site or Area. This suggests that buffer zones are best designed on a case-by-case basis, based on information on how the exploitation activities will be undertaken, including location, technologies, etc. If default values on the size and configuration of buffer zones are needed, because of a lack of site-specific designs due to time or information constraints, the defaults should be developed with a precautionary approach, and, where possible, derived from evidence-based buffers from other SINPs as similar as possible to the one under consideration. It is appropriate to revisit the size of buffer zones periodically through the ISA process, to consider new evidence both from environmental monitoring of the area, and the effectiveness of mitigation measures used in the mining operations.

12. It was noted that additional candidate sites for SINPs, including both active vent ecosystems and other vulnerable or sensitive ecosystems, will likely be discovered through further research and studies. Participants discussed how information on newly discovered vulnerable or sensitive ecosystems can be used, and the following steps were suggested:

- Contractors report the discovery of new vulnerable or sensitive ecosystems, through their exploration activities, with supporting information, and submit to ISA as part of their annual reporting process. The Legal and Technical Commission can consider if further discussion or appropriate actions would be needed, based on the information received;
- Newly discovered vulnerable or sensitive ecosystems would be described and assessed against the criteria for SINPs, before any recommendations can be made regarding their conservation status or management measures;
- In addition to contractors' exploration activities, new vulnerable or sensitive ecosystems can also be discovered by scientific communities. While the contractors are required to report environmental information to ISA, scientific organizations are not. The importance of sharing data among different organizations, through various platforms (e.g., UN Decade of Ocean Science for Sustainable Development) and in the framework of the REMP was also highlighted in this regard, noting ISA's draft action plan on marine scientific research in support of the UN Decade, currently being considered by the Assembly[15];
- Existing practices in the regional fisheries management organizations (RFMOs) for the identification, assessment and approval of vulnerable marine ecosystems (VMEs), as well as developing management measures, can serve as reference for ISA. In the fisheries context, the list of VMEs is updated as required;
- ISA may consider developing its own guidance on SINPs, including a list of indicator species and thresholds for defining SINPs, building on the experiences of other relevant processes, and tailored to the context of exploitation of mineral resources; and
- Implementation of the REMP should provide incentives for contractors to report new sites, not disincentives.

[15] The Action Plan was adopted by the Assembly in December 2020, after the conduct of this workshop (see decision ISBA/26/A/17 : https://isa.org.jm/files/files/documents/ISBA_26_A_17-2017623E.pdf; see the Action Plan : ISBA/26/A/4 : https://isa.org.jm/files/files/documents/ISBA_26_A_4-2007068E.pdf)

Areas in Need of Protection (AINPs)

13. AINPs may be established 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 cover multiple biogeographical provinces, habitats and ecological gradients.

14. Regarding management measures for the 3 AINPs (Kane Fracture Zone, Vema Fracture Zone, and Romanche Fracture Zone System), the following points were suggested:

- They would each be protected as an integrated system;
- They would be protected from direct or indirect impacts from future exploitation of mineral resources in the Area;
- Management of AINPs may allow different types of activities based on a zonation scheme, for example: (i) a core zone of full protection, (ii) a buffer zone of sufficient size to provide protection from external effects, (iii) and possibly other zones where activities compatible to the management objectives of AINPs can be allowed, as identified by ISA and compatible with the legal framework of ISA. This topic, however, needs further discussion and development;
- They would include buffer zones of sufficient size to protect the AINPs from potential plumes and other indirect effects. For example, studies show that materials from plumes can potentially travel long distances (e.g., Abell et al. 2013), and such studies can inform future consideration on the size of buffer zones, together with knowledge on evolving technology; and
- Intra-basin transportation of fine particles from mining plumes may need to be monitored in the AINPs.

15. The AINPs in general have been investigated less extensively compared to SINPs. All 3 AINPs identified in the Evora workshop are located outside contract areas, and cover large areas, as such monitoring may require collaborative efforts within the framework of ISA's mandate on marine scientific research as well as the UN Decade of Ocean Science for Sustainable Development. Participants noted a need for ISA to take an active role in facilitating such cooperation.

Site/Areas in Need of Precaution (S/A Precaution)

16. At the Evora workshop two categories of S/A Precaution were identified: inferred active hydrothermal vents sites and potential cold-water coral habitat (based on habitat suitability models)

17. Participants highlighted a need to have a clear pathway for S/A Precaution to be assessed against relevant criteria, when sufficient scientific information becomes available. During the exploration phase, if S/A Precaution are described and meet relevant criteria, supported by scientific information, they can be considered as SINPs or AINPs. If inferred or predicted areas are found not to meet the criteria for SINPs or AINPs their S/A Precaution status may be removed. Activities in such sites/areas should apply a precautionary approach until the status of the area/site has been assessed.

18. In the case of inferred active vents, contractors may apply increased survey efforts to verify if the site is present or not, following the same suggestions above, in paragraph 12, for the discovery of new sites.

19. 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 need to be validated through surveys, and encounters of indicator species (e.g., VME indicator species) need to be reported.

Other issues

20. Areas identified through the application of network criteria based on a regional analysis have not been discussed in detail at this workshop. Participants highlighted the need for such discussions in the future REMP process in this region, possibly through another expert workshop with a supporting regional analysis. Work has been done on oceanographic sub-regions (Yearsley et al 2020) and could serve as a starting point.

21. Thresholds, describing the abundance, density, encounter rate and/or other parameters used to describe the occurrence of vulnerable and sensitive ecosystem features, would be useful for consistent implementation of SINP/AINP management measures. These thresholds may need to be adaptive, and likely change as new data/information is collected and new knowledge of habitat and species responses becomes available. Further expert discussion and a process for periodic updates on appropriate parameters and thresholds will be required.

22. Participants shared the experience from FAO's work[16] on defining "significant adverse impacts": Significant adverse impacts are those that compromise ecosystem integrity (i.e., ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively. When determining the scale and significance of an impact, the following six factors should be considered: (i) the intensity or severity of the impact at the site being affected; (ii) the spatial extent of the impact relative to the availability of the habitat type affected; (iii) the sensitivity/vulnerability of the ecosystem to the impact; (iv) the ability of an ecosystem to recover from harm, and the rate of such recovery; (v) the extent to which ecosystem functions may be altered by the impact; and (vi) the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages.

23. Contractors implement their contractual obligations and plans of work as approved by ISA. Some may conduct environmental survey activities outside their contract areas (e.g., AINPs or Areas in need of Precaution), in the framework of cooperation with scientific institutions but they are not obliged to do so. Research activities by contractors outside contract areas could be funded by either the contractors themselves or a third-party, e.g., within the framework of national research programmes. It was noted that some contractors in the CCZ had already started environmental survey activities in the APEIs, including through collaborative efforts with the scientific community.

24. It was also mentioned that from a contractor's perspective, for effective implementation of the REMP, the plan should contain the following elements:

- Definition of the sites/areas in need of protection/precaution, as well as the location and size of these sites/areas;
- Clear guidance about how new sites/areas can be described as SINPs or AINPs, including the type of data and information a contractor needs to provide; and
- List of activities that are allowed and/or prohibited in different zones (e.g., core, buffer, and other zones) of SINPs or AINPs.

25. It was also noted that active and inactive hydrothermal sites can appear together, sometimes at short distances. The establishment of core and buffer zones of SINPs should take such geomorphological characteristics into account to allow for activities compatible with the management objectives as identified by ISA.

26. Some participants highlighted the impact reference zones (IRZs) and the preservation reference

[16] FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO, 2009)

zones (PRZs) as important spatial instruments. IRZs and PRZs are types of spatial management measures that are already envisaged in the exploration regulations. Their primary purpose is to support monitoring and impact assessment, but they may nevertheless support the scientific approaches for ABMT identified in this report. The REMP could provide guidance to contractors in the future selection of sites for IRZs and PRZs. Under the regulations, an IRZ means an area to be used for assessing the effect of activities in the Area on the marine environment and which is representative of the environmental characteristics of the Area. A PRZ means an area in which no mining shall occur to ensure representative and stable biota of the seabed to assess any changes in the biodiversity of the marine environment. This workshop, however, could not discuss this issue, but noted the need for further work in this regard.

