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Report of the Chair of the Legal and Technical Commission on the work of the Commission during the twenty-seventh session

Regional environmental management plan for the Area of the northern Mid-Atlantic Ridge with a focus on polymetallic sulphide deposits

Issued by the Legal and Technical Commission

I. Introduction and background

1. In accordance with the United Nations Convention on the Law of the Sea and the 1994 Agreement relating to the implementation of part XI of the Convention, the International Seabed Authority is the organization through which the States parties to the Convention administer the mineral resources of the International Seabed Area and promote, control and organize current exploration and future mining activities for the benefit of humankind as a whole. At the core of the mandate of the Seabed Authority lies also its duty to take all necessary measures to ensure effective protection of the marine environment from harmful effects that may arise from activities in the Area. Pursuant to article 145 of the Convention, the Authority 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.

2. To that end, pursuant to article 165 of the Convention, the Legal and Technical Commission of the Authority is responsible for making recommendations to the Council on the protection of the marine environment, with respect to relevant rules, regulations and procedures, as well as a monitoring programme on the risks and impacts on the marine environment resulting from activities in the Area. In addition, the Commission is responsible for keeping under review the rules, regulations and procedures on activities in the Area.

3. Three sets of exploration regulations have been adopted by the Authority on prospecting and exploration for polymetallic nodules, polymetallic sulphides and

cobalt-rich ferromanganese crusts,[1] which are supplemented by a series of recommendations issued by the Commission.[2] Draft regulations on exploitation of mineral resources in the Area are presently under consideration by the Council and will be supplemented by a set of standards and guidelines to support their implementation.[3]

4. In pursuance of the mandate under article 145 of the Convention, the Council, at its seventeenth session held in 2012, approved, in its decision ISBA/18/C/22, an environmental management plan for the Clarion-Clipperton Zone, on the basis of the recommendation of the Commission. Among other elements, the environmental management plan established objectives and priority actions at various levels, as well as a mechanism for review. In line with those provisions, the Commission reviewed progress in the implementation of the environmental management plan in 2016 and 2021 and identified further actions to advance the goals and objectives of the plan (see ISBA/26/C/43) On the basis of the recommendation of the Commission, the Council adopted in 2021 a decision relating to the review of the environmental management plan for the Zone, as contained in document ISBA/26/C/58.

5. Building on the experience of the environmental management plan for the Clarion-Clipperton Zone and International Seabed Authority workshops held for other regions, the development of regional environmental management plans (REMPs) became an essential element of the strategic plan of the Authority for the period 2019-2023 adopted by the Assembly in 2018 (ISBA/24/A/10) and, subsequently, a central part of the high-level action plan adopted by the Assembly in 2019 (ISBA/25/A/15, annex II). Strategic direction 3.2 of the strategic plan calls for efforts 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". Similarly, in 2020, the Assembly adopted the action plan of the Authority in support of the United Nations Decade of Ocean Science for Sustainable Development (ISBA/26/A/4), which identifies a number of expected outputs that highlight the role of scientific approaches to developing REMPs.

6. At its twenty-fourth session, in March 2018, the Council took note of a strategy proposed by the Secretary-General for the development of REMPs for key provinces in which exploration activities under contracts are carried out. The Council agreed with the priority areas that had been identified, including the Mid-Atlantic Ridge. The Council, at its twenty-fifth session, in 2019, took note of a report of the Secretary-General on the implementation of the strategy (ISBA/25/C/13), including a programme of work to develop the plans through a series of expert workshops.

7. To support the organization of the expert workshops, the secretariat prepared a guidance document to facilitate the development of REMPs. As requested by the Council in its decision ISBA/26/C/10, the guidance document is being further developed by the Commission with a view to recommending to the Council a standardized approach for the development of REMPs, including a template with indicative elements. In the guidance document, it is recalled that both contractors and sponsoring States "undertake […] to comply with […] the decisions of relevant organs of the Authority"[4] and reference is made, in that regard, to the decisions concerning REMPs.

8. As part of the implementation of this strategy, the Authority organized two expert workshops, in Szczecin, Poland in 2018 and Evora, Portugal in 2019, as well

[1] See ISBA/16/A/12/Rev.1, ISBA/18/A/11 and ISBA/19/C/17.

[2] See https://www.isa.org.jm/mining-code/recommendations.

[3] See https://www.isa.org.jm/mining-code/standards-and-guidelines.

[4] See annex IV, section 13.2 (b) in each set of the Authority's regulations on prospecting and exploration.

as a virtual expert workshop in 2020, in support of the development of a REMP by the Commission for the Area of the northern Mid-Atlantic Ridge.

9. The development and implementation of REMPs have become an integral part of the work of the Authority on the protection of the marine environment and have the potential to contribute to the effective conservation and management of marine biodiversity in areas beyond national jurisdiction. REMPs also have the potential to contribute to the achievement of Sustainable Development Goal 14 (Life below water) of the 2030 Agenda for Sustainable Development, namely, to conserve and sustainably use the oceans, seas and marine resources for sustainable development.

10. The present REMP contains references to measures that are applicable to the exploitation phase for which the draft regulations on exploitation of mineral resources in the Area are still under negotiation; those measures will therefore need to be aligned once the regulations have been adopted.

11. The REMP should be read in conjunction with the rules, regulations and procedures of the Authority relating to the protection of the marine environment referred to in paragraph 3 above, in particular, 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 and ISBA/25/LTC/6/Rev.1/Corr.1) and applicable standards and guidelines for environmental impact assessments, the establishment of baseline data and the preparation of environmental management and monitoring plans.

II. Guiding principles and approaches

12. The development and implementation of REMPs are guided by the following overarching principles with respect to the activities in the Area:

(a) **Common heritage of mankind**. The Area and its resources are the common heritage of humankind. All rights to the resources of the Area are vested in humankind as a whole, on whose behalf the Authority shall act;

(b) **Precautionary approach**. In principle 15 of the Rio Declaration on Environment and Development, it is specified that where there are threats of serious or irreversible damage to the environment, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation;

(c) **Transparency**. The Authority shall enable public participation in environmental decision-making procedures, in line with strategic direction 9 of the strategic plan of the Authority for the period 20192023 (see ISBA/24/A/10);

(d) **Application of an ecosystem approach**;

(e) **Incorporation of the best available scientific evidence into decision-making processes**.

III. Overarching goals

13. REMPs in the Area are developed to achieve the following overarching goals:

(a) Sustainably manage the resources in the Area;

(b) Ensure the protection and preservation of the marine environment;

(c) Maintain regional biodiversity and ecosystem structure, function and processes across the REMP areas;

(d) Enable the conservation of representative habitats and sensitive marine ecosystems;[5]

(e) Ensure environmental sustainability and functionality during and after exploitation activities;

(f) Ensure that activities are undertaken in an environmentally responsible manner in the Area;

(g) Promote access to, and sharing of, data and information relating to the protection and preservation of the marine environment in the Area, including environmental baseline studies;

(h) Facilitate cooperative research to better understand the marine environment to inform the implementation of the plan, including through the participation of developing States and multilateral exchange of views on environmental management issues;

(i) Encourage cooperation among contractors, sponsoring States, competent international and regional organizations, the scientific community and other stakeholders in the Area;

(j) Pay due regard to any human remains, archaeological or cultural objects as set out in article 149 and relevant Authority regulations;

(k) Work with competent organizations to ensure that activities in the REMP areas are conducted with reasonable regard for other activities in the marine environment;

(l) Pay due regard to traditional knowledge of indigenous peoples and local communities, as relevant to the implementation of REMPs.

IV. Purpose of the regional environmental management plan for the northern Mid-Atlantic Ridge

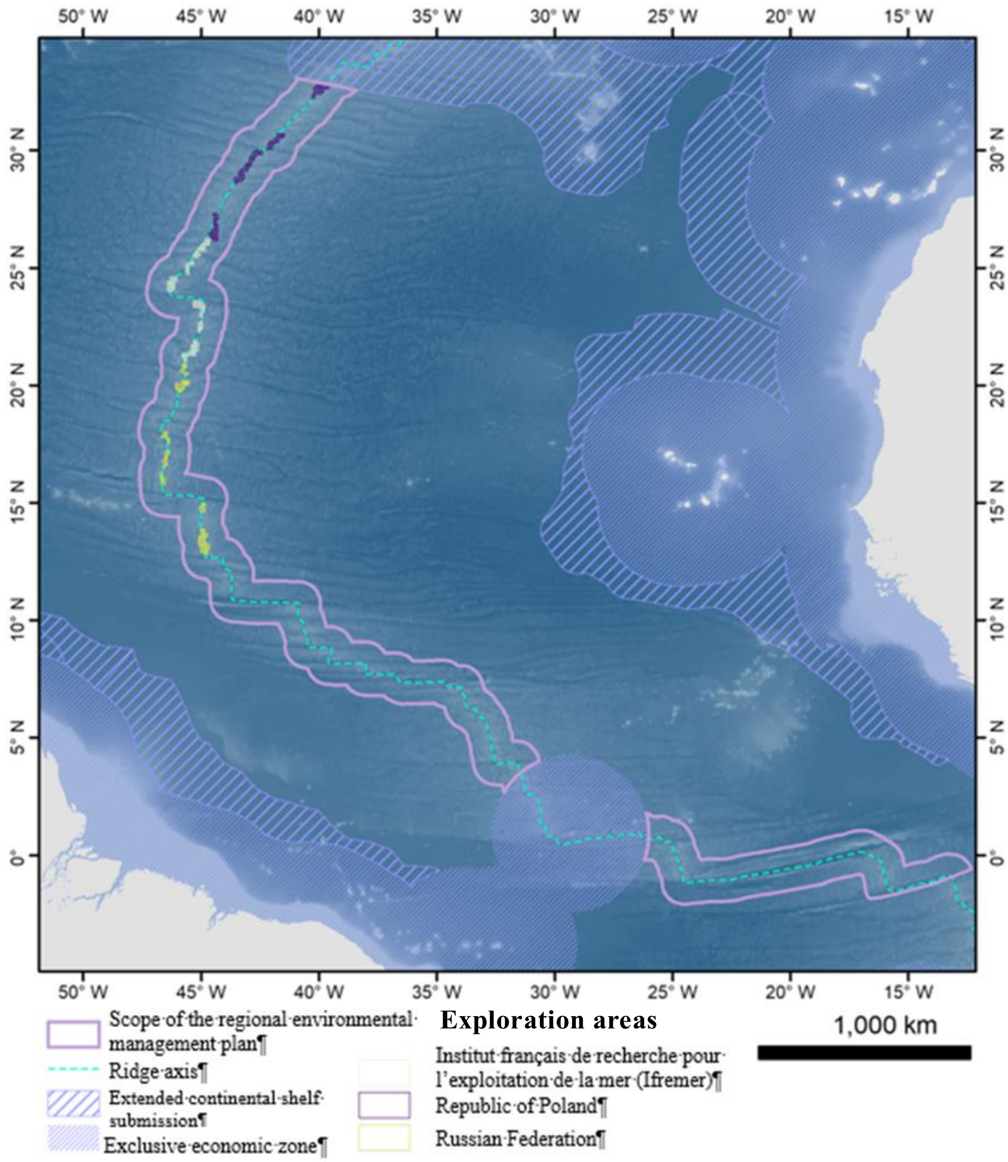
14. The purpose of the present REMP is to set in place conservation and management measures and tools across the region in the Area of the northern Mid-Atlantic Ridge to ensure the effective protection of the marine environment from harmful effects that may arise from activities in the Area, in accordance with article 145 of the Convention and the strategic plan of the Authority. To that end, the REMP establishes the principles, goals and objectives and identifies area-based and other management measures, as well as an implementation strategy. The REMP is an instrument of environmental policy.

V. Geographic scope of the regional environmental management plan

15. The Mid-Atlantic Ridge is an elevated area of seafloor that runs roughly north to south through the middle of the Atlantic Ocean. The REMP applies to the Area of the northern Mid-Atlantic Region. The geographical area covered under the plan extends 100 km on each side of the ridge axis to ensure a broad coverage of the ridge system, including its axis and ridge flanks. The geographical limits of the area covered under the REMP are shown in the figure below.

[5] Sensitive ecosystems have a narrow range of environmental conditions with ecological characteristics that make them susceptible to impacts and major change owing to disturbance.

Figure
Geographic scope of the regional environmental management plan for the Area of the northern Mid-Atlantic Ridge



VI. Environmental and geological setting and the exploration areas for polymetallic sulphide deposits

16. Existing sets of scientific data and information on the geology, oceanography and biological communities of the Mid-Atlantic Ridge have been compiled and synthesized in the data report and regional environmental assessment[6] as inputs to the preparation of the REMP. Drawing on those scientific compilations, the environmental characteristics of the Mid-Atlantic Ridge are summarized below.

[6] See https://www.isa.org.jm/event/workshop-regional-environmental-plan-area-northern-mid-atlantic-ridge#BckDocs.

17. The Mid-Atlantic Ridge covers the rocky ridge and a wide range of geomorphological features. The ridge itself has an active spreading centre, with a pronounced central rift valley, while the flanks of the Mid-Atlantic Ridge comprise mainly (greater than 95 per cent) gentle slopes and discontinuous flat plains, which are largely sedimented. The flat plains are generally aligned parallel to the axis of the ridge. Steep (gradients greater than 5 per cent and mainly hard substrate) slopes comprise only about 5 per cent of the Mid-Atlantic Ridge area although in the context of a largely sedimented Atlantic Ocean basin, the Ridge provides a large proportion of hard substrata habitat.

18. The Mid-Atlantic Ridge is a slow-spreading ridge system. The ridge axis is displaced into numerous segments by fracture zones, which can offset the ridge by hundreds of metres to hundreds of kilometres. The combination of processes of magmatism with highly fractured oceanic crust in spreading centres along the Mid-Atlantic Ridge resulted in the formation of a series of hydrothermal vent sites;[7] hydrothermal vent sites are also sourced from fluid-rock reactions that generate heat in the mantle-type rock of oceanic core complexes. The hydrothermal activity at those sites and the resulting precipitation of sulphide minerals have formed hard substrate sulphide-rich systems and, in some places, metal-rich sediments. Several active vents can be located within an active vent field. Within an active vent field, in some locations, sulphide-rich habitat remains hydrothermally active, while in other locations, hydrothermal activity has ceased rendering the vents hydrothermally inactive[8] (inactive vent site). These vent field dynamics result in a diverse mosaic of habitat elements and landscape processes.

19. The large-scale circulation of the North Atlantic consists of largely wind-driven, surface-intensified gyre circulations interacting with a significant density-driven meridional overturning component in which warm surface water is drawn to high latitudes, where they are transformed and returned as dense, deep water. It is the open connection to the Nordic Seas and the Arctic that allows this strong overturning circulation, mediated by the relatively shallow ridge between Greenland and Scotland, which must be traversed by newly formed deep water.

20. The complex hydrographic setting around the Mid-Atlantic Ridge in general and the presence of the ridge itself lead to enhanced vertical mixing and turbulence, which results in areas of increased ocean productivity. The presence of the northern Mid-Atlantic Ridge disrupts the ocean circulation, creating regions of high biomass that may arise from topographic influences on water circulation, bathymetrically induced fronts, and upwelling nutrient-rich deep water. As a result of those factors, the Mid-Atlantic Ridge concentrates biomass over its flanks and summits, creating regions of high productivity.

21. Within the northern Mid-Atlantic Ridge REMP area, there are both bathyal and abyssal regions, as well as two recognized biogeographical provinces at bathyal depths with a biogeographic transition in the vicinity of the Romanche Fracture Zone. Multiple biogeographic regions also apply to the mesopelagic environment in the REMP area.

22. The pelagic environment exhibits large gradients in light, heat and availability of surface-derived food, all of which are, in general, negatively correlated with depth.

[7] Vent site: Hydrothermal occurrence comprising (a group of) hydrothermally active or inactive vents that may cluster around a main structure, for example, a mound or volcano or along a fracture or fissure. Sites can be separated from another site by several tens to hundreds of metres of seafloor that may show some hydrothermal alteration, metalliferous sediments and small-scale structures (for example, talus fans and minor fault scarps).

[8] Inactive: An inactive hydrothermal field does not exhibit fluid flow but may potentially become active again through geological changes.

However, compared with the adjacent abyssal and pelagic environments, the presence of the Mid-Atlantic Ridge has the effect of greatly concentrating biomass. The midwater environment hosts many different species and communities, including those living in mesopelagic or bathypelagic environments. The movement of currents around the ridge and strong diurnal vertical migration of plankton and nekton play an important role in connecting epipelagic and deeper ecosystems.

