WORKSHOP ON THE DEVELOPMENT OF A REGIONAL ENVIRONMENTAL MANAGEMENT PLAN FOR THE AREA OF THE NORTHWEST PACIFIC

26 October – 6 November 2020, Online Workshop

INTRODUCTION

1. In accordance with the UN Convention on the Law of the Sea ("the Convention") and 1994 Agreement relating to the implementation of Part XI of the Convention, the International Seabed Authority (ISA), on behalf of the States Parties to the Convention, is mandated to administer the mineral resources in the Area and to control and organize current exploration activities, as well as future mining activities, in the Area for the benefit of humankind as a whole. The Authority is also mandated to take necessary measures with respect to activities in the Area to ensure effective protection of the marine environment from harmful effects and to adopt appropriate rules, regulations and procedures for, *inter alia*, the prevention, reduction and control of pollution and other hazards to the marine environment, the protection and conservation of the natural resources of the Area, and the prevention of damage to the flora and fauna of the marine environment.[1]

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

3. At its twenty-fourth session, in March 2018, the Council took note of a strategy proposed by the Secretary-General for the development of regional environmental management plans (REMPs) for key provinces where exploration activities under contracts are carried out.[3] The Council agreed with the priority areas that had been identified on a preliminary basis as the Mid-Atlantic Ridge, the Indian Ocean triple junction ridge and nodule-bearing province, as well as the North-West Pacific and South Atlantic for seamounts.[4] The Council also noted that the preliminary strategy laid out a coherent and coordinated approach to the process and identified as essential that REMPs be developed in a transparent manner under the auspices of the Authority, in light of its jurisdiction under the Convention and the Agreement relating to the implementation of Part XI of the Convention.[5]

4. As noted by the Council, the implementation of this preliminary strategy has started with the organization of two workshops, including one organized in Qingdao, China, in May 2018, which addressed the design of a REMP for cobalt-rich ferromanganese crusts in the Northwest Pacific Ocean.

1 United Nations Convention on the Law of the Sea, art.145.

2 See ISBA/17/LTC/7; ISBA/17/C/19 and ISBA/18/C/22.

3 See ISBA/24/C/3.

4 Since the adoption of the council decision as contained in ISBA/24/C/3, a new application for exploration for polymetallic nodules in the Northwest Pacific has been approved. The discussions of this workshop therefore included both seamounts and abyssal plains in the Northwest Pacific region.

5 ISBA/24/C/8, para 10.

The report of this workshop is available at https://isa.org.jm/node/19343.

5. Building on the experience of the environmental management plan for the CCZ and initiatives taken for other regions, the development of REMPs became an essential element of the strategic plan for the period 2019–2023[6] adopted by the Assembly in 2018 and, subsequently, a central part of the high-level action plan[7] adopted by the Assembly in 2019. Strategic direction 3.2 of the high-level action plan provides that the Authority is to "*develop, implement and keep under review regional environmental assessments and management plans for all mineral provinces in the Area where exploration or exploitation is taking place to ensure sufficient protection of the marine environment as required by, inter alia, Article 145 and Part XII of the Convention*".

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

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

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

9. With the above background, the ISA, in collaboration with the Ministry of Oceans and Fisheries (MOF) of the Republic of Korea and the Korea Institute of Ocean Science and Technology (KIOST), convened the Workshop on the Development of a Regional Environmental Management Plan for the Area of the Northwest Pacific, via an online platform from 26 October to 6 November 2020.

10. The workshop aimed to: i) review, analyze and synthesize scientific data and information on biogeography; physical, geological and environmental settings; biodiversity, ecosystem features and habitats of the Northwest Pacific seamounts and nodule areas; ii) review current exploration activities within contract areas for cobalt-rich ferromanganese crusts and polymetallic nodules in the Northwest Pacific region; iii) describe potential areas that could be impacted by future exploitation of mineral resources in the Area and would require enhanced management and precautions; and iv) discuss a framework to address cumulative impacts from future exploitation activities in order to achieve effective protection of the marine environment.

11. The results of this workshop will provide scientific inputs to the next workshop in this region, which will focus on identifying management approaches and measures for developing draft elements for inclusion in the REMP for the Northwest Pacific region.

12. The workshop was attended by 36 participants in their individual expert capacities. The full list of workshop participants is provided in Annex I to this report.

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6 ISBA/24/A/10

7 ISBA/25/A/15, annex II

8 IBSA/25/C/13

ITEM 1. OPENING OF THE WORKSHOP

13. The Secretary-General of the International Seabed Authority, together with representatives of the Ministry of Oceans and Fisheries of the Republic of Korea, and the Korea Institute of Ocean Science and Technology, opened the workshop at 6 p.m. (Jamaica; GMT-5) on Monday, 26 October 2020.

14. Mr. Michael Lodge, the Secretary-General of the ISA, delivered his opening remark through a video message. He began with expressing his gratitude to the Ministry of Ocean and Fisheries of the Republic of Korea and the Korea Institute of Ocean Science and Technology, for their support in the organization of the workshop. He also thanked Mr. Se-Jong Ju and Mr. Malcolm Clark, members of the Legal and Technical Commission, for their contribution to the workshop as Co-Chairs. Sincere appreciation was also extended to the technical support team from the Duke University and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) for their technical support. Mr. Lodge underscored the ISA's mandate to ensure the protection of the marine environment from harmful effects which may arise from activities in the Area, and its obligation to develop measures and tools toward this end. He highlighted that the development of REMPs is at the core of the Authority's efforts to the implementation of this mandate. He noted that the work on REMPs began with scientific discussions on the design of a network of APEIs in the CCZ and resulted in the adoption of the first REMP for the CCZ by the Council of the Authority in 2012. He recalled the Council's endorsement of a strategy for the development of REMPs in 2018, being guided by the principles that all REMPs should be developed under the auspices of the Authority and should be established in priority areas before exploitation starts. He then underscored that the workshop was a continuation of the Qingdao workshop (2018) and highlighted the progress made thus far. He noted that the workshop aimed to further refine the scientific approaches and synthesize scientific data and information on various environmental features of the Area in the Northwest Pacific. Lastly, he commended the efforts by different experts in the preparation of the draft Regional Environmental Assessment and data report and thanked all participants for their continued support for the work of the Authority.

15. Mr. Sang-Keun Song, Director General for Marine Policy Bureau of the Ministry of Oceans and Fisheries of Korea delivered his opening statement through a video message. He welcomed everyone to the workshop and expressed deep appreciation to the Secretary-General of the ISA and contributors for organizing the workshop. Additionally, he thanked participants for their willingness to be a part of the process. He then highlighted the investment made over 30 years by the Government of the Republic of Korea as a sponsoring State, in the exploration of deep-sea mineral resources and environment, which was evidenced by three successive contracts with the ISA, for the exploration of all three mineral resources. He emphasized the commitment of the Ministry (as a Contractor) and Korea (as a sponsoring state) to remain compliant with ISA regulations and noted the value placed on the current workshop. He underscored the Government's willingness to collaborate with the ISA Secretariat on the workshop and expressed his hope that it would advance the development of a REMP for the Northwest Pacific region. In closing, he underlined the Government's continued effort to protect the marine environment in the Area from potential adverse impact of future exploitation activities, and expressed confidence that effective REMPs would provide enabling conditions for the achievement of sustainable management of resources.

16. Mr. Woong-Seo Kim, the President of the Korea Institute of Ocean Science and Technology (KIOST), delivered his opening remarks through a video message. He began by expressing gratitude to the Secretary-General and his team at the secretariat for their efforts in organizing the workshop. He also conveyed appreciation to Mr. Sang-Keun Song, Director General for Marine Policy Bureau of the Ministry of Oceans and Fisheries of Korea, for the generous sponsorship provided. Appreciation was also extended to all participants. He underscored KIOST's contribution to the Republic of Korea's research and development activities on deep-sea mineral resources and environment and highlighted that the Institute's research was not limited to exploration for polymetallic nodules, polymetallic sulphides, and cobalt-rich ferromanganese crusts, but included biological and environmental impacts associated

with the exploration and future exploitation of deep-sea mineral resources. He noted KIOST's support for the work of the Authority since 1996, and their ongoing work of collecting baseline environmental data on the deep-sea ecosystem, which is important for the ISA's development of REMPs. He emphasized KIOST's continued commitment to the protection of the marine environment and the promotion of sustainable development. In closing, he emphasized the importance of continued collaboration and encouraged everyone to use the opportunity to strengthen the scientific basis required for the development of a REMP in the Northwest Pacific.

ITEM 2. WORKSHOP BACKGROUND, SCOPE AND EXPECTED OUTPUTS

17. Malcolm Clark and Se-Jong Ju, members of Legal and Technical Commission of ISA, were invited as co-chairs to moderate the workshop deliberation.

18. Under this agenda item, participants had before them two council documents (ISBA/24/C/3 and ISBA/25/C/13).

19. Jihyun Lee (ISA secretariat) provided a presentation on the workshop background.

20. Wanfei Qiu (ISA secretariat) provided a presentation on the workshop scope, objectives and expected outputs.

21. Patrick Halpin (Duke University) provided a presentation on "approaches for spatial planning".

22. Piers Dunstan (CSIRO) provided a presentation on "developing scientific methods for cumulative impact assessments".

23. At the plenary, it was noted:

a. That the development of REMPs is being undertaken under the auspices of the Authority in accordance with the decision by the Council;

b. That development of REMPs is at the core of the ISA's commitment to the protection of marine environment, and the application of a precautionary approach in the context of its mandate under the UN Convention on the Law of the Sea as well as the ISA Strategic Plan (2019-2023) and its high level action plans (HLAPs);

c. That REMPs are established by a decision of the Council, on recommendations of the Legal and Technical Commission, and each Contractor is to comply with the decisions of the Council relating to REMPs;

d. That this workshop focuses on compilation and analysis of scientific data and information to support the application of area-based management tools and addressing cumulative impacts, building on the experience of the environmental management plan of CCZ and its network of APEIs;

e. That the workshop deliberation will be based on best available scientific information available and accessible at the time of the workshop;

f. That data paucity issues would be addressed through modelling using proxy data (e.g. habitat suitability modeling), applying conservation targets, and identifying priority areas for future research and monitoring in support of adaptive management;

g. That contractors who have contracts with ISA for exploration of cobalt-rich ferromanganese crusts (CFC) and polymetallic nodules (PMN) deposits in this region were invited to the workshop and their experts were actively engaged for the preparation of draft report on regional environmental assessment prior to the workshop;

h. That it is important to actively promote cooperation among, as well as between, contractors and other scientific communities, noting the example of COMRA's joint cruises with other contractors in the region;

i. That it is necessary to consider biological/ecological characteristics (e.g. migratory routes) and ecosystem features (e.g. Mariana trench) of cultural significance;

j. That while the application of area-based management tools (ABMTs) can be done through both top-down approach (e.g. assessing at broader scale) and bottom-up approach (e.g. starting with the specific ecosystem features/sites where biological/ecological data are available), this workshop will focus on a top-down approach in view of limited data availability on specific ecosystem features; and

k. That both CFC deposit areas and PMN deposit areas would be considered together at the regional scale, in applying ABMTs.

24. Relating to the geographic scope of the workshop, the following points were noted:

- The geographic scope of this workshop may not necessarily be the same as the geographic scope of the REMP to be developed. The scope of the workshop will cover an area large enough to provide sufficient scientific information, taking into account two mineral provinces (e.g. CFC and PMN) and biogeography; and
- Considering the seamounts as key ecosystem features for this region, the planning unit needs to be designed taking into consideration the three-dimensional nature of ecosystem/habitat features and resource distribution.

25. For overall data compilation, this workshop explored a broad region across the Northwest Pacific (1°N to 40°N, 132°E to 179°E). For specific workshop discussions, the workshop focused on the Area between 10°N and 27°N latitude and 146°E to 164°E longitude.

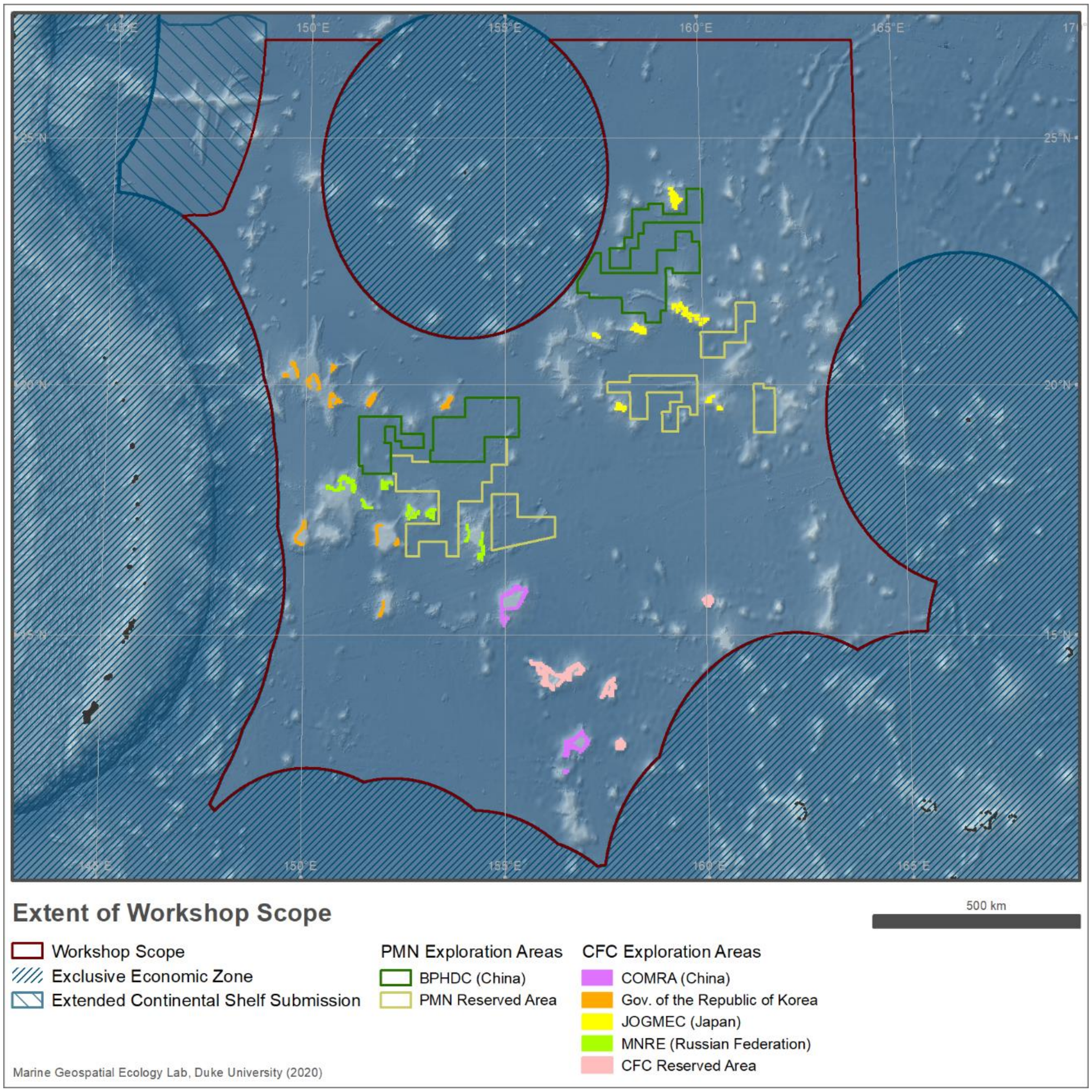

Figure 1. Workshop scope

26. With regard to ABMTs, the following aspects are highlighted:

- ABMTs can be complemented with non-ABMT tools;
- Combining different ABMTs can provide increased flexibility and more robust protection of both broad habitat areas and vulnerable sites;
- Spatial planning often combines both site criteria as well as network criteria;
- Increased spatial precision will require increased data coverage and level of details;
- Defining the appropriate biogeographic spatial extent of a REMP is a fundamental step in the planning process;
- Defining tractable evaluation criteria for assessing different network configurations (e.g. size, spacing, placement) will be fundamental to REMP planning; and
- Planning for adaptive management in anticipation of changes in data, knowledge, new technologies, and other changes will likely be required.

27. Participants also discussed the modalities of break-out session in particular regarding how information and views can be exchanged between the two habitat groups – group 1 (seamount benthic habitats) and group 2 (pelagic and abyssal plain habitats), during the break-out session. It was clarified that the respective facilitators on area-based management tools and cumulative impact assessment would synthesize the inputs from two habitat groups, while also promoting exchange of information and views between individual participants during plenary discussion and via emails, with assistance of rapporteurs and secretariat staff.

28. The secretariat informed participants how the workshop discussion would be recorded by rapporteurs, compiled and incorporated into the final draft report, which would then be made available for review by participants on the final day of the workshop.

ITEM 3. REVIEW, ANALYSIS, AND SYNTHESIS OF RELEVANT SCIENTIFIC DATA, INFORMATION, AND MAPS RELATING TO GEOLOGICAL SETTINGS WITHIN CONTRACT AREAS, DISTRIBUTION OF RESOURCES (CRUSTS AND NODULES), AND BIODIVERSITY AND ECOSYSTEM PATTERNS IN THE NORTHWEST PACIFIC

29. Under this agenda item, participants had before them:

a. Draft report on regional Environmental Assessment that described biological and environmental conditions in the Northwest Pacific, prepared by a team of experts; and
b. Draft data report compiling environmental and biological information, biogeographic classification, and other geo-spatial information in GIS layers, prepared by Duke University/MGEL in support of the workshop objectives.

30. Wanfei Qiu (ISA Secretariat) and Rachel Boschen-Rose (Seascape Consultants Ltd.) delivered a presentation to introduce the draft report on regional environmental assessment, followed by Patrick Halpin's (Duke University) presentation on the draft data report.

31. Then, the following presentations were delivered on geological settings, resource distribution and exploration activities in the region:

a. Maria Kruglyakova and Vyacheslav Melnik (Yuzhmorgeologiya, Russia): Geological exploration, oceanography and environmental studies in the Russian exploration area for cobalt-rich ferromanganese crusts;

b. Sang-Joon Pak (Korea Institute of Ocean Science and Technology): Exploration activities by the Republic of Korea and spatial distribution of ferromanganese crusts on seamounts in the Western Pacific; and

c. Huaiming Li (Second Institute of Oceanography, China): Geology and polymetallic nodule resources of the seamount and basin area in the Northwest Pacific Ocean.

32. Next, the following presentations were delivered on biodiversity, ecosystems and oceanographical settings:

a. Xue-wei Xu (Second Institute of Oceanography, China): Overview of ecosystems and biological communities in the seamount area of the Northwest Pacific Ocean;

b. Tina Molodtsova (Shirshov Institute of Oceanography of the Russian Academy of Sciences): Biodiversity and ecosystem setting, including connectivity – Seamount and Abyssal plain benthic habitats;

c. Cherisse Du Preez (Fisheries and Oceans Canada): Pelagic biological communities; and

d. Masayuki Nagao (Advanced Industrial Science and Technology, Japan): Oceanography and sediment fluxes.

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

a. The overarching environmental goals and objectives for the region;

b. Information contained in the draft report on Regional Environmental Assessment and draft data report as a basis for developing an REMP; and

c. Critical data/information gaps: distribution patterns, temporal variability, trophic relationships, and ecosystem function, among others.

34. To facilitate the discussion, Malcolm Clark provided a presentation on environmental goals and objectives, as a context for the workshop deliberation. He described the hierarchy of goals, objectives, management actions, indicators and thresholds, and suggested that an overarching environmental goal could be the conservation of biodiversity and ecosystem integrity, further supported by a suite of more detailed environmental objectives specific to defining ecosystem structure and function.

35. Summaries of the above presentations are provided in Annex II to this report, and a summary of the plenary discussion in response to the above presentations is provided under Annex III.