27. At the workshop, a paper on the compilation of scientific information to describe active vents on the Mid-Atlantic Ridge as potential sites in need of protection, submitted by a group of experts, building on the results of Evora workshop, was made available to the participants to support their deliberations.

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Annex IV

Summary of workshop discussion on non-spatial management measures

1. Participants were engaged in a break-out session discussion on potential non-spatial management measures for consideration as part of a REMP for the Area of the northern Mid-Atlantic Ridge (MAR). The break-out session discussion was guided by a series of questions considered at the regional scale (summarized in the Section I below) and the scale of future contract areas for exploitation (summarized in the Section II). The questions addressed: existing potential pressures (A), expected management outcomes (B), suggested management measures (C), key impact parameters and cumulative impact thresholds (D), and how information can be used by contractors and other actors (E). This summary provides the main points of discussion during the break-out session, accompanied by explanatory notes, where appropriate.

I. Regional scale

A. What are the key existing and potential pressures to biodiversity/ecosystem at the regional scale, including those other than future exploitation activities?

2. The key points under this question can be summarized as follows:

- Removal and modification of habitats and removal of individuals or populations (especially source populations), which can lead to loss of connectivity;
- Removal and modification of habitats that can lead to loss of habitat representativity;
- Release of returned water plume (particles, contaminants, and altered water chemistry) in midwater that can disrupt larval dispersal and gene flow at all ocean depths leading to loss of connectivity or ecosystem function[17];
- Disruption of migratory behavior of migratory species[14];
- Cumulative impacts that could lead to serious harm to some ecosystems[14];
- Reduction and/or change in distribution of available habitat due to impact from climate change and other human activities that would require reassessment of any future ABMTs to be established by ISA;
- Underwater sound from surface vessel, from riser pipe pumps, particularly in the Sound Fixing and Ranging (SOFAR) channel and at the seabed;
- Light from vessel that can attract birds disrupting their behavior and at the seabed[14];
- Introduction of invasive species from vessels that can lead to loss of ecosystem function and biodiversity, noting the competence of IMO on this issue.

3. The above list of pressures is not exhaustive, instead it represents the key pressures identified by participants. For a more comprehensive treatment of potential pressures arising from future mineral exploitation activities at the contract area scale, participants made reference to the Evora Workshop report[18] and the Draft Report on Assessing Cumulative Impacts[19].

4. Regarding the removal and modification of habitats, some species on the MAR also occur in similar habitats on continental shelves or seamounts. Removal or modification of habitats on the MAR could disrupt the connectivity of these habitats at a regional scale, reducing the amount of available habitat for these species and consequently their population viability. Habitats that could be modified through future exploitation activities would not be representative of the original pre-disturbance state for these habitats, noting the time scale of mining contracts that are in the temporal scale of decades, while some vulnerable or sensitive species live in the temporal scale of hundreds or thousands of years.

5. Removal or modification of habitats could make an affected site unsuitable for the original biological populations in that location, or individuals and populations could be removed through future

[17] These points were only considered to be relevant at the regional scale if multiple sites within an area undergo exploitation activities at the same time.
[18] Evora Workshop report: https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf
[19] Draft Report on Assessing Cumulative Impacts: https://isa.org.jm/files/files/documents/Draft-report-cumulative-impacts.pdf

exploitation activities. Where the population impacted is a source population, this could have serious consequences for regional connectivity of that species.

6. If the returned water is discharged in the midwater environment, creating a plume, this may have the potential for regional impacts given that water column processes such as larval dispersal and population connectivity occur at regional scales. Pressures exerted by returned water plumes may lead to effects that propagate through the midwater ecosystem resulting in altered ecosystem function.

7. The timing of migration and the location of migratory routes, feeding and breeding grounds of many species are not known. If exploitation activities across the region disturb migratory behavior, this could have regional-scale impacts for some species.

8. Future exploitation activities would occur against a backdrop of broader pressures, including climate change (e.g., changing ocean temperature, ocean acidification, deoxygenation) and pollution from land and ship-based sources. These pressures may be cumulative, acting together to reduce the resilience of ecosystems, and potentially reducing the effectiveness of some future ABMTs to be established by ISA. Participants noted the work done by the Evora workshop and post-Evora workshop working group on qualitative modelling of cumulative impact assessment[16].

9. Where low-frequency sound generated during future exploitation activities can be emitted within the SOFAR (Sound Fixing and Ranging) channel, the sound may travel hundreds of kilometres. This noise could potentially disrupt the communication and behavior of diving marine mammals, such as whales, across large distances.

10. Vessels travelling to the exploitation sites (to collect ore or deliver supplies) could transport non-indigenous/invasive species to the region, for example, through ballast water or attachment to the vessel or other equipment. Depending on the invasive species involved, this could result in changes to ecosystem function within the region. IMO's competence on this issue was noted.

B. What are the expected management outcomes at the regional scale?

11. The key points under this question can be summarized as follows:

- Minimize habitat loss to maintain ecosystem viability;
- Ensure connectivity is maintained amongst populations;
- Maintain representativity of habitats at the regional scale;
- Maintain migratory corridors;
- Maintain feeding and breeding grounds;
- Maintain water column ecosystem function; and
- Control exploitation activity to remain within cumulative impact thresholds.

12. Participants considered how the standard mitigation hierarchy (avoid, minimize, restore, and offset) could be applied to the MAR. It was considered that the two most effective actions would be to avoid or minimize impacts. There is considerable uncertainty about the viability and effectiveness of restoration activities in the deep sea, and offsetting would not be possible for equivalent habitat. Where full restoration to the pre-disturbance state is not possible, participants considered the possibility of remediation to facilitate at least partial recovery of an impacted site.

C. What are the suggested management measures and approaches at the regional scale?

13. The key points under this question can be summarized as follows:

- Apply the mitigation hierarchy (avoid, minimize, restore, and offset) to all major impacts from future exploitation activities20;
- Require contractors to prevent significant impacts outside of their exploitation contract areas;

[20] https://www.ser.org/page/SERStandards

- Set thresholds for potentially toxic contaminants and particulate impact on biota in the sites/areas in need of protection, identified using the process described by the Evora workshop (SINPs/AINPs);
- Set limits on area of each habitat that can be impacted per length of ridge axis;
- Set thresholds for acceptable levels of potentially toxic contaminants in returned water;
- Set thresholds for acceptable levels of particulate content of returned water;
- Identify migratory corridors for avoidance of impact;
- Identify reproductive seasons for avoidance of impact;
- Establish a network of areas to be protected to maintain connectivity and representativity of habitats/species at the regional scale;
- Assess relinquished blocks to identify if they contain SINPs/AINPs that may require protection from any direct/indirect impacts of exploitation activities;
- Set thresholds for acceptable levels of noise from vessel and any noise emitted in the SOFAR channel;
- Set thresholds for acceptable deviation from baseline information on habitats before action is taken;
- Establish a robust monitoring programme at the regional scale, building on contractors' environmental baseline studies within their contract areas for exploration;
- Assess cumulative impacts of future exploitation activities periodically to inform future process of updating the REMP;
- Set thresholds for acceptable levels of light pollution from surface vessel (plankton and birds); and
- Set thresholds for definition of SINPs.

14. Participants considered that the thresholds would set the boundaries for the contractors to work within, allowing them to develop technologies with the least environmental impact. Such an approach would encourage contractors to apply Best Available Technique (BAT) and Best Environmental Practice (BEP) in their management of impacts.

15. In terms of developing thresholds it was broadly agreed that further work would be needed to define their properties, recognizing that this may be challenging, given the paucity of information relating to the response of biological communities to future exploitation activities. It was suggested that determining the threshold for what would be considered 'significant' impacts could draw on existing definitions from bodies such as the Food and Agriculture Organization of the United Nations (FAO)[21] as well as existing frameworks and strategies, such as the European Union Marine Strategy Framework Directive22 and those developed by OSPAR[23]. It was further suggested that thresholds may need to be periodically reviewed as more information becomes available on environmental baselines and biological responses to pressures.

16. Participants considered that establishing a network of protected areas to maintain connectivity and representativity of all important habitats and species on the MAR would benefit from further discussion with appropriate experts to address the network criteria, including representativity, adequacy, replication, and connectivity.