23. The benthic environment of the northern Mid-Atlantic Ridge is a complex patchwork of habitats spanning a depth range of thousands of metres and encompassing varied seabed geomorphological types. The diverse range of benthic habitats can be broadly grouped into four types: (a) hydrothermal hard substrata habitat (subdivided into hydrothermally active and inactive sulphide-rich habitat); (b) exposed non-sulphide hard substrate (such as basalt); (c) soft sediment (including from pelagic and hydrothermal sediment areas); and (d) the water column 50 m above the seafloor (benthopelagic). These deep-sea benthic habitats are dynamically connected over a range of spatial scales through dispersal processes and interactions with the pelagic ecosystem. Distinguishing between hydrothermally active and inactive sulphide habitats can be challenging, but it is essential because active and inactive habitats support very different biological communities, with different resilience and recovery potential.

24. In the northern Mid-Atlantic Ridge, more than 20 vent sites of polymetallic sulphides have been discovered to date. Distances between hydrothermal sites vary considerably, from 10 to more than 100 km. It has been estimated that all known sites represent 20 to 30 per cent of the predicted number of undiscovered sites. Further advancement in the resource assessment of the sulphide areas may result in the discovery of more vent sites.

25. The environmental setting of the Mid-Atlantic Ridge influences the development of the present REMP in a number of ways. The complex geomorphology and high heterogeneity of habitats make it challenging to identify a representative network of sites or areas that can capture the full range of biodiversity and environmental gradients across the region. Distinct habitats and communities, such as active hydrothermal vent systems, occur at a much finer spatial scale compared with abyssal plain and other deep-sea environments. As such, the goals, objectives and management measures developed under the REMP were designed to reflect those regional characteristics.

26. It should be noted that polymetallic sulphide deposits differ from polymetallic nodule and cobalt-rich ferromanganese crust deposits. This applies to the more complex geological and geomorphological setting and the presence of specific physicochemical conditions and biocenoses associated with hydrothermal vents, as well as to the limited surface extent of polymetallic sulphide deposits on the ocean floor. The surface area of known polymetallic sulphide deposits is measured at a scale of several hundreds of metres, although polymetallic sulphide deposits develop deep into the subsurface, reaching several hundreds of metres of thickness depending on the geodynamic setting and hydrothermal activity. In comparison, the surface area of cobalt-rich ferromanganese crust deposits is dozens of times larger and, in the case of polymetallic nodule deposits, hundreds to thousands of times larger. Owing to the large difference in surface extent of the different mineral deposits, it is likely that potential environmental impacts from exploiting such deposits will be on very different spatial and possibly also temporal scales.

27. As of July 2021, three contracts have been granted by the Authority for the exploration of polymetallic sulphides in the Area of the northern Mid-Atlantic Ridge. Several polymetallic sulphide vent sites are present within existing contract areas for exploration. One of the obligations of contractors is to relinquish parts of their

exploration area. At the end of the relinquishment process, the exploration area for each contractor shall not exceed 2,500 km^2. All relinquished areas revert to the Area.

VII. Region-specific goals and operational objectives

A. Region-specific goals

28. As noted in the Introduction and background section (paras, 5 and 6 above), and in line with the mandate of the Authority and the overarching goals described in paragraph 13 above, the REMP is aimed at achieving the following environmental goals at the regional scale for the northern Mid-Atlantic Ridge:

(a) Prevent habitat loss and degradation to maintain ecosystem viability;

(b) Maintain representative habitats and sensitive marine ecosystems;

(c) Maintain connectivity amongst and between populations;

(d) Maintain regional biodiversity and ecosystem structure, function and processes;

(e) Maintain migratory corridors;

(f) Maintain feeding and breeding grounds;

(g) Consider the impact of climate change.

B. Operational objectives

1. Operational objectives for the area covered under the regional environmental management plan

29. As noted in the Introduction and background section (paras. 5 and 6), and in line with the mandate of the Authority, the following operational objectives apply to the geographical scope of the REMP (see figure above):

(a) Determine the types and distribution of habitats, including through modelling, to assess representativity at the regional scale;

(b) Determine patterns of connectivity between populations of species that are important for maintaining ecosystem function and processes by describing oceanographic circulation for water masses in the region;

(c) Identify and designate, where appropriate, areas and sites in need of protection and establish a process for the review of such sites and areas;

(d) Monitor and assess impacts from activities in the Area;

(e) Identify and map corridors of migratory species such as marine mammals, turtles and seabirds;

(f) Identify feeding and breeding grounds for species such as marine mammals, large nekton and seabirds;

(g) Compile, analyse and synthesize data and information, in collaboration with contractors, the scientific community and competent international and regional organizations, regarding the benthic and pelagic ecosystems as well as food web and energy pathways, thereby enhancing the understanding of ecosystem structure and functioning at a regional level;

(h) Understand and assess cumulative environmental impacts in the REMP area;

(i) Assess the distribution of habitats and model potential responses to impacts from climate change and human activities, which may inform the design of future area-based management tools[9] to be established under the REMP;

(j) Establish a process for periodically assessing environmental baseline data for the region;

(k) Encourage the development of monitoring and mining technologies that can help to effectively address and minimize the potential environmental risks to the Mid-Atlantic Ridge systems that may be posed by the exploitation of polymetallic sulphides.

2. Operational objectives for contract areas

30. The following operational objectives are for the contract areas and their surroundings that may be affected by the activities with implications for the wider REMP area:

(a) Avoid harmful effects on vent sites with diverse and/or abundant biological communities, including vent communities in areas around a potential mine site;

(b) Avoid or minimize harmful effects on sensitive habitats[10] and communities, including coral and/or sponge biogenic habitats in the contract areas and surrounding areas;

(c) Avoid or minimize harmful effects on important species for the maintenance of ecosystem functioning and integrity;

(d) Manage harmful effects on ecologically important sediment systems;

(e) Manage cumulative impacts from activities occurring in the contract areas.

VIII. Management measures

A. Overall consideration

31. It will be particularly important to ensure that the implementation of management measures is coordinated with the implementation of environmental baseline studies and monitoring programmes by contractors. Other exploration activities, including large-scale sampling, testing of mining components and test mining, require a prior environmental impact assessment, in accordance with the recommendations of the Commission (ISBA/25/LTC/6/Rev.1 and ISBA/25/LTC/6/Rev.1/Corr.1). Management measures contained in the REMP should complement the implementation of the activities relating to environmental baseline studies and monitoring.

32. Contractors are encouraged to conduct environmental surveys outside their contract areas, in cooperation with the scientific community and, in particular, scientists from developing States.

33. The REMP does not include area-based management tools identified through the application of network criteria such as representativity and connectivity. It is noted that further work will be needed on the application of such criteria.

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[9] Area-based management tools are spatial instruments for conservation and for managing different forms of ocean use. A multitude of these tools exist in marine areas within and beyond national jurisdiction, ranging from tools for the regulation of specific human activities (e.g., fisheries, shipping or mining) to cross-sectoral tools such as marine-protected areas and marine spatial planning.

[10] Habitats that exist within a narrow range of environmental conditions with ecological characteristics that make them susceptible to impacts and major change owing to disturbance.

34. It is also noted that criteria are needed for assessing the occurrence of sensitive ecosystem features in the application of the criteria for area-based management tools and for evaluating and controlling the impacts of mining activities. Those criteria and thresholds may need to be adaptive and will likely change as new data and information are collected on the impacts of mining activities and new knowledge on habitat and species responses becomes available.

35. Thresholds are needed for evaluating and controlling the impacts of mining activities, as such thresholds would be useful for consistent implementation of non-spatial management measures.

B. Area-based management tools

36. Three types of area-based management tools are considered under the REMP: areas in need of protection, sites in need of protection and sites and areas in need of precaution.

1. Areas in need of protection

37. Areas in need of protection are large-scale areas of ecological importance owing to their uniqueness and/or biodiversity. They are described using, in the context of the Authority, the scientific criteria outlined in annex IV to the present document.

38. Areas in need of protection are aimed at protecting regional-scale ecosystem features, which are important in terms of basin-scale water mass exchange, biogeographical zonation and transitions, connectivity and ecosystem function. Because of their large areal extent and up to abyssal depths, they may cover multiple biogeographical provinces, habitats and ecological gradients.

39. In these areas in need of protection, the following management measures will be applied:

(a) They will be protected from direct or indirect impacts of the exploitation of mineral resources in the Area;

(b) Each of them will be protected as an integrated system;

(c) For the management of the areas in need of protection, where applicable, a zoning scheme should be developed, for example, a core zone of full protection to maintain the sustainability of biological populations; a buffer zone of sufficient size to protect the core zone from indirect effects; and possibly other zones. The zoning scheme should be in place before any exploitation activities in the areas in need of protection occur.

40. On the basis of the outcomes of the workshop held in Evora, Portugal,[11] the REMP identifies three areas in need of protection (Kane Fracture Zone, Vema Fracture Zone and Romanche Fracture Zone System), as listed in annex I.

2. Sites in need of protection

41. Sites in need of protection are fine-scale sites described on an individual basis, using the scientific criteria provided in annex IV. The identification of such sites is intended with a view to managing activities that would have harmful effects.

42. The management of sites in need of protection will be aimed at maintaining ecosystem and community integrity, for example, ecosystem structure and function and associated features from the direct and indirect impacts of exploitation of mineral resources.

[11] See https://isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf.

43. The following management measures shall be applied to all sites in need of protection:

(a) The sites will be protected from the direct and indirect impacts of exploitation of mineral resources. Contractors operating in the vicinity of a site will be required to provide sufficient information and data to ensure that there will be no direct or indirect impacts on the sites, before any proposed exploitation activities can be approved;

(b) Zoning schemes will be developed for the sites, including, for example, a core zone of full protection; a buffer zone of sufficient size to protect the core zone from indirect effects; and possibly other zones in which activities compatible with the management purpose of the sites can be allowed. Buffer zones may be asymmetrical in extent, reflecting the contractors' activities, local oceanography and site geography;

(c) Contractors should delineate, following guidance from the Commission, the specific boundaries of these sites located within their respective contract areas, to a sufficient resolution and precision to allow for management measures as outlined in paragraph 42 above to be applied to protect the habitats, species and ecosystem function of each site;

(d) Contractors may prepare a clear description, through detailed mapping (including physical and biological features), of the different zones in terms of their areal extent, based on the goals and objectives of the REMP, including the identification of a set of different zones and the corresponding set of allowed and/or prohibited activities, which may vary between zones;

(e) Zonation schemes and boundaries should be reviewed by the Commission to ensure that the delineation is in line with the goals and objectives of the REMP. Due consideration will be given to the activities of the contractors. The design of the zoning schemes shall be proportionate to the risks imposed by the exploitation activities.

44. Information on newly discovered sensitive ecosystems and communities will be compiled and used for the future process of identifying sites in need of protection, as follows:

(a) Contractors shall report the discovery of new sensitive ecosystems and communities through their exploration activities, with supporting information including the spatial configuration of such ecosystems and communities, to the Authority as part of their annual reporting process. Such data will be made available through the DeepData database;

(b) In addition to contractors' exploration activities, new sensitive ecosystems and communities can also be discovered by the marine scientific community, which is encouraged to report such discoveries to the Authority so that the Commission may consider their status;

(c) The Commission will consider whether further discussion or appropriate actions would be needed, based on the information received, and will provide its recommendation to the Council at the first available opportunity, taking into account the schedule of meetings.

45. The REMP identifies 11 active vent ecosystems whose existence has been confirmed through direct observation as sites in need of protection.[12] The sites are located within the existing contract areas for exploration, as listed in annex II. They

[12] See the full description of the 11 sites as contained in appendix 1-1 to annex IX to the report on the workshop held in Evora, Portugal, available at https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf.

represent the total number of vent ecosystems discovered to date. Each site in need of protection identified includes the whole vent ecosystem, which may include multiple vents (see annex II).

3. Sites and areas in need of precaution

46. Sites and areas in need of precaution are either fine-scale sites or large-scale areas that have been predicted to have features that may give the site or area important conservation value.

47. When scientific information from further research and direct observation becomes available to the Authority, the Commission will assess whether the site or area in need of precaution should be designated as a site or area in need of protection and make the recommendation to the Council at the first available opportunity, taking into account the schedule of meetings. Information provided by the scientific community and communicated to the Authority can be reviewed by the Commission to help assess whether the site or area in need of precaution should be classified as a site or area in need of protection. If the site or area is found not to meet the criteria for sites or areas in need of protection, its status as a site or area in need of precaution may be removed.

48. Contractors planning to undertake exploitation activities in the site or area in need of precaution are required to apply a precautionary approach and to report to the Authority discoveries of sensitive ecosystems and communities in order for the status of the site or area to be assessed by the Commission. Contractors shall not start exploitation activities until the status of the site or area in need of precaution is assessed by the Commission.

49. The REMP identifies 12 inferred active hydrothermal vent systems as sites in need of precaution, based on the detection of hydrothermal plumes in the water column but not linked to in situ observations associated with active vent sites, and areas of potential cold-water octocoral habitat, drawn from habitat suitability models, as areas in need of precaution, as listed in annex III. Additional sites and areas in need of precaution may be added to future versions of the REMP.

C. Non-spatial management actions

50. Other non-spatial management actions were identified during the expert workshops to complement the area-based management tools and to ensure sound environmental management of exploration and exploitation activities in a way that is consistent with the goals and objectives of the REMP.

1. At the scale of the area covered under the regional environmental management plan

51. The following non-spatial management actions will be applied by the Authority at the regional scale (see figure above for the geographical scope of the REMP):

(a) Assessment of potential cumulative impacts in the REMP area;

(b) Assessment of potential transboundary impacts in areas under the jurisdiction of coastal States;

(c) Development of multiple thresholds based on scientific knowledge, which can enable timely detection of areas where impacts are approaching serious harm. The determination of the thresholds for what would be considered "serious harm" to marine ecosystems and their biodiversity will draw on existing frameworks and strategies and benefit from engagement with experts. Thresholds and monitoring protocols should be in place before any exploitation activities commence.

2. At the scale of contract areas

52. The REMP will apply the following non-spatial management actions at the scale of contract areas:

(a) In sites in need of protection, contractors will ensure the management of the mining plume to minimize adverse impacts on the vent communities;

(b) Contractors should monitor hydrothermal activity to watch for interruption or disruption to hydrothermal flows upon which vent communities rely and that may arise from exploitation activities;

(c) Contractors will monitor sensitive habitats, such as coral and sponge biogenic habitats, and significant communities of fauna within contract areas and their surroundings that may be affected by exploitation activities. Such habitats and communities should be targeted in the environmental management and monitoring plan;

(d) Contractors will actively manage the removal of any sediment overlying the mineral resources (overburden) and its deposition to avoid serious harm to the marine environment in areas surrounding the contract area;

(e) Contractors should control the release and dispersal of metals from exploitation activities beyond the contract areas. The dewatering plume (particles, contaminants and chemically altered water chemistry) should be discharged as close to the seafloor as practical, noting that release in midwater may have wider impacts beyond the contract areas;[13]

(f) Contractors should control the generation of underwater noise from surface vessels and riser pipe pumps, particularly in the sound fixing and ranging channel, and from mining equipment at the seabed, to avoid interference with pelagic fauna communications, particularly marine mammals;[14]

(g) Contractors should control the light from vessels to avoid the attraction of birds and fishes and disrupt their behaviour as long as it can be done safely;

(h) Contractors should prevent the introduction of invasive species from vessels and other parts of the production infrastructure;

(i) Contractors should apply temporal suspension of mining operations during significant biological events (for example, major spawning aggregations).

IX. Knowledge gaps and implementation strategy

53. In the context of implementing the REMP, the following priorities to address gaps in knowledge have been identified. The list can be amended to take account of new scientific evidence. A summary of the present section is provided in annex V.

A. Regional-scale research needed to enhance a comprehensive understanding of the regional environmental baseline and spatial and temporal variations

(a) **Bathymetry, geology and regional-scale high-resolution mapping**. Efforts should continue to collate data and information from different sources,

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[13] These points are considered to be relevant at the regional scale only if multiple sites within an area undergo exploitation activities at the same time.

[14] International Maritime Organization Guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life (2014); and Convention on Biological Diversity and Convention on Migratory Species resolution 12.14 (2017).

including the DeepData database, to develop regional-scale knowledge of morphology and geology, in order to provide a regional baseline and to guide future sampling efforts;

- The secretariat should continue discussions with contractors and competent international organizations to establish how such data already in the DeepData database and from other sources could be used to address this gap.