36. ISA secretariat informed that the draft report on Regional Environmental Assessment and draft data report will be further updated based on comments and additional information to be provided by workshop participants.

ITEM 4. SCIENTIFIC APPROACHES AND TOOLS IN SUPPORT OF AREA-BASED MANAGEMENT AND ASSESSMENT OF CUMULATIVE IMPACTS

37. Building on the presentations and the results of deliberations under the previous agenda items, participants discussed scientific approaches and tools in support of: 1) area-based management; and 2) assessment of cumulative impacts. In this regard, Patrick Halpin (Duke University) and Piers Dunstan (CSIRO) were invited as facilitators to moderate the respective discussions. The facilitators briefed participants on suggested approaches to producing outputs under this agenda item.

38. With regard to ABMTs, it was noted that there are two approaches to applying ABMTs: 1) a coarse filter approach, which targets the representation of broad ecosystem features and gradients; and 2) a fine filter approach, which targets unique sites that may be of particularly high values or at particularly high risk. The current interpretation of APEIs established in the CCZ is an example of a coarse filter approach and that this type of ABMTs could be augmented with the inclusion of fine-filter sites in need of protection. At the plenary discussion, ISA secretariat clarified that the polygons being described by the workshop as areas/sites meeting ABMT criteria would represent the results of scientific analysis of the workshop participants, rather than any specific management boundaries, at this stage, and the results of this workshop will be further reviewed by the future workshop in this region with a focus on developing management measures, in support of the work by the Legal and Technical Commission in its consideration of developing a proposal for ABMTs as part of the development of a REMP.

39. Participants then split into the following break-out groups to undertake focused-discussions:
Group 1: Seamount benthic habitats
Group 2: Pelagic and abyssal plain habitats

40. The breakout sessions were divided into two, with a plenary session in between. For each breakout session, each group had a chance to discuss scientific approaches and tools in support of both area-based management and assessment of cumulative impacts, with the respective facilitator.

41. After the first breakout session, participants gathered in a plenary session and each facilitator

reported on the progress made in their respective breakout discussion. Participants then exchanged their observations and insights based on the results of the first breakout session.

42. Next, participants returned to their respective group for further breakout discussions, building on the results of the previous discussions.

43. Lastly, participants gathered in a plenary session to exchange their observations and insights, including on critical areas that would require further scientific inputs, and to synthesize the results of break-out session discussions.

44. The results from the break-out session discussions are summarized in Annex IV for cumulative impact assessment and Annex V for ABMTs.

ITEM 5. SUMMARY AND CONCLUSION

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

46. ISA secretariat informed that the draft workshop report would be further updated based on comments and additional information gathered during the final plenary of the workshop as well as any additional comments and clarifications to be provided by workshop participants, within two weeks after the workshop.

ITEM 6. CLOSURE OF THE WORKSHOP

47. The workshop was closed at 10 p.m. (Jamaica; GMT-5) on Friday, 6 November 2020.

Annex I

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Annex II

Summary of Theme Presentations

<u>Presentations delivered under agenda item 2</u>

Workshop background

By Jihyun Lee

Ms. Jihyun Lee (ISA secretariat) introduced the context for the workshop, by explaining the process of development of REMPs, which the Council had decided to undertake under the auspices of the Authority. Development of REMPs is at the core of the ISA's commitment to the protection of marine environment, and the application of a precautionary approach, in line with its mandate under the UN Convention on the Law of the Sea, and the strategic directions as outlined in the ISA Strategic Plan (2019-2023) and the high-level action plan. REMPs are established by a decision of the Council, on recommendations of the Legal and Technical Commission (LTC), and each Contractor is to comply with the decisions of the Council, relating to REMPs. In its 25th session, the Council encouraged the secretariat and the LTC to make progress on the development of regional environmental management plans, in particular where there are currently exploration contracts, including Northwest Pacific. She provided information on the progress so far in organizing a series of expert workshops on the development of REMPs. She also informed the participants that in its 26th session, the Council highlighted the need for standardized approaches for the development, approval and review of the REMPs. Pursuant to this decision, the LTC is currently working on further development of the guidance to facilitate the development of REMPs. She also informed the participants that the scientific preparation has been undertaken in collaboration with various partner organizations and scientific groups to support the workshop deliberation, and thanked the experts, who provided inputs for the preparation of draft regional environmental assessment.

Workshop scope, objectives and outputs

By Wanfei Qiu

Ms. Wanfei Qiu (ISA secretariat) began by highlighting that this workshop is a continuation from the Qingdao Workshop in 2018. She mentioned that the workshop objectives are to: i) review, analyze and synthesize scientific data and information on biogeography; physical, geological and environmental settings; biodiversity, ecosystem features and habitats in the Area of the Northwest Pacific; ii) review current exploration activities and distribution of resources (cobalt-rich ferromanganese crusts and polymetallic nodules) in the Northwest Pacific region; iii) describe potential areas that could be impacted by future exploitation of mineral resources in the Area and would require enhanced management measures and/or precautions; and iv) discuss a framework to address cumulative impacts from future exploitation activities in order to achieve effective protection of the marine environment. The outputs of the workshop would include the description and documentation of approaches for applying area-based management tools (ABMTs), as well as a qualitative model for the assessment of cumulative impacts. She then explained that the results of this workshop would provide scientific inputs to the next workshop in this region, which would focus on identifying management measures for developing draft elements for inclusion in the REMP for the Northwest Pacific region.

Approaches for spatial planning

By Patrick N. Halpin

Mr. Halpin presented an overview of spatial planning approaches and described the relationship between spatial and complementary non-spatial approaches. He began the presentation by emphasizing the results of the previous REMP workshops, highlighting the 2018 Szczecin REMP workshop which concluded that REMP planning should include "[...] the primary goal of facilitating seabed mining while maintaining biodiversity, protecting unique and representative habitats, and preserving ecosystem function through both area-based management tools (ABMTs) and non-ABMTs." He described the potential interaction between broader scale cumulative impacts analysis, area-based management, and finer scale adaptive management approaches. He also described criteria-based approaches noting that the selection of areas for protection in spatial planning are often based on criteria that must be interpreted through quantitative regional analysis and/or qualitative scientific expert judgment. These criteria may be applied to attributes or properties of individual species, ecological communities, habitats, or broader ecosystems. The application of the criteria may also focus on the inherent attributes of species or habitats or on their vulnerability to disruption or damage. In this regard, the differences between site-level and network-level criteria were presented. Next, Mr. Halpin described two approaches to applying ABMTs: 1) a coarse filter approach, which targets the representation of broad ecosystem features and gradients; and 2) a fine filter approach, which targets unique sites that may be of particularly high values or at particularly high risk. He suggested that the current interpretation of APEIs is an example of a coarse filter approach and that this type of ABMTs could be augmented with the inclusion of fine scale sites in need of protection. He compared the differences between the APEIs described for the CCZ region and the needs of the NW Pacific region. He also suggested that a purposefully configured mixed portfolio, combining large areas to protect and buffer intact gradients of habitats augmented with specific sites in need of protection, may provide the most flexibility to satisfy both mining interests and protection needs. Lastly, he noted that a portfolio of ABMT areas could include areas of increased precaution or other categories of use, in addition to closure areas. These areas could require more intensive pre-use exploration, mapping, and monitoring.

Developing cumulative impact assessments

By Piers Dunstan

Mr. Dunstan began his presentation by introducing the basis for adaptive management, which has three key components: (1) a clear understanding of objectives and desired outcomes; (2) an assessment process that includes all potential positive and negative effects of development; and (3) a monitoring program that can test this assessment and ensure that the desired outcomes are being achieved. He then described the process used to assess cumulative impacts and the data needed to support this. He also emphasized that understanding the effects of cumulative impacts in a region is multitiered process, which requires the description of the distribution of key ecosystems, key effects on the ecosystems and then understanding how these components interact. He noted that qualitative models represent a working hypothesis about how an ecosystem works. They should: a) identify the important components and processes in the system; b) document assumptions about how these components and processes are related; c) identify the linkages between these components/processes and anthropogenic pressures; and d) identify knowledge gaps or other sources of uncertainty. Next, Mr. Dunstan explained how the participants would construct conceptual models during the workshop. This process includes first identifying bounds of the system of interest, key model ecosystem components and subsystems, and natural and anthropogenic pressures, then describing relationships of stressors, ecological factors, and responses. He then provided an example of previous work on developing qualitative models to assess the potential risks from future mining operations in the region of the Northern Mid-Atlantic Ridge (nMAR). He concluded his presentation by highlighting that the outputs of the models can be used to develop monitoring questions (e.g., what will be impacted, by what pressures and over what time scale) and identify the best indicator species/groups.

Overview of the draft Regional Environmental Assessment report for the Northwest Pacific Ocean

By Rachel Boschen-Rose

Ms. Boschen-Rose introduced the draft Regional Environmental Assessment (REA) report for the Northwest Pacific Ocean, which compiled available scientific information on the geological, oceanographical and biological communities in the Northwest Pacific region. The draft report was structured around the categories of information required for environmental baseline studies, as set out in the ISA Recommendations ISBA/25/LTC/6/Rev.1. The regional overview provided by the draft REA report highlights previous research and ongoing scientific studies in the region. The draft report also provides an initial view of regional environmental patterns, including identification of topics where regional-scale information may be lacking. In general, there is a mix of regional-scale and local-scale environmental information available for the different topics included in the draft REA report. There are also content gaps in the draft report, which may be addressed after the workshop, through contributions from additional experts. Other gaps may represent real knowledge gaps, and it may not be possible to address these gaps without further scientific research within the region.

Enhanced collaboration between groups conducting scientific research in the Northwest Pacific Ocean has the potential to address knowledge gaps, and to strengthen both local and regional environmental baselines. Examples of areas for potential collaboration include: sharing existing sample location information; exchanging biological samples and taxonomic information; combining local-scale information to build a regional-scale picture; and collectively addressing knowledge gaps through shared approaches.

Review of relevant scientific data/information/maps compiled for the workshop

Patrick Halpin

Mr. Halpin reviewed the compilation of scientific data and information prepared for the workshop and presented in a document entitled *Data Report: Produced as a background document for the Workshop on the Regional Environmental Management Plan for the Area of the Northwest Pacific*. He explained that the baseline data layers developed for this workshop are developed from open access data sources to provide consistency between regional efforts, along with many data specific to the Northwest Pacific region. More than 100 data layers were prepared for this workshop. The presentation covered three general types of data: (1) environmental data, (2) biological data, (3) biogeographic classification, (4) human uses, and (5) areas defined for management and/or conservation objectives. The biogeographic data focused on major biogeographic classification systems. The biological data portion of the presentation covered a variety of data sources to include data and statistical indices compiled by the Ocean Biodiversity Information System. The physical data layers included bathymetric and physical substrate data, oceanographic features and remotely sensed data. The data report also presented information from the ISA DeepData. The report also identified a number of published scientific papers that listed additional data resources. Mr. Halpin noted that there were likely a significant number of scientific data sets and papers for the Northwest Pacific region that were not located in internationally accessible sites. He recommended that the workshop participants rely on local experts to help identify critical regional data sets and analyses that could be identified to supplement their efforts.

Geological exploration, oceanography and environmental studies in the Russian exploration area for cobalt-rich ferromanganese crusts

By Maria Kruglyakova and Vyacheslav Melnik

In the Russian exploration area for cobalt-rich ferromanganese crusts (CFC), oceanographic analysis shows four depth levels of currents: from the sea surface to the layer of the density jump (500-600 m water depth); deeper than the layer of the density jump to the top of the guyots; from the top of the guyots to 100 m above the seafloor; bottom currents at 50-100 m above the seafloor.

The vertical section of the water column shows the greatest variability of parameters (temperature, salinity, oxygen content, fluorescence, and turbidity) in the upper active layer from the surface down to 600 m water depth. The constant thermocline is situated in the layer from 50 to 500 m water depth and coincides with the halocline. The upper quasi-homogeneous mixed layer occurs at about 50 m. The water depth of the oxygen maximum is at about 90 m and that of fluorescence at about 120 m. There are two minima of oxygen content including an intermediate zone at a depth of 150-200 m and the main one below the thermocline at a water depth of about 600 m. The minimum of fluorescence is observed at a water depth of about 250 m. The parameters of turbidity in the water column increase towards the seafloor due to the effect of bottom currents on loose sediment particles in the bottom layer.

Benthic communities of megafauna, macrofauna, and meiofauna were studied on four seamounts of the Russian exploration area. The most common groups of megafauna animals include coral polyps, sea lilies, ascidians, and glass sponges. The distribution of megafauna on the seamounts is extremely variable. The average number of megafauna shows very low values. Coral polyps, sea lilies and ascidians can form large clusters in local areas and can reach several thousand individuals per hectare.

Most of the seamount areas are occupied by a solid substrate. The sediment, located mainly at the top of the seamount and in some flat areas of its slopes, consists entirely of calcareous shells of foraminifera, radiolarians, pteropods, and gastropopds and their fragments. The sediment is very dense and hard; therefore, the macrofauna and meiofauna animals are very small and few in number. The macrofauna is dominated by polychaetes, priapulids and bivalve molluscs. Meiofauna animals consist mainly of nematodes and harpacticoids.

Exploration activities by the Republic of Korea and spatial distribution of ferromanganese crusts on seamounts in the Western Pacific Ocean

By Sang-Joon Pak

One of KIOST's strategies to assess the spatial distribution of Fe–Mn crusts was the combination of multibeam echo sounder (MBES) and seabed observation. This method results in a positive correlation between high backscatter intensity, steep seabed slopes, and the occurrence of cobalt-rich ferromanganese crust. In regional exploration, comparison between MBES backscatter and video footage is a valuable tool for assessing the potential of cobalt-rich ferromanganese crust deposits. The periphery of the summit area of the individual seamounts is the potential area for cobalt-rich ferromanganese crusts but could be partly covered by sediments owing to fluctuations in oceanographic conditions. The results indicate that exploration has to focus more on the area around the outer rim of the seamount summits to identify potential sites for potential future exploitation of mineral resources. Future mining activities, consequently, would require enhanced management measures and precaution.

Geology and polymetallic nodule resources of the seamount and basin area in the Northwest Pacific Ocean

By Huaiming Li, Zhenggang Li, Yang Wang, and Hongyi Wang

The geographic framework in the NW Pacific Ocean ('NWPO') is defined by *three Seamount groups and two interposed pelagic basins*. The pelagic basins exhibit tectonic features different from the area between the Clarion and Clipperton Zone (CCZ) of the central Pacific Ocean and, in general, from mid-Ocean ridges. There are more than 165 seamounts with irregular but continuous distribution on the international seabed area of the NWPO. Only about 63 seamounts have summits between 1,000 and 2,000 meter depths, but they occupy nearly half of the entire seamount group areas. A typical seamount includes summit, upper and lower flanks, which exhibit different morphologies, tectonic and collapse stages and community characteristics. The areas in between the three seamount groups form pelagic basins of mostly flat and undulating seafloor. There is continuous occurrence of PMN from the bases of the seamounts to the central basins. Mineralogical and element geochemical compositions of polymetallic nodules from the NWPO area indicate that the PMNs largely belong to the hydrogenetic type. The abundance of the PMNs is higher than in the central Pacific Ocean. The types of the PMNs from the NWPO are dominated by spheroidal and ellipsoidal nodules with large and medium sizes. The main metal concentrations show elevated Co contents and lower Cu, Ni values than regular mixed and diagenetic nodules, which is consistent irrespective of differences in abundance. Regions with high abundance and continuity of PMN occurrences are typically found on the lower seamount flanks and in the interposed pelagic basins.

Overview of ecosystems and biological communities in the seamount area of the Northwest Pacific Ocean

By Xue-Wei Xu

In the Northwest Pacific, there are vast seamounts as well as abyssal plains. Currently, five contract areas are located within or around three seamount chains, namely Marcus-Wake seamount chain, Magellan seamount chain, and Marshall seamount chain. This study area was referred to as the Triangle Area (TA) in the context of this study. This presentation introduced three key characteristics of the seamount ecosystems in the TA, including typical habitats and representative species, spatial and temporal distribution, and connectivity and resilience.

First, the typical substrates found in the seamounts comprise hard substrates, including crust, crushed stone, nodule and rocks, and soft substrates, mainly sediment. Local complex topography frequently implies biological hot spots for benthos. On the surface, the predominant bacteria are SAR11 and SAR86, belonging to the Proteobacteria, and Prochlorococcus is the most abundant cyanobacteria. At the bottom, many benthic megafauna are found attached to or in association with cold-water corals and sponges. Some of these are vulnerable marine ecosystem (VME) indicator species, typically because of their slow growth rates, high longevity, and slow recovery. Second, abundance of marine organisms increase from the south to the north in the TA, based on the observation of plankton, pelagic fish and benthos. Seamount biodiversity is affected by water depth and numerous environmental factors, such as primary productivity, hydrodynamic conditions, chemical characteristics, seamount topography, side of a seamount, and substrate. Third, the plankton and benthic ecosystem in the TA demonstrates good connectivity based on current data. It appears that very little is known about the specific resilience of this area. However, the most severely damaged species by bottom trawling are sessilebenthic megafauna, such as sponges and cold-water corals. He highlighted that survey results indicate that the three seamounts and their adjacent areas meet the criteria for Sites in Need of Protection. These sites are located in the northwest part, the northeast part and the southwest part of the TA, respectively. Future research and monitoring would be needed to enhance knowledge about these ecosystems.

Biodiversity and ecosystem setting, including connectivity – Seamount and Abyssal plain benthic habitats

By Tina N. Molodtsova

Benthic habitats in the Area of the NW Pacific are represented by two distinctive habitats: seamounts and abyssal plains. Only a limited number of seamounts were ever studied in this area and most of them are in the contract areas. Studies are mostly carried out at sedimented plateaus and upper slopes of the seamounts down to 2000 m. Size classes mostly include mega- and meiofauna, with macrofauna usually neglected. Very limited data is available on individual taxa, including life cycles, larval dispersal, connectivity, and gene flow. In current biogeographic classification where predicted patterns of faunal distribution based mostly on abiotic factors and productivity, plateaus and slopes of seamounts belong to the West-Pacific lower bathyal province, while the easternmost part of the region may have closer affinity with the North Pacific lower bathyal province. Apart from the work carried out by contractors in the area several scientific cruises were organized in the1980s by Shirshov institute of Oceanology and TINRO (Russia). Based on the visual observations by these cruises, at least 49 OUT of megafauna were reported in Ita Mai Tai (Weija) and IOAN (Ioah or Govorov) guyots with high densities of hexactinellid sponges and habitat-forming cnidarians reported at the edge of the plateaus, vertical walls and edges of terrasses. Based on the 1986 cruise of FV Novoulyanovsk (TINRO), Orlov (19891) reported 134 species of 53 families of midwater and benthic fish in 14 seamounts studied in the area, including Alepocephalidae, Derichthydae, Nettestomidae, Synaphobranchidae, Haulosauridae and Macrouridae. Abyssal plains in the area are less studied. Only few megafauna taxa were reported and described from depths >3000 m. Meiofauna studied (off Xufu Guyot) seems to be more connected to fauna of neighboring seamounts than to the Central Pacific basin. The entire abyssal plain belongs to the North Central Pacific abyssal province. More studies in both depth zones are needed, especially in areas beyond the contract areas.

Pelagic biological communities

By Cherisse Du Preez

The surface and midwater environments of the Area of the Northwest Pacific Ocean are within a large, low-nutrient biogeographic region. However, the biological communities that thrive there are diverse and dynamic, supporting ecologically, commercially, and culturally important species, from tiny microbes to giant whales. Biodiversity helps to increase, maintain, and promote the provision of pelagic ecosystem functions.