17. Thresholds will need to be determined to identify SINPs and may draw on the experience from the FAO's process for determining VMEs. Participants suggested that there would need to be a mechanism for adding new indicator species or habitats and for updating the properties of the thresholds to accommodate new information.

18. Setting limits on the area of each habitat that can be impacted per length of ridge axis and periodically assessing total impacts from exploitation activities were deemed particularly important in the

[21] FAO International Guideline for the Management of Deep-sea Fisheries in the High Seas: http://www.fao.org/fishery/topic/166308/en
[22] https://ec.europa.eu/info/research-and-innovation/research-area/oceans-and-seas/eu-marine-strategy-framework-directive_en
[23] OSPAR hazardous substances strategy: https://www.ospar.org/work-areas/hasec/hazardous-substances

context of managing cumulative impacts at the regional scale.

D. What are the suggested key impact parameters and cumulative impact thresholds at the regional scale?

19. The key points under this question can be summarized as follows:

- Set a threshold of area of each habitat that can be impacted per length of ridge axis;
- Assess migratory species in vicinity of mining vessels and determine any changes caused by the presence of these vessels, noting the competence of IMO regarding vessels;
- Consider climate change pressures (e.g., changes to temperature, pH and currents) that may lead to a reduction and/or change in distribution of available habitat, which will make these habitats more vulnerable to the impacts from exploitation activities; and
- Monitor Essential Ocean Variables (EOVs) and OHI[24] parameters.

20. Cumulative impacts were considered in the context of mineral exploitation activities in multiple locations in the region at the same time, and other anthropogenic activities, against a backdrop of environmental impacts related to climate change.

21. Participants suggested that the identification of key impact parameters at the regional scale could take into account existing references, such as the EOVs[25] developed by the Global Ocean Observing System (GOOS), and the OHI[26]. Many of these parameters could be monitored at the regional scale using remote or autonomous approaches, such as satellite imagery, ARGO floats, Autonomous Underwater Vehicles (AUVs), or hydrophones.

22. Participants also suggested that regional assessments of population connectivity or changes in biodiversity, using information collected during contractor environmental baseline studies and monitoring activities, could be used to monitor the cumulative impacts of exploitation activities by multiple contractors on connectivity and biodiversity at the regional scale.

23. Setting threshold properties for the area of each habitat that can be impacted per length of ridge axis and monitoring the total impacts from exploitation activities were deemed particularly important in the context of managing cumulative impacts at the regional scale, including possible management response.

II. At the scale of contract areas

A. What are the existing and potential pressures to biodiversity/ecosystem at the contract area scale, including those other than future exploitation activities?

24. The key points under this question can be summarized as follows:

- Removal and modification of habitats and removal of individuals or populations (especially source populations) that can lead to loss of connectivity;
- Removal and modification of habitats that can lead to loss of habitat representativity;
- Smothering of seabed organisms by the mining plume;

[24] In the other group discussion under Thematic Segment C of this workshop, it was noted that while developing or applying OHI could facilitate communication of ecosystem health status with a wide range of non-specialists, it could be difficult to establish the cause of any observed changes in health index status. It should be noted that participants did not reach consensus on the application of OHI.

[25] Essential Ocean Variables (EOV): https://goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114

[26] Ocean Health Index (OHI): http://www.oceanhealthindex.org/ It should be noted that participants did not reach consensus on the application of OHI.

- Introduction of potentially toxic contaminants from the mining and returned water plumes;
- Underwater sound from the riser pipe;
- Underwater sound at the seabed;
- Underwater sound from vessels that can disrupt communication by fish and mammals;
- Light at seabed that can disrupt bioluminescent activity and physiological functions of organisms;
- Light on surface vessel that can disrupt bird behavior and plankton; and
- Electromagnetic impact at seabed and along power cables.

25. This list of pressures is not exhaustive, instead it represents the key pressures identified by participants. For a more comprehensive treatment of potential pressures arising from future mineral exploitation activities at the contract area scale, participants made reference to the Evora Workshop report[27], the Draft Report on Assessing Cumulative Impacts[28], as well as a paper by Washburn et al (2019)[29].

B. What are the expected management outcomes at the contract area scale?

26. The key points under this question can be summarized as follows:

- Management of the areas for exploitation to prevent impact on hydrothermal vent communities and other SINPs[30] ;
- Limitation of indirect effects on SINPs away from the exploitation areas, e.g., plumes, toxicity, smothering, by setting thresholds of impact and establishing buffer zones;
- Limiting impact on hydrothermal vent faunas due to subsurface hydrological flow changes;
- Ensuring overburden removal and placement does not impact hydrothermal vent faunas and fauna of other SINPs; and
- Establishing effective networks of protected areas.

27. Similar to discussions at the regional scale, some participants considered that establishing a network of protected areas to maintain connectivity and representativity of all habitats and species on the MAR would benefit from further discussion with appropriate experts.

C. What are the suggested management measures at the contract area scale?

28. The key points under this question can be summarized as follows:

- Determine and apply thresholds for identification of a SINP;
- Control mining activities and mining impacts on active vent ecosystems;
- Control mining activities and mining impacts on SINPs;
- Require assessment of whether newly discovered active vent ecosystems or sites in need of precaution can be described as SINPs to be included in a revised REMP;
- Require seabed surveys and habitat mapping of the area predicted to be impacted by the mining plume;
- Apply thresholds for impact of mining plume (particles and toxic contaminants) on SINPs;
- Apply spatial closure of mining operations if a SINP is identified within an area that can be impacted by the mining plume during mining operation;

[27] Evora Workshop report: https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf
[28] Draft Report on Assessing Cumulative Impacts: https://isa.org.jm/files/files/documents/Draft-report-cumulative-impacts.pdf
[29] Washburn, Travis W., Phillip J. Turner, Jennifer M. Durden, Daniel OB Jones, Philip Weaver, and Cindy L. Van Dover. "Ecological risk assessment for deep-sea mining." Ocean & coastal management 176 (2019): 24-39.
[30] This workshop focused on SINPs, as AINPs described by the Evora workshop are not overlapping with any contract areas for exploration, while not excluding the possibility that there could be a new application for exploration in these AINPs.

- Apply thresholds for noise at seabed and in riser pipe pumps;
- Apply thresholds for light pollution at seabed and on ship; and
- Apply temporal closure of mining operations during unexpected biological events (e.g., major aggregation activity).

29. Participants considered how encountering previously unknown potential SINPs or ANIPs could be managed at the contract area scale. Suggestions were made that the process to follow in the case of an encounter could be developed, drawing on the experience of FAO/RFMO's processes regarding VME indicator taxa or habitats that are encountered during bottom-contact fishing. Participants suggested that the threshold for an encounter could be based on parameters that could be obtained from seafloor imagery, such as organism density or feature spatial extent.

30. Applying management measures to SINPs that were identified during detailed surveys carried out by contractors prior to exploitation is relatively straightforward, given that these are static features that can be easily mapped. Participants considered the application of management measures to mobile fauna or periodic biological events, such as aggregations, to be more challenging as there is a greater likelihood that these may not be observed during environmental baseline surveys. It was suggested that a mechanism to address any significant unexpected biological events could be developed in a manner similar to a mechanism to address encountering potential SINPs.

31. Consideration was given as to whether regional thresholds would be needed for noise or light pollution generated during mineral exploitation activities, or whether these could be addressed through more broadly applicable standards or guidelines. Participants suggested that whilst more widely applicable standards or guidelines may be useful, there may be a need for specific regional thresholds depending on, for example, the seabird or marine mammal populations in the region.

D. What are the suggested key impact parameters and cumulative impact thresholds at the contract area scale?

32. The key points under this question can be summarized as follows:

- Thresholds for impact from the mining plume (particulates and potentially toxic contaminants) on biota including in the SINPs;
- Thresholds for returned water plume impact (particulates and potentially toxic contaminants) on pelagic fauna;
- Thresholds for noise in the SOFAR channel and derived from surface vessels;
- Assess bird populations around mining vessels and determine any impact caused by these vessels; and
- Thresholds for serious harm[31].

33. Similarly to developing thresholds for impacts considered at the regional scale, it was broadly agreed that more work would be needed to define their properties recognizing that this may be challenging, given the paucity of information relating to the response of biological communities to future exploitation activities.