(b) **Oceanography**. Elucidating deep-water circulation through the ridge would provide an understanding of plume dispersion and patterns of species connectivity through larval transport. Temporal observations will also be important;

- The secretariat should continue to establish how such data already in the DeepData database and from other sources could be used to address this gap and encourage contractors to enhance sampling efforts and collaborate with each other and with the scientific community to establish regional patterns of ocean chemistry, currents and other oceanographic parameters throughout the water column.

(c) **Regional patterns of biodiversity**. Practical first steps at this scale may focus on basic ecological matrices and on a compilation of available regional data on taxa linked to spatial, temporal and environmental variables. Species distribution models at the regional scale should be developed for a range of taxa for which there is adequate information on distribution or abundance/biomass;

- The Commission, supported by the secretariat, should establish how such data already in the DeepData database and from other sources could be used to address this gap.

(d) **Population connectivity**. Initial monitoring and research efforts may focus on validating existing connectivity models. A standardized approach can be established using suitable indicator species for regional analyses of connectivity to provide regional baselines against which changes can be monitored;

- The Commission, in collaboration with experts, should identify groups of species that could serve as indicators and assess appropriate analytical methodologies.

(e) **Migratory corridors of seabirds, marine mammals, sea turtles, fishes or other large animals**. Monitoring and research may focus initially on mapping key habitats that serve as feeding and breeding grounds. Potential impacts from light and underwater noise or plumes on migration corridors and key habitats should be assessed;

- The Commission, supported by the secretariat, should establish how such data already in the DeepData database and from other sources could be used to address this gap and collaborate with experts to develop sensitivity maps.

(f) **Trophic connectivity/relationships**. Monitoring and research are needed to focus on measurements at different trophic levels;

- The secretariat, in discussion with the Commission, should enter into discussions with contractors, scientific communities and competent international and regional organizations to establish how new sampling and data already in the DeepData database and from other sources could be used to address this gap.

(g) **Ecosystem function**. Efforts will be needed to develop a model for ecosystem function at the scale of the Mid-Atlantic Ridge. Studies on community structure may be an essential first step in better understanding relationships within the ecosystem, which may be followed by experimental studies on ecosystem tipping points;

- The secretariat should encourage the scientific community to collaborate with contractors to carry out research to address this knowledge gap.

(h) **Resilience and recovery**. Monitoring and research priorities should focus on the abundance or health of indicator species, changes in community profiles and biological traits linked to sensitivity;

- The secretariat should encourage the scientific community to carry out research to address this knowledge gap under the Authority's Action Plan for Marine Scientific Research in support of the United Nations Decade of Ocean Science for Sustainable Development.

(i) **Risk analyses at the regional scale**. Frameworks and methodologies, such as cumulative impact analyses and scenario planning, should be developed and applied, in order to identify and assess risks, prepare mitigation action plans and establish key thresholds that trigger management actions;

- The Commission will draw on existing approaches and schemes and, in discussion with the secretariat, develop a series of expert discussions.

B. Research to support area-based management

(j) **Habitat mapping (both physical and biological)**. The range of habitats will need to be defined and then mapped within the REMP region to establish environmental baselines;

- The Commission, supported by the secretariat, in collaboration with scientific communities, contractors and international and regional organizations, should establish how such data already in the DeepData database and from other sources could be used to address this gap.

(k) **Area-based management tool networks**. The incorporation of network criteria such as representativity and connectivity will be important in the future development of the REMP. The design of area-based management tool networks will be assessed against region-specific goals such as the protection of representative habitats;

- The Commission, supported by the secretariat, should lead expert discussions on the development and application of network criteria.

(l) **Zoning scheme**. There are important gaps in understanding and designing the size and characteristics of core, buffer and possibly other zones;

- The Commission, in collaboration with experts and contractors, will develop a zoning system and prepare a clear description of the different zones (for example, core and buffer) in terms of their environmental characteristics and areal extent for each site in need of protection and area in need of protection.

(m) **Development of criteria to evaluate the status of the site or area in need of precaution**. The development of such criteria is needed to guide decisions where new scientific data on environmental characteristics, or faunal composition and abundance of sensitive ecosystems and communities, have been provided;

- The Commission, supported by the secretariat, should lead expert discussions on the development and application of these criteria.

(n) **Better knowledge of sites in need of protection, areas in need of protection and sites or areas in need of precaution**. Given that such areas may be located outside contract areas and cover large geographical space, contractors are encouraged to collaborate with scientific organizations to conduct joint surveys. In the case of sites and areas in need of precaution, habitat suitability models can be useful for showing areas where new sites are potentially more likely to be discovered, and contractors and scientists are encouraged to record quantitative measurements of potential sensitive ecosystems through visual surveys;

- The Commission, in collaboration with experts, may facilitate collaborative survey and scientific research efforts with member States, international and regional organizations and multinational research projects.

C. Research to support non-spatial management

(o) **Behaviour, interactions and impact of natural and exploitation plumes**. This will focus on the physical and chemical characterization of natural hydrothermal plumes, as well as plumes from exploitation activities;

- The secretariat should encourage the contractors and scientific communities to carry out research to address this knowledge gap.

(p) **Underwater noise**. The activities and behaviour of marine larvae, fishes and marine mammals should also be monitored to understand the impacts of noises and to inform the development of relevant thresholds;

- The secretariat should encourage the contractors and scientific communities to address this knowledge gap.

(q) **Development of thresholds**. The following thresholds, together with their indicators and methodologies for measuring the thresholds, will be developed for acceptable levels of:

(i) Toxic contaminants and particulates generated in the benthic environment;

(ii) Toxic contaminants in returned water;

(iii) Particulate content of returned water;

(iv) Sediment dispersion, deposition and resuspension;

(v) Changes in the ecological baseline of habitats;

(vi) Cumulative impacts;

(vii) Noise from vessels and noise emitted in the water column and benthic environment;

(viii) Light from vessels and in the benthic environment.

- The Commission, with support from the secretariat, will review and adapt, as appropriate, existing schemas on development and use of thresholds in collaboration with competent international, regional and national organizations. The Commission will facilitate the engagement of experts through workshops and working groups to address this gap.

D. Activities for addressing knowledge gaps

54. The REMP should be implemented progressively by the Authority as recommended by the Commission, taking into account external expert views as appropriate. Contractors should give due consideration to the applicable measures and actions of the REMP in carrying out their activities in the Area.

55. Additional resources may be needed to ensure the adequate implementation of the REMP; this should be the subject of a separate detailed proposal to be developed by the secretariat.

56. A collaborative approach will be essential for monitoring and research at the regional scale. To that end, the secretariat should facilitate collaboration among contractors, sponsoring States, scientific communities and programmes, and competent international and regional organizations in the implementation of the priorities. Such collaboration is aimed at bringing together knowledge and resources, supporting the development of thresholds and sharing best practices. Specific collaboration should be directed towards, inter alia: (a) developing mechanisms for reviewing environmental data in the DeepData database; and (b) intercalibration studies to ensure coherence, consistency and comparability within the DeepData database.

57. The implementation of the research programmes should also create opportunities for capacity-building for developing States, including through collaboration with international and regional organizations and initiatives.

58. Technology will play an important role in future environmental management and monitoring. The secretariat will facilitate a forum on technology development to link engineers, contractors and scientists and to better understand how technology is evolving, the impacts of new technologies, and how technology advancements can improve the ability to monitor the marine environment.

X. Review of the progress in the implementation of the regional environmental management plan

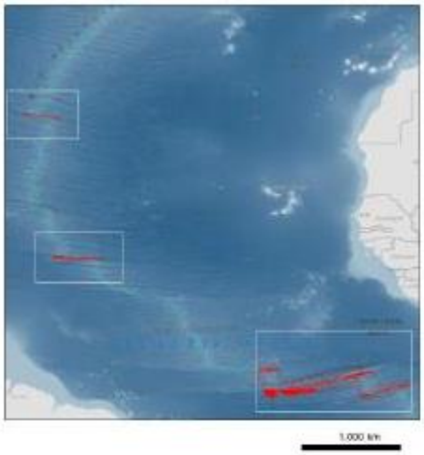
59. The progress in the implementation of the REMP is to be reviewed by the Commission at least every five years, as required, focusing on the key elements of the plan, including the environmental setting, the management measures and the knowledge gaps and implementation strategy. The review will be undertaken to determine its suitability or need for amendment, on the basis of the best available data and information and in alignment with the rules, regulations and procedures of the Authority.

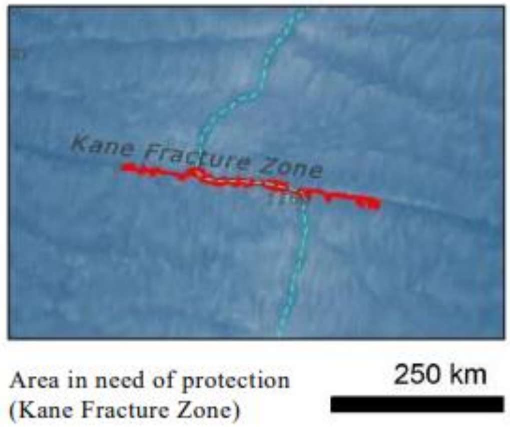
60. The Commission will report the results of the review to the Council, and where appropriate, provide recommendations to the Council on amendments to be considered for strengthening the scientific basis and improving the implementation of the plan.

Annex I

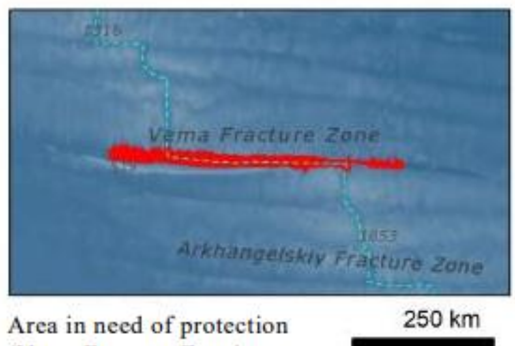
List of areas in need of protection, with coordinates

Maps of the areas in need of protection: Kane Fracture Zone (A), Vema Fracture Zone (B) and Romanche Fracture Zone System (C)





Area in need of protection
(Kane Fracture Zone)



Area in need of protection
(Vema Fracture Zone)

Area in need of protection
(Romanche Fracture Zone System)

Fracture zones: Background

1. Fracture zones are common topographic features of the global oceans that arise through plate tectonics. They are characterized by two strongly contrasting types of topography. Seismically active transform faults form near mid-ocean ridges where oceanic crust is formed and the continental plates drift in opposing directions at their junction. Seismically inactive fracture zones, where the plate segments move in the same direction, extend beyond the transform faults, often for hundreds of kilometres. In the Atlantic basin, most fracture zones originate from the Mid-Atlantic Ridge and are nearly perfectly west–east-oriented. There are about 300 fracture zones occurring on average every 55 km along the ridge, with the offsets created by transform faults ranging from 9 to 400 km in length (Müller and Roest, 1992). The deep west-to-east fracture zones (for example, the Vema Fracture Zone, Romanche Fracture Zone and Kane Fracture Zone) seem to guide the spatial and temporal distribution of thermal fronts and water masses (Belkin and others, 2009).

1. Kane Fracture Zone

2. The Kane Fracture Zone can be traced as a distinct topographic trough from the Mid-Atlantic Ridge near 24°North to the 80-m.y. B.P. isochron (magnetic anomaly 34 time) on either side of the ridge axis for a total of approximately 2,800 km. Major changes in trend of the fracture zone occur at approximately 72 m.y. B.P. (anomaly 31 time) and approximately 53–63 m.y. B.P. (anomaly 21–25 time), which are the result of major reorientations in spreading directions in the central Atlantic Ocean (Purdy and others, 1979). The Kane Fracture Zone offsets the ridge axis over 150 km in a left-lateral sense (Ballu and others, 1997). The eastern intersection between the Kane Fracture Zone and the Mid-Atlantic Ridge constitutes the MARK area and has been intensively surveyed by SeaBeam and Simrad (Gente and others, 1991). The rift valley in the MARK area is 10 to17 km wide and 3,500 to 4,000 m deep, reaching a depth of 6,100 m in the nodal basin at the Ridge-Transform Intersection. The motion along the transform segment is dextral and the measured full spreading rate in the area is close to 3 cm per year.

3. The transform valley varies from 6 to 8 km in width. It is composed of a series of 4,500-metre-deep basins separated by shallower saddles. The relatively disturbed topography of the valley floor suggests that the sedimentary cover is probably thin. The northern wall of the Kane Fracture Zone shows an irregular pattern with a succession of 4,500 metre-deep lows separated by north–south trending highs representative of the oceanic crust created along a north–south ridge axis. Towards the east, the sedimentary cover attenuates the sharpness of the relief (Auzende and others, 1994).

4. The southern wall of the Kane Fracture Zone consists of four successive massifs. They show different stages of vertical evolution from the Ridge-Transform Intersection (zero age) to about the middle part of the Kane Fracture Zone (4-5 mega-annum). The easternmost inside-corner massif located (Auzende and others, 1994) at the Ridge-Transform Intersection reaches to less than 1,200 m depth, while the top of the westernmost massif is at about 2,500 m depth. Each massif shows a convex shape with a steep wall towards the transform valley. Their width is remarkably constant, at about 20 km, and they are separated by deep, north-south depressions several kilometres wide (Auzende and others, 1994).

5. The cirriped species (Young, 1998), ascidians (Monniot and Monniot, 2003) and carnivore sponges (Hestetun and others, 2015) are found at different depths.

Location

6. The Kane Fracture Zone and the surrounding oceanic domain is probably the more intensively surveyed area of the North Atlantic basin. It is located around 23°40' North (see figure above) and offsets the Mid-Atlantic Ridge by about 150 km.

Table 1
Turning points for the Kane Fracture Zone

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
1	-46.9892065	23.9425133	37	-45.2212396	23.7546986
2	-46.9458730	23.9236403	38	-45.1398621	23.7544606
3	-46.8666369	23.9593322	39	-45.1541388	23.6795076
4	-46.8233970	23.9389840	40	-45.0156542	23.6638032
5	-46.7938254	23.9250680	41	-44.9721101	23.6909290
6	-46.7367184	23.8943729	42	-44.9369214	23.6617369
7	-46.6596238	23.8950868	43	-44.8917116	23.6724444
8	-46.5466267	23.8639910	44	-44.8438238	23.6683564
9	-46.5275673	23.8700657	45	-44.7941537	23.6641163
10	-46.4621286	23.8909227	46	-44.7555812	23.6696408
11	-46.4507959	23.9186683	47	-44.7315466	23.6730831
12	-46.4448775	23.9331582	48	-44.6780087	23.6366773
13	-46.3890791	23.9407724	49	-44.6302088	23.6148615
14	-46.3425606	23.9682552	50	-44.5371719	23.6153374
15	-46.2955663	23.9634963	51	-44.4795617	23.6252559
16	-46.2705820	23.9450555	52	-44.4517220	23.6081238
17	-46.2384592	23.9236403	53	-44.4221229	23.6083881
18	-46.2220409	23.8929453	54	-44.3717721	23.6088376
19	-46.1950341	23.8415489	55	-44.3503569	23.5895640
20	-46.1539884	23.8671281	56	-44.2632686	23.5867086
21	-46.1165119	23.8213235	57	-44.2104446	23.5824256
22	-46.0778729	23.8080737	58	-44.1140764	23.5688627
23	-46.0379896	23.8094262	59	-44.0148529	23.5517306
24	-45.9707699	23.8379797	60	-43.9423067	23.5213487
25	-45.9322226	23.8094262	61	-43.9295214	23.5211506
26	-45.8274073	23.8046673	62	-43.9319845	23.4730260
27	-45.7827924	23.8445232	63	-43.9367934	23.4385125
28	-45.7631619	23.8088313	64	-43.9434964	23.4107037
29	-45.6959421	23.8171594	65	-43.9848717	23.3996830
30	-45.6626297	23.7814675	66	-44.0177083	23.4467963
31	-45.5981463	23.8094262	67	-44.0498310	23.4225258
32	-45.5400874	23.7755189	68	-44.0748153	23.4039660
33	-45.4865496	23.7927700	69	-44.0869506	23.4703530
34	-45.4503817	23.7580298	70	-44.1383469	23.5174663
35	-45.3768564	23.7901526	71	-44.1619036	23.5096141
36	-45.3083279	23.7944356	72	-44.1419161	23.4325196

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
73	-44.2083031	23.4496517	109	-46.1587746	23.7497769
74	-44.2604133	23.5381676	110	-46.2265892	23.7521564
75	-44.3382217	23.5395953	111	-46.2836963	23.7652434
76	-44.4180254	23.5577506	112	-46.2967833	23.8223505
77	-44.4515113	23.5653687	113	-46.3645980	23.8401964
78	-44.5609392	23.5774287	114	-46.4332999	23.8417231
79	-44.5752160	23.5167525	115	-46.4716737	23.8425759
80	-44.6116217	23.4989065	109	-46.1587746	23.7497769
81	-44.6380338	23.5296016	110	-46.2265892	23.7521564
82	-44.6473137	23.5917055	111	-46.2836963	23.7652434
83	-44.6775601	23.5891633	112	-46.2967833	23.8223505
84	-44.7236944	23.6224006	113	-46.3645980	23.8401964
85	-44.7289892	23.6230057	114	-46.4332999	23.8417231
86	-44.8236317	23.6338220	115	-46.4716737	23.8425759
87	-44.8236435	23.6337152	109	-46.1587746	23.7497769
88	-44.8275578	23.5981301	110	-46.2265892	23.7521564
89	-44.8532560	23.5317431	111	-46.2836963	23.7652434
90	-44.9032544	23.5553326	112	-46.2967833	23.8223505
91	-44.9450140	23.5428405	113	-46.3645980	23.8401964
92	-44.9835613	23.5542619	114	-46.4332999	23.8417231
93	-45.0064933	23.6071720	115	-46.4716737	23.8425759
94	-45.0725506	23.6308039	109	-46.1587746	23.7497769
95	-45.1962553	23.6315615	110	-46.2265892	23.7521564
96	-45.2551470	23.6440537	111	-46.2836963	23.7652434
97	-45.3092797	23.6375101	112	-46.2967833	23.8223505
98	-45.3390230	23.6623755	113	-46.3645980	23.8401964
99	-45.4125483	23.6852183	114	-46.4332999	23.8417231
100	-45.4990417	23.7267399	115	-46.4716737	23.8425759
101	-45.5817280	23.7255502	109	-46.1587746	23.7497769
102	-45.6186369	23.7069466	110	-46.2265892	23.7521564
103	-45.6780962	23.6934275	111	-46.2836963	23.7652434
104	-45.7542389	23.7326886	112	-46.2967833	23.8223505
105	-45.8196741	23.6934275	113	-46.3645980	23.8401964
106	-45.8986722	23.7480361	114	-46.4332999	23.8417231
107	-45.9648485	23.7366899	115	-46.4716737	23.8425759
108	-46.0357292	23.7037781			

2. Vema Fracture Zone

7. The Vema Fracture Zone is one of the longest fracture zone traces in the Atlantic and covers crustal ages up to >100 Ma. Along the walls of the Fracture Zone, crust is exposed representing seafloor ages covering this range.