Surface microorganisms in the Area play critical roles in productivity, carbon export, and nutrient regeneration and are typified by large-scale ecological connectivity and temporal changes in abundance. Seasonal variability is linked to fall-winter mixing and blooms, and daily variability is linked to the vertical migration of the deep-scattering layer (DSL). The DSL delivers nutrients from the surface down to 1,000 m depth and is often associated with enhanced productivity and biomass. Larger zooplankton and mesopelagic fishes are also part of the DSL. Mesopelagic fishes from 200 to at least 1,000 m are the dominant constituent of the world’s fish biomass. In general, Northwest Pacific pelagic fishes and other nektons are highly migratory; however, some species gather at shallow seamount summits, either temporarily or long-term.

The Northwest Pacific surface and midwater environments have high fisheries production. There are two Regional Fisheries Management Organisations that oversee these fisheries: the Western and Central Pacific Fisheries Commission (tuna and billfish fisheries) and the North Pacific Fisheries Commission (pelagic and benthic fisheries, including squid). While it is unlikely that Pacific salmon migration routes overlap the Area, oceanic fishes may be vulnerable to indirect effects, such as food web disruptions, beyond the immediate scale of the anthropogenic activity (salmon species managed by the North Pacific Anadromous Fisheries Commission). Many air-breathing megafauna migration routes also overlap with the Area, including threatened and endangered seabirds, turtles, and whales.

These pelagic communities are already impacted by ocean warming, deoxygenation, acidification, overfishing and bycatch, ship strikes, artificial noise and light, pollution, etc. Potential disturbances to the pelagic communities related to future seabed mining activities include artificial light, anthropogenic noise, increased particle load or potential toxic contaminants, changes in temperature or nutrients, physical removal, and other disturbances. The literature suggests responses of pelagic species to such disturbances include changes in behavior and foraging, masking of biological cues, physiological injuries, reduced fitness and reproductive success, removal and mortality—with recovery times dependent on the nature of the event, natural variability of the system, and the species mobility, size, and generation time. Knowledge gaps for regional environmental management of the pelagic communities include multi-scale spatio-temporal species distribution data, trophic relationships, ecosystem functions, connectivity, and resilience and recovery.

Oceanography and sediment fluxes

By Masayuki Nagao, Kyoko Yamaoka, and Ayumi Tsukasaki

This presentation discussed oceanography and sediment fluxes in the NW Pacific based on the observation data collected in Japan's exploration area for cobalt-rich ferromanganese crusts in the region. In this region there are many eddies at different scales and durations generated by, for example, the Northwest Pacific Subtropical Gyre. Acoustic Doppler Current Profiler (ADCP) is commonly used to obtain vertical profiles of velocity and direction of currents. However, it is more difficult to measure water velocity in abyssal zone than in coastal zone because of insufficient acoustic backscatter. For this reason, the ADCP data on JA02 Seamount (Lamont Guyot) was compared with the second version of Japan Coastal Ocean Predictability Experiment (JCOPE2) reanalysis velocity data. The results indicated that high energy concentrations were identified at semidiurnal (12h) and diurnal (24h) periods. Also, velocity power spectra in the high frequency (short-period) zone differed among the layers, possibly because of low amounts of suspended matter. In the low frequency (long-period) zone, the spectra were found to be almost the same. Overall, the ADCP velocities correspond reasonably well to those in the JCOPE2 reanalysis data.

To investigate the interaction between surface productivity and seamount communities, monthly average net primary production (NPP) was estimated at four locations around JA02, 04 and 06 Seamounts (Lamont, Maloney, and Xufu Guyots) in Japan's exploration contract area using long-term satellite datasets for the period of 2002–2018. The estimated NPP varied seasonally at all stations. The seasonal fluctuation range and pattern were almost identical among the four locations. The NPP maximums (234-262 mg C/m^2/day) were observed from February to May, while the NPP minimums (131-139 mg C/m^2/day) were observed from August to October. The values were consistent with the range of NPP which had been estimated around the North Pacific Subtropical Gyre using satellite data (Longhurst et al., 1995, Gregg et al., 2003). On the other hand, a distinctively sharp peak of sinking particle fluxes in late summer was observed in all sediment trap experiments around the three seamounts. This seasonal pattern of the fluxes was inconsistent with the satellite-based NPP data. It was proposed that the late summer peak of fluxes reflects short-lived or subsurface blooms induced by passing typhoons, which were difficult to detect by a satellite. This suggests that one of the most important factors for POC flux to the seabed in the NW Pacific could be the intensity and frequency of typhoons. This also indicates the potential impacts of the global climate change on the energy transfer from the surface ocean to the deep-sea ecosystems.

Annex III

Summary of discussion on review, analysis and synthesis of relevant scientific data, information, and maps relating to geological settings within contract areas, distribution of resources (crusts and nodules), and biodiversity and ecosystem patterns in the Northwest Pacific

Discussion pertaining to the draft Data report for the Northwest Pacific Ocean

1. Participants discussed the scale of the processes documented in the draft data report, such as connectivity, and the implications for spatial planning. There is in general a lack of knowledge on connectivity within a single seamount and between different seamounts, making it difficult to apply general network criteria for connectivity.

2. Data paucity in other aspects was also highlighted. Only a small number of seamounts have been explored in this region, and the Northwest Pacific has complex topography and differs significantly from other regions such as the Clarion-Clipperton Zone (CCZ) and northern Mid-Atlantic Ridge. Participants highlighted that deep-sea ecosystems found on seamounts of the Northwest Pacific are fundamentally different from those found on abyssal plains of the CCZ or on hydrothermal vents of the Mid-Atlantic Ridge.

3. It was explained that spatial planning approaches have been applied with best available data in other global processes (e.g. CBD's process on ecologically or biologically significant marine areas, FAO' process on vulnerable marine ecosystems, and IMO's process on particularly sensitive sea areas), including in the areas of data paucity. The best practice is to document the rational and assumptions underlying the use of proxy data and modeling analysis. This process can also inform future scientific research and monitoring efforts, by illustrating the key priority areas that such efforts should address.

Discussion pertaining to the draft regional environmental assessment (REA) for the Northwest Pacific Ocean

1. Participants appreciated that the Regional Environmental Assessment (REA) document was a valuable synthesis of the available information in the Northwest Pacific region, and that this provided a sound basis for workshop discussions. Participants also noted that the REA is a draft document, which will be updated incorporating any comments or additional information provided by the workshop participants. As a living document, it is anticipated that it will be further updated in the future as additional information becomes available for the Northwest Pacific region.

2. Participants exchanged views on the regional environmental and resource information contained within the opening presentations and the REA document. Some of the overarching concerns raised included uncertainty surrounding the degree of data availability for the estimated 160 seamounts and surrounding abyssal basins in the Northwest Pacific region, how data paucity could be addressed, and whether there were additional sources of environmental information that could be included in the REA. Several workshop participants indicated that the draft REA can be further improved by incorporating information from publicly available data sources that resulted from NOAA's CAPSTONE effort. Participants also suggested that information on traditional ecological knowledge and maritime archaeology could be incorporated into the REA, while noting that the REA follows a structure that is based on LTC recommendations ISBA/25/LTC/6/Rev.1.

3. Participants considered additional information that could be included in the REA document, including information that could be added after the workshop, and potential information that is not yet available but could be included in future versions of the REA report following further scientific research in the region. To facilitate discussion amongst participants, the workshop co-chair delivered a short presentation on the content gaps that were identified in the data report and the REA. Discussion was held on additional sources of information that could be used to address these gaps, and where further scientific research would be required to address knowledge gaps.

4. The following content gaps were discussed for the geology chapter of the REA:

- Regional-scale information on sediment fluxes, including Particulate Organic Carbon (POC) fluxes to the seafloor;
- Distribution of cobalt-rich ferromanganese crusts on seamounts, including the relative prospectivity of seamounts with different morphologies, and the potential for overlap between crust and polymetallic nodule resources;
- Detailed bathymetry and geomorphology of specific seamounts (e.g. in the Marshall Islands group); and
- Various geophysical data layers from NOAA National Centers of Environmental Information (e.g. seafloor mapping data, sub-bottom mapping data, water column mapping data).

5. With respect to sediment and POC fluxes, participants noted that a paper on sediment flux in the region was recently accepted for publication and could be shared with the intention of providing additional site-specific information on sediment fluxes. Moving towards a regional-scale understanding of sediment and POC flux would require additional sediment traps to be deployed in the wider Northwest Pacific region. Participants considered that continued investigation of the linkages between satellite-derived chlorophyll estimates and sediment trap data, including the influence of passing typhoons and satellite observations over longer time periods, could further support the detection of regional gradients in sea surface primary productivity. Given that the benthic biological communities are reliant on sea surface primary productivity for their nutrition, regional gradients could help to identify spatial units to inform environmental management considerations.

6. Regarding the distribution of mineral resources, participants clarified that exploration areas focused on the outer rim of guyots or seamounts, and that steep seamount slopes are not the best conditions for crust development. It was considered that conical and flat-topped features had similar prospectivity potential. It was further considered that there was limited overlap in the distribution of seamount crust and polymetallic nodule resource distribution, given that nodules occurred on the abyssal plains, and the majority of crust deposits were located on the slope close to the top of the seamounts.

7. For the detailed bathymetry and geomorphology of specific seamounts, it was suggested that additional information is available in the scientific literature, from surveys conducted by scientific institutions within the region, or potentially from publicly-available databases, such as those managed by NOAA's National Centers of Environmental Information[9].

8. The following content gaps were discussed for the oceanography chapter of the REA:

[9] NOAA databases relevant to geology: https://maps.ngdc.noaa.gov/viewers/bathymetry/; https://maps.ngdc.noaa.gov/viewers/geophysics/; https://service.ncddc.noaa.gov/website/EXAtlas/viewer.htm; https://service.ncddc.noaa.gov/website/EXAtlas/viewer.htm;

- Regional-scale patterns in physical and chemical water properties;
- Temporal variation in oceanographic processes; and
- Local circulation patterns around seamounts, including the effects of tidal flow and other oceanographic processes.

9. Participants considered that some of the content gaps for regional-scale spatial and temporal patterns in oceanographic processes could be addressed using the information from additional scientific literature from the region; through looking to datasets from nearby regions, such as the Hawaii Ocean Time Series[10]; and through additional data sources, such as the Argos float programme[11], eWOCE dataset[12], GEOTRACES dataset[13], and databases managed by NOAA's National Centers of Environmental Information[14].

10. With respect to additional information on the local circulation patterns around seamounts, this may be addressed through studies being conducted as part of the establishment of environmental baselines within exploration contract areas. Participants provided clarification on the role of tides in current flow around seamounts. It was explained that based on the studies conducted in the contract areas of Ministry of Natural Resources and Environment of the Russian Federation, long-wave processes and tides are the main causes for formation of currents in the near- bottom area at the studied seamounts within contractor areas. The interaction between these processes and the physical structure of the seamount can substantially increase current speeds (up to 10 cm per second), compared to the current speeds observed on the surrounding abyssal plains (typically 1 – 2 cm per second).

11. The following content gaps were discussed for the biology chapter of the REA:

- Spatial distribution information on taxa and communities, including well-studied sites and large-scale studies;
- Temporal variability in biological processes, including time series data;
- Connectivity of benthic biota, including population connectivity;
- Trophic relationships for the marine environment of both seamount and abyssal plains, including linkages to the overlying water column;
- Ecosystem function of the benthic and pelagic environments in the region;
- Resilience and recovery of benthic and pelagic taxa and communities to potential future impacts from exploitation of mineral resources and other anthropogenic activities in the region; and
- Information on specific taxa and size groups where limited information is currently available, such as microorganisms, small benthic invertebrates (meiofauna and macrofauna), vulnerable marine ecosystem indicator species, commercially important species, and culturally-significant taxa. In particular, occurrence data from NOAA's National Database on Deep-Sea Coral and Sponges[15].

12. Participants considered that additional scientific literature may help to address some of the regional-scale content gaps identified in the Biology Chapter, particularly if studies conducted in nearby regions

10 Hawaii Ocean Time Series: https://hahana.soest.hawaii.edu/hot/hot-dogs/interface.html

11 Argos float programme: https://argo.ucsd.edu/

12 eWOCE dataset: https://www.ewoce.org/data/index.html

13 GEOTRACES dataset: https://www.geotraces.org/cruise-overview/

14 NOAA databases relevant to oceanography: https://www.ngdc.noaa.gov/maps/water_column_sonar/index.html; https://www.ncei.noaa.gov/access/data/global-ocean-currents-database/sadcp_oer_inv.html; https://service.ncddc.noaa.gov/website/EXAtlas/viewer.htm; https://www.nodc.noaa.gov/gocd/sadcp_oer_inv.html

15 https://deepseacoraldata.noaa.gov/

could be referred to. Examples included published information from the seamounts on the Mariana forearc, publicly-available information collected during scientific and telepresence exploration expeditions in the broader region (particularly in and around Hawaii), and connectivity studies conducted on biological communities at the Wake, the Marcus Islands, and the Hawaiian Islands. It was also suggested that contractors may have collected additional environmental information in the region from prospecting prior to applying for exploration contracts, and that where available, this historical information could be shared to support the establishment of regional environmental baselines.

13. Regarding information on specific taxa and size groups, it was noted that additional information may be available for some taxa, but there may also be knowledge gaps that would require further scientific research to address. For smaller organisms, such as microbes, the content gaps in the REA are thought to be knowledge gaps. Participants suggested that the information submitted by contractors,in the ISA database (DeepData), may provide additional site-specific information for some groups. It was also noted that the section summaries in the Friday Harbour CCZ workshop report indicate the types of information available for the CCZ, and that this report could be used to identify trends that may be expected to occur in the abyssal environments of the Northwest Pacific region.

14. For some vulnerable marine ecosystem (VME) indicator species, such as corals and sponges, one potential additional data source identified by participants was the NOAA Deep-Sea Coral Data Portal[16]. National invertebrate collections, such as those housed at the US National Museum of Natural History, Smithsonian Institution[17], and the Bernice P. Bishop Museum, were also suggested as data sources. However, these sources do not necessarily record absences, i.e., cases where surveyed areas did not have any corals or sponges present. Studies conducted within exploration contract areas will also help to resolve patterns of coral and sponge distribution. For example, studies of seafloor imagery within the contract area of the Russian Federation suggests that approximately 70 – 80 % of coral taxa (at genus level or higher) were observed at all four studied seamounts.

15. With respect to commercially important species, participants noted that commercial fisheries data are available for some pelagic species, including catch effort information from Regional Fisheries Management Organisations, such as the North Pacific Fisheries Commission, and the Western and Central Pacific Fisheries Commission. However, these data may not always be spatially explicit regarding catch information.

16. The need for further information on culturally-important taxa in the Northwest Pacific region was also discussed, including the importance of traditional ecological knowledge. Participants noted a new paper on highly migratory culturally significant taxa in the Pacific Ocean[18].

17. Following the conclusion of discussion on content gaps within the draft REA report, the ISA Secretariat provided clarification on the process for updating the draft report after the workshop. Participants would be given two weeks after the closure of the workshop to make specific comments on the draft REA report and to provide additional data to the ISA Secretariat. The report would be revised considering these contributions and in consultation with the workshop co-chairs.

16 NOAA Deep-Sea Coral database: https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm
17 US National Museum of Natural History, Smithsonian Institution: https://collections.nmnh.si.edu/search/iz/
18 Vierros, M. K., et al. 2020. Considering Indigenous Peoples and local communities in governance of the global ocean commons. Marine Policy, 119: 104039.

Annex IV

Results of break-out group discussion on qualitative modeling for cumulative impacts assessment

I. Introduction and general description of qualitative mathematical modelling approaches for assessing cumulative impacts

1. Workshop deliberation on this subject was guided by a strategy of model building that recognizes a practical trade-off between realism, generality and precision when building models of complex systems (Levins 1966, 1998). To obtain a manageable model, one typically sacrifices one attribute for the other two (Fig. 1). Qualitative process models emphasize generality and realism, but lack precision, while quantitative process models can be both precise and realistic but are not generalisable (i.e., application of model to changed circumstance requires reparameterization). A third approach is through statistical models, which emphasize precision and generality. In the latter, there are precise insights into the general pattern of correlations among variables, but at the cost of causal understanding of the processes involved. In practice, a robust strategy considers all three modelling approaches, such that models are mutually informative and build upon the strengths and insights provided by each approach.

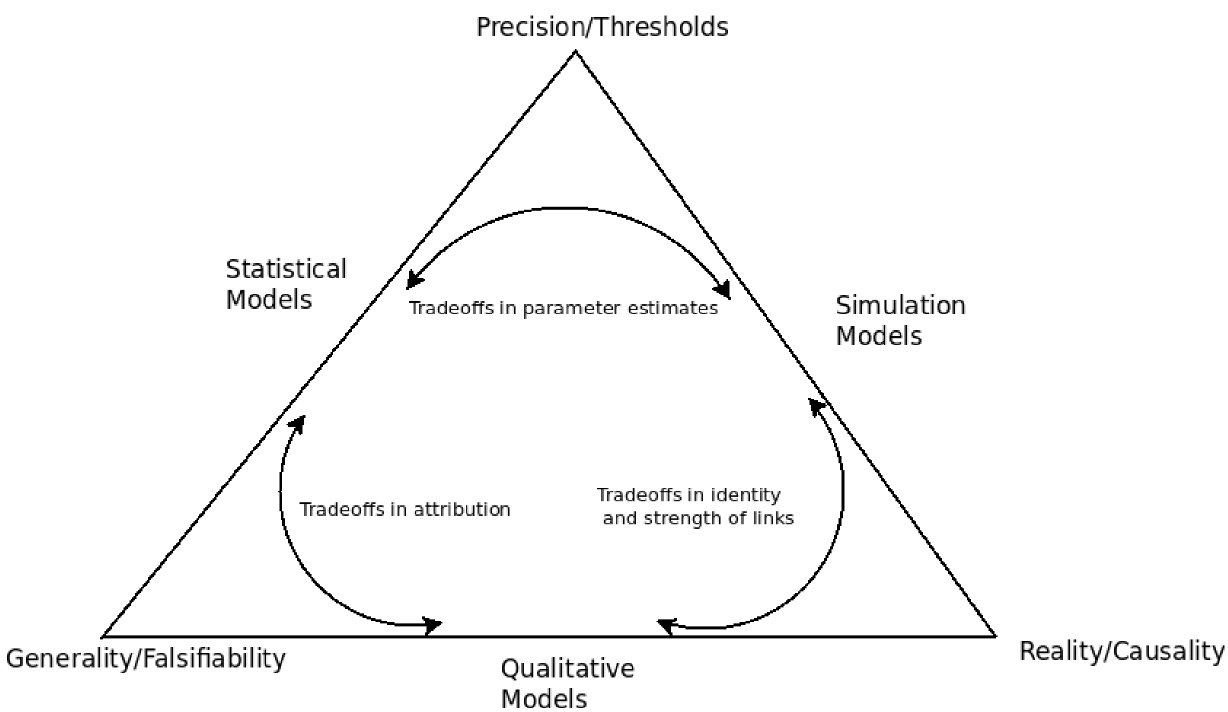


Figure 1. Trade-offs comparison among different types of mathematical modelling approaches.

2. Qualitative mathematical models represent a working hypothesis about how an ecosystem works. They should: identify important components and processes in the system; document assumptions about how these components and processes are related; identify the linkages between these components, processes

and anthropogenic pressures, and also identify knowledge gaps or other sources of uncertainty. These models are useful in identifying the potential cumulative impacts of pressures on ecosystem components and the best indicators for those impacts. They can be applied to a very broad range of ecosystems from coastal marine systems to deep-sea systems (Dunstan et al. 2020).

3. Steps or tasks in constructing qualitative mathematical models include identifying the bounds of the system of interest; determining key model components, subsystems, and interactions; identifying natural and anthropogenic stressors (pressures); describing relationships of stressors, ecological factors, and responses; and identifying clear knowledge gaps in the system.