34. It was suggested that there may need to be multiple thresholds for impacts derived from the same pressure, to address the range of sensitivities displayed by different species or communities.

[31] Please refer to the definition of "serious harm" included in the draft regulations on the exploitation of mineral resources in the Area: "Serious Harm" means any effect from activities in the Area on the Marine Environment which represents a significant adverse change in the Marine Environment determined according to the rules, regulations and procedures adopted by the Authority on the basis of internationally recognized standards and practices informed by Best Available Scientific Evidence. The current text of the draft regulation (ISBA/25/C/Wp.1) is found here: https://isa.org.jm/files/files/documents/isba_25_c_wp1-e_0.pdf

Developing multiple thresholds could also enable more rapid detection of where impacts are approaching serious harm. Participants suggested that determining the threshold/s for what would be considered 'serious harm' would benefit from engaging with appropriate experts.

35. As for developing thresholds for regional scale impacts, it was suggested that establishing thresholds could draw on existing frameworks and strategies. It was further suggested that thresholds for impact at the contract area scale may need to be periodically reviewed as more information becomes available on environmental baselines and biological responses to pressures.

E. How can this information be used by contractors, individually and collectively? For example, in environmental impact assessments and environmental monitoring and management systems, etc.

36. The key points under this question can be summarized as follows:

- While individual contractors should comply with the management measures outlined in the REMP and submit their survey data from exploration activities to ISA, they should consider sharing relevant data and resources to support the implementation of the REMP (e.g., conducting environmental surveys beyond individual contract areas, in particular for the sites in need of protection/precaution etc.);
- Compliance should be carried out in a transparent manner; and
- Contractors can be encouraged to provide environmental information on adjacent areas of the ridge axis so as to understand habitat heterogeneity along the ridge.

37. It was noted that data sharing amongst contractors was facilitated by the ISA DeepData database, and that environmental data are made available to the public through the ISA website, which would help provide a regional context for environmental baselines in contract areas. Environmental data in DeepData need to be analyzed and synthesized to assess status and trends of marine ecosystems, and effects of exploitation activities at the regional scale.

38. Regarding transparency in compliance with the management measures identified in the REMP, participants considered that multiple aspects of compliance would benefit from transparency. It was suggested that contractors should implement their obligations in a transparent manner and cooperate in the implementation of REMP.

39. Conducting environmental surveys beyond individual contract areas was considered particularly important in the context of providing a broader perspective for application of management measures at both contract area and regional scales. Encouraging contractors to engage in this activity collaboratively would help to establish regional environmental baselines and strengthen the evidence base for decision-making process of ISA on environmental protection and management at the regional scale.

40. Further compilation and assessment of environmental information would be needed for sites/areas in need of precaution so that adequate management measures can be considered through the future REMP process.

Annex V

Summary of workshop discussion on monitoring, research, and technical priorities at the regional scale to support effective implementation of a REMP and address knowledge gaps

1. Participants engaged in break-out discussions on monitoring, research, and technical priorities at the regional scale to support the effective implementation of a REMP for the Area of the northern Mid-Atlantic Ridge (MAR) and to address knowledge gaps. Break-out discussions addressed the following three topics: A) priorities for monitoring and research to address key pressures; B) priorities for monitoring and research to support achieving management outcomes; and C) priorities for technical development to support the application of suggested management measures. A summary of the break-out group discussions on other topics related to these questions is provided in Section D. This annex provides the main points of the break-out discussions, accompanied by explanatory notes where appropriate.

A. What could be the priorities for monitoring and research that can address key existing and potential pressures to biodiversity of ecosystems at the regional scale, as well as sites or areas in need of protection?

2. Participants identified the following biological and ecological properties for monitoring and research:

- Population connectivity;
- Migratory connectivity;
- Trophic connectivity/relationships;
- Ecosystem function; and
- Resilience and recovery.

3. Participants considered the measurements that would be needed to monitor these priorities, including the potential methods, equipment and collaborative approaches that could be used to obtain these measurements.

4. It was suggested that population connectivity could be determined using molecular tools on specimens collected by direct sampling. Potential connectivity could be determined based on a combination of information on habitat distribution, ocean currents and life history traits. Data validation of larval dispersal patterns and recruitment could be achieved using sediment traps or larval pumps for the former, and high-resolution imagery using underwater vehicles for the latter.

5. Participants suggested that the migratory connectivity of marine mammals, sea turtles, or other large animals in the surface and midwater environments could be monitored through collaboration with the existing initiatives and projects, using network analyses, tagging approaches and passive acoustic methods involving hydrophones placed on the seafloor or on buoys at the surface. Migratory species could also be monitored using passive acoustic methods in the region through hydrophones placed at the seafloor or on buoys at the surface, for example, the Migratory Connectivity in the Ocean (MiCO)[32], and the Ocean Tracking Network (OTN)[33].

6. Monitoring trophic connectivity would enable the detection of disruption in food chains, which could have implications for broader ecosystem function. Participants suggested that trophic structure could be monitored through measurements at different trophic levels. For example, at the top of the food chain, monitoring could focus on changes in abundance of top predators. At the base of the food chain, surface primary productivity could be measured using satellite-based remote sensing. Important midwater trophic linkages could be monitored through measuring diel vertical migrations and the location of the deep-

[32] Migratory Connectivity in the Ocean (MiCO): https://mico.eco/
[33] Ocean Tracking Network (OTN): https://oceantrackingnetwork.org/

scattering layer using acoustic methods.

7. Measuring changes to biological or functional trait profiles can contribute to monitoring ecosystem function, although its effectiveness is contingent on detailed trait data being available for the taxa considered. Several existing trait databases were identified as potential sources of trait information to support a trait-based approach to monitoring ecosystem function. Trait profiles exist for some vent species[34] but traits are not well known for many non-vent deep-sea species on the MAR. Ongoing projects are aiming to address this gap in functional trait information, for example, the Biological Traits Information Catalogue (BIOTIC)[35], EMODNet Biology Portal[36], and the Fun Azores Project[37]. However, information on trait profiles would need to be augmented by information on trophic flows, functional diversity, and redundancy of traits at the major trophic levels, for ecosystem function to be monitored effectively. Tools such as stable isotope analyses, diet studies, and size spectra analyses could all contribute to a wider body of information on ecosystem function.

8. Participants suggested a four-step process for developing appropriate measurements for monitoring ecosystem function: (1) understanding ecosystem function in the region of interest; (2) modelling ecosystem function for that region; (3) identifying proxies or indicators for ecosystem function based on the developed model; and (4) undertake monitoring activities for the indicators identified or for appropriate proxies if necessary.

9. Participants recognized that understanding regional resilience and recovery would require the establishment of robust regional environmental baselines against which to monitor changes. Monitoring resilience and recovery could utilize high resolution imagery obtained from seafloor observatories to visually assess the abundance or health of indicator species, alongside other sampling methods to assess changes to community trait profiles focusing on biological traits linked to sensitivity. Participants further suggested that direct observations of biological community responses to small-scale disturbances or experiments could inform models and predictions of resilience and recovery. Predictions of the potential resilience and recovery of MAR biological communities could also draw on observed responses to disturbances from other industries, such as offshore oil and gas.

10. Participants also discussed the potential application of indices to track ecosystem health, such as the OHI[38],while recognizing that there were reservations regarding the application of the OHI. It was noted that while developing or applying OHI could facilitate communication of ecosystem health status with a wide range of non-specialists, it could be difficult to establish the cause of any observed changes in health index status.

11. Participants identified the following physical and chemical parameters as priorities for regional monitoring and research:

- Physical and chemical characterization of any plumes associated with exploitation activities;
- Patterns in ocean currents;
- Ocean chemistry; and
- Underwater noise.