8. Several studies have been carried out on an uplifted ridge to the south of the younger regions of the Vema Fracture Zone and the active plate boundary (the Vema

Transform Fault) has also been extensively studied in terms of its deeper crustal structure (Lagabrielle and others, 1992; Mamaloukas-Frangoulis and others, 1991) and lithologies (Cannat and others, 1991; Devey and others, 2018).

9. An important component of the deep-sea habitat is the water masses and their movements above the seafloor. They have relevance both for nutrient supply (trace metals, oxygen) as well as larval dispersal (near-bottom currents). The Vema Fracture Zone is an important conduit through the Mid-Atlantic Ridge for cold and dense bottom water flowing from the western to the eastern Atlantic basin (Fischer and others, 1996).

10. Published records of vesicomyid clams *A. southwardae* in the Vema Fracture Zone suggest the presence of reducing habitats in this area (Krylova and others, 2010). Indications for chemoautotrophic life have also been reported for the active Vema transform fault (Cannat and others., 1991; Krylova and others, 2010). Recently, this evidence was confirmed by pore water anomalies along an east–west transect, indicating the advection of methane-rich fluids in this area (Devey and others, 2018). Patterns of faunal connectivity and abundance at the region demonstrate that the Vema Fracture Zone may act as a conduit for dispersal for the western and eastern basins. Along the Vema Fracture Zone, macrofauna abundances were generally higher on the eastern side than in the west (Brandt and others, 2018). Alive habitat-forming scleractinian corals (*Enallopsammia*) and octocorals (*Isididae, Corallidae*) were reported from 094 James Cook cruise (Robinson, 2013).

Location

11. The Vema Fracture Zone is located at 10° 46' North and is a narrow ~5,000-metre-deep valley that offsets the Mid-Atlantic Ridge by 320 km (Kastens et al., 1998).

Table 2
Turning points for the Vema Fracture Zone

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
1	-44.4142454	11.0104244	19	-44.0763620	10.9809191	37	-43.5643020	10.9228602
2	-44.4028240	10.9847262	20	-44.0440013	10.9523656	38	-43.5538044	10.9504854
3	-44.3923544	10.9942441	21	-44.0116406	10.9380888	39	-43.5462181	10.9704495
4	-44.3809330	11.0237494	22	-43.9792800	10.9476066	40	-43.5090985	10.9609316
5	-44.3723669	11.0589654	23	-43.9459675	10.9951959	41	-43.4526236	10.9406359
6	-44.3419098	11.0627726	24	-43.9202693	11.0009066	42	-43.4481843	10.9390406
7	-44.3295366	11.0399297	25	-43.8905824	10.9962498	43	-43.4053540	10.9304745
8	-44.3181152	11.0189905	26	-43.8717283	10.9932923	44	-43.4018732	10.9356957
9	-44.3066938	10.9894852	27	-43.8308016	11.0037619	45	-43.3844147	10.9618834
10	-44.2933688	10.9752084	28	-43.8172856	10.9959642	46	-43.3596683	10.9628352
11	-44.2667189	11.0028101	29	-43.8060552	10.9894852	47	-43.3349219	10.9333299
12	-44.2410207	11.0266047	30	-43.7917784	10.9656905	48	-43.3246115	10.9281746
13	-44.2238886	11.0227976	31	-43.7784535	10.9352334	49	-43.3063684	10.9190531
14	-44.1962868	11.0142316	32	-43.7584660	10.9323781	50	-43.2711524	10.9142942
15	-44.1658297	10.9923405	33	-43.7384785	11.0332672	51	-43.2615039	10.9215305
16	-44.1652042	10.9922333	34	-43.6775643	11.0332672	52	-43.2521167	10.9285710
17	-44.1325173	10.9866298	35	-43.6375894	10.9790155	53	-43.2264185	10.9618834
18	-44.1030119	10.9980512	36	-43.6042769	10.9295227	54	-43.1988168	10.9590281

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
55	-43.1626490	10.9276192	98	-42.2958136	10.8824152	141	-41.0953732	10.8086461
56	-43.1217222	10.9609316	99	-42.2822484	10.8933549	142	-41.0439769	10.8143568
57	-43.0874580	10.9495102	100	-42.2717788	10.8962103	143	-40.9859180	10.8143568
58	-43.0769884	10.9352334	101	-42.2548169	10.8812439	144	-40.9583251	10.8160291
59	-43.0665187	10.9181013	102	-42.2394181	10.8676568	145	-40.9231003	10.8181640
60	-43.0531938	10.9266674	103	-42.2191173	10.8802239	146	-40.8858614	10.8066376
61	-43.0370134	10.9371370	104	-42.1994431	10.8924031	147	-40.8831253	10.8057908
62	-43.0122670	10.9409442	105	-42.1737450	10.8819335	148	-40.8660124	10.8046240
63	-42.9979903	10.9257156	106	-42.1657278	10.8786985	149	-40.8412468	10.8029354
64	-42.9780028	10.9085835	107	-42.1194933	10.8600425	150	-40.8330699	10.8380479
65	-42.9646778	10.9181013	108	-42.0595308	10.8609943	151	-40.8250665	10.8724157
66	-42.9570635	10.9095353	109	-42.0388271	10.8750728	152	-40.8136451	10.8809817
67	-42.9503795	10.8886475	110	-42.0357362	10.8771746	153	-40.8060308	10.8448139
68	-42.9494493	10.8857407	111	-41.9967131	10.8828853	154	-40.7992088	10.8206269
69	-42.9432564	10.8878947	112	-41.9837514	10.8739742	155	-40.7955612	10.8076943
70	-42.9275582	10.8933549	113	-41.9662560	10.8619460	156	-40.7831387	10.8056239
71	-42.8856797	10.8943067	114	-41.9386542	10.8628978	157	-40.7781093	10.8047857
72	-42.8698745	10.8835304	115	-41.8863061	10.8619460	158	-40.7755553	10.8043600
73	-42.8647404	10.8800300	116	-41.8634351	10.8719521	159	-40.7441648	10.7991283
74	-42.8609388	10.8830517	117	-41.8558490	10.8715271	160	-40.7003827	10.7867551
75	-42.8276209	10.9095353	118	-41.8301508	10.8724157	161	-40.6952066	10.7990142
76	-42.8123923	10.9019210	119	-41.8101633	10.8847889	162	-40.6822988	10.8295854
77	-42.7752727	10.8819335	120	-41.7521045	10.8800300	163	-40.6575524	10.8276818
78	-42.7457674	10.8933549	121	-41.7362711	10.8698149	164	-40.6404203	10.7848515
79	-42.7229246	10.8771746	122	-41.7225992	10.8609943	165	-40.6251917	10.7962729
80	-42.6629621	10.8790782	123	-41.6930938	10.8657532	166	-40.5536493	10.7874293
81	-42.6401193	10.8847889	124	-41.6464564	10.8676568	167	-40.5350895	10.8088444
82	-42.5934819	10.8866924	125	-41.6105851	10.8676568	168	-40.5262062	10.7810444
83	-42.5655454	10.8702592	126	-41.5969636	10.8676568	169	-40.5062187	10.7753337
84	-42.5611212	10.8676568	127	-41.5788797	10.8743192	170	-40.4871830	10.8067426
85	-42.5535951	10.8710777	128	-41.5512780	10.8686085	171	-40.4808378	10.8495332
86	-42.5401820	10.8771746	129	-41.5074375	10.8657983	172	-40.4424491	10.8552836
87	-42.5333948	10.8724613	130	-41.4770388	10.8638496	173	-40.4195786	10.8319721
88	-42.5059177	10.8533800	131	-41.3989925	10.8581389	174	-40.4115955	10.8238350
89	-42.4735571	10.8571871	132	-41.3770859	10.8634496	175	-40.3872456	10.7905622
90	-42.4554731	10.8695603	133	-41.3675836	10.8657532	176	-40.3216518	10.8131274
91	-42.4345339	10.8705121	134	-41.3637683	10.8632096	177	-40.3109443	10.7760078
92	-42.4002697	10.8495728	135	-41.3333193	10.8429104	178	-40.2795354	10.7860016
93	-42.3707643	10.8762228	136	-41.2705016	10.8419586	179	-40.2488403	10.8138413
94	-42.3636235	10.8840437	137	-41.2352855	10.8457657	180	-40.2387673	10.7848515
95	-42.3507769	10.8981139	138	-41.1895999	10.8248265	181	-40.2149727	10.7829479
96	-42.3306837	10.8834115	139	-41.1790902	10.8227702	182	-40.1810257	10.8516747
97	-42.3117537	10.8695603	140	-41.1458178	10.8162604	183	-40.1597692	10.8200675

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
184	-40.1635763	10.7877069	227	-40.7041898	10.7458283	270	-41.4399192	10.6953838
185	-40.1664317	10.7458283	228	-40.7365505	10.7591533	271	-41.4732316	10.6725410
186	-40.1426371	10.7391659	229	-40.7604207	10.7639274	272	-41.5036887	10.6496981
187	-40.1093246	10.7629605	230	-40.7928747	10.7704182	273	-41.5038510	10.6487249
188	-40.1003620	10.8745175	231	-40.7936576	10.7705747	274	-41.5103512	10.6097232
189	-40.0796606	10.8002783	232	-40.8536200	10.7772372	275	-41.5208209	10.6021089
190	-40.0589593	10.8488194	233	-40.9459431	10.7772372	276	-41.5360494	10.6144821
191	-40.0398443	10.7620087	234	-41.0239894	10.7800926	277	-41.5455673	10.6401803
192	-40.0360372	10.8153086	235	-41.0572328	10.7793620	278	-41.5542483	10.6496330
193	-39.9836891	10.7867551	236	-41.1106018	10.7781890	279	-41.5883976	10.6868177
194	-39.9531498	10.7658139	237	-41.1629499	10.7743819	280	-41.6226618	10.6658785
195	-39.9525870	10.7521359	238	-41.2124427	10.7639123	281	-41.6445528	10.6734927
196	-39.9518089	10.7332254	239	-41.2160798	10.7540402	282	-41.6826242	10.6772999
197	-39.9524469	10.7145231	240	-41.2191052	10.7458283	283	-41.7264063	10.6896731
198	-39.9536609	10.6789395	241	-41.1905517	10.7420212	284	-41.8073080	10.7125159
199	-39.9694123	10.6849141	242	-41.1420107	10.7325034	285	-41.8882096	10.7106123
200	-40.0055801	10.6782517	243	-41.0687233	10.7334552	286	-41.9710149	10.6944320
201	-40.0236640	10.6677820	244	-40.9659306	10.7363105	287	-42.0243148	10.6896731
202	-40.0417479	10.6487463	245	-40.8954985	10.7401176	288	-42.0899879	10.7077570
203	-40.0617354	10.6601678	246	-40.8909974	10.7413680	289	-42.1870699	10.6982391
204	-40.0807711	10.6782517	247	-40.8612343	10.7496355	290	-42.2736823	10.7001427
205	-40.1407335	10.6830106	248	-40.8288736	10.7515391	291	-42.4269196	10.6991909
206	-40.1959370	10.6772999	249	-40.7974647	10.7277444	292	-42.5858676	10.6972873
207	-40.2330566	10.6953838	250	-40.7993683	10.6887213	293	-42.7533817	10.6963356
208	-40.2597065	10.6696856	251	-40.8079343	10.6630231	294	-42.9294618	10.6963356
209	-40.2835011	10.6763481	252	-40.8212593	10.6220964	295	-42.9875206	10.6953838
210	-40.2968261	10.6906249	253	-40.8450539	10.5954464	296	-43.0874580	10.7010945
211	-40.3272832	10.6972873	254	-40.8736075	10.5963982	297	-43.2083346	10.7077570
212	-40.3567885	10.7039498	255	-40.8935949	10.6201928	298	-43.2978023	10.7144195
213	-40.3558368	10.6772999	256	-40.9097753	10.6639749	299	-43.3882219	10.7248891
214	-40.3653546	10.6677820	257	-40.9421359	10.6925284	300	-43.4672200	10.7372623
215	-40.3881974	10.6772999	258	-40.9982912	10.7049016	301	-43.5519288	10.7458283
216	-40.4015224	10.6858659	259	-41.0211341	10.6830106	302	-43.6309269	10.7477319
217	-40.4111157	10.6906626	260	-41.0373144	10.6953838	303	-43.7222982	10.7677194
218	-40.4148474	10.6925284	261	-41.0630126	10.7134677	304	-43.7519900	10.7651847
219	-40.4500634	10.7001427	262	-41.1153607	10.7115641	305	-43.8003445	10.7610569
220	-40.4786169	10.6820588	263	-41.1448660	10.7134677	306	-43.8581073	10.7833919
221	-40.4881348	10.6915766	264	-41.1724678	10.7010945	307	-43.8717283	10.7886586
222	-40.4995562	10.7077570	265	-41.2476587	10.6991909	308	-43.9221729	10.7762855
223	-40.5109776	10.7220337	266	-41.2904890	10.7068052	309	-43.9440640	10.7562980
224	-40.5614222	10.7325034	267	-41.3190426	10.7020463	310	-44.0078335	10.7553462
225	-40.6366132	10.7382141	268	-41.3809086	10.6830106	311	-44.1030119	10.7553462
226	-40.6834141	10.7434874	269	-41.4008960	10.6972873	312	-44.1374665	10.7615729

Points	Longitude	Latitude	Points	Longitude	Latitude	Points	Longitude	Latitude
313	-44.1820101	10.7696230	323	-44.6165497	10.8795345	333	-44.5179899	11.0294601
314	-44.2362618	10.7791408	324	-44.6193874	10.9177036	334	-44.5008578	10.9970994
315	-44.3124045	10.7791408	325	-44.6196756	10.9215791	335	-44.4827739	10.9799673
316	-44.3790294	10.7753337	326	-44.6223126	10.9735988	336	-44.4665936	11.0142316
317	-44.4104383	10.7962729	327	-44.6230222	10.9821396	337	-44.4513650	11.0561101
318	-44.4627865	10.8000801	328	-44.6017470	10.9723530	338	-44.4370883	11.0694350
319	-44.5551095	10.8057908	329	-44.5798559	10.9856780	339	-44.4151972	11.0513511
320	-44.6070384	10.8074659	330	-44.5674827	11.0294601	340	-44.4142454	11.0104244
321	-44.6108045	10.8332848	331	-44.5522542	11.0618208			
322	-44.6114455	10.8376793	332	-44.5322667	11.0570618			

3. Romanche Fracture Zone System

12. The Romanche Fracture Zone System is characterized by parallel ridge crests and trenches that extend in the east-west direction approaching the north-east Brazilian and West African continental margins. Crests are generally characterized by a roughed topography but may also include sediment-covered and relatively flat areas and gentle slopes. The Romanche Fracture Zone System may reach a depth of 7,761 m.