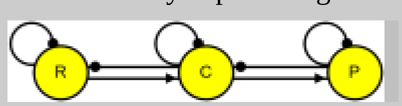
4. Qualitative mathematical models need to portray the ecological system at a level of resolution that is useful to the purposes of the risk assessment, striking a balance between simplicity and complexity. They should not seek to represent the entire system with myriad components and processes; rather the focus is on the dominant processes and feedbacks that sustain and regulate the main components of interest, along with potential anthropogenic pressures and natural stressors relevant to the ecosystem (sensu Gross 2003; Dambacher et al., 2009).

5. A qualitative mathematical model is implemented through a partial specification of the system. In a partially specified system, only the qualitative nature of the relationships between variables is specified. Under this approach, the effect of one variable on another can be specified only through the sign of its effect, e.g., positive (+), negative (-) or no (0) effect. Qualitative modelling is based on representing the qualitative nature of the relationships shared between system components and variables (Puccia & Levins 1991). This approach sacrifices precision in model details and predictions but gains a causal understanding of a system that is pertinent to a broad range of contexts and applications (Justus 2005; 2006).

6. The method of qualitative mathematical modelling is based on the analysis of system structure using signed directed graphs (hereafter signed digraphs) (Puccia & Levins 1985). A signed digraph is a graphical representation of variables and their interactions, where the nodes or vertices of the graph represent the system variables, and the graph edges or links represent both the sign and the direction of the direct effect of one variable on another, i.e., a positive (+), a negative (-) or a null (0) effect. Signed digraph models of ecosystems commonly include trophic interactions; for example, in a predator-prey interaction the positive benefit to a predator of consuming a prey represents a rate of birth, and the negative effect to the prey represents a rate of mortality (Box 1).

Box 1. Qualitative mathematical models and their analysis

The below signed digraph is a straight-chain system with a basal resource (R), consumer (C) and predator (P). There are two predator-prey relationships, where the predator receives a positive direct effect (*i.e.*, nutrition, shown as link ending in an arrow (🡐)), and the prey receives a negative direct effect (*i.e.*, mortality, shown as link ending in a filled circle (●— included also are self-effects, such as density dependent growth.



Prediction of perturbation response. One can predict the direction of change in each variable (*i.e.*, increase, decrease, no change) due to a sustained input or pressure to the system. Consider a pressure on the system in the way of food supplementation to the predator that increases its reproductive capacity. The predicted response of C is determined by the sign of the link leading from P to C, which is negative (denoted P —● C). The predicted response of R will be positive because there are two negative links in the path from P to R (P —● C —● R), and their sign product is positive (*i.e.*, - x - = +). In this system, there is complete sign determinacy for all response predictions, as there are not multiple pathways between variables with opposite signs.

7. Based on the qualitative structure of a system detailed in a signed digraph, one can assess the scope or potential for a system to be stable, and if it is stable, then how it will respond to a perturbation that shifts the system to a new equilibrium. Under a sudden and small pulse perturbation, a stable system will return to its former equilibrium but if the system is unstable, then it will either be attracted to a new equilibrium in which abundances or values of the variables are shifted to different levels, or the system may even collapse, leading to the extinction of one or more components.

8. A sustained change in a system parameter, or a press perturbation, will displace the system to a new equilibrium point. This system displacement occurs through a change in the growth rate of one or more input variables, which then creates a series of direct and indirect effects that are transmitted to other variables through the system's network of interactions. Based on the structure of these interactions, one can predict changes in the equilibrium abundances and rate of turnover in model variables. Obtaining a clear description of the interaction structure based on the direct effects of the system enables disentangling complex relationships between variables that can be key when evaluating system response to perturbations. Once the structure of a signed digraph model is defined, it can be analysed to determine predictions for perturbation response (Puccia & Levins 1985; Dambacher et al., 2002; 2003). These qualitative predictions can be assessed to determine their relative potential for sign determinacy. A model variable that receives only positive direct and indirect effects from a perturbation can only have a positive response, if a variable only receives negative effects it can only have a negative response. Where a variable receives both positive and negative effects, then its response is qualitatively ambiguous, but here a probability for the response sign can be determined based on the relative balance of positive and negative effects involved. Dambacher et al. (2002) and Hosack et al. (2008) developed a method to assign probabilities of sign determinacy based on results of numerical simulations of signed digraph models. For instance, a variable that receives three positive and one negative effect from a pressure will, in computer simulations, have a positive response greater than 90 percent of the time. Here we use this approach to distinguish completely determined response predictions (i.e., sign determinacy equal to 100%) from those that are ambiguous, and further identify those with a relatively high probability of sign determinacy set at ≥80%, and those with a low probability of sign determinacy (<80%).

9. Qualitative mathematical models can be created almost entirely from the description of processes and narratives. The scope and bounds of the studied system or problem is first defined, and the components of interest are then identified. Variables are chosen with respect to the research or management problem that motivated the formulation of the model. In establishing the relationships between variables, one asks 'what is the direct influence of one variable on another', and 'what else in the system determines the creation or destruction of a variable'. In addition to biological variables, model components can also include physical and environmental factors as well as social and economic processes.

10. Workshops with domain experts and literature reviews are a primary source of system description. Additionally, symbolic analysis of process-based equations can help elucidate interactions that are not clearly defined through a verbal description, as frequently is the case for self-damping of a variable or for modified interactions (Dambacher & Ramos-Jiliberto 2007).

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II. Results of group discussions

11. For the purpose of the modelling exercise, two levels of cumulative impacts will be considered:

- where a single pressure can have a cumulative impact across multiple ecosystem components in the model. In this case, the impact from an initial direct pressure on one ecosystem component is propagated to other ecosystem components through the web of interactions established in the model, showing the expected changes to parts of the ecosystem that are not directly impacted.
- where multiple individual pressures are combined into perturbation scenarios. The direct effect of these combined pressures on individual ecosystem components are again propagated to other components through the model, allowing calculation of cumulative impacts to the ecosystem.

12. This modelling approach enables the identification of which pressures are most likely to cause the largest change, either individually or when combined.

13. It should be noted that although participants were divided into two groups (I- pelagic and abyssal plain and II- benthic seamounts) to enable interactive discussion in small groups, the linkages between the benthic and pelagic ecosystems were also discussed and incorporated in the models for the two ecosystems. Particulate Organic Matter was common to both models and acted to transfer primary production from the pelagic system to the benthic seamount system. Pelagic impacts are common to both systems and are described as part of the pelagic results.

II.1 Pelagic and Abyssal Plain Ecosystems Model

14. The expert group initiated the modelling exercise by recalling the relevant subsystems to be considered in the model, namely the pelagic and abyssal plain environments. In this context, experts were

invited to identify the ecosystem values and activities that can affect those values, as well as ecosystem components, physical and ecological processes interacting with those components.

15. In addition to the overarching environmental goals presented in plenary session (para. 34, page 7) – conservation of biodiversity and ecosystem integrity – participants suggested that ecosystem services, such as nutrient recycling, carbon sequestration and ecosystem resilience, should also be considered as values for the modelling exercise.

16. The participants highlighted that polymetallic nodules occur only in areas where particulate organic matter (POM) is very low, as well as areas of low primary productivity, such as those found in the in the Clarion Clipperton Zone (CCZ). However, in the Northwest Pacific region, the large number of seamounts can create localized upwelling or downwelling, altering the primary productivity and the POM. Yet, the benthic ecosystem associated with polymetallic nodules is located between 4 and 6 Km deep, which is still well below the carbonate compensation depth (CCD). The ecosystem components identified by the expert group are listed in Table 1 below. A brief description of each variable is also provided.

17. Key physical and ecological processes to be considered in the model included, *inter alia*: currents, sediment deposition, local turbulence, flocculation, resuspension, growth of benthonic and pelagic organisms.

18. The potential natural and anthropogenic impacts identified by the participants, in the context of abyssal plain and pelagic ecosystems, included: future exploitation of mineral resources, fisheries, pollution, and climate change.

Table1. Description of physical and biological components included in ecosystem model.

Variable name	Description
Phytoplankton	Photosynthesizing microalgae that form the base of the food chain (e.g., Coccolithophores and photosynthetic prokaryotes). Phytoplankton are found mostly in euphotic waters < 200 m).
Zooplankton	Small heterotrophic animals in the upper water column that feed on phytoplankton and/or smaller zooplankton. Mostly in the - mesopelagic zone (< 1000 m). Examples are copepods and euphausiids.
Nekton	Free swimming aquatic animals of relatively small size. As defined in this discussion, this group would contain a diversity of species and groups, such as squids, jellyfish, small and juvenile fishes.
Whales	Large bodied marine mammals, here including a diversity of species (e.g., Sperm whales, Blue whales, Spinner dolphins, and Minke whales). These are highly migratory species that likely feed and transit through the area.
Fishes	Small and medium size fishes (e.g., juvenile tuna, Bramidae, Nomeidae), larger than nekton.
Predatory fishes	Large predatory fish species (sharks, billfishes, tuna).
Birds and Turtles	Migratory seabirds (e.g., shearwaters, albatross, etc.) and turtles (loggerhead, leatherback, etc.) that utilize the area as a migratory pathway and feeding region.

POM, particulate organic matter	Organic detritus from dead plankton, exudates and animal faeces. These often form aggregates, known as marine snow, that fall towards the seafloor.
DOM, dissolved organic matter	Water soluble compounds of organic carbon from a variety of sources (biological and geological).
Carcass falls	Primarily deceased whale carcasses that fall to the abyssal sea floor. Could also include other large bodied predatory fishes and other mammals. The occurrence is sporadic.
Microbial Communities	Communities of microscopic organisms living in the bottom water, in the sediment, and in the polymetallic nodules, that feed on detrital matter and DOM. The reported taxonomic groups include Archaea, Protobacteria, Chloroflexi, Actinobacteria, etc., but are largely understudied in the abyssal regions. They are known to perform various ecosystem services such as primary production, organic matter transformation, nitrogen cycling, metal cycling, and also provide diverse genetic resources.
Infauna	Organisms (mostly invertebrates belonging to meiofauna and macrofauna size classes) living in the seafloor sediments (usually the upper 10 cm). These organisms are either suspension feeders (filtering organics from the water column at the seafloor) or deposit feeders (consuming organic material from the sediment).
Epifauna	Organisms living on the surface of soft sediment or on hard substrates, including polymetallic nodules. These are mostly invertebrates (belonging to meiofauna and macrofauna size classes) and can include a wide diversity of species and feeding habits, such as suspension feeders (e.g., deep-sea corals and sponges) and detritivores (e.g., echinoderms).
Demersal fishes & invertebrates	Fish and invertebrates, mainly megafauna, that are living on or near the seafloor, and are found associated with the sediment and / or the polymetallic nodules . Invertebrates include many species of demersal cephalopods, shrimp and crabs. Fishes include macrourids, *Careproctus* (snailfishes) and others.
Deep Nekton	These organisms include bathypelagic and mesopelagic species of fishes and invertebrates (~1000 m to 5000 m). These species are notable for extensive diel vertical migrations and are estimated to comprise the majority of fish biomass in the world's oceans. Taxonomic groups include myctophids and cephalopods (e.g., squids).
Deep Predators	These organisms include mesopelagic predators (e.g., sixgill sharks, anglerfishes, etc.) and larger cephalopods.

II.1.1 Model Assumptions and Scenarios

Description of pelagic and abyssal plain ecosystems

19. The pelagic ecosystem, mainly the upper water layer, is composed at its base by the plankton (phyto and zooplankton). The plankton is consumed by nekton, which is in turn consumed by relatively larger fishes. The latter are either consumed by birds or by predatory fishes. Finally, whales, other cetaceans, and sharks are the top of the food chain, and feed on phyto, zooplankton, nekton and fishes. Deep nekton and

deep predators are associated to the bathypelagic and the mesopelagic water layers. The deep nekton is alimented by the POM sinking from the surface and by the zooplankton. The deep predators consume the deep nekton. These two groups of organisms have the particularity of migrating vertically. During the last session, the addition of turtles to the model was considered as certain endangered species (Leatherback, loggerhead) are known to migrate through the region. Turtles would feed on nekton, and have similar behavior than birds. As such, it has been decided to group turtles with birds.

20. The link between pelagic and benthic abyssal plain ecosystems takes place through the sinking of POM / DOM towards the seafloor; POM is the key ecosystem component and is mainly derived from the plankton population (composed of organic detritus from dead plankton, exudates and animal feces). That POM sinks through the water column and feeds the infauna and epifauna suspension feeders at the seabed. But the link between POM and Epifauna is not a prey-predator relationship, but rather a sink - epifauna population has no feedback loop influence on the POM concentration. At the seafloor, epifauna detritivores feed on infauna and are consumed by demersal fishes and invertebrates. In parallel, the microbial communities consume the DOM, sinking from the surface, and are consumed by the infauna and epifauna. Additionally, disturbance regime, such as carcass falls can occur, influencing each benthic component. It must be noted that the ecosystem is not limited by space availability, and the competition remains low.

21. The signed digraph for the ecosystem model is provided in Figure 2 and detailed information for the individual linkages within the model is provided in Table 2.

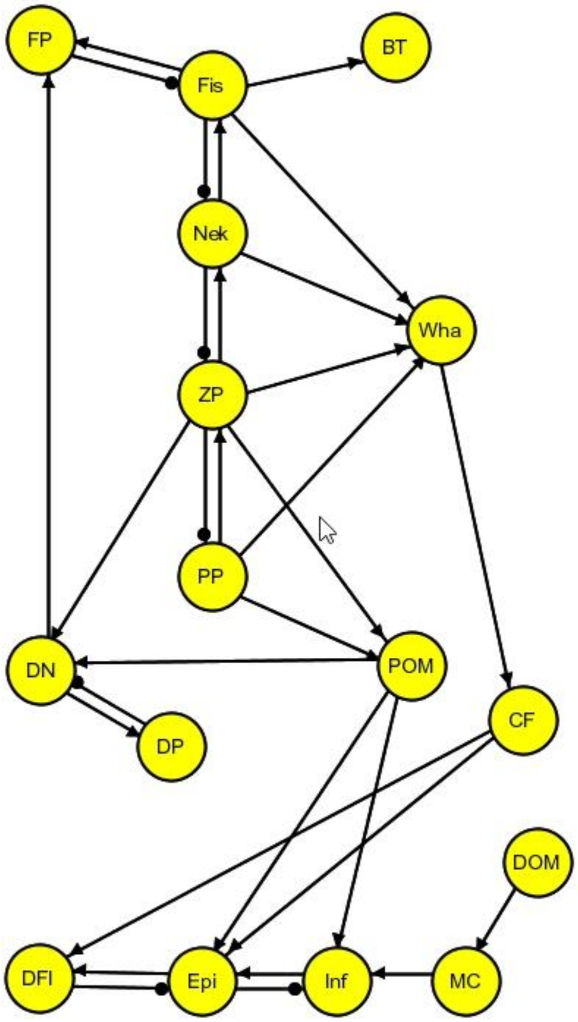


Figure 2 : signed digraph for the ecosystem model for the abyssal & pelagic ecosystem. The abbreviations are as follows: Phytoplankton (PP), Zooplankton (ZP), Nekton (Nek), Whales (Wha), Fishes (Fis), Predatory fishes (FP), Birds and Turtles (BT), Particulate organic matter (POM), dissolved organic matter (DOM), Carcass falls (CF), Microbial Communities (MC), Infauna (Inf), Epifauna (Epi), Demersal fishes and invertebrates (DFI), Deep Nekton (DN), Deep Predators (DP). The components of the pelagic ecosystem shown here are the same for the seamount ecosystem (Table 5). The connection to the benthic seamount model occurs through POM, which occurs in both models and transfers primary production to seamount benthic habitats. Impacts on pelagic components for mining on benthic seamount habitats are the same as identified in this model.

Table 2. Ecosystem interactions of physical and biological components of model; effects are positive (🡐) or negative (O—) in sign.

Effect to	**Effect sign**	**Effect from**	**Description**	**Reference**
Phytoplankton	O—	Zooplankton	Zooplankton consuming phytoplankton (predation mortality)	Gaudy et al 2004, Carlotti et al. 2008

Zooplankton	←	Phytoplankton	Zooplankton consuming phytoplankton	Gaudy et al 2004, Carlotti et al. 2018
	○—	Nekton	Nekton consuming zooplankton (predation mortality)	Ikeda et al. 2008
Nekton	○—	Fishes	Fishes consuming nekton (predation mortality)	Allain 2005
	←	Zooplankton	Nekton consuming zooplankton (predation mortality)	Ikeda et al. 2008
Whales	←	Phytoplankton, Zooplankton, Nekton, Fishes	Whales consuming a variety of prey species (predation mortality)	Kawamura 1980
Fishes	○—	Predatory Fishes	Large predatory fishes consuming other fishes (predation mortality)	Weng et al. 2016,
	←	Nekton	Fishes consuming nekton (predation mortality)	Allain 2005
Predatory fishes	←	Fishes, Deep Nekton	Large predatory fishes consuming other fishes and deep nekton (predation mortality)	Choy et al. 2013, Young et al. 2015, Choy et al. 2017
Birds and Turtles	←	Fishes	Birds and turtles consuming smaller fishes and nekton (predation mortality)	Gagne et al. 2018
POM, particulate organic matter	←	Phytoplankton, Zooplankton	Decomposition of material from pelagic food web (e.g., excess phytoplankton decomposing and being consumed while sinking out of the photic zone or consumption and excretion of planktonic organisms)	Lampitt et al. 1993
Carcass falls	←	Whales	Dead whales and other large-bodied animals sinking to the seafloor	Smith and Baco 2003
Microbial Communities	←	DOM	Consumption/incorporation of DOM by microbes on the seafloor	Rich et al. 1997
Infauna	←	POM, Microbial communities	Consumption of POM and microbial communities by infauna living in the sediment	Sweetman et al 2018
	○—	Epifauna	Consumption of infauna by epifauna (predation mortality)	Drazen and Sutton 2017

Epifauna	←	POM, Carcass falls, Infauna	Consumption of POM, detritus, whale falls and infaunal communities by epifauna living on the seafloor	Smith and Baco 2003, Drazon and Sutton 2017
	○—	Demersal fishes & invertebrates	Fishes and invertebrates living on or near the seafloor predating on the epifaunal community (predation mortality)	Drazen and Sutton 2017, Gartner et al. 1997
Demersal fishes & invertebrates	←	Carcass falls, Epifauna	Consumption of carcass falls and predation on epifauna by fishes and invertebrates living on or near the seafloor	Smith and Baco 2003, Drazen and Sutton 2017
Deep Nekton	←	POM, zooplankton	Consumption of POM (e.g., marine snow) and zooplankton by deep nekton communities	Summarized in Drazen and Sutton 2017, Choy et al. 2017
	○—	Deep Predators	Deep predatory fish feeding on the deep nekton community (predation mortality)	Gartner et al. 1997, Drazen and Sutton 2017, Choy et al. 2017
Deep Predators	←	Deep Nekton	Deep predatory fish feeding on the deep nekton community (predation mortality)	Gartner et al. 1997, Drazen and Sutton 2017, Choy et al. 2017

Description of the potential mining operation

22. The collection of polymetallic nodules will be composed of:

- a vehicle at the seabed, collecting the nodules in the top layer of sediment. The nodules are separated from the sediment in the vehicle at the seafloor. Most of the sediment will be released at the seabed forming a slurry layer and a plume of suspended particles. Alternatively, the sediment could continuously be compacted and pressed to pellets, and finally released at the back of the collector, to prevent the formation of a plume and provide hard ground for species re-colonization.

- The riser pipe system, through which the nodules (crushed to homogeneous sizes to allow a continuous flow in a distinct transport medium with sufficient buoyancy or not) are pumped to the surface support vessel. Pumps are located along the riser pipe at approximately 1000 m intervals.