12. Regarding plumes, participants suggested that monitoring may need to consider three different plumes: the natural hydrothermal plume, the operational mining plume, and the plume associated with returning mining wastewater to the marine environment. Participants suggested that the natural hydrothermal plume should be monitored for temporal changes in composition, both to strengthen

[34] Chapman et al. 2019. 'sFDvent: A global trait database for deep-sea hydrothermal vent fauna'. Global Ecology and Biogeography, 28(11): 1538 – 1531. https://doi.org/10.1111/geb.12975
[35] Biological Traits Information Catalogue (BIOTIC): http://www.marlin.ac.uk/biotic/
[36] EMODNet Biology Portal: https://www.emodnet.eu/en/biology
[37] Fun Azores Project: https://funazores.pt/index.php
[38] Ocean Health Index (OHI): http://www.oceanhealthindex.org/ It should be noted that participants did not reach consensus on the application of OHI.

environmental baselines and to detect any changes in hydrothermal activity that may be linked to exploitation activities. Monitoring ecosystem responses to plumes resulting from exploitation activities would benefit from research on the metal speciation and associated ecotoxicology of both natural and mining-induced plumes. Understanding and accurately predicting the behavior and characteristics of plumes would require more detailed knowledge of physical oceanography and current interactions with the topography of the MAR. Participants proposed that one of the key monitoring priorities would be to determine suitable methods for measuring plume spread, to inform the construction and validation of accurate plume dispersal models.

13. Participants suggested that ocean currents could be monitored at a regional scale using current meters, Acoustic Doppler Current Profilers (ADCPs), including using oceanographic moorings and bottom landers, satellite data, and Argo floats and other floats and drifters[39]. Autonomous chemical sensors mounted on Argo floats and other drifters could be used to measure oxygen profiles in the water column to 4,000 m depth. Community respiration rates are linked to available oxygen, and changes in oxygen profiles could be linked to changes in ecosystem function.

14. Regarding underwater noise, participants proposed the use of hydrophones for passive acoustic monitoring of background noise, in addition to the activity of fishes and mammals.

15. Participants identified the need to conduct measurements at the appropriate spatial and temporal scales for the environmental parameter considered, with suitable spatial and temporal resolution to inform monitoring. The importance of time series data for long term records of natural variability and the high frequency of measurements needed to address seasonality were considered. The need for sufficient spatial resolution of bathymetric maps to enhance the performance of ocean circulation models was also raised. Swarms of AUVs, gliders, and multiple cabled or non-cabled observatories were tools proposed for high spatial and temporal coverage for remote sampling.

B. What could be the priorities for monitoring and research that can support achieving the expected management outcomes at the regional scale as well as at sites or areas in need of protection?

16. Participants based discussion within this section on a subset of the expected management outcomes at the regional scale identified in Annex IV. Priorities for monitoring and research were discussed in the context of supporting the achievement of the following expected regional scale management outcomes:

- Minimize habitat loss to maintain ecosystem viability;
- Ensure connectivity is maintained amongst populations;
- Maintain representativity of habitats at the regional scale;
- Maintain migratory corridors;
- Maintain feeding and breeding grounds;
- Maintain water column ecosystem function; and
- Control exploitation activity to remain within cumulative impact thresholds.

17. Regarding the application of the mitigation hierarchy, participants suggested that a distinction should be made between monitoring priorities to assess status or trends in the regional environment (regular monitoring) and monitoring to trigger rapid management responses (emergency monitoring).

18. Participants suggested that monitoring to trigger management actions should focus on variables that fulfil the criteria of specificity, sensitivity, and responsiveness. These variables should also meet the SMART criteria (Specific, Measurable, Achievable/Attributable, Relevant and Timely/Targeted). The choice of monitoring variables would also need to align with the timescales of the management actions. For example, different taxa may need to be monitored to assess changes at different spatial and temporal

[39] Argo Float Programme: https://argo.ucsd.edu/

scales.

19. In terms of monitoring and research to support minimization of habitat loss, participants suggested that habitats would first need to be comprehensively defined and mapped within the region to establish environmental baselines with respect to habitat quality, quantity and distribution/patchiness. This process would benefit from the definition of appropriate spatial and temporal scales for regional environmental baseline data collection and subsequent surveys to support monitoring.

20. Participants suggested that targets would need to be established for the spatial coverage and quality of protected habitat needed to maintain ecosystem viability. Continued monitoring of changes to non-mined habitat would support the identification of changes in ecosystem viability that may occur as a result of exploitation activities, against a background of variations in regional environmental baseline due to natural events or climate change.

21. With respect to monitoring and research priorities that could support the maintenance of population connectivity, participants proposed the need for regional analyses of connectivity to provide appropriate regional baselines against which changes could be monitored. Participants suggested that datasets generated by different contractors and stored within the ISA DeepData repository could be combined and assessed with support from population connectivity experts. For connectivity data to be combined in regional scale studies, a standardized approach would be needed to identify suitable indicator species and apply molecular methods to the connectivity studies conducted by different contractors.

22. Participants discussed the need for, and challenges associated with, long-term monitoring of population connectivity on regional scales. In cases where sufficient information is available, a suitable network of connected sites could be established prior to exploitation activities, and the associated monitoring could focus on processes that have the potential to disrupt connectivity. However, given the limited information available on population connectivity, initial monitoring efforts may focus on validating existing connectivity models and monitoring important connections. Participants suggested that establishing a monitoring strategy for population connectivity would benefit from discussion with appropriate experts, potentially through a future workshop.

23. Regarding monitoring and research priorities to support maintenance of migratory routes and breeding and feeding groups, participants noted that the wide-ranging nature of migratory species makes direct monitoring of these ecological properties challenging. Migratory species could be subject to a range of pressures from multiple sources along their migration routes and at feeding and breeding sites, thus it may be difficult to identify responses specific to mineral exploitation activities.

24. Participants suggested that network analyses could be used to identify important migratory routes with data from initiatives such as the MiCO Project, and other data sources of cetaceans in the North Atlantic. Monitoring and research priorities to support management outcomes for migratory species may benefit from ISA's collaboration with the Convention on the Conservation of Migratory Species of Wild Animals.

25. Participants considered that monitoring could focus on regional changes in exploitation activities that may impact the suitability of migration corridors, such as underwater noise or plume generation, and that these changes could be mapped against any observed behavioral changes in migratory animals to identify potential linkages.

26. Monitoring and research priorities to support the maintenance of feeding and breeding grounds may involve a similar approach to that taken for migratory routes, except that the focus would be on maintenance of key habitats. Participants indicated that suitable feeding or breeding grounds sometimes occur at shallower depths than the ore bodies of interest. As a result, some feeding and breeding grounds may not be actively studied during environmental baseline surveys, despite the potential for impacts on these locations. Collaborative efforts amongst actors may be needed to monitor impacts of feeding or breeding grounds from mineral exploitation activities when these activities occur beyond the current extent

of baseline data collection.

27. Participants noted that it may be challenging to monitor ecosystem functions directly. Instead, it may be necessary to monitor key species that serve these functions and manage the pressures acting on those species. It was further suggested that there may be non-linear relationships between species and function, and that further research could help to identify the location of tipping-points to inform monitoring efforts and associated management actions.

28. Suggested priorities for monitoring the maintenance of ecosystem function included acoustic monitoring for changes in the location of the deep-scattering layer, with the intention of triggering management actions where changes exceed established thresholds. Participants also considered monitoring metal burdens in mesopelagic (midwater) fauna to determine if these organisms had been exposed to higher concentrations of metals in the water column than would be expected based on environmental baseline information. Such monitoring could include periodic biological sampling to analyze metal concentrations within tissues. However, such an approach would depend on having sufficiently detailed environmental baseline information to be able to separate the effects of the natural hydrothermal vent plume and any plumes associated with exploitation activities. It was noted that monitoring to ensure maintenance of ecosystem function is particularly challenging in the pelagic environment where mobile organisms may be able to avoid or escape plume impacts, whilst some drifting organisms could become trapped within the plume envelope for long distances.

29. Identifying priorities for monitoring and research to support management of cumulative impacts from exploitation activities could be more challenging to identify, given the many levels of 'cumulative' impacts that these priorities may need to address. For example, impacts could be cumulative in the sense of: (1) multiple biological responses propagating through an ecosystem resulting from a single pressure; (2) biological responses to a combination of pressures arising from the exploitation activities of a single contractor; (3) biological responses to a combination of pressures from the exploitation activities of multiple contractors occurring within the same area at the same time. Impacts could also be cumulative across sectors, or in combination with climate change induced pressures.