13. The Romanche Fracture Zone System dramatically affects the Atlantic deep-water circulation, chiefly determined by the northward flow of the Antarctic Bottom Water (>4,000 m) and the southward flow of the North Atlantic Deep Water (1,500-4,000 m). In the western side, these water masses flow through conduits created by the Romanche Fracture Zone System (Dunn et and others, 2018) connecting the North and South Atlantic deep environments. (Huang and Jin, 2002). The influence of the Romanche Fracture Zone System on the circulation patterns of the North Atlantic Deep Water and the Antarctic Bottom Water have been regarded as a key element in testing the deep-water fauna dispersal hypothesis (German and others, 2011).

14. The Equatorial Atlantic has been characterized by an elevated diversity and abundance of pelagic organisms, compared with the adjacent northern and southern subtropical gyres of the Atlantic. In essence, that has been explained by the effect of complex surface circulation patterns, elevated temperature and productivity regimes. Data in support of these patterns are found in specific plankton and micronekton studies focusing on euphasiids (Gibbons, 1997), myctophids and other mesopelagic fish (Bakus, 1977) and cephalopods (Rosa and others, 2008; Perez and Bolstad, 2011). The area also concentrates important catches of large pelagic fishes, including the yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) and swordfish (*Xiphias gladius*) (https://iccat.org) (Fonteneau and Soubrier, 1996). The area is a feeding ground for a West African population of leatherback turtles (*Demochelis coriacea*) and olive ridley turtles (*Lepidochelys olivacea*) (both critically endangered according to International Union for Conservation of Nature and Natural Resources criteria) (Billes and others, 2006; Fretey and others, 2007; Georges and others, 2007; Witt and others, 2011; Da Silva and others, 2011).

15. Limited data are available on benthic and benthopelagic fauna, but models tend to predict a relatively high seafloor biomass, particularly in the Western Equatorial area (Wei and others, 2010). The data derived from surveys conducted in the southern

Mid-Atlantic Ridge have also revealed a high benthic diversity (Perez and others, 2012).

Location

16. The area extends approximately 300 km across the Equatorial Atlantic basin from the western border of the Guinea Basin (10°West) in the east to the north-east limit of the Brazilian continental margin (32°West) in the west and encloses three major fracture zones: St Paul's, Romanche and Chain.

Table 3
Turning points for the Romanche Fracture Zone System

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
1	-15.7433035	0.5282108	34	-16.8685433	0.1364343	67	-17.5575127	-0.0941358
2	-15.6772096	0.4858205	35	-16.8807940	0.1228710	68	-17.6003430	-0.0955635
3	-15.6700018	0.4802524	36	-16.9101039	0.0876991	69	-17.6902867	-0.1169787
4	-15.6786903	0.4812178	37	-16.9164859	0.0800407	70	-17.7364469	-0.1162897
5	-15.7043885	0.4683687	38	-16.9293350	0.0400658	71	-17.7859410	-0.1155510
6	-15.7124237	0.4598314	39	-16.9311298	0.0365959	72	-17.8330543	-0.1326831
7	-15.7272313	0.4440982	40	-16.9507502	-0.0013369	73	-17.8353147	-0.1350691
8	-15.7586402	0.4226831	41	-17.0064296	-0.0198967	74	-17.8587525	-0.1598090
9	-15.8414455	0.4112617	42	-17.0649643	-0.0170413	75	-17.8674357	-0.1639897
10	-15.8871311	0.4126894	43	-17.1149330	0.0043738	76	-17.8972998	-0.1783688
11	-15.9071186	0.3984126	44	-17.1290158	0.0150768	77	-17.9615452	-0.2083500
12	-15.9656533	0.3841358	45	-17.1506249	0.0314997	78	-18.0200800	-0.2226267
13	-15.9999176	0.3941296	46	-17.1469461	0.0100402	79	-18.0200800	-0.2226267
14	-16.0180902	0.4064610	47	-17.1420588	-0.0184690	80	-18.0729040	-0.2540356
15	-16.0398925	0.4212554	48	-17.0957417	-0.0506896	81	-18.1014575	-0.2540356
16	-16.0969996	0.4255384	49	-17.0885713	-0.0556777	82	-18.1266972	-0.2447368
17	-16.1441129	0.4112617	50	-17.0763857	-0.0641546	83	-18.1285834	-0.2440419
18	-16.1856866	0.3710291	51	-17.0992285	-0.0884251	84	-18.1324125	-0.2469520
19	-16.1883709	0.3684314	52	-17.1491972	-0.0941358	85	-18.1642753	-0.2711677
20	-16.2589652	0.3194708	53	-17.1929826	-0.0780044	86	-18.2085333	-0.2911552
21	-16.2768868	0.3070413	54	-17.2034489	-0.0741484	87	-18.2485082	-0.2940106
22	-16.3611197	0.2870538	55	-17.2166281	-0.0632612	88	-18.2597151	-0.2919991
23	-16.4582018	0.2385128	56	-17.2362855	-0.0470225	89	-18.3041876	-0.2840168
24	-16.5581391	0.2028209	57	-17.2648390	-0.0284627	90	-18.3798545	-0.3011489
25	-16.5981141	0.2013932	58	-17.2768751	-0.0264567	91	-18.4341062	-0.3225641
26	-16.6090872	0.2076113	59	-17.2991033	-0.0227520	92	-18.4969239	-0.3339855
27	-16.6409444	0.2256637	60	-17.3547827	-0.0398841	93	-18.5383266	-0.3439792
28	-16.6709256	0.2413682	61	-17.3593644	-0.0446651	94	-18.6016202	-0.3568283
29	-16.7116082	0.2421078	62	-17.3658566	-0.0514395	95	-18.6302924	-0.3482267
30	-16.7494478	0.2427958	63	-17.3876192	-0.0741484	96	-18.6396916	-0.3454069
31	-16.7893816	0.2102183	64	-17.4490093	-0.0755760	97	-18.7234486	-0.3872854
32	-16.8036995	0.1985379	65	-17.4540338	-0.0761722	98	-18.7976878	-0.3948997
33	-16.8408191	0.1671290	66	-17.5332422	-0.0855698	99	-18.8890591	-0.4139354

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
100	-18.9575876	-0.4348747	143	-21.7310873	-0.9355133	186	-22.0984761	-1.4266340
101	-19.0527660	-0.4462961	144	-21.7765224	-0.9374887	187	-22.1993653	-1.4304411
102	-19.1403302	-0.4596210	145	-21.8186515	-0.9393204	188	-22.2218533	-1.4343917
103	-19.1701634	-0.4799076	146	-21.9347692	-0.9545489	189	-22.3402294	-1.4551875
104	-19.1879194	-0.4919817	147	-22.0356584	-0.9964275	190	-22.4544435	-1.4666089
105	-19.2242026	-0.4850706	148	-22.1079940	-1.0249810	191	-22.5103432	-1.4886539
106	-19.2278944	-0.4843674	149	-22.1147699	-1.0511168	192	-22.5895969	-1.5199089
107	-19.3078443	-0.4843674	150	-22.1213189	-1.0763773	193	-22.7533038	-1.5389446
108	-19.3858906	-0.4881746	151	-22.1135256	-1.1257355	194	-22.9360464	-1.5408481
109	-19.4410941	-0.4805603	152	-22.1098975	-1.1487130	195	-22.9931535	-1.5713052
110	-19.4962976	-0.4843674	153	-22.0394655	-1.1601344	196	-23.0902355	-1.5427517
111	-19.4962976	-0.5110670	154	-21.9519013	-1.1296773	197	-23.2710745	-1.5713052
112	-19.4962976	-0.5300531	155	-21.8453015	-1.0763773	198	-23.4252636	-1.5294267
113	-19.5857653	-0.5605102	156	-21.7786766	-1.1182559	199	-23.4703826	-1.5226280
114	-19.6561973	-0.5795459	157	-21.7101481	-1.1087380	200	-23.5642241	-1.5084875
115	-19.7380508	-0.5833530	158	-21.6359089	-1.1296773	201	-23.6708240	-1.5046803
116	-19.8002061	-0.5882279	159	-21.6035482	-1.1011237	202	-23.6941213	-1.4933158
117	-19.8351328	-0.5909673	160	-21.3846378	-1.1030273	203	-23.7488703	-1.4666089
118	-19.9112756	-0.6252315	161	-21.3579879	-1.0725702	204	-23.8668915	-1.4799339
119	-19.9204613	-0.6300946	162	-21.3027844	-1.0364024	205	-23.9297093	-1.4532840
120	-19.9759969	-0.6594958	163	-21.1999916	-1.0383060	206	-23.9449379	-1.3980805
121	-20.0457409	-0.6841113	164	-21.1124275	-0.9964275	207	-23.9335164	-1.3048056
122	-20.0730789	-0.6937600	165	-21.0534168	-1.0344988	208	-23.9339910	-1.3034935
123	-20.1036332	-0.6937600	166	-20.9734670	-1.0820880	209	-23.9592449	-1.2336739
124	-20.1587395	-0.6937600	167	-20.8364100	-1.1030273	210	-23.9658771	-1.2153379
125	-20.1663538	-0.7032779	168	-20.7336173	-1.1315808	211	-24.1676554	-1.1963022
126	-20.1685128	-0.7045733	169	-20.7227829	-1.1577639	212	-24.3028088	-1.2305664
127	-20.1949073	-0.7204100	170	-20.7170582	-1.1715987	213	-24.3096208	-1.2714387
128	-20.2297826	-0.7147849	171	-20.7107745	-1.1867843	214	-24.3142302	-1.2990949
129	-20.2539179	-0.7108921	172	-20.6669924	-1.3009985	215	-24.3151822	-1.3447925
130	-20.3080600	-0.7126109	173	-20.7431351	-1.3124199	216	-24.3180373	-1.4818375
131	-20.3738428	-0.7146993	174	-20.7696558	-1.3029903	217	-24.3069251	-1.5498997
132	-20.4880569	-0.7070850	175	-20.8287957	-1.2819628	218	-24.3028088	-1.5751124
133	-20.6346317	-0.7375421	176	-20.9277813	-1.2724449	219	-24.4378293	-1.5779253
134	-20.7526530	-0.7851313	177	-21.0305740	-1.2876735	220	-24.4855514	-1.5789195
135	-20.8992278	-0.8003599	178	-21.1847631	-1.3029020	221	-24.5179121	-1.5732088
136	-21.0819704	-0.8422384	179	-21.3123022	-1.3485877	222	-24.5481324	-1.6015403
137	-21.1695345	-0.8498527	180	-21.4227092	-1.3790448	223	-24.5483692	-1.6017623
138	-21.2875558	-0.8707919	181	-21.5559590	-1.4037912	224	-24.5523194	-1.6274390
139	-21.3960592	-0.8898276	182	-21.6701731	-1.4075983	225	-24.5674049	-1.7254943
140	-21.5540554	-0.9050561	183	-21.8243622	-1.4114055	226	-24.7292082	-1.7864085
141	-21.6367311	-0.9173044	184	-21.9538049	-1.4095019	227	-24.9804793	-1.7521443
142	-21.6568482	-0.9202847	185	-21.9754926	-1.4120702	228	-25.1460898	-1.6664837

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
229	-25.2279432	-1.6322194	272	-24.5479608	-1.0885707	315	-22.5424835	-1.0024951
230	-25.3310983	-1.6235196	273	-24.5279058	-1.0957699	316	-22.4339801	-0.9653755
231	-25.3364423	-1.6131804	274	-24.4850755	-1.0881557	317	-22.3026339	-0.9187381
232	-25.3653032	-1.5573415	275	-24.4403416	-1.0929146	318	-22.2713908	-0.8944977
233	-25.3952779	-1.4844442	276	-24.3832346	-1.0881557	319	-22.2474304	-0.8759078
234	-25.4188246	-1.4091952	277	-24.2775865	-1.0586504	320	-22.1646251	-0.8406917
235	-25.4357646	-1.3321670	278	-24.2071545	-1.0434218	321	-22.1573532	-0.8378569
236	-25.4450205	-1.2642300	279	-24.1519510	-1.0367593	322	-22.1084699	-0.8188007
237	-25.4580336	-1.1315198	280	-24.0938921	-1.0329522	323	-22.0675875	-0.8113222
238	-25.4587202	-1.1245182	281	-24.0491583	-1.0377111	324	-22.0304235	-0.8045239
239	-25.4587543	-1.1243620	282	-24.0053762	-1.0481807	325	-21.9533290	-0.7902472
240	-25.4125894	-1.1178989	283	-23.9615941	-1.0386629	326	-21.8809934	-0.7750186
241	-25.3555352	-1.1335428	284	-23.9206674	-1.0272415	327	-21.8029471	-0.7635972
242	-25.3388261	-1.1381244	285	-23.8702228	-1.0281933	328	-21.7883437	-0.7648400
243	-25.3341129	-1.1339656	286	-23.8359585	-1.0158201	329	-21.7582132	-0.7674043
244	-25.3186007	-1.1202784	287	-23.7607676	-1.0348557	330	-21.6858776	-0.7531276
245	-25.2507861	-1.1143297	288	-23.7207926	-1.0281933	331	-21.5983134	-0.7359954
246	-25.1948687	-1.1274168	289	-23.6836730	-1.0167718	332	-21.4926653	-0.7264776
247	-25.1460898	-1.1143297	290	-23.6532159	-1.0053504	333	-21.4650636	-0.7102973
248	-25.0794649	-1.1000530	291	-23.5999160	-1.0072540	334	-21.3993905	-0.7160080
249	-25.0101540	-1.0953539	292	-23.5190143	-0.9967844	335	-21.3698852	-0.7083937
250	-25.0092708	-1.0952941	293	-23.4561966	-0.9882183	336	-21.3061156	-0.7026830
251	-24.9664405	-1.1143297	294	-23.3971859	-0.9853630	337	-21.2480568	-0.6893580
252	-24.9190292	-1.1421581	295	-23.2982004	-0.9644237	338	-21.2099854	-0.6769848
253	-24.9117129	-1.1464525	296	-23.2020701	-0.9606166	339	-21.1871426	-0.6655634
254	-24.8546058	-1.1476422	297	-23.1897098	-0.9534476	340	-21.1585890	-0.6646116
255	-24.8396682	-1.1417843	298	-23.1775592	-0.9464002	341	-21.1071927	-0.6674670
256	-24.7939295	-1.1238476	299	-23.1544809	-0.9330148	342	-21.0710249	-0.6569973
257	-24.8077304	-1.0938664	300	-23.1240238	-0.9101720	343	-21.0358088	-0.6436724
258	-24.7858394	-1.0710236	301	-23.0926149	-0.9187381	344	-21.0015446	-0.6408170
259	-24.7477680	-1.0700718	302	-22.9888704	-0.9092202	345	-20.9358715	-0.6293956
260	-24.7420988	-1.0668322	303	-22.8708492	-0.9006541	346	-20.8873305	-0.6246367
261	-24.7211180	-1.0548432	304	-22.8181635	-0.8757276	347	-20.7988145	-0.6046492
262	-24.6954199	-1.0348557	305	-22.7823332	-0.8587756	348	-20.7750469	-0.5983435
263	-24.6729291	-1.0357208	306	-22.6966726	-0.8616310	349	-20.7055396	-0.5799028
264	-24.6706735	-1.0358075	307	-22.6955167	-0.8694913	350	-20.6198791	-0.5570600
265	-24.6468789	-1.0529397	308	-22.6871548	-0.9263523	351	-20.5532541	-0.5427832
266	-24.6173735	-1.0358075	309	-22.7021356	-0.9422695	352	-20.4599793	-0.5180368
267	-24.6107111	-1.0120129	310	-22.7023833	-0.9425327	353	-20.3914508	-0.5047118
268	-24.5469415	-1.0043986	311	-22.7157083	-0.9691826	354	-20.2743813	-0.4675922
269	-24.5536040	-1.0272415	312	-22.7071053	-0.9808827	355	-20.2020457	-0.4457012
270	-24.5650254	-1.0529397	313	-22.6919137	-1.0015433	356	-20.1525529	-0.4409423
271	-24.5650254	-1.0824450	314	-22.6081567	-1.0082058	357	-20.1259029	-0.4457012