- The surface ship, receiving the nodules from the vertical pumping system. On the surface ship, the nodules are separated from the remaining transport medium. In early concepts, this medium was composed of seafloor water and remaining sediment. It has been shown, however, that seawater does not provide the necessary buoyancy and that larger amounts of sediment disturb a continuous flow and create riser collapses. Alternative concepts therefore involve the use of close circuits with higher density transport media similar to drilling fluids. The nodules are separated from transport medium and stored before transshipment. During the process, two scenarios were considered:

- Older concept: Disposal of return seawater including fine sediment particles;
- New concept: the sediment is largely avoided and separated in the collector. A continuous transport medium is used in the riser technique instead of seawater.

- The return plume: The bottom water which came up the pipe with the nodules and the sediment are then returned to the ocean. The depth for discharging this return water is yet not defined. Following recent suggestions to minimize impacts in the mesopelagic zone, experts assumed water return below the thermocline. However, best practice would be to return this water as close as possible to the seabed. Therefore, two scenarios were included in the model:
  - Scenarios A: Return water between 1000 m below surface and the seabed (assume that the effects won't be different if 1500, 2000 or 3000 m deep).
  - Scenario B: Return water near to the seafloor (perhaps 20-50 m above seafloor) where it will mix with the seabed plume

Description of the potential effects on ecosystems from polymetallic nodule exploitation, other human activities, and climate change

23. The participants discussed the potential direct effects associated with future mining activities, and potential impacts from fisheries, pollution, and climate change, as summarized in Table 3.

Table 3. Potential pressures and effects from natural and anthropogenic activities on pelagic and abyssal plain ecosystems of the NW Pacific region.

Pressure	Pressure effect	Direct effect on	Description	Reference
Removal of hard substrate at the seafloor and of the top 10 – 30 cm of sediment	P1) negative	Microbial communities, Infauna, Epifauna	Nodules provide the only hard substrate. They host attached organisms and organisms lodged in their crevice spaces. All nodules will be removed over very broad areas (200 km^2 per contractor per year) and nodules will not regrow to appreciable size for millions of years. In the sediment most organisms live in the top few millimetres and are dependent on the bioactive layer in the top millimetre or so. Mining will destroy the top ~10-20 cm of the sediment column plus the organisms in it over the areas mentioned above. Small scale experiments have shown that ecosystems and biogeochemical functions do not regenerate well even over several decades.	Weaver et al, 2019: Vanreusel et al. 2016: Jones et al. (2017); Gollner et al. 2017
Compaction of the soil by the vehicle and	P1) positive	Microbial communities, Infauna	Sediment compaction under the tracks of the seabed mining tool will reduce porosity and permeability and	De Stigter (2020); Haffert et al., 2020;

Pressure	Pressure effect	Direct effect on	Description	Reference
Alteration of the chemical property of sediment			thereby restrict porewater diffusive exchange and potentially hinder recolonization by benthic fauna. This may be of minor concern because the compacted sediment will be broken-up by the grouser plates of the tracks of the mining tool, and most of the compacted sediment will be blanketed by redeposited sediment. Additionally, the pore water content would be released in the bottom layer, altering the water chemistry of the bottom water, therefore influencing the microbial communities. Finally, the removal of sediment might surface the oxic-anoxic transition layer (deep oxic-transition layer in the CCZ, but this should be verified for the NW Pacific region). Where bioreactive organic matter is redistributed, microbial communities may be restored or enhanced.	Weaver and Billett (2019); Billett et al (2019)
Slurry layer, defined as the material (liquified sediment) which remains after the nodule uptake	P2) negative	Infauna, Epifauna	The mining process will remove the top 10-30 cm of the seabed and disaggregate the muddy sediment. This sediment will be removed from the nodules and dumped at the rear of the vehicle where it will form a new layer on the seabed. This sediment will have a much higher water content than the unmined seabed and form a slurry. Organisms will find it difficult to recolonise this slurry which may take many years to centuries to consolidate.	Weaver and Billett (2019)
Mining plume (seabed)	P3) negative	Infauna, Epifauna, Demersal fishes & Invertebrates	The ejected sediment mentioned above will also create a plume of suspended sediment with high particle load near the mining vehicle where it will smother all seabed animals. At greater distance, where the particle load is lower, infauna may be less affected but filter feeders will be impacted or killed. This	Weaver and Billett (2019): Gillard et al (2019); Drazen et al., (2019)

Pressure	Pressure effect	Direct effect on	Description	Reference
			plume will also affect animals in the benthic boundary layer, with the plume extending to 100s metres above the seafloor. The lateral distance over which impacts may occur could be up to tens of kilometres.	
Return plume (A)	P4) negative	Deep Nekton, Deep predators	The water returned from nodule processing on the support ship could be discharged in mid water where its particulate load will affect suspension feeding animals in the mesopelagic and bathypelagic zones.	Drazen et al., (2019).
Return plume (B)	P5) negative	Infauna, Epifauna, Demersal fishes & Invertebrates	Same as P3 If return plume contains toxic contaminants, mortality or severely reduced fitness with potential for sublethal impacts can persist for years, causing continued degradation.	Drazen et al.,(2019) Fisher et al. (2014); Girard and fisher (2018); Girard et al. (2018); Cordes et al. (2016).
Noise from mining vehicle at the mine site	P6) negative	Demersal fishes & Invertebrates, Deep Nekton, Deep Predators,	There is potential for noise from the nodule mining vehicle to impact animals on the seabed and in the benthic boundary layer. More research is needed. Noise would actually travel further than the sediment cloud. Therefore, noise effect would be detected in the secondary area too and should not be neglected. Additionally, the proximity of seamounts in the NW Pacific region would induce echo and deflections of the noise generated in the abyssal plains. Physical trauma to internal organs, reduced fitness, reduced survivorship for vertebrates and invertebrates have been documented 100s to 1000s of meters from a sound source.	Frosch (1964), Kuperman (2001); Nedeles et al. (2017); Popper and Hawkins (2019), Halvorsen et al. (2012), McCauley et al. (2003), (Carroll et al. 2017). Larsen, Ole Næsbye et al. (2018), Hawkins & Popper (2018)
Noise from surface vessel	P7) negative	Birds and Turtles, Whales	Detrimental injury, tissue damage, physical change, and masking of biologically significant sounds may	Andre et al. (2011), Kaartvedt et al.

Pressure	Pressure effect	Direct effect on	Description	Reference
			change behaviour and compromise fitness, communication, foraging and feeding, bonding, breeding, predator avoidance, habitat avoidance, etc. with long-term impacts and unknow recovery, reduced foraging time, masking of biological sounds, physiological effects, injuries—can be temporary or permanent—and mass stranding. Diving sea birds exposed to underwater noise pollution are expected to suffer implications for survival and fitness.	(2020), Packard et al. (1990), Peña (2019), Røstad, et al. (2006), Sole et al. (2013) DeRuiter and Doukara (2012); Gomez et al. (2016); Richardson et al. (1995); Joy et al. (2019); Cox et al. (2006); CBD (in review) ; Erbe et al. (2018)
Noise from pumps on riser pipes in SOFAR (sound-fixing-and-ranging) layer	P7) negative	Whales, deep nekton & deep predators	Sound is transmitted very long distances in the SOFAR layer and it may impact communication between cetaceans that use this layer for their long-distance communication.	Drazen et al., (2019)
Light from mine vehicle	P8) negative	Epifauna, Demersal fishes & Invertebrates	Amplifying effects of P3	Kaartvedt et al, (2019)
Light from surface vessel	P9) negative	Birds, Fishes	Can attract birds at night and prevent them moving too far from ship leading to inability to forage naturally. Collisions caused by lighting on vessels can be fatal or non-impact with reduced fitness. Lighting may also affect migratory birds that are attracted to the red waveband. A study by Ludvigsen et al. (2018) observed that the vast majority of the pelagic community exhibit a strong light-escape response in the presence of artificial light. This effect was observed down to 100 m depth and 190 m away from the ship.	Burke et al, 2012: Marquenie et al., 2014: Montevecchi, 2006: Poot et al., 2008; Ludvigsen et al. (2018) Troy et al. (2013)

Pressure	Pressure effect	Direct effect on	Description	Reference
Light from surface vessel may affect plankton	P9) positive	Predatory Fishes	Lights can attract and concentrate small fish and squid, possibly because they can continue to chase their prey by visual means. These concentrations of fish and squid can in turn attract larger predators such as dolphins which leads to their higher predation. It is not known if the green lights have any positive impact on the migration of plankton or attraction of fish and squid.	Ludvigsen et al. (2018);
Toxicants	P10) negative	Demersal fishes & Invertebrates	Metals can affect metabolism. At present it is not known whether nodule mining will involve the release of metals. If released, toxins can progressively increase in chemical concentration with increasing trophic status (biomagnification), with lethal results.	Koschinsky et al (2003) Cossaboon et al., (2019)
Nutrients enrichment	P11) positive	Phytoplankton, Epifauna	Increase primary productivity and sedimentation	Boyd et al (2010)
Climate-change induced events such as typhoons	P12) positive	Phytoplankton	Climate changes would potentially increase the occurrence of typhoon, and thus the sedimentation, as well as increase the mixed layer.	Yamaoka
Fisheries	P13) negative	Fishes, Predatory Fishes	Fishing in the area appears to be on pelagic highly migratory species (tuna, billfish, etc.) with possibly some small pelagic (squids, chub mackerel, maybe pacific saury).	Wallace et al. (2010);
Marine Debris	P14) negative	Phytoplankton, Zooplankton, Birds and Turtles, Whales, Fishes, Predatory Fishes, Nekton	Marine debris, especially plastics, is known to be one of the rising pressures in the marine environment. The proximity of the western garbage patch with the NW Pacific Region renders this pressure important.	De Stephanis et al. (2013); Roman et al. (2019)

24. The participants discussed potential combinations of pressures to develop tangible pressure scenarios. Regarding the environmental impact of polymetallic nodule exploitation, a substantial amount

of work has been achieved for the CCZ area. Not all the available information is directly transferrable to the NW Pacific region, but the following assumptions can be made:

- The removal of nodules as the only hard substrate is by far the biggest pressure on the benthic ecosystem. For the qualitative assessment of cumulative impacts, the removal of hard substrate is the direct footprint of the mining activity;
- The second biggest pressure is the seabed plume and the slurry in the secondary impact area, surrounding the mining area;
- The third biggest pressure is the return plume, but this concern becomes less relevant if the return depth is at the seabed (see above); and
- Even if there is no return plume, the effects caused by the above pressures (removal of nodules, seabed plume and slurry) will still be much larger than the effects due to light, noise, toxicants and nutrients.

25. Two matrixes of perturbations have been considered for the scenarios: (i) The combinations of perturbations in the mined area, and (ii) The combinations of perturbations in the secondary impact area, where nodules are not removed, but where the seabed plume would extend. In each matrix, a series of scenarios have been discussed : (1) Each individual pressure isolated (S0), (2) The combination of the key concerns (S1-S2-S3), (3) the combination of all mining-related activity effects (S4-S5-S6), and (4) the combination of all mining-related activity effects cumulated with other pressures (S7-S8-S9). Subsequently, within each triplicate series, various return water options are assumed: (a) No return plume, potentially resolved by future technologies and/or no impact on the ecosystem (S1-S4-S7), (b) Return plume along the water column, with effects on the pelagic communities (S2-S5-S8), and (c) Return plume at the seabed (S3-S6-S9).

26. The detailed list of scenarios can be found in the Table 4 below.

Table 4. Perturbation scenarios assembled from combined effects of pressures detailed in Table 3.

Perturbation scenario	**Pressure effect number from Table 3**	**Brief perturbation description**
	(i) In the Area of future mining	
S0	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14	Impact of individual pressure
S1	P1, P2, P3	Key environmental concerns and long-term effects in the mined area, but assuming no return plume, potentially resolved by future technologies and/or no impact on the ecosystem. Cumulative impact of mining activities on seafloor on benthic and demersal community/ecosystems

Perturbation scenario	Pressure effect number from Table 3	Brief perturbation description
S2	P1, P2, P3, P4	Key environmental concerns and long-term effects in the mined area, but assuming a return plume along the water column, with effects on the pelagic communities Cumulative impact of mining activities on seafloor and returning plume in upper pelagic zone on both upper pelagic, benthic and demersal community/ecosystems
S3	P1, P2, P3, P5	Key environmental concerns and long-term effects in the mined area, but assuming a return plume at the seabed Cumulative impact of mining activities on seafloor and returning plume in deeper pelagic zone on pelagic, benthic and demersal community/ecosystems
S4	P1, P2, P3, P6, P7, P8, P9, P10, P11	Combination of all mining-related activity effects in the mined area, but assuming no return plume, potentially resolved by future technologies and/or no impact on the ecosystem. Cumulative impact of mining activities on seafloor, light, noise, toxicants and nutrient input on pelagic, demersal and benthic ecosystems
S5	P1, P2, P3, P4, P6, P7, P8, P9, P10, P11	Combination of all mining-related activity effects in the mined area, but assuming a return plume along the water column, with effects on the pelagic communities Cumulative impact of mining activities on seafloor, returning plume in upper pelagic zone, light, noise, toxicants and nutrient input on pelagic, demersal and benthic ecosystems
S6	P1, P2, P3, P5, P6, P7, P8, P9, P10, P11	Combination of all mining-related activity effects in the mined area, but assuming a return plume at the seabed Cumulative impact of mining activities on seafloor, returning plume in deep pelagic zone, light, noise, toxicants and nutrient input on pelagic, demersal and benthic ecosystems
S7	P1, P2, P3, P6, P7, P8, P9, P10, P11, P12, P13, P14	Combination of all mining-related activity effects in the mined area, but assuming no return plume, potentially resolved by future technologies and/or no impact on the ecosystem, cumulated with other pressures Cumulative impact of mining activities on seafloor, light, noise, toxicants and nutrient input, typhoon, fisheries and marine debris on pelagic, demersal and benthic ecosystems

Perturbation scenario	Pressure effect number from Table 3	Brief perturbation description
S8	P1, P2, P3, P4, P6, P7, P8, P9, P10, P11, P12, P13, P14	Combination of all mining-related activity effects in the mined area, but assuming a return plume along the water column, with effects on the pelagic communities, cumulated with other pressures Cumulative impact of mining activities on seafloor, returning plume in upper pelagic zone, light, noise, toxicants and nutrient input, typhoon, fisheries and marine debris on pelagic, demersal and benthic ecosystems
S9	P1, P2, P3, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14	Combination of all mining-related activity effects in the mined area, but assuming a return plume at the seabed, cumulated with other pressures Cumulative impact of mining activities on seafloor, returning plume in deep pelagic zone, light, noise, toxicants and nutrient input, typhoon, fisheries and marine debris on pelagic, demersal and benthic ecosystems
(ii) **In the Secondary Impact Area**		
S10	P3	Key environmental concerns and long-term effects in the secondary impact area (namely the seabed plume), but assuming no return plume, potentially resolved by future technologies and/or no impact on the ecosystem. Impact of mining plume at seafloor on benthic and demersal community/ecosystems distant from mining site
S11	P3, P4	Key environmental concerns and long-term effects in the secondary impact area (namely the seabed plume), but assuming a return plume along the water column, with effects on the pelagic communities Cumulative impact of mining plume at seafloor and returning plume in upper pelagic zone on upper pelagic, benthic and demersal community/ecosystem
S12	P3, P5	Key environmental concerns and long-term effects in the secondary impact area (namely the seabed plume), but assuming a return plume at the seabed Cumulative impact of mining plume on seafloor and returning plume in deeper pelagic zone on pelagic, benthic and demersal community/ecosystems

Perturbation scenario	Pressure effect number from Table 3	Brief perturbation description
S13	P3, P7, P9, P10, P11	Combination of all mining-related activity effects in the secondary impact area, but assuming no return plume, potentially resolved by future technologies and/or no impact on the ecosystem. Cumulative impact of mining plume on seafloor, light and noise from mining vessel, toxicants and nutrient input on pelagic, demersal and benthic ecosystems
S14	P3, P4, P7, P9, P10, P11	Combination of all mining-related activity effects in the secondary impact area, but assuming a return plume along the water column, with effects on the pelagic communities Cumulative impact of mining activities on seafloor, returning plume in upper pelagic zone, light and noise from mining vessel, toxicants and nutrient input on pelagic, demersal and benthic ecosystems
S15	P3, P5, P7, P9, P10, P11	Combination of all mining-related activity effects in the secondary impact area, but assuming a return plume at the seabed Cumulative impact of mining activities on seafloor, returning plume in deep pelagic zone, light and noise from mining vessel, toxicants and nutrient input on pelagic, demersal and benthic ecosystems
S16	P3, P7, P9, P10, P11, P12, P13, P14	Combination of all mining-related activity effects in the secondary impact area, but assuming no return plume, potentially resolved by future technologies and/or no impact on the ecosystem, cumulated with other pressures Cumulative impact of mining activities on seafloor, light and noise from mining vessel, toxicants and nutrient input, typhoon, fisheries and marine debris on pelagic, demersal and benthic ecosystems
S17	P3, P4, P7, P9, P10, P11, P12, P13, P14	Combination of all mining-related activity effects in the secondary impact area, but assuming a return plume along the water column, with effects on the pelagic communities, cumulated with other pressures Cumulative impact of mining activities on seafloor, returning plume in upper pelagic zone, light and noise from mining vessel, toxicants and nutrient input, typhoon, fisheries and marine debris on pelagic, demersal and benthic ecosystems
S18	P3, P5, P7, P9, P10, P11, P12, P13, P14	Combination of all mining-related activity effects in the secondary impact area, but assuming a return plume at the seabed, cumulated with other pressures

Perturbation scenario	Pressure effect number from Table 3	Brief perturbation description
		Cumulative impact of mining activities on seafloor, returning plume in deep pelagic zone, light, noise, toxicants and nutrient input, typhoon, fisheries and marine debris on both pelagic, demersal and benthic ecosystems

II.1.2 Model outcomes

27. The predicted responses of ecosystem components in the model to individual or multiple pressures were classified according to their probability for sign determinacy as either certain negative (dark red), likely negative (light red), zero (white), likely positive (light blue), certain positive (dark blue), or sign indeterminate (yellow). Certain positive or negative responses were predicted where all pathways of linkages leading from a pressure to an ecosystem component were of the same sign and the probability for sign determinacy is 100%. Zero responses were predicted where the ecosystem component had an absence of any effects being transmitted from the pressure. Likely positive or negative responses were predicted where the majority of pathways caused effects with the same sign and the probability for sign determinacy is ≥80%.

Cumulative impact single pressures

28. Single pressures that were the result of mining activities typically had a direct impact of the benthic system. Where significant habitat removal or alteration occurred (ie P1, P2, P3, P5) the impacts were uniformly negative to the benthic components. Pressures originating from the mining operations that impact the pelagic system (P4, P6, P7, P8) impact parts of the pelagic ecosystem which may cause ecosystem effects in the abyssal system. Light (P9) has both positive and negative impacts on the pelagic ecosystem, which may cause some changes to Deep Nekton and Deep Predators. Pressures that are associated with the area, but not derived from mining (P11, P12, P13, P14) cause a variety of different impacts to the pelagic system, which will be important when considering the cumulative impact of all activities in the area.

Cumulative impact multiple pressures

29. When impact is limited to those pressures that only act on the seafloor as a result of direct extraction (S1, S2, S3) the pelagic system is only slightly impacted (S2) but seafloor assemblages are heavily impacted. These scenarios would be relevant if technologies were able to mitigate all the pressures that impact the pelagic system. As more pressures are added to the pelagic ecosystem (S4, S5, S6, S7, S8, S9) impacts become progressively more broadly distributed through both the pelagic and abyssal ecosystems. In all these scenarios, the abyssal ecosystem remains heavily impacted and Birds and Turtles (BT) are also impacted in all scenarios.

30. The impacts of the return plume on areas outside the main mining area were considered in Scenarios 10, 11, 12. In those cases, Demersal Fishes and Invertebrates (DFI) are impacted and other parts of the abyssal ecosystem may be impacted. Once the pressures from surface operations are added (S13, S14, S15), the pelagic ecosystem is changed and Birds and Turtle (BT) are impacted in all scenarios. The addition of pressures from other activities in the area (S16, S17, S18) significantly impacts the pelagic ecosystem, and Demersal Fish and Invertebrates.