30. Monitoring of cumulative impacts also requires the accurate identification of cause and effect, so that effective management actions can be applied to the source of the pressure. Participants suggested that monitoring to understand the impact of one pressure amongst many would benefit from identifying indicator taxa that are sensitive to the individual pressure of interest, but more robust to other pressures that may be happening at the same time or place. However, designing and implementing monitoring activities may become complicated by the reality that cumulative impacts are not always additive, with the potential for interaction effects making it more difficult to identify suitable thresholds.

31. Participants noted that the post-Evora Workshop qualitative cumulative impact modelling exercise[40] provided an important first step in understanding and addressing cumulative impacts on the MAR, and that this work could help to identify further research and monitoring priorities in the context of managing cumulative impacts on the MAR. It was further suggested that this work could be used as a starting point for collaboration with other competent bodies to consider collaborative approaches for managing cumulative impacts. The experience of other competent bodies in managing cumulative impacts, for example the cumulative effects assessments conducted by OSPAR[41], could help to inform suitable research and monitoring priorities for cumulative impacts in the context of REMP development. Participants also highlighted cumulative impact assessment approaches that had been discussed in the scientific literature[42,43].

[40] Draft Report on Assessing Cumulative Impacts: https://isa.org.jm/files/files/documents/Draft-report-cumulative-impacts.pdf
[41] OSPAR cumulative effects assessment: https://www.ospar.org/news/cumulative-effects-assessment
[42] Cormier et al. 2019. 'Putting on a bow-tie to sort out who does what and why in the complex arena of marine policy and management'. Science of the Total Environment, 648: 293 – 305. https://doi.org/10.1016/j.scitotenv.2018.08.168.
[43] Hammar at al. 2020. 'Cumulative impact assessment for ecosystem assessment for ecosystem-based marine spatial planning'. Science of the Total Environment, 734: 139024. https://doi.org/10.1016/j.scitotenv.2020.139024.

C. What could be the priorities for technology development that can support applying the suggested management measures at the regional scale as well as at sites or areas in need of protection?

32. Participants identified multiple technological approaches to support the application of management measures at the regional scale, and to potentially reduce environmental impacts from future exploitation activities.

33. In terms of technological approaches to support the application of management measures, it was suggested that monitoring the extent and nature of plume impacts, such as turbidity or altered water chemistry, could be undertaken using AUVs, gliders and fixed moorings. Particle or chemical measurements taken using sensors mounted on autonomous and fixed platforms could be used to determine if thresholds for plume impact have been exceeded. It was noted that different chemical sensors may be needed for different types of platforms.

34. Participants discussed the potential for near real-time environmental data generation using seafloor observatories, accompanied by effective online data visualization tools enabling activities to be monitored in real time. The Lofoten-Vesterålen (LoVe) Ocean Observatory[44] was raised as an example of this approach.

35. The potential for generating real-time data on exploitation activities at a regional scale was also considered. Such an approach may enable causal links to be established between specific mining activities and changes in observed environmental status. Technological developments to support this approach could build on existing vessel tracking technology used for monitoring bottom-contact fisheries activities.

36. Participants also suggested that improvements in automation and machine learning could support analysis of the large multi-parameter datasets generated by autonomous monitoring technologies.

37. In terms of technologies that could reduce environmental impacts, participants suggested that innovations that would enhance plume settlement, for example through encouraging flocculation, could help to reduce the spatial and temporal extent of impacts from fine particulate material suspended in the water column. Engineering approaches that limit the removal of unwanted materials, such as overburden, prior to mining could help to reduce sediment mobilization and so plume formation.

38. Additional technologies identified by participants to reduce exploration and exploitation impacts included the use of deep-tow systems for acoustic mapping to restrict sonification to a smaller portion of the water column. Changes to hydrothermal fluid flow could be monitored by measuring fluid discharge rates or heat flux at active vent sites, and application of geophysical methods such as controlled source electromagnetics (CSEM).

D. Other discussion points

39. Participants suggested that many monitoring and research priorities would benefit from enhanced collaboration at the regional scale. Potential opportunities and frameworks for collaboration in the context of a REMP for the MAR are discussed further in Annex VI, and only a brief summary of the discussion points specific to regional monitoring are listed below:

- Regional monitoring could be enhanced through collaboration that improves the regional environmental baseline against which to measure impacts. For example, enhancing the temporal and spatial resolution and coverage of environmental data across the region. Sharing data could also enable regional-scale analyses of connectivity and biodiversity to be conducted.

[44] The Lofoten-Vesterålen (LoVe) Ocean Observatory: https://love.equinor.com/

- By combining expertise and resources, collaboration amongst actors could help to develop a cost-effective regional monitoring plan. A collaborative approach to regional monitoring could help to generate meaningful ecological data collected at suitable temporal and spatial resolution and scale.
- Collaborative approaches could also support the standardization of technologies or methods used to establish environmental baselines and to monitor impacts. For example, developing standardized approaches to identifying suitable indicator species for monitoring impacts at the regional scale. Collaboration with other actors could also identify established monitoring approaches that could be modified for regional monitoring of impacts from exploitation activities.

40. Participants also considered how the identified monitoring and research priorities could be further refined to focus monitoring and research efforts. The main points raised under this discussion included:

- Identifying priority indicators for monitoring depends upon the function of monitoring. For example, monitoring for regional environmental status and trends may require different indicators than monitoring to support the achievement of management outcomes.
- Whilst it may be possible to monitor a wide range of ecological properties, participants considered that a practical first approach could prioritize regional monitoring of basic metrics, such as species diversity, richness, or evenness. Measuring a few targeted components to a high standard may generate information in a better way to support the achievement of management outcomes.
- Through the post-Evora Workshop qualitative cumulative impact modelling exercise[45], some ecosystem components were predicted to have a particularly negative response to potential pressures from exploitation activities. Potentially sensitive ecosystem components or individual pressures that were predicted to induce particularly negative ecosystem responses could be further investigated as potential indicators for MAR ecosystem responses to exploitation pressures.
- Consideration could be given to employing a structured approach to identifying appropriate indicators for regional-scale monitoring. Participants referred to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)[46] as an example of an approach that could be adapted for the deep-sea ecosystems of the MAR. Employing a structured approach to identification of priority indicators would benefit from further discussion, potentially through a dedicated workshop.
- Identification of priorities for monitoring could also consider broader social or cultural priorities for monitoring of future exploitation impacts.

[45] Draft Report on Assessing Cumulative Impacts: https://isa.org.jm/files/files/documents/Draft-report-cumulative-impacts.pdf
[46] Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): https://www.ipbes.net/

Annex VI

Summary of break-out session discussion on collaboration among stakeholders and capacity development of various actors to support effective implementation of a REMP and address knowledge gaps

1. During this break-out session, participants discussed the following questions, building on the results from the break-out sessions on area-based management (Thematic segment A, see Annex III), non-spatial management measures (Thematic segment B, see Annex IV), and monitoring and research (Thematic segment C, see Annex V):

- What could be the priority collaborative activities that can support achieving the expected management outcomes, which are identified in thematic segments A and B?
- What could be the priority capacity development activities that can support applying the suggested management measures at the regional scale identified in thematic segments A and B?
- How can contractors jointly identify and implement priorities for monitoring and research, which are identified in thematic segment C?

2. To facilitate the discussion, one of the moderators, Gordon Paterson, provided a brief introduction to existing mechanisms and initiatives for collaboration and capacity building, which have been undertaken under the auspices of ISA, in particular those with contractors and the scientific community. Future collaborative and capacity building efforts could build on existing mechanisms and initiatives.

3. Where appropriate, participants were asked to consider the roles of, and collaborations among various ISA stakeholders, including contractors, the scientific community and other stakeholders. Key points from the discussion under each question are summarized below.

Question 1. What could be the priority collaborative activities that can support achieving the expected management outcomes, which are identified in Thematic segments A and B?

4. Participants identified a number of priority activities and elaborated on the actions for implementing such activities. It should be noted, however, this list is not intended to be exhaustive and the ordering below was not based on a detailed assessment of importance.