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
358	-20.0983012	-0.4504601	401	-18.5335676	-0.1068660	444	-17.2791158	0.2319693
359	-20.0535673	-0.4333280	402	-18.5173547	-0.0960573	445	-17.2315266	0.2262586
360	-20.0354834	-0.4171477	403	-18.5123042	-0.0926903	446	-17.1820338	0.2319693
361	-20.0069299	-0.4000156	404	-18.5107248	-0.0916374	447	-17.1420588	0.2510050
362	-19.9726657	-0.3981120	405	-18.4859784	-0.0821196	448	-17.1268303	0.2776549
363	-19.9431603	-0.3847870	406	-18.4777502	-0.0829424	449	-17.1363481	0.2985942
364	-19.9088961	-0.3733656	407	-18.4760312	-0.0831143	450	-17.1150060	0.3185136
365	-19.8632105	-0.3686067	408	-18.4479070	-0.0859267	451	-17.1077946	0.3252442
366	-19.8394158	-0.3628960	409	-18.3803304	-0.0821196	452	-17.0583018	0.3309549
367	-19.8118141	-0.3524263	410	-18.3508250	-0.0668910	453	-17.0183269	0.3461834
368	-19.7718391	-0.3533781	411	-18.2861037	-0.0450000	454	-16.9440877	0.3595084
369	-19.7204428	-0.3391013	412	-18.2204306	-0.0221571	455	-16.8888842	0.3766405
370	-19.7111859	-0.3319015	413	-18.2134256	-0.0171536	456	-16.8482317	0.3717129
371	-19.7033107	-0.3257764	414	-18.1871181	0.0016375	457	-16.8260664	0.3690262
372	-19.6673113	-0.3164862	415	-18.1528539	0.0206732	458	-16.7918022	0.3576048
373	-19.6443000	-0.3105478	416	-18.1490477	0.0259066	459	-16.7594415	0.3595084
374	-19.6301963	-0.3090632	417	-18.1376253	0.0416124	460	-16.7386597	0.4026706
375	-19.6081322	-0.3067407	418	-18.1109754	0.0454195	461	-16.7346951	0.4109048
376	-19.5424591	-0.3010300	419	-18.0976504	0.0625517	462	-16.7175630	0.4299404
377	-19.4863038	-0.2991264	420	-18.0929302	0.0845790	463	-16.6547452	0.4508797
378	-19.4862398	-0.2991308	421	-18.0919397	0.0892016	464	-16.5557597	0.4527833
379	-19.4311003	-0.3029335	422	-18.0514486	0.0940606	465	-16.5404827	0.4520889
380	-19.4377628	-0.3324389	423	-18.0443505	0.0949123	466	-16.5138811	0.4508797
381	-19.4481116	-0.3464097	424	-18.0500612	0.0720695	467	-16.5073013	0.4410100
382	-19.4567985	-0.3581370	425	-18.0024719	0.0758767	468	-16.5043544	0.4365895
383	-19.4263414	-0.3609924	426	-17.9605934	0.0949123	469	-16.4986526	0.4280369
384	-19.4120646	-0.3467156	427	-17.8406686	0.1215623	470	-16.4713381	0.4305976
385	-19.3302112	-0.3324389	428	-17.7721401	0.1329837	471	-16.4377384	0.4337476
386	-19.2455024	-0.3200657	429	-17.7484158	0.1263936	472	-16.3939563	0.4375547
387	-19.1864917	-0.3000782	430	-17.7378759	0.1234659	473	-16.3444635	0.4375547
388	-19.1132043	-0.2905603	431	-17.6535564	0.1422035	474	-16.3254278	0.4432654
389	-19.0770923	-0.2796773	432	-17.6350832	0.1463087	475	-16.2492851	0.4489761
390	-19.0437241	-0.2696211	433	-17.6321382	0.1457732	476	-16.2416708	0.4832404
391	-19.0104116	-0.2524890	434	-17.5932047	0.1386944	477	-16.1902744	0.4889511
392	-18.9152332	-0.2334533	435	-17.5721965	0.1557635	478	-16.1614530	0.5004797
393	-18.8570271	-0.2142968	436	-17.5627476	0.1634408	479	-16.1522031	0.5041796
394	-18.8400422	-0.2087069	437	-17.5061609	0.1667694	480	-16.1122281	0.5327332
395	-18.7991155	-0.1963337	438	-17.4980262	0.1672480	481	-16.0341818	0.5289260
396	-18.7534298	-0.1753944	439	-17.4953944	0.1685639	482	-16.0040498	0.5289260
397	-18.7010817	-0.1573105	440	-17.4561477	0.1881872	483	-15.9523283	0.5289260
398	-18.6553960	-0.1458891	441	-17.4256906	0.2015122	484	-15.9104498	0.5251189
399	-18.6192282	-0.1401784	442	-17.3781014	0.2034158	485	-15.8704749	0.5289260
400	-18.5754462	-0.1297088	443	-17.3228979	0.2224514	486	-15.8381142	0.5441546

Points	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*	*Points*	*Longitude*	*Latitude*
487	-15.7829107	0.5460581						
488	-15.7804302	0.5485387						
489	-15.7433035	0.5282108						

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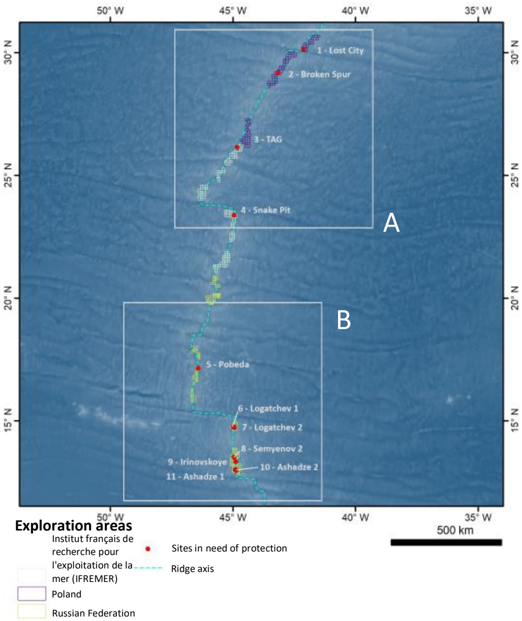
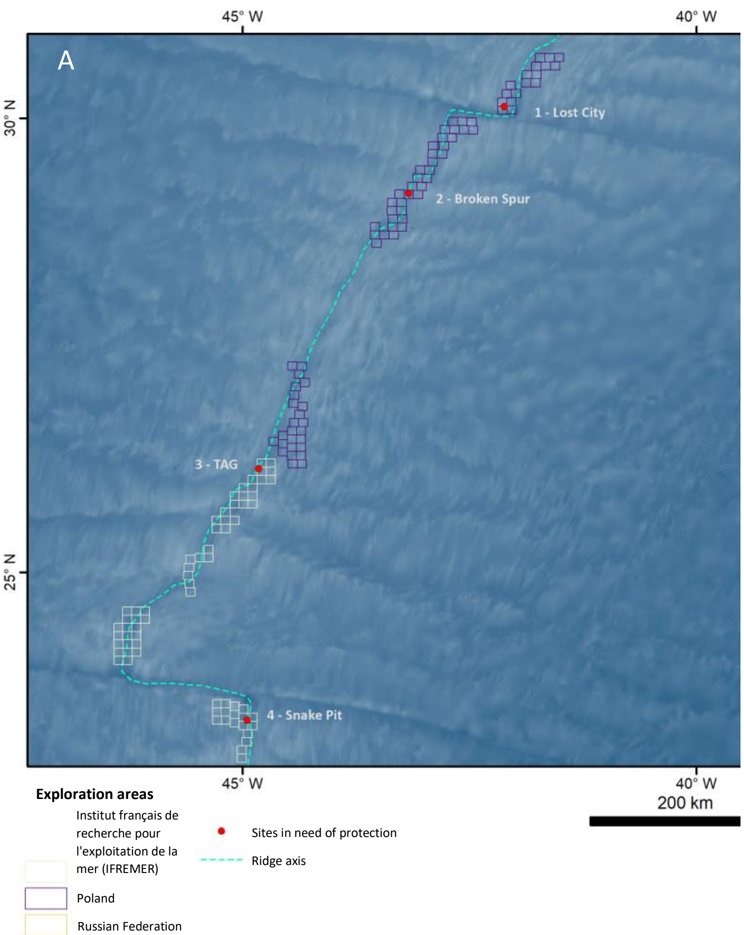
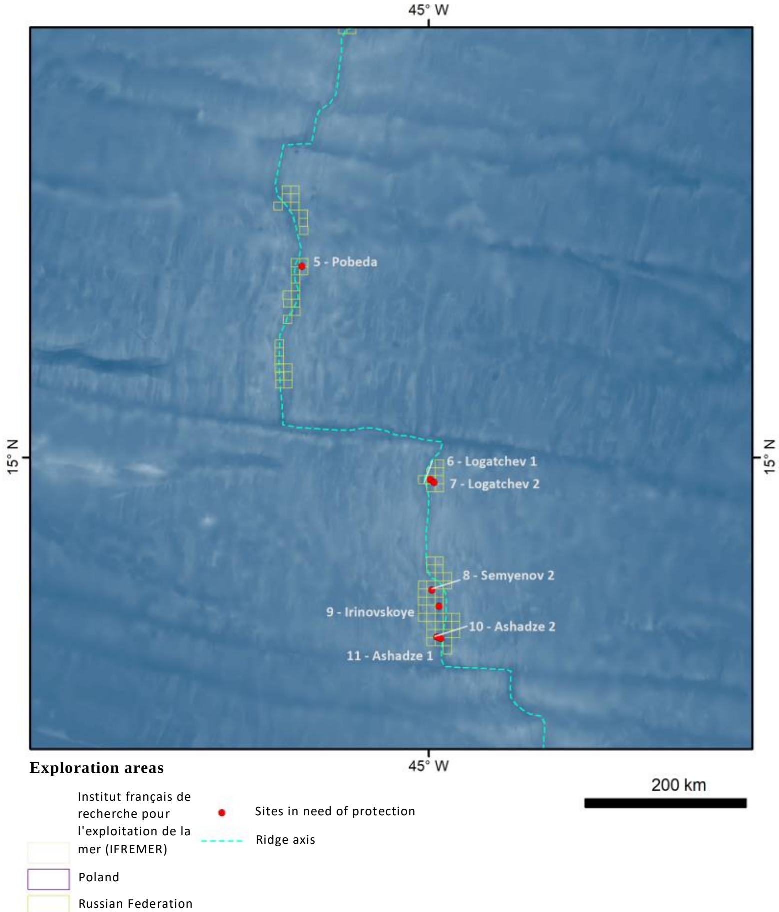
Annex II

List of sites in need of protection, with coordinates

Maps of sites in need of protection







I. Hydrothermal vents: background

1. Sites in need of protection are designed to preserve specific examples of ecosystems and habitats that are vulnerable to disruption or impact from human activities. Currently, only active hydrothermal vents have been identified as regionally important ecosystem features in potential need of fine-scale site protection. A total of 11 sites along the Mid-Atlantic Ridge have been identified, some of which have been the subject of research by the scientific community as well as by contractors. Some sites have been the focus of a decade's or longer-term study. In addition, a further 12 inferred sites have been identified but not investigated. Currently, no other fine-scale sites have been detected and assessed (for example, coral gardens, sponge biogenic habitats, sediment habitats).

II. Description of sites in need of protection[15]

1. Lost City – Node ID 967

2. The Lost City hydrothermal site was discovered in 2000 (Kelley and others, 2001 and 2005; Blackman and others, 2001) on the Atlantis Massif (an oceanic core complex), 30°North, Mid-Atlantic Ridge, bounded to the south by the Atlantis Fracture Zone. It remains to date a singular site among hydrothermal systems, characterized by diffusely venting, low-temperature (90 Celsius maximum) carbonate monoliths (30–60 m in height) on a relatively shallow (720–800 m) region of the Mid-Atlantic Ridge. The site is located on 1.5-Myr-old crust, nearly 15 km from the spreading axis. Fluids emanating from the seabed are dominated by heat and products of exothermic serpentinization of peridotite (ultramafic rock) rather than seawater-basalt reactions. Fluids emanating from Lost City are alkaline (pH 9 to 11), hydrogen- and methane-rich, and devoid of dissolved metals. The fauna of Lost City vents is visually dominated by wreckfish (*Polyprion americanus*), cutthroat eels (*Synaphobranchus kaupi*) and large geryonid crabs (Kelley and others, 2005). Lost City hydrothermal vents are posited as a contemporary analogue for conditions where life on early Earth may have originated (Sojo and others, 2016), where there is abiogenic production of organic carbon (Proskurowski and others, 2008) and where there are conditions similar to those that might support life within oceans of extraterrestrial planetary bodies (Judge, 2017). Lost City was also recognized as a potential site of outstanding universal value in the high seas (Freestone and others, 2016).

Location

Latitude: 30.1250
Longitude: -42.1183
Number of vent sites within vent field: 4
See: https://vents-data.interridge.org/ventfield/lost-city

2. Broken Spur – Node ID 663

3. Broken Spur comprises at least three hydrothermally active (365ºC) mounds (up to 40 m high) and two weathered sulfide mounds on the neovolcanic ridge of the rift valley (3,100 m). Venting fluids are clear, with diffuse (50°C) venting at the base of chimneys (Murton and others, 1994 and 1995; Vereshchaka and others, 2002). Quantitative studies of vent communities at Broken Spur have been reported in Rybakova and Galkin (2015) and Copley and others (1997). No change in shrimp density was detected at an interval of 15 months (Copley and others, 1997). Broken Spur differs from other vent sites on the Mid-Atlantic Ridge in that the hydrothermal fluids have elevated sulfide concentrations and low methane concentrations (Desbruyères and others, 2000).

4. The shrimp *Rimicaris exoculata* occurs in low densities, with the exception of larger populations at one structure (Copley and others, 1997). Other dominant taxa endemic to discrete active hydrothermal vents on the Mid-Atlantic Ridge include crabs (*Segonzacia mesatlantica*), nematodes, limpets and anemones (*Parasicyonis ingolfi*). Perhaps the most unique feature of the Broken Spur hydrothermal field is

[15] The following descriptions are summaries of those contained in appendix 1 to annex X to the Report of the Workshop on the Regional Environmental Management Plan for The Area of the Northern Mid-Atlantic Ridge, available at https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf.

that it is a zone in which two species of mussels (the northern species *Bathymodiolus azoricus* and the southern species *B. puteoserpentis*) overlap and in which they hybridize (O'Mullan and others, 2001; Breusing and others, 2016). Broken Spur is characterized by a high diversity of microhabitats with diverse gradients of temperature, fluid flux and mineral substrata (Murton and others, 1994 and 1995; Copley, 1997). The mussel species at Broken Spur are bioengineers that host associated invertebrate assemblages (Rybakova and Galkin, 2015).

Location

Latitude: 29.1700
Longitude: -43.1717
Number of vents: at least three mounds
See: https://vents-data.interridge.org/ventfield/broken-spur

3. TAG – Node ID 1181

5. The basalt-hosted TAG active hydrothermal vent site is to date the largest known sulfide occurrence on the mid-Atlantic ridge system at a nominal depth of 3,500 m (Karson and others, 2015). It is a complex environment, with high-temperature black-smoker complexes and a large apron with lower-temperature, diffuse flow. The site has been supported by hydrothermal activity for at least 150,000 years, with episodic high-temperature activity lasting tens to hundreds of years (Lalou and others, 1990 and 1995). In addition to the hydrothermally active TAG mound, there are numerous inactive or extinct sulfide mounds, recently mapped by Murton and others (2019). Biomass at the active TAG site is dominated by dense aggregations of "blind" shrimp (*Rimicaris exoculata*) on black-smoker chimneys. There is a large literature on the feeding strategies of these shrimp, their derived eyes modified for detecting dim sources of light, and their reproductive biology and connectivity. On the lower-temperature, sulfide apron, there are abundant shrimp-eating anemones (*Maractis rimicarivora*). Mussels are so far absent at the active TAG mound (Galkin and Moskalev, 1990), although they are found at every other known active vent on the northern Mid-Atlantic Ridge. Because the active TAG mound hosts large (Van Dover and others, 1988; Gebruk and others, 1993; Copley and others, 2007) and stable (Copley and others, 1997 and 2007) populations of *Rimicaris exoculata* and *Maractis rimicarivora* (Copley and others, 1997), these populations are considered to be important source populations for their respective metapopulations, i.e., the site is important as a reproductive area.