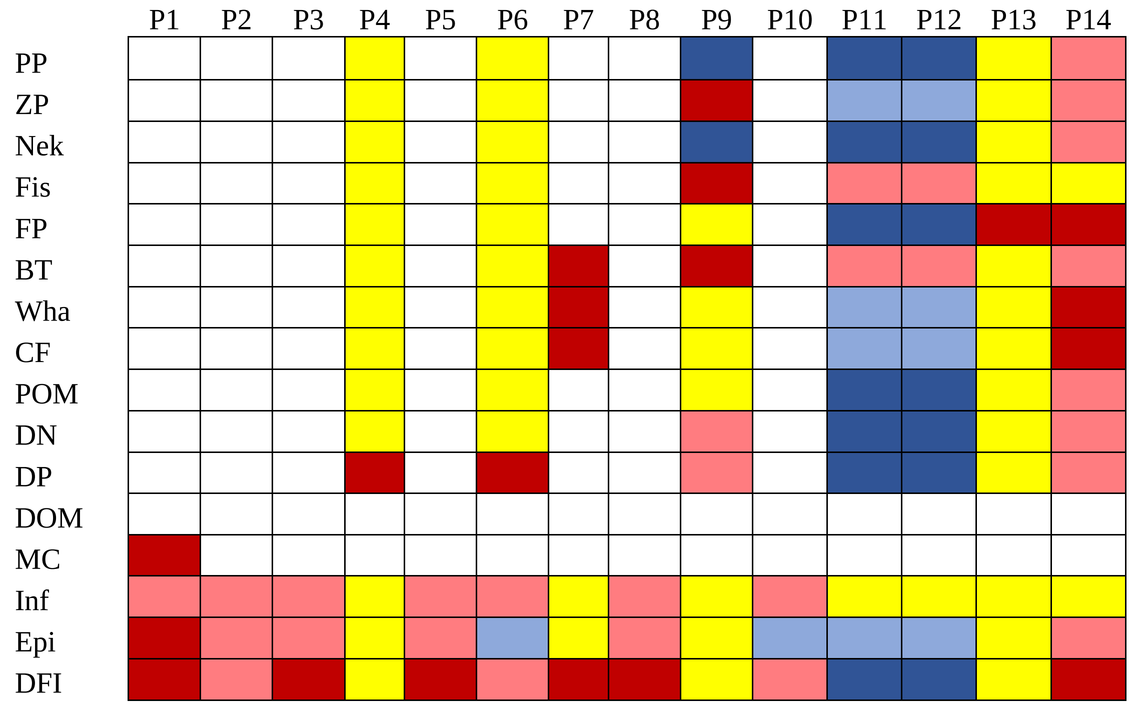


Figure 3. Qualitative response predictions of pelagic and abyssal plain ecosystem components (rows) to each of the pressure effects (columns) detailed in Table 3.

II.2 Seamount Benthic Ecosystems Model

31. The expert group initiated the exercise by recalling the relevant subsystems to be considered in the model, namely the benthic seamount habitats. In this context, experts were invited to identify the ecosystem values and activities that can affect those values, as well as ecosystem components, physical and ecological processes interacting with those components. Several participants raised cultural values that can be affected, however it was explained that such values were beyond the scope of the ecosystem model.

32. In addition to the overarching environmental goals presented in plenary– conservation of biodiversity and ecosystem integrity – participants suggested that ecosystem services, nutrient recycling, carbon sequestration and ecosystem resilience, should also be considered as values for the modelling exercise. However, these were not included as variables in the model due to their relatively rapid turnover compared to other variables. Several workshop participants also suggested that other ecosystem services, particularly fishing, food security, climate regulation, and cultural services, should be considered in future iterations of the model.

33. The participants discussed the scope of the model in relation to water depth and seamount topography. Seamounts in the NW Pacific region occur at depth ranges between 1000 to 5000m, with summits being typically located at 800 to 1500m depth, and the base at around 3500 to 4000m depth. The presence of shallower seamounts was highlighted, as for example, the Alba seamount (peaking at 550 m water depth) mentioned in the draft report on Regional Environmental Assessment. Various summit morphologies were described, such as flat, peaking, and irregular. For the model purposes, the group agreed that a typical seamount could be represented by:

- Seamount height: 3,500 m;

- Summit depth: 300-1000m (i.e. below the euphotic zone in any case);
- Diameter of the base of the seamounts: in the order of 10 – 100 km; although diameter size can range between 10 km to ≥200 km.

34. The ecosystem components identified by the expert group are listed in Table 5 below. A brief description of each variable is also provided.

35. Key physical and ecological processes to be considered in the model include, *inter alia*: currents, eddies, Taylor columns, nekton migration, plankton migration, POM fluxes, and larval transport.

36. The potential natural and anthropogenic impacts identified by the participants, in the context of benthic seamount ecosystems, included: future exploitation of mineral resources, fisheries, pollution, climate change, deoxygenation and ocean acidification.

Table 5. Description of physical and biological components included in ecosystem model.

Variable name	Description
CS: Carnivorous Sponges	A group of demosponges that feeds on zooplankon (rather than filter-feeding). Growth is tall and often tree-like.
Tun: Tunicates	Large sea squirts that occur alone or in clusters.
FFSS: Filter Feeding Sea Stars	A common deep-sea group of asteroids (Brisingidae) that feed on suspended particulates and zooplankton.
RP: Rock Pens	The subset of the group of Solitary octocorals, also commonly known as ‘sea pens’ (Order ‘Pennatulacea’) that occur in hard substrate areas.
SHC: Solitary Hard Corals	Scleractinian (CaCO3 skeleton) small single forms.
SC: Soft Corals	Alcyonacean corals that do not have a calcium carbonate skeleton. Some forms grow tall off the bottom.
OC: Other Corals	Corals that were not soft or solitary hard types. Predominantly corals within Alcyonacea that have skeleton, originally belonging to the now obsolete taxonomic grouping of ‘Gorgonacea’. Skeletons may be calcareous or proteinaceous. Includes also Antipatharia and Zoantharians that form skeletons e.g. Gold corals of the genus *Kulumanamana*.
GS: Glass sponges	A major sponge group (Hexactinellida) very common in the deep sea and in particular on seamounts that are filter feeders. Growth habit is vertical and may extend well over a metre off-bottom.
NCr: Non-stalked Crinoids	Comatulid crinoids known as “feather stars” that perch on corals, sponges and substratum edges to capture zooplankton. Capable of slow crawling and short swimming spurts.
CHC: Colonial Hard Corals	Scleractinians that build solid calcareous skeletons with colonial polyps thereby covering a lesser or greater extent of seafloor
SCr: Stalked Crinoids	Mostly non-comatulid crinoid known as “sea lilies” that are permanently attached (or drag the stalk with them crawling) to the bottom. Feeding on zooplankton and POM.
ES: Encrusting Sponges	Demosponges that coat a hard substratum.
EI: Embedded Invertebrates	Varied sedentary invertebrate species almost always located on large corals and sponges that have a tall growth habit. Appear to

	have mostly commensal relationship (but can be more predatory) using the foundation species to access stronger currents off-bottom
IP: Invertebrate predators	Invertebrates that range widely (such as gastropods, polychaetes, asteroids) to feed on corals, sponges and other benthic animals
IS: Invertebrate scavengers	Invertebrates feeding mostly on debris and dead/dying animals.
ID: Invertebrate detritivores	Includes molluscs, segmented worms, nematodes, etc. Includes small mobile fauna that live on or within sediment and rocks (e.g., meiofauna) that consume detrital particulate organic matter and/or indigenous microbial communities.
MC: Microbial Community	Microscopic Bacteria and Archaea that live in the bottom water, sediment, rocks, and polymetallic crusts. Different members can perform various ecosystem services such as primary production, organic matter transformation, nitrogen cycling, metal cycling, habitat formation; and they provide diverse genetic resources
LFC: Local fishes and Cephalopods	A group that lives associated with the seamount (e.g. synaphobranchid eels, octopods)
BPF: Bentho pelagic fishes	Fish groups that migrate between the water column and the near-bottom habitat. The benthopelagic is typically considered to encompass the seafloor and 100 m or so of water column immediately above the seafloor.
TDN: Transient Deep Nekton	Swimming fish and cephalopods that are migrators aggregated around seamount top during the day
TDZ: Trapped Deep Zooplankton	Vertically migrating zooplankton that are "trapped" by the summit depth or rotating circulation around seamount during the day
POM: Particulate organic matter	Organic detritus from dead plankton, exudates, animal plankton. These often form aggregates, known as marine snow, that fall towards the seafloor
Rec: Population recruitment	Arriving larvae of a particular species; recruitment means it successfully settles, metamorphoses and grows
BLV: Boundary Layer Velocity	Current speed in the layer above the bottom that is affected by friction with a solid boundary

II.2.1 Model Assumptions and Scenarios

Description of benthic seamount ecosystems

37. The seamounts of the NW Pacific region are colonized by various groups of organisms; given their importance of creating habitat for a myriad of associated species, sponges and corals are of particular ecological importance. Participants discussed grouping organisms according to their functional shape (more or less resistant to impact) and feeding patterns (e.g. filter feeders, scavenger). Participants highlighted the importance of foundation communities typically found on the seamounts, consisting of:

- Microbial communities
- Sponge gardens, including glass sponges, carnivorous sponges and encrusting sponges,

- Coral gardens, including colonial hard corals, solitary hard corals, soft corals, and other corals (e.g. gold corals) used by embedded invertebrates and non-stalked crinoids,
- Crinoids, including stalked crinoids (crinoids that cannot escape), and non-stalked crinoids (crinoids that can escape),
- Rock pens,
- Tunicates, and
- Brisingid sea stars, exist on some seamounts in high densities, and are mainly suspension feeders rather than scavengers.

38. Several of these foundation organisms (mainly glass sponges, soft corals, other corals and crinoids) also act as ecosystem engineers by lowering the velocity of boundary layer currents, thus creating turbulence that enhances food availability (increased organic matter) and local recruitment (larval deposition). It was noted that tunicates can be highly abundant (e.g. on Kotcebu Guyot, ascidian density reached 2600 individuals per hectare, i.e. 35 ascidians in a $7m^2$ portion of seabed; high abundances were also reported on the Necker ridge and several by CAPSTONE sites) but they are small (5 - 10cm size), hence are not considered habitat forming species, and they are carnivorous.

39. Participants discussed drivers of community structure and population distribution, indicating that competition for space on the seamounts is apparently not strong, while food limitation and recruitment dynamics are more relevant factors. These communities are found in many different seamounts and occupy different niches. One exception could be the colonial hard corals, which typically are not frequent, but can overrun other species and strongly compete for space if they become dense. However, there are no scientific studies on the factors of community structure in seamounts of the NW Pacific region.

40. The importance of brachiopods (suspension feeders) was discussed, but these organisms don't seem to be abundant in the NW Pacific region, and aren't often associated with crusts that have so far been explored.

41. Participants also highlighted the importance of commensal relationships established with foundation species. For instance, commensal non-stalked crinoids are found associated with soft corals, colonial hard corals and glass sponges; ophiuroids have commensal relationship with glass sponges, encrusting sponges and soft corals, colonial hard corals, but non-commensal ophiuroids can also be present. Other commensal or solitary invertebrates include crustaceans and gastropods. The expert group decided to establish three categories for representing different functional groups of invertebrates: commensal (embedded), detritivores and predators (e.g. urchins). A prey-predator link between invertebrate detritivores and predators was added. Invertebrate detritivores are also included in benthic communities across different size classes (meiofauna through megafauna) living on the seamount.

42. The multiple ecosystem functions provided by microbial communities were discussed. Microbial communities can provide primary productivity to the ecosystem, introducing a chemosynthetic component (but little research and data exist at this stage). The microbial communities would add an extra food source, particularly important for grazing organisms, infauna and meiofauna communities (part of the invertebrate detritivores). Additionally, microbial communities are important for nutrient cycling (including the transformation of organic carbon, creating organic compounds more or less available for other ecological components of the system). Yet, in qualitative modelling, due to the fast subsystem of nutrient recycling and the subsequent positive feedback loop, this function is implicitly mentioned by the presence of microbial communities. Finally, even if not explicitly mentioned in the model, it has been noted that

microbial communities are also an incredible reservoir of biodiversity, including genetic diversity and potentially involved in habitat formation (for crust) and habitat signaling (but there is little data on this).

43. Another additional ecological component are the scavenging communities, including amphipods, that should be kept separated from predators and detritivores. As such, the component “invertebrate scavengers” has been added to the model. They would be consumed by local fishes and cephalopods, but their habitat is unknown, as they have been studied only by baited traps. They are not specific to benthic seamount habitats, as they are also found in abyssal nodule fields.

44. In the water column, various ecological components interacting with the seamount were considered, such as:

- Local fishes and cephalopods (grouped, as they would have similar behavior) feed on invertebrates (detritivores/predators), deep transient zooplankton and trapped deep nekton.
- Zooplankton, specifically the trapped deep zooplankton due to topography and currents, interact with benthic organisms,
- Nekton, specifically the trapped deep nekton due to topography and currents, interact with benthic organisms,
- Bathypelagic fishes, specific to seamounts for spawning and feeding, feed on local fishes, invertebrate detritivores and transient deep nekton, but this predation relationship has been questioned by some participants (dashed lines).
- When considering the potential impacts of surface operations on pelagic species around seamounts the pelagic components of the pelagic-abyssal model (Figure 2) can be used. The key link between the models is POM, which is present in both models.

45. Across seamounts, there is not enough information regarding source-sink populations and connectivity to determine the relative importance between self-recruitment (i.e., internal recruitment that is implicit in the model for each ecological component) and external recruitment. Therefore, it has been suggested to use a generic variable “recruitment’ to represent the import of larvae from outside the seamount ecosystem, that would benefit all the ecological components considered. Consequently, it was noted that an increase of the benthic layer velocity (BLV) would suppress recruitment. Additionally, for the nekton communities, the early life stage, typically juveniles, get trapped in the benthic layer.

46. Participants highlighted the relevance of particulate organic matter (POM) to be explicitly mentioned in the model, as the role of POM and microbial communities are central food sources for this ecosystem. POM sinks from the upper part of the water column and provides food for all suspension feeders. In addition to POM, pelagic and benthic components are also linked through predation relationships, including:

- some trapped zooplankton are eaten by carnivorous sponges, stalked crinoids (all suspension feeders) and tunicates,
- Bathypelagic fishes also feed on embedded invertebrates in addition to the predation on local fishes and cephalopods, invertebrate detritivores, and transient deep nekton, although these links need further research, and
- Local fishes and cephalopods also feed on embedded invertebrates.

47. Seamount-induced chlorophyll enhancement (Leitner et al. 2020), cyclonic mid-ocean eddies (Drazen et al., 2011), and other oceanographic features enhance primary and secondary productivity over seamounts, enhancing the occurrence of aggregating fish, fish predators, sharks, marine turtles, marine mammals, and sea birds (Pitcher and Bulman 2007). For these biological components of the seamount ecosystem, please refer to Figure 2. The key link between the pelagic and seamount benthic models occurred through Particulate Organic Matter (POM), which is contained in both models.

48. The upper water column ecosystem around the seamounts was discussed but not addressed in the benthic seamounts model because it was assumed that the pelagic model (Figure 2) would cover the water column impacts. This assumption should be examined for explicit seamount interactions in the future. Participants highlighted that several migratory species use the seamounts for limited periods of time ('transient visitors'). Seamounts are well known to facilitate the dispersion of organisms between distant geographic areas by serving as navigational marks and stepping stones for the movement of many highly mobile organisms (Wilson and Kaufmann, 1987; Rogers, 1994; Garrigue et al., 2015; Rogers, 2018). Epipelagic fishes around the seamounts are mainly eels and ratfishes, that use benthic refuge, food and egg deposition. Nevertheless, experts highlighted the traditional cultural value of the ocean and its natural resources for Polynesian communities, as well as other cultural services (e.g. travelling from land to seabed). Some local cultures are still using ocean processes for traditional navigation in the region. Additionally, there are many known shipwrecks in this region. The loss of any living component here would have an influence on the cultural value of the ocean. Other important features not included in the model refer to other ecosystem services such as carbon sequestration, nutrient cycling, climate regulation, cultural services, scientific research, among others. These should be considered in future modelling exercises, since some of these may be impacted by seabed activities.

49. The signed digraph for the ecosystem model is provided in Figure 5 and detailed information for the individual linkages within the model is provided in Table 6.

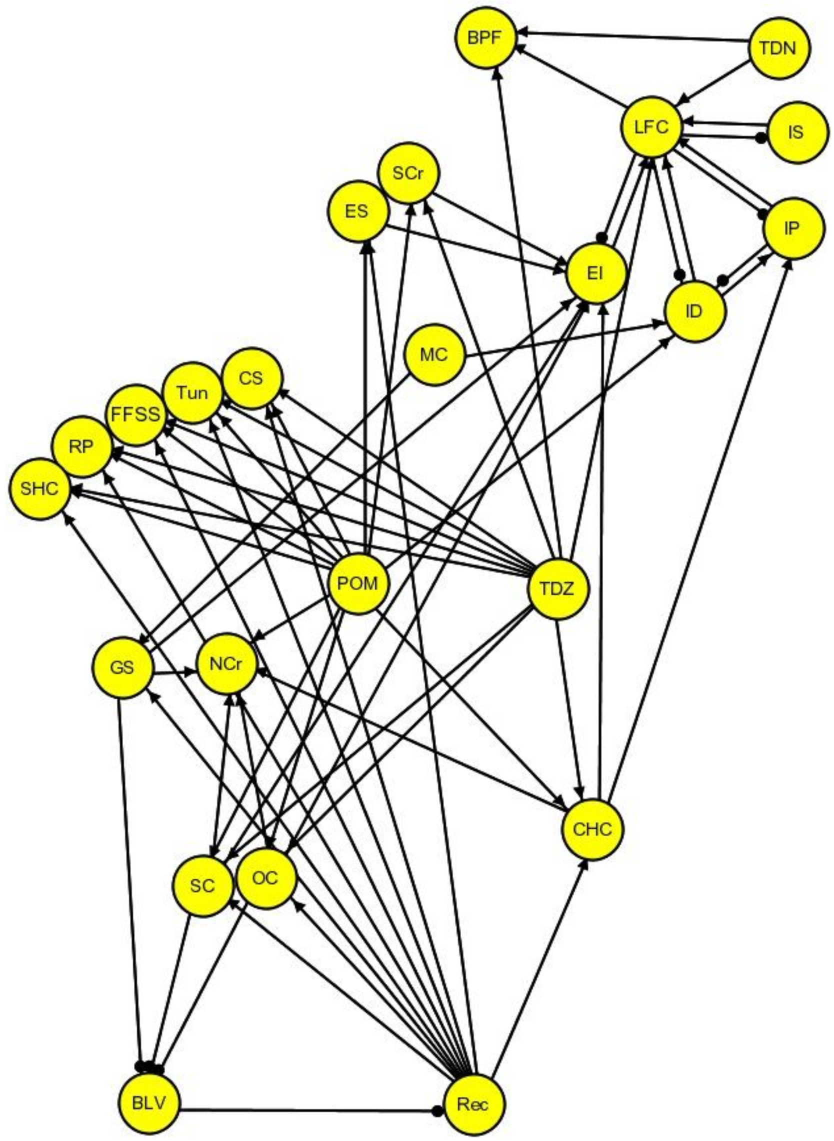


Figure 5: signed digraph for the ecosystem model for the benthic seamount ecosystem. The abbreviations are as follow: BLV: boundary layer velocity, BPF: benthopelagic fishes, CHC: colonial hard corals, CS: carnivorous sponges, EI: embedded invertebrates, ES: encrusting sponges, FFSS: filter feeding sea star, GS: glass sponges, ID: invertebrate detritivores, IP: invertebrate predators, IS: invertebrate scavengers, LFC: local fish and cephalopods, MC: microbial community, NCr: non-stalked crinoids, OC: other corals, POM: particulate organic matter, Rec: population recruitment, RP: rock pens, SC: soft corals, SCr: stalked crinoids, SHC: solitary hard corals, TDN: transient deep nekton, TDZ: trapped deep zooplankton, Tun: tunicates. For seamount pelagic components, refer to Figure 2. All pelagic components in the “abyssal & pelagic ecosystem” diagraph (connected to POM) are equally applicable to pelagic ecosystem associated with seamounts.