5. In addition to the actions for implementing individual priority activities, a number of cross-cutting actions were also identified, which would contribute towards multiple priorities:

- Establishing a high-level REMP forum to bring all relevant stakeholders together to identify common priorities, develop solutions and exchange best practices;
- Establishing forums and fostering partnerships among contractors, the scientific communities and industry to support technology development that reduces the impacts of activities and improve our ability for monitoring and research in the Area;
- Collaboration between ISA and other international organizations and regulatory bodies [47]with experience related to the priority activities listed below in a structured way, while noting that ISA has already established Memorandums of Understanding (MoUs) and agreement of cooperation with several international organizations; [48]

[47] For example the Convention on Migratory Species (Bonn Convention), The international Convention on the Conservation of Atlantic Tuna (ICCAT), InterRidge, ICES and RFMOs

[48] These include MOUs with the OSPAR Commission and the Intergovernmental Oceanographic Commission (UNESCO), as well as Agreement of Cooperation with the International Hydrographic Organisation. Further information can be found at https://isa.org.jm/legal-documents

- Collaborative work through sharing of data, knowledge and experiences (under ISA Action Plan in support of the UN Decade of Ocean Science for Sustainable Development)[49] and dissemination through joint publications and technical reports; and
- Sharing information on cruises to the MAR, and opportunities to participate in such cruises, through ISA or other platforms such as the InterRidge cruise database[50].

a) Identification and prioritization of knowledge gaps. Given the range of knowledge gaps to be addressed by different stakeholders, prioritization of such gaps was considered necessary to guide collaborative efforts. This priority activity can be achieved through:

- Alignment of monitoring and research programmes among different contractors; and
- A joint forum, facilitated by ISA, for the identification and review of knowledge gaps, which would guide future monitoring and research programmes.

b) Risk analyses at the regional scale, which can be achieved through the development and application of frameworks and methodologies, such as cumulative impact analyses and scenario planning, to identify and assess risks to ecosystems, habitats, communities and species. This may require collaboration among contractors, the scientific community and members of ISA.

c) Understanding of plumes and technology for plume reduction. This was noted as an area that would require collaboration among contractors, industry and the scientific community that have experience in conducting field experiments and developing models for plume simulation. ISA can facilitate the sharing and dissemination of knowledge and information from various studies. This priority can be addressed through:

- Combination of different methodologies (field experiments and models) to understand the behavior of plumes and inform the development of relevant thresholds;
- Sharing knowledge and information about the field experiments conducted by contractors and the scientific community;
- Building on experiences for plume monitoring at the local scale, which can help the design of large-scale plume monitoring programmes; and
- Partnership with engineering industry to develop technological solutions for plume reduction.

d) Technology development. It was suggested that participation from the engineering industry would be crucial for this priority activity, as technology is rapidly evolving and it is important to understand the impacts of different technologies on the environment. It was also mentioned that companies involved in the development of new technologies were often willing to collaborate with contractors, scientists and regulatory bodies, as they need to understand environmental standards with which technology must comply. This priority activity can be achieved through:

- A forum on technology development, which can be facilitated/fostered by ISA, to link engineers, contractors and scientists, to better understand how technology is evolving, the impacts of new technologies, and how technology advancements can improve our ability to monitor the environment;
- Test mining or testing of mining components as a practical way to test appropriate technology, noting that this would require considerable capital investment and may not be undertaken at a later stage in the exploration period; and

[49] ISBA/26/A/4
[50] https://www.interridge.org/cruise

- Collaboration between contractors and the scientific community in undertaking an Environmental Impact Assessment (EIA), required for test mining or testing of mining components, can provide a framework for bringing together different knowledge and expertise (engineering, environment and resources).

e) Structural properties critical for ecosystem function. It was highlighted that maintaining ecosystem function is often a key management goal in regulating various activities. However, ecosystem function is difficult to monitor, due to the non-linear relationships between structural properties and ecosystem function (see also paragraph (m) below). This priority activity can be addressed through:

- Experimental studies on "tipping points" beyond which further loss on structural properties may impact on ecosystem function, such studies are primarily research focused and would be led by the scientific community; and
- Studies on community structure, as an essential first step in understanding ecosystem function. Such knowledge can be developed through joint projects implemented by contractors and the scientific community.

f) Thresholds. It was recognized that thresholds are needed for various management needs, including the definition of vulnerable and sensitive ecosystems within the context of ISA, design of buffer zones, and controlling the impacts from plumes and toxic containments. This is an area that may benefit from dialogue and collaboration between ISA and other competent regulatory bodies, as well as scientific institutions, so that future efforts can build on the work already undertaken by other bodies. This priority activity can be achieved through:

- Implementing a phased approach for developing thresholds, the first phase being to identify which thresholds should be developed for the management needs and the second phase for defining these thresholds; and
- Creating opportunities to share knowledge and best available techniques on what and how thresholds have been developed in other sectors through workshops or joint research projects. Experiences from the OSPAR Commission, International Council for the Exploration of the Sea (ICES), Regional Fishery Bodies (RFBs), including Regional Fisheries Management Organizations (RFMOs), and regulatory bodies for other offshore industries were highlighted as particularly relevant for thresholds development in the context of the REMP[51].

g) Buffers and zonation. Similar to the development of thresholds, this area would also benefit from collaboration between ISA and other bodies with relevant experience in designing and implementing buffer zones. Collaboration with and among contractors and scientific organizations is also essential to address the key data gaps. This priority activity can be achieved through:

- Experimental studies and research to close key data gaps for defining buffers, such as data on hydrodynamic patterns and geophysical characteristic of vents fields, which are necessary for understanding the footprint around which to design buffer zones;
- Bringing expert groups together to work on related topics through workshops and joint surveys, with ISA playing a facilitating role. Technical reports or workshop reports are main products of such workshops, which would feed information to the REMP process;
- Field surveys may be needed to ground truthing the practicality of expert suggestions and findings from modelling and expert workshops; and

[51] Reference was also made to the development of indicators and thresholds for "good environmental status" under the EU Marine Strategy Framework Directive, and the IDEM project.

- Collaboration with other regulators, such ICES and RFBs in northern MAR, to build on existing experience.

h) Regional scale mapping and modelling. It was highlighted that environmental data at the regional scale need to be compiled to understand regional environmental settings important for planning monitoring and research, noting the Regional Environmental Assessment[52] and Data Report[53] prepared for this workshop. Such regional scale assessments can also be used to aid the selection of representative areas and sites in need of protection. This can be achieved through:

- Building on the data compiled in ISA DeepData, based on submissions by contractors through their annual reports of exploration activities;
- Collating data and information from different sources to develop regional scale knowledge of bathymetry, oceanography and geophysics and to provide a baseline, which may be achieved through collaborating with different organizations already tackling such challenges through regional-scale studies and initiatives, such as the Seabed 2030 project and EMODnet project of the European Union;
- Developing general oceanographic models that can be applied at the regional scale in northern MAR; and
- Building a fleet of AUVs to survey and develop regional-scale mapping and reduce the cost of sampling, which will require collaboration among contractors, engineers and scientific organizations.

i) Intercalibration for comparative analysis was considered as an important step in collating data from different contractors, academic peer-review articles and databases to ensure that the data were comparable and could be used for regional level studies. This could be achieved through:

- Collaboration with/among contractors, ISA members and the scientific community to analyze and develop intercalibration studies to ensure coherence within DeepData, and to bring together historic academic data as well as contemporaneous data;
- As part of this, process models and methodologies need to be developed or adapted from existing efforts to ensure compatibility between datasets, particularly historical datasets;
- Intercalibration of sensors and cooperative analysis for the development of sensor methodology; and
- Mechanisms for reviewing environmental data in DeepData. Studies from climate change science can be a good reference for harmonization of data and methodology.

j) Taxonomy and biogeography. It was mentioned that current taxonomic knowledge mainly focused on charismatic species in the MAR, which needs to be expanded to cover other species. Taxonomy and biogeography are important for understanding connectivity, larval biology, community composition and ecosystem functioning. Collaboration with/among ISA members, contractors and the scientific community will be needed. This priority activity can be achieved through:

- Compilation of a list of taxa in and along MAR, through joint efforts between contractors and scientific organizations which would be facilitated by ISA;

[52] https://www.isa.org.jm/files/documents/rea-feb2020-reduc.pdf

[53] https://www.isa.org.jm/files/documents/data_report-feb2020-reduc.pdf

- Practical taxonomic workshops for northern MAR for all groups of fauna, facilitated by ISA and coordinated by scientific organizations and contractors; and
- Intercalibration studies and workshops organized by ISA, together with contractors and scientific organizations to ensure a standardized taxonomy across the REMP.