Location

Latitude: 26.1367
Longitude: -44.8267
See: https://vents-data.interridge.org/ventfield/tag

4. Snake Pit – Node ID 1128

6. The Snake Pit hydrothermal field, located at the summit of Snake Pit Ridge, was so named because of the abundance of synaphobranchid cutthroat eels (*Ilyophis saldanhai*) observed during an *Alvin* dive in 1986. The high-temperature field was first discovered during an Ocean Drilling Programme site-survey cruise in 1985 (Karson and others, 1987) and was further explored by geologists during a French submersible dive series in 1988 (Gente and others, 1991). Snake Pit is located 25 km south of the Kane fracture. The valley has a depth of 3,800 m and a width of 15 km

and the seafloor is composed of tectonized basaltic lava (Karson and others, 1987). The graben formation occurred 2,850 to 2,500 years ago, the most ancient sulphides being approximately 4,000 years old (Lalou and others, 1995). Thus, Snake Pit is much younger than the TAG vent field. The vent field is located on the southern flank of the highest volcanic cone. It is composed of three mounds. Covering an area of 45,000m^2, the field is divided in distinct zones, all of which are characterized by the presence of a large talus mound of several metres on top of which active and extinct vents are perched (Fouquet and others, 1993; Honnorez and others, 1990). The most active mound and the larger sulphide deposits are the most eastern one; it was drilled during Ocean Drilling Programme leg 106 (Fouquet and others, 1993). Snake Pit is particularly remarkable for its high geochemical and mineralogical diversity (Fouquet and others, 1993; Honnorez and others, 1990; Kase and others, 1990).

7. The active zone had at least 12 active structures separated by a talus of intact inactive chimneys, massive sulphide blocks and deposits of hydrothermal sediments (Karson and others, 1987; Karson and Brown, 1988). High-temperature (366°C) fluids are vented from black-smoker chimneys and low-temperature (226°C) fluids seep from sulphide domes (Karson and Brown, 1988).

8. Located ~300 km south of TAG, Snake Pit has four known active sites: Moose (Elan), Beehive (Les Ruches), Fir Tree (Le Sapin) and Nail (Le Clou), an active site that is not well characterized (La Falaise) as well as several low-temperature sites. The major venting activity of the field is found at Les Ruches (100 m^2). This mound harbours a complex of several active sulphide structures (~>10 m high) as well as inactive chimneys. Elan (3,500 m, 80 m^2) is particularly distinctive, with the presence of chimneys with vertical conduits as well as large beehives and flanges that make it resemble moose antlers; this type of structure is not reported anywhere else. On the centre of the vent field, Le Sapin (a few m^2) is a 22-metre-high mound characterized by low-temperature diffuse flow areas. On the western part, Le Clou (40 m^2) and La Falaise constitute a large north-south area of ~130 m to 160 m, with an elevation of 65 m.

9. Relative to TAG, the Snake Pit sulphide mounds are small, but the surfaces of high-temperature chimneys are occupied by dense populations of *Rimicaris exoculata* shrimp (Segonzac, 1992). Three other species of shrimp have also been observed (*Rimicaris chacei*, *Mirocaris fortunata*, *Alvinocaris markensis*). Shrimp nurseries as well as areas of gastropod egg layouts have been observed (Sarrazin, pers. obs.). Unlike TAG, Snake Pit hosts mussels (*Bathymodiolus puteoserpentis*) whose distribution is restricted to Elan and Le Clou (Vereshchaka and others, 2002). Dense assemblages of peltospirid gastropods can be found in high-temperature habitats (Sarrazin and others, in prep). *Phymorhyncus* gastropods, anemones and ophiurids colonize the less active zones, at the base of the active sites. Zoarcid fish (*Pachycara thermophilum*) are particularly abundant (Sarrazin, pers. obs.). A description of the Snake Pit biological community was first provided by Segonzac and others (1992) and a quantitative study of biodiversity associated with Snake Pit mussel beds was reported by Turnipseed and others (2003). Like other active vent sites on the Mid-Atlantic Ridge, Snake Pit has been repeatedly visited by scientists, partly owing to its location within the contract area sponsored by France (Bicose cruises in 2014 and 2018; Hermine cruise in 2017). Recent biological studies were focused on connectivity (Breusing and others, 2016), physiological tolerances (Ravaux and others, 2019), microbial symbionts (Zbinden and others, 2017; Apremont and others, 2018) and trace metals (Demina and Galkin, 2016).

Location

Latitude: 23.3683
Longitude: -44.9500
Number of vent sites within vent field: 4
See: https://vents-data.interridge.org/ventfield/snake-pit

5. Pobeda

Introduction

10. During video profiling in this area, indications of modern hydrothermal activity were recorded. Extensive fields of shells of *Bathymodiolus puteoserpentis* and *Thyasira* sp. were discovered and samples of bivalves were taken using the TV-grab and geological square corer.

Location

Pobeda 1

Depth: 1,950–2,400
Latitude: 17.145
Longitude: -46.408

Pobeda 2

Depth: 2,800–3,100
Latitude: 17.138
Longitude: -46.403

6. Logatchev 1 – Node ID 960

11. The Logatchev-1, depth 2,900 to 3,050 m, formerly known as "14-45", was discovered in 1993–1994 during the seventh cruise of the research vessel *Professor Logatchev* (Batuyev and others, 1994). The Logatchev-1 area extends over approximately 600 m in the north-west south-east direction and comprises at least nine hydrothermal sites of various sizes and types (listed from north-west to south-east): Quest, Anya's Garden, Irin-2, Site F, Site B, Irina-1, Candelabra, Anna-Louise and Site A (Borowski and others, 2008; Fouquet and others, 2008). The major geological peculiarities of the Logatchev-1 hydrothermal system include its association with gabbro-peridotites, location close to the top of the rift wall and development of "smoking craters". The variety of habitats includes active chimney complex (Irina II), "smoking crater" (Anna-Louise), large sulphide body (Irina I) and diffuse flow sites (Anya's Garden and Site F).

12. The Logatchev vent community was described by Gebruk and others (2000). Van Dover and Doerries (2005) published a quantitative study on the mussel beds. The analysis of the symbioses between bivalves (*Bathymodiolus*, *Thyasira* and *Abyssogena*) and bacteria, based on histological observations (transmission electron microscopy), and nitrogen and carbon stable isotopes, was published by Southward and others (2001). The most striking biological feature of this hydrothermal field is the existence of a large population of vesicomyid clams at the Anya's Garden site, together with small populations of thyasirids *Thyasira* (*Parathyasira*) and mussels *Bathymodiolus puteoserpentis*. This is the only known live population of vesicomyids north of the equator on the Mid-Atlantic Ridge. The clams were referred to as *Ectenagena* aff. *kaikoi* in Gebruk and others (2000) but appeared to belong to the new genus and species *Abyssogena southwardae* (Krylova and others, 2010). The biomass on the mussel bed at Irina-2 exceeded 70 kg m^2 (wet weight with shells) and was the highest known for the Mid-Atlantic Ridge vent fields (Gebruk and others, 2000). Overall, the Logatchev area is dominated by mussels, which may be attributed to the presence in their gills of two types of symbionts: methane-oxidizing (dominant type) and sulphur-oxidizing (Southward and others, 2001). The large swarm of *Rimicaris exoculata* is a characteristic of the Irina-2 chimney complex. Prominent features of

the Logatchev field include the quantitative abundance of brittle stars *Ophioctenella acies* (at the Irina-2 site, their contribution to the abundance exceeds 80 per cent (Van Dover and Doerries, 2005)) and a high biomass and density of the species of *Phymorhynchus* (*P. moskalevi*, *P. ovatus* and *P. carinatus*) (Gebruk and others, 2010).

13. Community dynamics over a decadal scale at Logatchev were studied by Gebruk and others (2010). The most significant change in the community was at Irina-2, based on a comparison of data from March 2007 and July 1997. The population density of predatory gastropods *Phymorchynchus* spp. increased dramatically – more than four times. Some increase in the abundance of the brittle star *Ophioctenella acies* also was noted. Over the same 10-year period, the population of vesicomyids at Anya's Garden disappeared, with no signs of recovery in the whole area of Logatchev-1 (Gebruk and others, 2010).

Location

Latitude: 14.7520
Longitude: -44.9785
Number of vent sites within vent field: 10
See: https://vents-data.interridge.org/ventfield/logatchev

7. Logatchev 2 – Node ID 961

14. Logatchev-2 lies 5.5 km south-east of Logatchev-1 at the depth of 2,640 to 2,760 m. This area was also discovered in 1993–1994 concurrent with Logatchev-1 (Batuyev and others, 1994).

15. An extensive field (several tens of metres across) of dead mussel shells (*B. puteoserpensis*) was found on the slope of the mound that had a weakly active chimney on top expelling shimmering water. The mussel shells still had their periostracum, indicating a recent catastrophic collapse of a large population, apparently as a result of a rapid slowing down of the hydrothermal activity. Only a few live mussels, as well as shrimps *Chorocaris chacei* and *Mirocaris fortunata*, were recorded on the single active chimney (Gebruk and others, 2010).

Location

Latitude: 14.7200
Longitude: -44.9380
Number of vent sites within vent field: 1
See: https://vents-data.interridge.org/ventfield/logatchev-2

8. Semyenov-2 – Node ID 1122

16. This field was discovered on the thirtieth cruise of research vessel *Professor Logatchev*, in 2007 (Bel'tenev and others, 2007). It includes five vent sites and one of them, Semenov-2, is active (Bel'tenev and others, 2009). Distance from the ridge axis varies from 0.5 km (Semenov-4) to 10.5 km (Semenov-1) (Cherkashov and others, 2017). The active site Semenov-2 is located 3.5 km from the axis at the depth of 2,360 to 2,580 m and is related to basalts. This site consists of two deposits (sulfide mounds and products of their disintegration). The dimensions of the deposits are 600 x 400 m and 200 x 175 m, respectively. Age estimations of the site vary from 3.1 to 76 ka years (Cherkashov and others, 2017).

17. Information on biota comes from the only one TV-grab station (Station 275) taken at 13°30.82′North, 44°57.78′West, at a depth of 2,441 m. At least 12 taxa were

preliminary identified in this sample, including the mussel *Bathymodiolus puteoserpentis*, the gastropod *Phymorhynchus ovatus*, polychaetes *Amathys lutzi* and *Levensteiniella* sp., the pycnogonid *Sericosura heteroscela*, shrimps *Alvinocaris markensis* and *Opaepele susannae*, the crab *Segonzacia mesatlantica* and the brittle star *Ophioctenella acies* (Bel'tenev and others, 2009).

18. Of special interest is the record of the shrimp *O. susannae* (six specimens in the sample). This species has been described on the Mid-Atlantic Ridge from two locations south of the equator: Lilliput (9°32′South, 1,500 m) and Sisters Peak (4°48′South, 2,986 m) (Komai and others, 2007). The new record of *O. susannae* north of the equator is important for understanding relationships of hydrothermal vent fauna north and south of the equator on the Mid-Atlantic Ridge.

Location

Latitude: 13.5137
Longitude: -44.9630
Number of vent sites within vent field: 5
See: https://vents-data.interridge.org/ventfield/semyenov

9. Irinovskoe – Node ID 982 (former Mid-Atlantic Ridge, 13 19′North oceanic core complex)

19. The Irinovskoe hydrothermal field, explored during ROV(remotely operated vehicle) dives 553 and 557, is located on the northern region of the 13º20' North corrugated surface, 1.8 km from the footwall cutoff in the direction of extension. Coalescing mounds rise up to 10 to 20 m above the surrounding seafloor, masking corrugations of the detachment surface over an area 300 to 200 m in the across- and along-extension directions, respectively. During two ROV dives, two active vents at the summit of hydrothermal mounds, Active Pot and Pinnacle Ridge, were identified. Both show black-smoker fluids venting at 365 C from 1 to 2 metre-high cauldron-shaped structures with large exit orifices (several decimetres in diameter), clearly associated with very elevated heat and mass fluxes. Associated macrofauna was not observed in the initial explorations, while bacterial mats and diffuse lower-temperature outflow were limited to the immediate vicinity of these two active vents. The nearby hydrothermal mounds show both fallen and standing hydrothermal chimneys, up to 10 m in height (Escartin and others, 2017).

Location

Latitude: 13.3333
Longitude: -44.9000
See: https://vents-data.interridge.org/ventfield/mar-13-19n-occ

10. Ashadze 2 – Node ID 647

20. The Ashadze 2 site was discovered by monitoring anomalies in the electric potential (EP) recorded by the deep-towed Rift system during a 2003 cruise (Fouquet and others, 2008). There is a black-smoker field on serpentinized peridotites, 2.5 miles north-west of Ashadze 1. The Ashadze 2 field lies in the northern part of a wide terrace and has a small active crater with a mixture of carbonates and copper-rich sulfides. Fouquet and others (2008) state: "On the Ashadze 2 site, a large group of smokers occurs, in a crater-shaped depression, about 25 m in diameter at the bottom of the graben structure. This constructional structure may indicate the sometimes-explosive nature of the hydrothermal fluid emissions.". Two types of hydrothermal

deposits have been observed: massive copper-rich sulfides associated with the black smokers and carbonate/sulfides chimneys (Fouquet and others, 2007). Data from scientific surveys show that "the Ashadze 2 field is unusual; the small active crater can be interpreted as a hydrothermal volcano built up with a mixture of carbonates and secondary copper sulfides and copper chlorides. Massive sulfide chimneys are associated with the active smokers at the center of the crater." (Fourquet and others, 2008). This unusual system may provide valuable insights into the functional dynamics of hydrothermal vent systems.

No biological data are yet available.

Location

Latitude: 12.9917
Longitude: -44.9067
See: https://vents-data.interridge.org/ventfield/ashadze-2

11. Ashadze 1 – Node ID 646

21. Ashadze-1 (12° 58′North, 44° 51′West, 4,080 m) is the deepest known active hydrothermal vent field on the Mid-Atlantic Ridge. The Ashadze-1 hydrothermal vent site is organized around a group of three very active black-smoker vents. The 2-metre-high "Long chimney" is located at the top of a small mound (Fabri and others, 2011). There is a high diversity of microhabitats, with a complex of sulphide structures, high fluid-flow/diffuse-flow habitats that provide essential temperature/fluid/substrata gradients for hydrothermal vent faunal communities (ibid.). This is a black-smoker field on serpentinized peridotites, at the foot of the western slope of the Mid-Atlantic Ridge rift valley, and is the deepest active black-smoker field known as of 2009 (see https://vents-data.interridge.org/ventfield/ashadze).

22. The first observations on this site were numerous clear and black smokers and surprisingly few known symbiotic species dominant in other vent areas on the Mid-Atlantic Ridge. The most abundant species at Ashadze-1 are those usually found at the periphery of hydrothermal communities: sea anemones *Maractis rimicarivora* and chaetopterid polychaetes *Phyllochaetopterus* sp. Nov. (ibid.). As the deepest vent field on the Mid-Atlantic Ridge vent field, this site hosts a significant source population of hydrothermal vent fauna at depth (ibid.), maintaining connectivity along deeper sections of the Ridge. The site hosts abundant populations of the amphinomid polychaete *Archinome* sp. and scale worms (Polynoidae) such as *Iphionella* sp. and *Levensteiniella iris*. Two species of *Phymorhynchus* (gastropod) are also present and are considered as predators of other mollusks or necrophagous. Pycnogonids were also collected at the base of the chimneys. The carnivorous/necrophagous level is also represented by the crab *Segonzacia mesatlantica* and by the zoarcid fish *Pachycara thermophilum*. Some galatheids are also present (Fouquet and others, 2008). Ashadze-1 could be the stepping stone in species dispersal along the Mid-Atlantic Ridge between Logatchev and areas south of the equator (ibid., 2011).