Table 6. Ecosystem interactions of physical and biological components of the benthic seamount model; effects are positive (+) or negative (-) in sign.

Effect to	Effect sign	Effect from	Description	Reference
CHC, OC, NC, SC, SCr, ES, CS, Tun, FFSS, RP, SHC, ID	+	POM	Food source for most suspension feeders	Rogers et al. 2007; Fulton et al. 2007; Samadi, 2007; Colaco et al. 2013
GS, ID	+	MC	Food source	Orcutt et al. 2020
CS, Tun, FFSS, RP, SHC, SCr, SC, OC, CHC, BPF, LFC	+	TDZ	Food source	Fulton et al. 2007; Samadi, 2007; Colaco et al. 2013
EI	+	SCr, ES, GS, SC, OC, CHC	Habitat	Na et al. 2020; Xu et al. 2017; Zhang et al. 2018; Zhang et al. 2020
EI, IS, IP, ID	-	LFC	Predators	Fulton et al. 2007; Samadi, 2007; Colaco et al. 2013
LFC	+	EI, TDN, ID, IP, IS	Food source	Fulton et al. 2007; Samadi, 2007; Colaco et al. 2013
BPF	+	LFC, TDN	Food source	Fulton et al. 2007; Samadi, 2007; Colaco et al. 2013
BLV	-	OC, SC, GS	Structures reduce fluid velocity and create turbulence to facilitate larval recruitment	Mullineaux
OC, SC, GS, **EI, IS, IP, ID, CHC, OC, NC, SC, SCr, ES, CS, Tun, FFSS, RP, SHC, RP, CHC, LFC, NCr**	+	RP	Successful recruitment replaces and/or augments community components	Castelin et al., 2012; Clague et al., 2011; Miller et al., 2010; O'Hara et al., 2014; Varela et al., 2013; Aboim et al., 2005; Baco and Shank, 2005; Cho and Shank, 2010; Miller and Gunasekera, 2017; Rogers et al., 2006; Zeng et al., 2017, Na et al. 2020.
RP	-	BLV	Ameliorated boundary fluid flows benefit recruitment.	No reference in the Regional Environmental Assessment Report

Description of the potential mining operation

50. From an operation point of view, the summits would probably be avoided, because they are too heavily sedimented, and the bottom slopes would be too steep for operating the mining vehicle. However, mining technologies are likely to evolve over time, therefore such assumptions need to be revisited in the future.

51. The majority of the contract areas in the NW Pacific region are situated between 1300 and 2300 m water depth, around the edge of the summit, suggesting that this is where crusts accumulation is most abundant or exposed and where mining can most likely occur. These areas are also where some of the densest aggregations of suspension feeding communities are located, including corals, sponges and associated fauna.

52. The mining system for crusts exploitation on seamounts is still not fully developed. The type of summit will influence where the mining vehicle can operate. It was suggested that the summit would still be minable, along with the flanks. A far-reaching plume can still be expected. But this plume would probably be composed of coarser particles that stay on the seabed. A finer plume could also occur as part of the crusts recovery. Additionally, a downslope flow of sediment (avalanche like) may take place, affecting the base of the seamounts and the associated communities. Participants highlighted that many suspension feeders like corals will suffer significantly from such indirect mining impacts, as it will clog their feeding apparatus and smother them.

53. The collection system for polymetallic crusts will be composed of:

- a vehicle along the slope or on the summit of the seamount, excavating the crusts. The recovered crusts are sent to the vertical pumping system;
- The vertical pumping system to the surface, receiving a flow of seawater, crusts and remaining sediment from the seabed vehicle, and transporting them to the surface processing vessel. The pumping stations are placed roughly every km along the vertical pipe;
- The surface ship, receiving crusts from the vertical pumping system. On the surface ship, the ore is separated from the remaining seafloor water and sediment and stored before transshipment; and
- The return water: The fluid (bottom water), with the sediment and fine particles are then returned to the ocean, at depth.

Description of the potential effects on ecosystems from cobalt-rich ferromanganese crust exploitation, other human activities, and climate change

54. The participants discussed the potential direct effects associated with future mining activities, and potential impacts from fisheries, pollution, and climate change, as summarized in Table 7.

Table 7. Potential pressures and effects from natural and anthropogenic activities on benthic seamount ecosystems of the NW Pacific region.

Pressure	Pressure effect	Direct effect on	Description	Reference
Removal of crust	P1) negative	Rec	Loss of all community components and of habitat. Also	Gollner et al. 2017

			removes ability for self-recruitment in the recovery process, and delays recovery by altering larval dispersal, mortality of larvae, and decreased settlement success.	
Plume removal (plume generated by direct removal of crusts) – **Sedimentation**	P2) negative	CS, FFSS, SHC, Tun, RP, OC, SC, CHC, EI, ES, GS NCr, SCr, ID, MC, Rec	The sedimentation (i.e., particles falling out of suspension) would affect communities negatively by burying everything in the mining site. Some species are capable of 'cleaning' the sedimented layer, but have to consume more energy.	
Plume removal – Suspended sediment	P2) negative	CS, FFSS, SHC, Tun, RP, OC, SC, CHC, EI, ES, GS, NCr, SCr,	Suspended sediment would affect the filter and suspension feeders (corals, sponges) negatively by clogging feeding system/smothering	
Return plume – Sedimentation	P3) negative	CS, FFSS, SHC, Tun, RP, OC, SC, CHC, EI, ES, GS NCr, SCr, ID, MC, Rec	Smothering; increased sediment covers available hard substratum; clogs filter feeding apparatus, loss of suspension feeders. If plume contains toxic pollutants: mortality or severely reduced fitness with potential for sublethal impacts to persist for years causing continued degradation.	Topçu et al. 2019; fisher et al. (2014); Girard and Fisher (2018); girard et al. (2018); Cordes et al. (2016).
Return plume – Suspended sediment	P3) negative	CS, FFSS, SHC, Tun, RP, OC, SC, CHC, EI, ES, GS, NCr, SCr,	Increased handling time to sort the 'chaff' from suspended matter; diminished fitness	Syvitski et al. 2000; Anthony & Faricius, 2000
Return plume – Temperature	P3) negative	BFP, LFC, MC (-)	Elevated temperature – effect probably short-lived and not likely to have long-term impact Individuals of some deep-sea species expected to suffer impeded growth, metabolism, reproductive success, and survival.	Impacts summarised by Millier et al., (2018)
Return plume – Sedimentation	P4) negative	CS, FFSS, SHC, Tun, RP, OC, SC, CHC, EI, ES, GS NCr, SCr, ID, MC, Rec	Smothering; increased sediment drapes over desirable hard substratum; clogs filter feeding apparatus, loss of suspension feeders	Topçu et al. 2019
Return plume – Suspended sediment	P4) negative	CS, FFSS, SHC, Tun, RP, OC, SC,	Increased handling time to sort the 'chaff' from suspended matter; diminished fitness	Syvitski et al. 2000; Anthony &

		CHC, EI, ES, GS, NCr, SCr,		Faricius, 2000
Return plume – Temperature	P4) positive	BFP, LFC, MC (+)	Elevated temperature – effect probably short-lived and not likely to have long-term impact	
Noise	P5) negative	BPF, LFC, Rec	Fish are soundscape sensitive; changes in behaviour and physiology documented	Cox et al. 2018
Electromagnetism	P6) negative	BPF, LFC	Vibration and pulse would affect the mobile ecological component. The scale however is not really known.	
Light	P7) negative	BPF, LFC, ID, IP, IS,	Fish with visual systems affected; rods overwhelmed	Widder et al. 2005
Toxicants	P8) negative	BPF, LFC	The toxicity associated with leaching crusts depends on the metal content of the crusts. Crusts contain high levels (5 times above ambient) of U, Sb, As, Sr, Cd, Tm, Lu, Yb, Ni, Zn, Co, Mn, Cu, Cr. However, how the elevated level of metal (e.g., As, Cu) would influence the organisms is uncertain. It might concentrate along the food chain, and as such influence mainly BPF andLFC. It must be recalled that there is little data about toxicity on organisms in the benthic habitat, at these depths, , but that there is a risk of bioaccumulation at higher trophic levels. Additionally,as an example, in the MIDAS Project, it was highlighted that combination of metals have more complicated response to understand than one isolated metal.	Cossaboon et al. (2019)
Nutrients	P9) positive	MC	Uncertain effect	
Abandoned equipment	P10) negative	CS, FFSS, SHC, Tun, RP, OC & SC, plus CHC, ES, GS, NCr, SCr	Anthropogenic structures provide elevation off bottom to access currents –promote settlement; eventually structure loss (erosion or cleanup) will destroy the recruits. However this is assuming there are no toxic chemicals or paints associated with the structures	Schlining et al. 2013
Abandoned equipment	P11) Positive	CS, FFSS, SHC, Tun, RP, OC &	Addition of hard substrate can create new habitat, assuming there	

		SC, plus CHC, ES, GS, NCr, SCr	are no toxic chemicals or paints associated with the structures.	
Ocean acidification	P12) Negative	MC (-), CHC, NCr, SCr, FFSS, SHC, RP, OC, SC	Decreasing pH from excess CO2 input raises the critical solubility depth of aragonite/calcite – the skeletal component of listed taxa; hypercapnia	Bindoff et al. 2019; Levin et al. 2020
Ocean acidification	P13) Positive	MC (+), CHC, NCr, SCr, FFSS, SHC, RP, OC, SC	Ocean acidification might have positive effect on some species of the microbial communities	
Ocean deoxy-genation	P14) negative	BPF, LFC, TDN, TDZ	OMZ intensifies with diminishing dissolved oxygen; influence on fish with higher oxygen demand	Gallo & Levin
Typhoons	P15) positive	POM	Passing typhoons can induce phytoplankton blooms that lead to an increase in the amount of POM being transported from the surface to the seafloor.	Sun et al., 2010; Lin, 2012; Ye et al., 2013; Zhao et al., 2015; Liu and Tang, 2018; Wang et al., 2020
Temperature rise	P16) negative	BPF, LFC, TDN,	Temperature increase from climate change may not be large in deep sea but have a large effect on metabolic demand on fishes – and the need for greater energy from food. Little is known about how temperature will affect benthic communities at these depths. However, it is likely most deep-sea species are not adapted to substantial changes in temperature since they have existed in an environment without large natural temperature variations. Mobile species may adjust their depth to stay with a proper temperature range, but sessile species will be less likely to be able to adapt.	Deutsch et al. 2015
Fisheries	P17) negative	CS, FFSS, SHC, Tun, RP, OC & SC; BPF, CHC, GS, NCr, Scr	Long-lining extracts fish (migrators); lost gear very common on seamounts tangled in foundation species. Based on Global Fishing Watch data, there is already significant fishing in the region.	Watling & Auster, 2017

55. The facilitators considered the potential combinations of pressures to develop tangible scenarios. However, these were not discussed with the workshop participants during the seamount breakout group. Two matrices of perturbations have been considered for the scenarios: (i) The combinations of perturbations in the mined area, and (ii) The combinations of perturbations in the secondary impact area, where crust are not removed, but other pressures would extend. The detailed list of scenarios can be found in the Table 8 below.

Table 8. Perturbation scenarios assembled from combined effects of pressures detailed in Table 7. It should be noted that these were developed by the facilitators and that these were not discussed during the breakout session.

Perturbation scenario	**Pressure effect number from Table 6**	**Brief perturbation description**
		(i) In the Mined Area
S0	P1, P2, P3, P4, P5,P6, P7,P8, P9, P10, P11, P12, P13, P14, P15, P16, P17	Impact of individual pressure
S1	P1, P2	Impact from removal of crust and seabed plume
S2	P1, P2, P3	Impact from removal of crust and seabed plume, assuming a negative effect of the temperature from return plume
S3	P1, P2, P4	Impact from removal of crust and seabed plume, assuming a positive effect of the temperature from return plume
S4	P1, P2, P3, P5, P6, P7, P8, P9	Impact from removal of crust and seabed plume, assuming a negative effect of the temperature from return plume , combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients
S5	P1, P2, P4, P5, P6, P7, P8, P9	Impact from removal of crust and seabed plume, assuming a positive effect of the temperature, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients
S6	P1, P2, P3, P5, P6, P7, P8, P9, P10	Impact from removal of crust and seabed plume, assuming a negative effect of the temperature, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential negative effect of abandoned equipment is included.

Perturbation scenario	Pressure effect number from Table 6	Brief perturbation description
S7	P1, P2, P4, P5, P6, P7, P8, P9, P11	Impact from removal of crust and seabed plume, assuming a positive effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential positive effect of abandoned equipment is included.
S8	P1, P2, P3, P5, P6, P7, P8, P9, P10, P12, P14, P15, P16, P17	Impact from removal of crust and seabed plume, assuming a negative effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential negative effect of abandoned equipment is included, but also a negative effect due to ocean acidification, ocean deoxygenation, typhoons, seawater temperature increase and fisheries.
S9	P1, P2, P4, P5, P6, P7, P8, P9, P11, P13, P14, P15, P16, P17	Impact from removal of crust and seabed plume, assuming a positive effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential positive effect of abandoned equipment is included, but also a positive effect due to ocean acidification on microbial communities, ocean deoxygenation, typhoons, seawater temperature increase and fisheries.
(ii) In the secondary impact area		
S10	P2	Impact of individual pressure, assuming no return plume.
S11	P2, P3	Impact from seabed plume, assuming a negative effect of the temperature from return plume.
S12	P2, P4	Impact from seabed plume, assuming a positive effect of the temperature from return plume.
S13	P2, P3, P5, P6, P7, P8, P9	Impact due removal of crust and plume, assuming a negative effect of the temperature, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients
S14	P2, P4, P5, P6, P7, P8, P9	Impact from seabed plume, assuming a positive effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients.

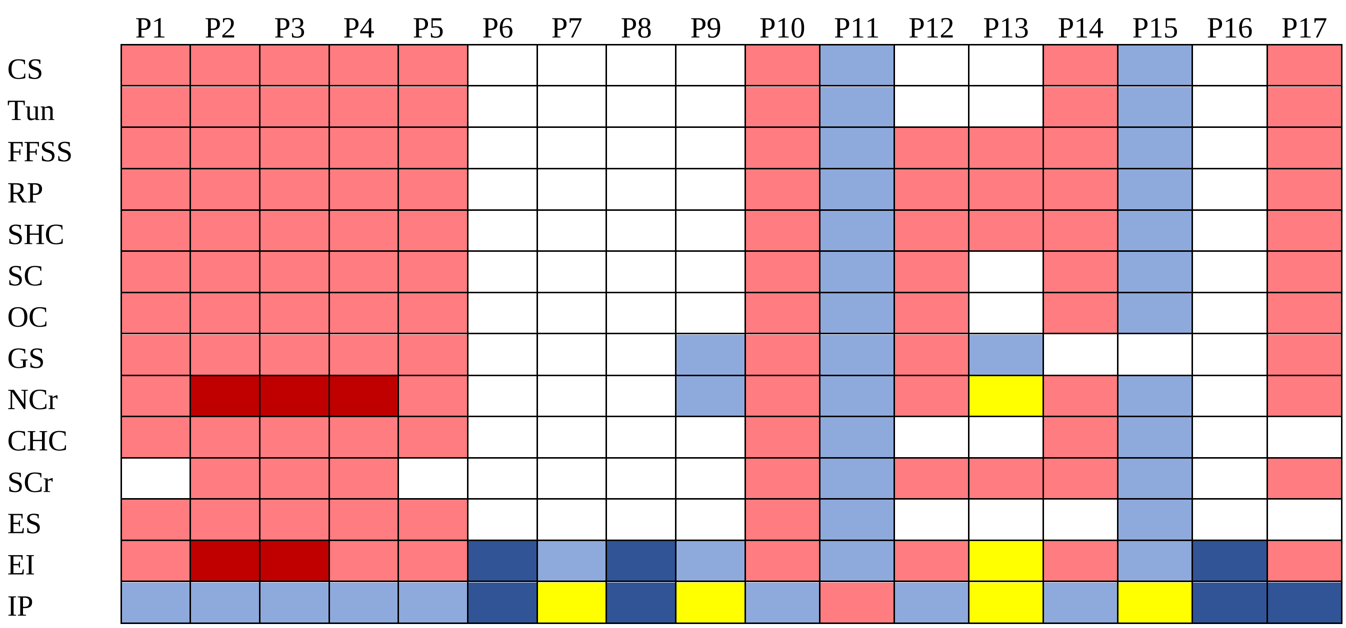
Perturbation scenario	Pressure effect number from Table 6	Brief perturbation description
S15	P2, P3, P5, P6, P7, P8, P9, P10	Impact from seabed plume, assuming a negative effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential negative effect of abandoned equipment is included.
S16	P2, P4, P5, P6, P7, P8, P9, P11	Impact from seabed plume, assuming a positive effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential positive effect of abandoned equipment is included.
S17	P2, P3, P5, P6, P7, P8, P9, P10, P12, P14, P15, P16, P17	Impact from seabed plume, assuming a negative effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential negative effect of abandoned equipment is included, but also a negative effect due to ocean acidification, ocean deoxygenation, typhoons, seawater temperature increase and fisheries.
S18	P2, P4, P5, P6, P7, P8, P9, P11, P13, P14, P15, P16, P17	Impact from seabed plume, assuming a positive effect of the temperature from return plume, combined with the operational effects of light, noise, electromagnetism, toxicants and nutrients. The added potential positive effect of abandoned equipment is included, but also a positive effect due to ocean acidification on microbial communities, ocean deoxygenation, typhoons, seawater temperature increase and fisheries.

II.2.2 Model outcomes

56. The predicted responses of ecosystem components in the model to individual or multiple pressures were classified according to their probability for sign determinacy as either certain negative (dark red), likely negative (light red), zero (white), likely positive (light blue), certain positive (dark blue), or sign indeterminate (yellow). This classification was performed by the session facilitator and that this was not discussed during the breakout session. Certain positive or negative responses were predicted where all pathways of linkages leading from a pressure to an ecosystem component were of the same sign and the probability for sign determinacy is 100%. Zero responses were predicted where the ecosystem component had an absence of any effects being transmitted from the pressure. Likely positive or negative responses were predicted where the majority of pathways caused effects with the same sign and the probability for sign determinacy is ≥80%.