k) Connectivity studies. It was highlighted that limited knowledge about connectivity is a major knowledge gap for the application of the network criterion on connectivity, and various studies are needed including population genetics, refuge areas and corridors. These priority activities can be achieved through:

- Workshops to establish approaches and methodologies, and to share and calibrate data and methodologies;
- Multidisciplinary research projects using a range of methodologies in taxonomy, population genetics, oceanography, etc. and establish collaborative experiments; and
- Participation of scientists during contractors' exploration cruises to enable the sampling different populations for connectivity studies.

l) Better knowledge of AINPs and S/A-Precaution, which requires collaborative efforts among ISA members, contractors and the scientific community. This can be achieved through:

- Multidisciplinary cruises led by scientific organizations to conduct surveying and mapping large areas in need of protection, and to support monitoring of such areas;
- Surveying and mapping areas in need of precaution to ground truth modelling predictions, which may be done through collaboration between modelers, the scientific community and contractors to develop research proposals and gain ship-time;
- A roadmap for cruises in the northern MAR, which can be facilitated through ISA or in collaboration with InterRidge and other relevant international and regional organizations;
- Multinational cruise projects and cruise programme, such as the Vema-TRANSIT expedition project; and
- Review if all VME and EBSA criteria can be applied in the context of ISA. Participants noted that the paper submitted by a group of experts on the compilation of scientific information to describe active vents on the Mid-Atlantic Ridge as potential sites in need of protection, building on the results of the Evora workshop, could inform this discussion.

m) Multi-scale, long-term monitoring. It was highlighted that monitoring should ideally be multi-scale, long-term and three-dimensional, which is important for understanding ecosystem structure and function. This will be an important area of collaboration among the scientific community (providing expertise on the monitored parameters/ecological properties), contractors (providing detailed information about the monitored area) and the engineering industry (providing new technology). The challenges of undertaking monitoring within a realistic timescale were highlighted. It would be important to identify key parameters for routine, possibly real-time monitoring (see also paragraph 14 below). This priority activity can be achieved through:

- Development of a network of sensors, autonomous vehicles, energy supply, and communication means;
- Partnership with industry to develop real-time, regular and long-term monitoring technology; and
- Incentivizing funding and investments on the development of observatories from contractors as well as third parties.

n) Larval studies. Ecological and dispersal dynamic were considered important to understand resilience in species and identify where risk to recruitment is highest. This priority activity can be achieved through joint field and lab experiments developed by contractors and scientific organizations.

o) Maintain migratory corridors, which can be achieved through:

- Building on existing research projects such as the MiCO Project by the Duke University/MGEL;
- Potential collaboration with other bodies, such as the Convention for the Conservation of Migratory Species of Wild Animals (the "Bonn Convention") and International Commission for the Conservation of Atlantic Tunas; and
- Tracking of pelagic species, such as deep-water sharks, to establish migratory routes in the MAR. Such monitoring is technically feasible but still in its infancy.

6. Participants also considered the following potential priority activities identified in other break-out sessions, but did not discuss in detail due to time constraints.

- Minimize habitat loss to maintain ecosystem viability;
- Maintain representativity of habitats at the regional scale;
- Maintain feeding and breeding grounds; and
- Control exploitation activity to remain within cumulative impact thresholds.

Question 2. What could be the priority capacity development activities that can support applying the suggested management measures at regional scale identified in Thematic segment A and B?

7. It was noted that capacity building in research and education with a special emphasis on developing countries is an ISA mandate within UNCLOS. Enhancing the capacity of developing States to participate in activities in the Area with regard to deep-sea mining and environmental protection is a main objective of the ISA's training strategy[54]. Priorities for capacity building by ISA within the context of the REMP can include:

- A dialogue to align the different interests and priorities between developing countries and contractors with respect to their training programme;
- Build capacity within ISA (in-reach): via internships, secondment, bringing experienced people into ISA secretariat for a short period to share their experience;
- Implementing ISA Deep-Sea literacy strategy to inform member states, key decision makers in ocean science governance, sponsoring States and the civil society about the REMP development and implementation; and
- Implementing recommendations from the ISA workshop on capacity development, resources and needs assessment, held in February 2020[55].

8. Contractors have a legal obligation to provide trainings for individuals from developing States. The following priorities activities were suggested for contractors' training programme within the context of the REMP:

- Better alignment of contractors' training programmes with the priorities identified by developing States, which are relevant to the results of this workshop, and focused programme of training and capacity building to strengthen results of this workshop;

[54] ISBA/26/A/7: Implementing a programmatic approach to capacity development

[55] ISBA/26/A/12

- Providing further opportunities for early career scientists to be included in their work, whilst recognizing that some contractors already support MSc and PhD programmes, in relation to the results of this workshop; and
- Opportunities for internships, which may help scientific exchanges and capacity development of early career scientists, in relation to this workshop.

9. Management of future exploitation activities and related issues of environmental protection are often not a priority topic for international organizations or national organizations of member States and thus may be overlooked in decision making for funding schemes. The role of sponsoring States was discussed, in relation to the results of this workshop. A contractor has to comply with the legal rules of the sponsoring State and the sponsoring State has an obligation to regulate the activities of the contractor. The following priority activities were suggested for other organizations and stakeholders, in relation to the results of this workshop:

- The decision makers in the sponsoring States are key in developing REMPs. Continued communication between the ISA secretariat and member states is one way to ensure that ISA related issues, such as exploration and exploitation of mineral resources and environmental protection in the Area, are incorporated into the agenda for the development of domestic legislation and policies, and to provide support for the efforts of these States by ISA and other relevant international organizations, in relation to the implementation of the REMP;
- Ocean decision makers and marine spatial planners need to be made aware of ISA related issues, in particular in relation to the REMP; and
- It is necessary to raise the awareness of political decision makers and funding bodies on the work of ISA, in particular the REMP, and to work towards the establishment of relevant funded research programmes.

10. Participants also discussed the need to involve a wide range of stakeholders in REMP processes, following the communication strategy to be released by ISA, to ensure a wide understanding of the aims and objectives of the REMP and that the REMP adequately reflects stakeholder needs.

Question 3 How can contractors jointly identify and implement priorities for monitoring and research, which are identified in Thematic segment C?

11. It was recognized that communications among contractors take place at two levels - technical and strategic. There are opportunities for communications that facilitate collaboration at strategic levels, such as the ISA annual contractors' meeting. This workshop identified the need for fostering collaboration at both levels, possibly through high-level forums and through various technical activities (expert workshops, joint projects and cruises). The role of ISA in incentivizing and facilitating such collaboration was also highlighted.

12. The incentives for contractors to implement priorities for monitoring and research could come from environmental standards and requirements imbedded in ISA rules, regulations and procedures, and improved opportunities for collaboration with the scientific community with access to funding, cruise-time, samples and data. The need to understand the context of monitoring data may incentivize the contractors to extend their surveys beyond the confines of the contract areas.

13. The incentives for the scientific community to collaborate with the industry and contractors were also discussed. The issue being that research scientists are rewarded for undertaking novel, curiosity-driven research, while much of the contractors' work is focused on environmental baselines and monitoring. A number of activities and incentives were discussed, including:

- Providing funding opportunities to support priority research areas for contractors and the industry;
- Provide opportunities for joining contractor cruises to the MAR; and

- Sharing of samples and data with the scientific community, and to support studies of post-graduate and early career scientists.

14. To implement the priorities for monitoring and research, the following was suggested:

- Identifying ecological properties and essential biological variables for monitoring;
- Identifying ecological properties and essential biological variables for monitoring at a range of spatial and temporal scales. Contractors may benefit from discussions with academic institutions and other organizations, building on existing initiatives, e.g. the Ocean Health Index[56] and indicators for good environmental status in the European Union;
- Scenarios for management and implementation of the REMP, feeding into risk assessment; and
- Applying adequate code of conducts in undertaking monitoring and research as well as sharing the results.

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[56] http://www.oceanhealthindex.org. It should be noted that participants did not reach consensus on the application of OHI.