Location

Latitude: 12.9733
Longitude: -44.8633
See: https://vents-data.interridge.org/ventfield/ashadze

Geographical Information System coordinates for sites in need of protection

Site in need of protection	*Longitude*	*Latitude*
Lost City	-42.1183000	30.1250000
Broken Spur	-43.1717000	29.1700000
TAG	-44.8267000	26.1367000
Snake Pit	-44.9500000	23.3683000
Pobeda	-46.4166670	17.1333330
Logatchev 1	-44.9785000	14.7520000
Logatchev 2	-44.9380000	14.7200000
Semyenov 2	-44.9630000	13.5137000
Irinovskoe	-44.8833330	13.3333330
Ashadze 2	-44.9067000	12.9917000
Ashadze 1	-44.8633000	12.9733000

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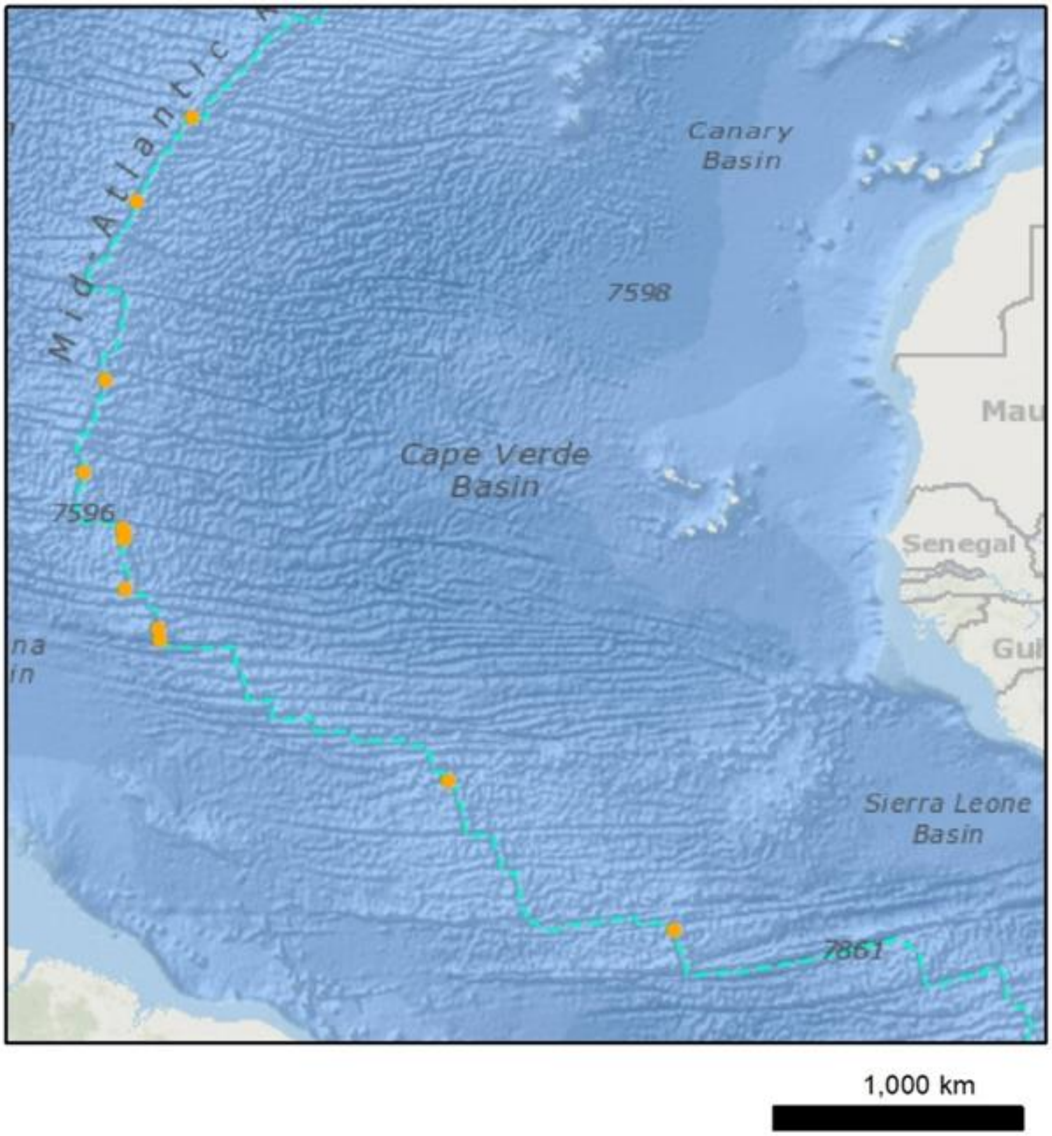
Annex III

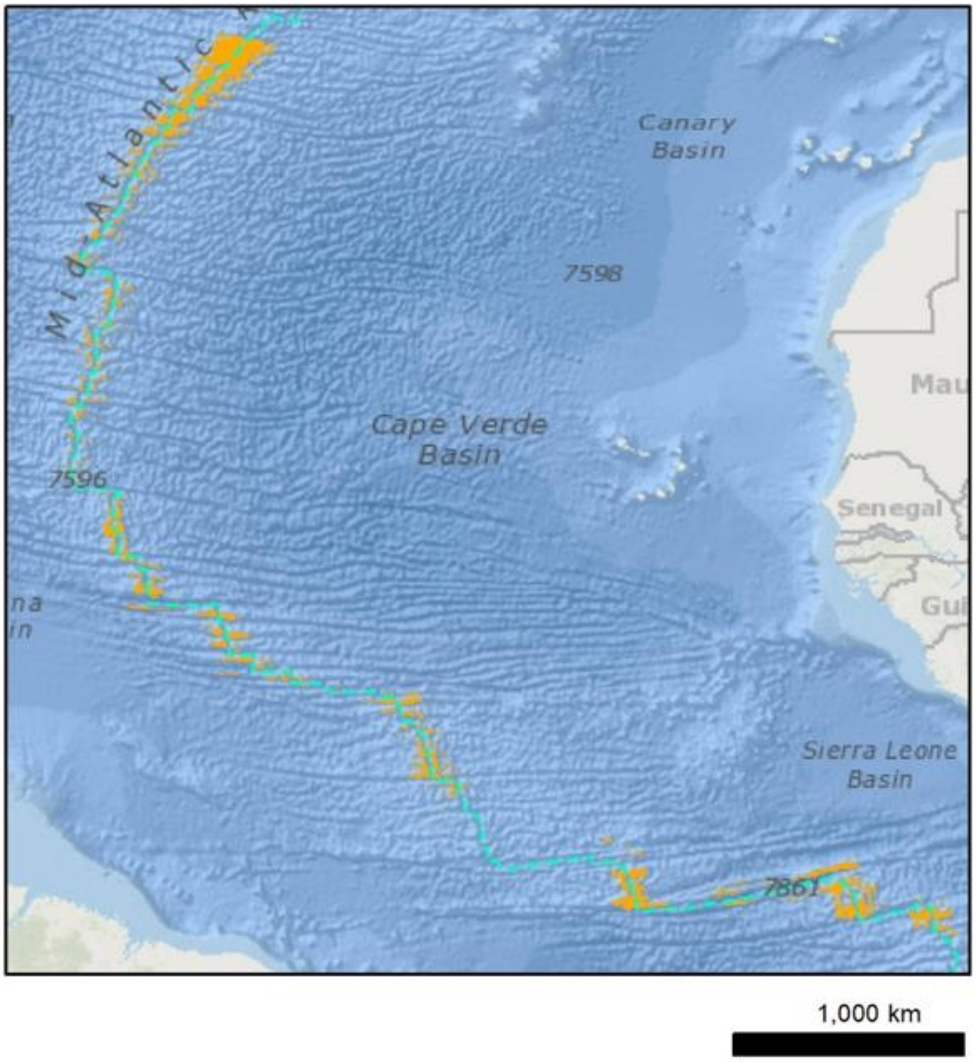
Sites and areas in need of precaution

Sites in need of precaution (inferred active sites)



Site in need of precaution	*Longitude*	*Latitude*
Mid-Atlantic Ridge, 30°North	-42.5000000	30.0333000
Mid-Atlantic Ridge, 27°North	-44.5000000	27.0000000
Puy des Folles	-45.6417000	20.5083000
Mid-Atlantic Ridge, 17°09'North	-46.4200000	17.1500000
Mid-Atlantic Ridge, south of 15°20'North fracture zone	-45.0000000	15.0833000
Mid-Atlantic Ridge, 14 54'North	-44.9000000	14.9200000
Logatchev 3	-44.9667000	14.7083000
Neptune’s Beard	-44.9000000	12.9100000
Mid-Atlantic Ridge, 11°26'North	-43.7035000	11.4482000
Mid-Atlantic Ridge, 11°North	-43.6483000	11.0380000
Markov Deep	-33.1800000	5.9100000
Mid-Atlantic Ridge, segment south of St. Paul system	-25.0000000	0.5000000

Areas in need of precaution (Octocoral habitat suitability: Ridge area)



Annex IV

Scientific criteria applied for the identification and description of area-based management tools in the northern Mid-Atlantic Ridge

The criteria below are adopted from the criteria developed by other component international organizations; for details, see the report of the workshop held in Evora, Portugal, from 25 to 29 November 2019.[16]

- **Uniqueness or rarity**. An area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include (a) habitats that contain endemic species; (b) habitats of rare, threatened or endangered species that occur only in discrete areas; (c) nurseries or discrete feeding, breeding or spawning areas.
- **Functional significance of the habitat**. Discrete areas or habitats that are necessary for: (a) the survival, function, spawning/reproduction, or recovery of species; (b) particular life history stages (for example, nursery grounds or rearing areas); (c) rare, threatened or endangered marine species.
- **Structural complexity**. An ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In such ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.
- **Special importance for connectivity**. Areas that are required for a population to survive and thrive.
- **Vulnerability, fragility, sensitivity or slow recovery**. Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.
- **Biological productivity**. Area containing species, populations or communities with comparatively higher natural biological productivity.
- **Biological diversity**. Area contains comparatively higher diversity of ecosystems, habitats, communities or species or has higher genetic diversity.
- **Naturalness**. Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.

[16] https://www.isa.org.jm/files/files/documents/Evora%20Workshop_3.pdf.

Annex V

Summary of knowledge gaps, research priorities, actions and responsibilities under paragraph 53 of the regional environmental management plan

Knowledge gaps	*Research priorities*	*Actions needed*	*Lead International Seabed Authority organ*	*Supporting International Seabed Authority organ*	*Indicative timeline*
Regional-scale research needed to enhance a comprehensive understanding of the regional environmental baseline and spatial and temporal variations (paragraph 53, section A) **Designed to support the achievement of the region-specific goals and operational objectives under section VII**					
Bathymetry, geology and regional-scale mapping	Collate data and information from different sources, including the DeepData database, to develop regional-scale knowledge of bathymetry and geology.	Continue discussions with contractors and competent international organizations to establish how such data already in the DeepData database and from other sources could be used to address this gap	Secretariat		Long-term, continuous efforts
Oceanography	Elucidate deep-water circulation through the ridge Temporal observations will also be important.	Continue to establish how such data already in the DeepData database and from other sources could be used. Encourage contractors to enhance sampling efforts and collaborate with each other and with scientific communities.	Secretariat		Long-term, continuous efforts
Regional patterns of biodiversity	Practical first steps at this scale may focus on basic ecological matrices and on a compilation of available regional data on taxa linked to spatial, temporal and environmental variables. Species distribution models at the regional scale should be developed for a range of taxa for which there is adequate information on distribution or abundance/biomass.	Establish how such data already in the DeepData database and from other sources could be used to address this gap.	Legal and Technical Commission	Secretariat	Long-term, continuous efforts

Knowledge gaps	*Research priorities*	*Actions needed*	*Lead International Seabed Authority organ*	*Supporting International Seabed Authority organ*	*Indicative timeline*
Population connectivity	Initial efforts may focus on validating existing connectivity models. A standardized approach can be established using suitable indicator species for regional analyses of connectivity.	Identify groups of species that could serve as indicators and develop appropriate analytical methodologies.	Legal and Technical Commission	Secretariat	Long-term, continuous efforts
Migratory corridors of seabirds, marine mammals, sea turtles or other large animals	May focus on mapping key habitats that serve as feeding and breeding grounds. Potential impacts from light and underwater noise or plumes on migration corridors and key habitats should be assessed.	Establish how such data already in the DeepData database and from other sources could be used. Collaborate with experts to develop sensitivity maps.	Legal and Technical Commission	Secretariat	Long-term, continuous efforts
Trophic connectivity/ relationships	May focus on measurements at different trophic levels.	Enter into discussions with contractors, scientific communities and competent international and regional organizations to establish how new sampling and data already in the DeepData database and from other sources could be used to address this gap.	Secretariat	Legal and Technical Commission	Long-term, continuous efforts
Ecosystem function	Develop a model for ecosystem function at the scale of the Mid-Atlantic Ridge. Studies on community structure may be an essential first step in better understanding relationships within the ecosystem, which may be followed by experimental studies on ecosystem tipping points.	Encourage the scientific community to collaborate with contractors to carry out research.	Secretariat		Long-term, continuous efforts

Knowledge gaps	*Research priorities*	*Actions needed*	*Lead International Seabed Authority organ*	*Supporting International Seabed Authority organ*	*Indicative timeline*
Resilience and recovery	Focus on the abundance or health of indicator species, changes in community profiles and biological traits linked to sensitivity.	Encourage the scientific community to carry out research to address this knowledge gap under the International Seabed Authority's Action Plan for Marine Scientific Research in support of the United Nations Decade of Ocean Science for Sustainable Development.	Secretariat		Long-term, continuous efforts
Risk analyses at the regional scale	Develop and apply frameworks and methodologies, such as cumulative impact analyses and scenario planning, to identify and assess risks, prepare mitigation action plans and establish key thresholds that trigger management actions.	Draw on existing approaches and schemes and develop a series of expert discussions.	Legal and Technical Commission	Secretariat	Before start of exploitation activities
Research to support area-based management (paragraph 53, section B) **Designed to support the achievement of operational objectives for the area covered under the regional environmental management plan (section VII, paragraph 29)**					
Habitat mapping (both physical and biological)	The range of habitats will need to be defined and then mapped within the regional environmental management plan region.	In collaboration with scientific communities, contractors and international and regional organizations, establish how such data already in the DeepData database and from other sources could be used to address this gap.	Legal and Technical Commission	Secretariat	Before start of exploitation activities
Area-based management tool networks	Incorporation of network criteria such as representativity and connectivity in the future development of the regional environmental management plan. The design of area-based management tool networks will be assessed against region-specific goals.	Lead expert discussions on the development and application of the network criteria.	Legal and Technical Commission	Secretariat	Before start of exploitation activities

Knowledge gaps	*Research priorities*	*Actions needed*	*Lead International Seabed Authority organ*	*Supporting International Seabed Authority organ*	*Indicative timeline*
Zoning scheme	Understand and design the size and characteristics of core, buffer and possibly other zones.	In collaboration with experts and contractors, develop a zoning system and prepare a clear description of the different zones (e.g., core and buffer) reflecting the contractors' activities, the environmental characteristics and the areal extent for each site and area in need of precaution.	Legal and Technical Commission	Secretariat	Before start of exploitation activities
Development of the criteria used to evaluate the status of sites and areas in need of precaution	Develop criteria to guide decisions where new scientific data on environmental characteristics, or faunal composition and abundance of sensitive ecosystems and communities, have been provided.	Expert discussions on the development and application of such criteria.	Legal and Technical Commission	Secretariat	Before start of exploitation activities
Better knowledge of sites in need of protection, areas in need of protection and sites and areas in need of precaution	Encourage joint surveys between contractors and scientific organizations. Record quantitative measurements of potential sensitive ecosystems through visual surveys in sites and areas in need of precaution.	Facilitate collaborative survey and scientific research efforts.	Legal and Technical Commission	Secretariat	Long-term, continuous efforts
Research to support non-spatial management (paragraph 53, section C) **Designed to support the achievement of operational objectives for contract areas (section VII, paragraph 30)**					
Behaviour, interaction and impact of natural and exploitation plumes	Physical and chemical characterization of natural hydrothermal plumes, as well as plumes from exploitation activities.	Encourage the contractors and scientific communities to carry out research.	Secretariat		Before start of exploitation activities

Knowledge gaps	*Research priorities*	*Actions needed*	*Lead International Seabed Authority organ*	*Supporting International Seabed Authority organ*	*Indicative timeline*
Underwater noise	Monitor the activities and behaviour of marine larvae, fishes and marine mammals, to understand the impacts of noises and to inform the development of relevant thresholds.	Encourage collaboration between contractors and scientific communities.	Secretariat		Before start of exploitation activities
Development of thresholds and their indicators and methodology	Establish thresholds for acceptable levels of: • Toxic contaminants and particulates generated in the benthic environment • Toxic contaminants in returned water • Particulate content of returned water; • Sediment dispersion, deposition and resuspension • Changes in ecological baseline of habitats • Cumulative impacts • Noise from vessels and any noise emitted in the water column and benthic environment • Light from vessels and in the benthic environment	Review and adapt, as appropriate, existing schemas on the development and use of thresholds in collaboration with competent international, regional and national organizations. Facilitate the engagement of experts through workshops and working groups to address this gap.	Legal and Technical Commission	Secretariat	Before start of exploitation activities