Cumulative impact single pressures

57. The seventeen individual pressures detailed in Table 7 were used to predict the cumulative impact on the twenty-four ecosystem components through the web of interactions provided in the ecosystem model (Figure 6). This exercise was completed by the session facilitator after the workshop discussions, in response to request from some workshop participants. The first five pressures were predicted to have a negative impact for most of the benthic invertebrate community, but with a positive response predicted for invertebrate predators and scavengers and an ambiguous response for invertebrate detritivores. These non-negative responses are driven by release of predation pressure from a predicted decrease in local fish and cephalopods. Pressures P6, P7 and P8 where all mine related pressures acting through benthopelagic fish and local fish and cephalopods, with a predicted decrease in the latter providing a release in predation pressure and positive response prediction for their prey, namely embedded invertebrates, and invertebrate predators, scavengers and detritivores. An ambiguous response prediction for invertebrate detritivores arises from the varied response of two different predators (i.e., invertebrate predators and local fish and cephalopods). In pressure P7 ambiguous responses for invertebrate predators, scavengers and detritivores arise from the direct impact of mine light on them but also their predators (local fish and cephalopods). Enrichment of the microbial community in pressure P9 resulted in a relatively discrete impact on invertebrates that utilize them as a resource with flow-on effects to other invertebrates; it also results in subsequent enrichment or habitat, giving positive response predictions or a negative response in invertebrate scavengers, due to an increase in their local fish and cephalopod predators. Symmetrically opposite responses were obtained from P10 and P11 for the habitat forming or destroying effect of abandoned equipment. Similarly, ocean acidification pressure effects P12 and P13 were generally negative to habitat forming invertebrates, which produced generally negative response predictions for most groups. But a possible positive effect to the microbial community in P13 had a positive response for glass sponges that decreased the sign determinacy of many other responses in the system. Deoxygenation pressure P14 had a negative effect on most groups which enrichment from typhoons a positive effect. The negative effect of an increase in temperature on fish and other nekton resulted in a release in predation for some invertebrates but no effects to the rest of the system. The habitat destruction from fishing operations was predicted to reduce most of the benthic invertebrate community except for a predicted increase in invertebrate predators and scavengers.



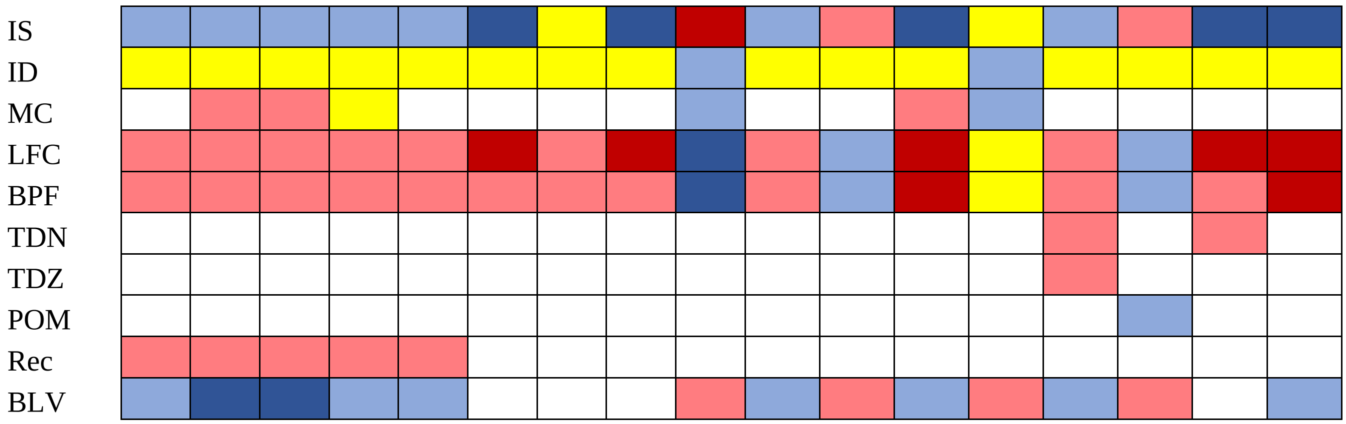


Figure 6. Qualitative response predictions of benthic seamount ecosystem components (rows) to each of the pressure effects (columns) detailed in Table 7.

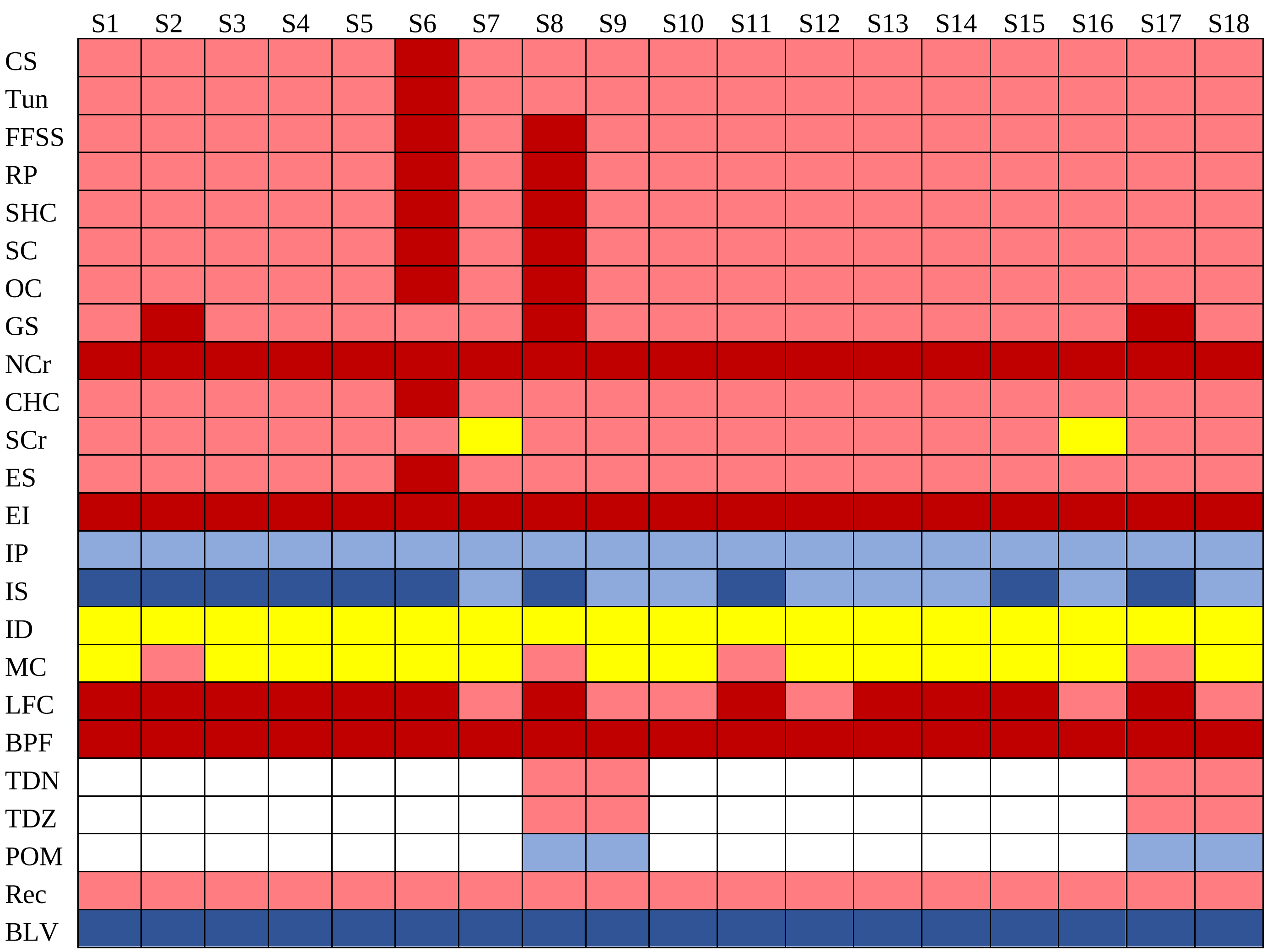


Figure 7. Qualitative response predictions of cumulative impacts to benthic seamounts ecosystem components (rows) from future exploitation of mineral resources, fisheries, pollution, and climate change

the perturbation scenarios detailed in Table 7. These predictions were developed by the session facilitators after the workshop discussions.

Cumulative impact multiple pressures

58. The eighteen perturbation scenarios detailed in Table 8 were used to predict the cumulative impact from the various possible pressures resulting from multiple exploitation activities or climate change effects on the seamount ecosystem (Figure 7). This analysis was completed by the facilitators after the workshop, in response to request from some workshop participants. A very strong pattern of response predictions is seen across the eighteen scenarios with a negative response prediction for all invertebrate groups except for invertebrate predators and scavengers. Response predictions for invertebrate detritivores and the microbial community were largely sign indeterminate. There was no appreciable difference between scenarios posed within or outside of the mining area.

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Pelagic and abyssal plain ecosystem

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Annex V

Main results of break-out group discussion on area-based management tools

I. Background

1. One of the important purposes of the REMP workshop is to apply area-based management tools (ABMTs) by compiling scientific information to describe potential areas that could be protected from potential impacts of future exploitation activities in order to fulfill ISA's mandates for effective protection of the marine environment, in line with Article 145 of the Convention.

2. In order to describe potential areas that are in need of protection, the workshop considered several types of ABMTs, building on the experience from the environmental management plan for the Clarion-Clipperton Zone (CCZ-EMP) as well as the Evora workshop for northern Mid-Atlantic Ridge area. The workshop discussed three general categories of approaches that could be useful for spatial management to support the REMP process for the Area of the Northwest Pacific Ocean. These tools include fine-scale sites in need of protection and areas of coarse-scale planning (e.g. areas of particular environmental interest, or APEIs, in the CCZ). Participants to this workshop also noted that the Evora workshop considered sites in need of increased precaution where research and monitoring would benefit further description of sites with regard to its potential need for enhanced conservation efforts.

3. This section provides a review of possible area-based planning approaches, not in an exhaustive manner, which can be applied to describe potential areas through workshop discussion, for designation of areas or sites requiring enhanced protection measures as part of regional environmental management planning process. This section compiles potentially relevant scientific criteria for applying area-based management tools, including their relevance to the activities in the Area. This section draws on document ISBA/17/LTC/7 (CCZ-EMP) as well as reports of ISA workshops held on REMPs in Qingdao (China) in May 2018, Szczecin (Poland) in June 2018, and Evora (Portugal) in November 2019[19].

4. In general, area-based planning requires two types of criteria and scales of analysis: (1) individual site criteria that provide guidance on the priority, size, shape, and orientation of individual sites; and (2) network or regional criteria that provide guidance on the representativity, adequacy, spatial configuration, connectivity and other broader criteria guiding the development of the entire collection of sites.

Areas/sites in need of protection

5. In the ISA context, individual site criteria have been applied in the identification of potential ABMTs in the process of developing the REMP for the northern Mid-Atlantic Ridge (Table 1). Such potential ABMTs include sites in need of protection (SINPs) and areas in need of protection (AINPs). Individual sites are assessed against each criterion based on the available scientific information for the site. This approach draws on the Convention on Biological Diversity (CBD)'s scientific criteria for ecologically or biologically significant marine areas (EBSAs), and United Nations Food and Agriculture Organization (FAO)'s criteria for identifying vulnerable marine ecosystems (VMEs).

[19] Links to the workshop report can be found at https://www.isa.org.jm/minerals/environmental-management-plan-clarion-clipperton-zone

Table 1. Scientific criteria applied for the identification and description of ABMTs in the northern Mid-Atlantic Ridge

The criteria below are adopted from the criteria developed by other component international organizations, for details please refer to the report of the Evora workshop[20]. • **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 (i) habitats that contain endemic species; (ii) habitats of rare, threatened, or endangered species that occur only in discrete areas; (iii) nurseries or discrete feeding, breeding, or spawning areas. • **Functional significance of the habitat**: Discrete areas or habitats that are necessary for (i) the survival, function, spawning/reproduction, or recovery of species; (ii) particular life history stages (e.g. nursery grounds or rearing areas); (iii) or of 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 these 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.

Network of Areas of Particular Environmental Interest (APEIs)

6. ISA has also established a network of areas of particular environmental interest (APEIs) under the CCZ-EMP.[21] The initial design of the APEI network and its review in 2021 took into consideration key elements of the second category of criteria (i.e. network criteria), in particular representativity, connectivity and replicated ecological features..[22] The size, shape and configuration of individual APEIs were based on simple criteria stating that each APEI:

- should take into account biophysical gradients which affect the biogeography of marine biodiversity in the planning region;
- should protect a full range of habitat types found within each subregion;
- should be large enough to maintain minimum viable population sizes for species potentially restricted to a subregion;
- should be surrounded by a buffer zone to ensure that biota and habitats in the protected area are not affected by anthropogenic threats occurring outside the APEIs; and
- the boundaries should be straight lines to facilitate rapid recognition and compliance.

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

21 ISBA/17/LTC/7.

22 See ISBA/17/LTC/7 and ISBA/26/C/43

Table 2. Example of network criteria.[23]

Network criteria
Ecologically important areas Representativity Connectivity Replicated ecological features Adequate and viable sites

Areas/Sites in need of precaution

7. Areas/sites in need of precaution may be considered as sites that contain: (i) proxies or indicators of species and habitat that would, if their presence was confirmed by direct observation, be likely to enhance protection through area or adaptive management measures; and (ii) conditions that contribute to the vulnerability of species and habitats of conservation importance.

8. Examples of accepted proxies or indicators of species and habitats of conservation importance include:

- Geophysical features typically associated with the presence of species and habitat of conservation importance, such as benthic topographic complexity and/or substrate.
- Presence, predicted presence, or high abundance of suitable habitat for SINPs or AINPs, as provided by habitat suitability modelling for indicator species.
- Environmental conditions known to increase the vulnerability of species and habitat of conservation importance, including barriers or filters to dispersal and habitat conditions that can be associated with species and habitats of conservation importance.

9. Activities within areas in need of precaution should proceed with: (i) enhanced studies to confirm whether or not SINPs or AINPs are present; (ii) heightened awareness that SINPs or AINPs may be in the area; and (iii) greater efforts to reduce the environmental impact of seabed activities.

II. Summary of break-out group discussion on approaches for applying ABMTs

10. The purpose of break-out group discussion is to locate, describe and document the environmental features and areas that are considered important to be highlighted in the context of a regional environmental management plan. One of the purposes for the workshop was to develop a well described and documented portfolio of sites and areas representing critical features and functions of ecosystems, as well as special and vulnerable sites.

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23 Based on CBD, 2008. Scientific guidance for selecting areas to establish a representative network of marine protected areas, including in open ocean waters and deep-sea habitats (Conference of the Parties to the Convention on Biological Diversity decision IX/20, annex II).

A. Potential AINPs

11. This workshop focused primarily on the description of potential AINPs. The description of potential AINPs focused on two different habitat targets: (1) seamount complex & adjacent slopes/plain areas that intersect with cobalt-rich ferromanganese crusts (CFC), and (2) abyssal basin areas that intersect with polymetallic nodule (PMN) resources. The location, boundary mapping and description of these areas were addressed using different approaches, as described below.

12. Among the network criteria described above, only representativity, connectivity and replicated ecological features were discussed in detail at the workshop.

13. **Approaches for seamount complex & adjacent slopes/plain areas.** The location of representative seamount complex and adjacent slope areas were identified primarily through an assessment of seamount depth classes, benthic position indices (BPI) and modeled habitat characteristics. Emphasis was placed on identifying seamount areas exhibiting similar depth zones and BPI to areas identified for CFC exploration. This focus was intended to locate areas outside of contract and reserve areas that potentially contain representative habitats and features, as well as rare habitats (i.e., shallow seafloor). Through interactive mapping, the results of these analyses were used to locate and draw boundaries around clusters of seamount complexes to also include lower slope and adjacent abyssal plain areas that exhibited similar depth and geomorphology features to the contract areas for the exploration of cobalt-rich crusts. A total of 9 AINPs were described as potentially meeting the criteria for AINPs (Figure 1).

14. ***Approaches for abyssal basin areas***. The location of representative abyssal basin areas were identified primarily through an assessment of seamount depth classes, slopes, BPI and modeled habitat characteristics. In this case, 3 regularly shaped (200km x 200km) AINPs (AINP 1, 5 and 8 in Figure 1) were located in centralized locations along a North-South latitudinal and primary productivity gradient. These areas were intentionally positioned to allow for an additional 100km buffer distance to existing contract and reserved areas using approaches modeled after the CCZ EMP example. In addition, 2 smaller abyssal areas (AINP 11 and 13 in Figure 1) were added to supplement depth zones not fully covered and underrepresented in the proposed network (i.e. 5000-5500m depth areas).

15. A total of 14 potential AINPs were discussed by workshop participants, including 9 for seamount complex & adjacent slopes/plain areas, and 5 for abyssal basin areas. This network of potential AINPs contains 34% of the seafloor within the region. Scientific information for the description of each potential AINP is compiled in Appendix 1-1 to this Annex.

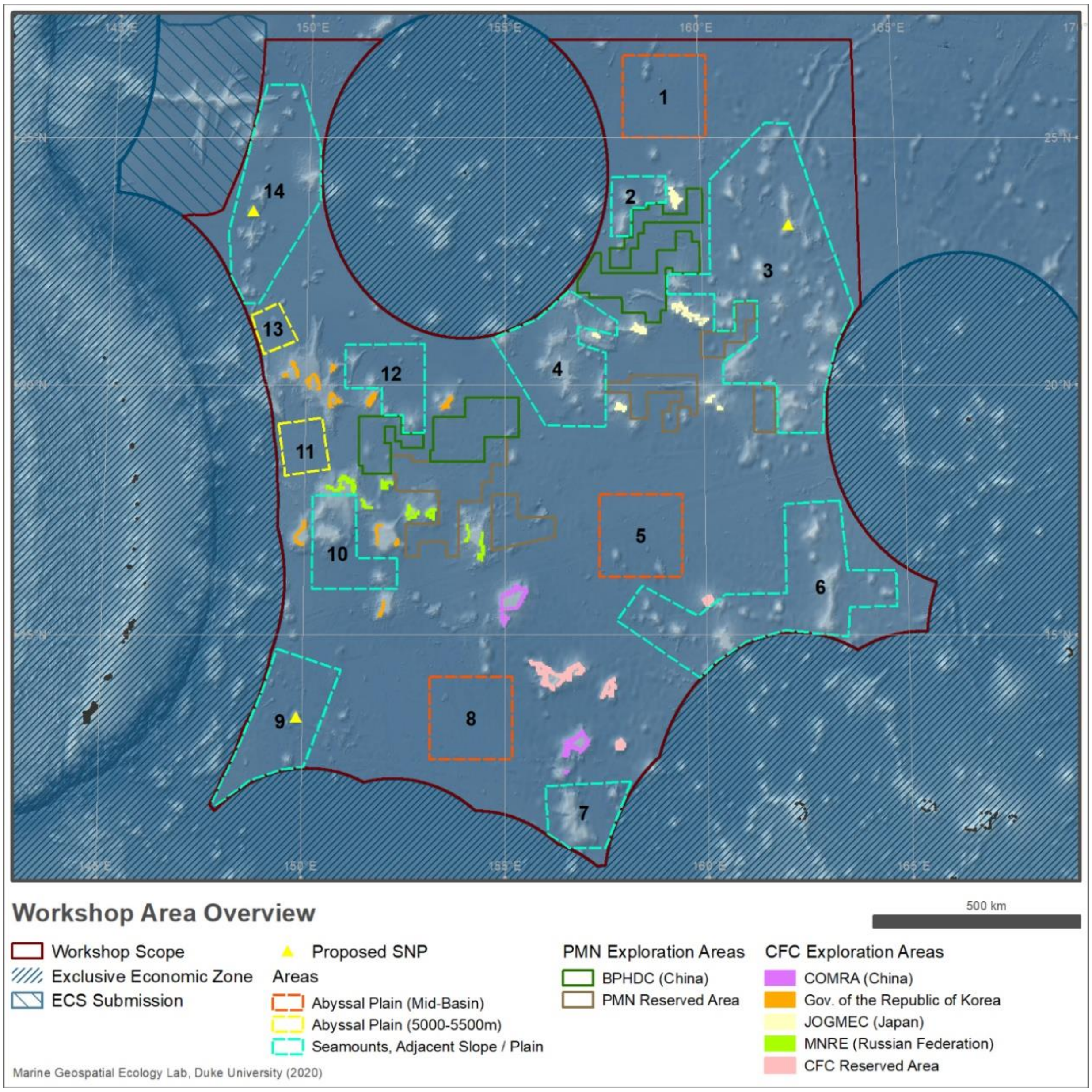


Figure 1. Areas described as potential AINPs (AINP 1-14).

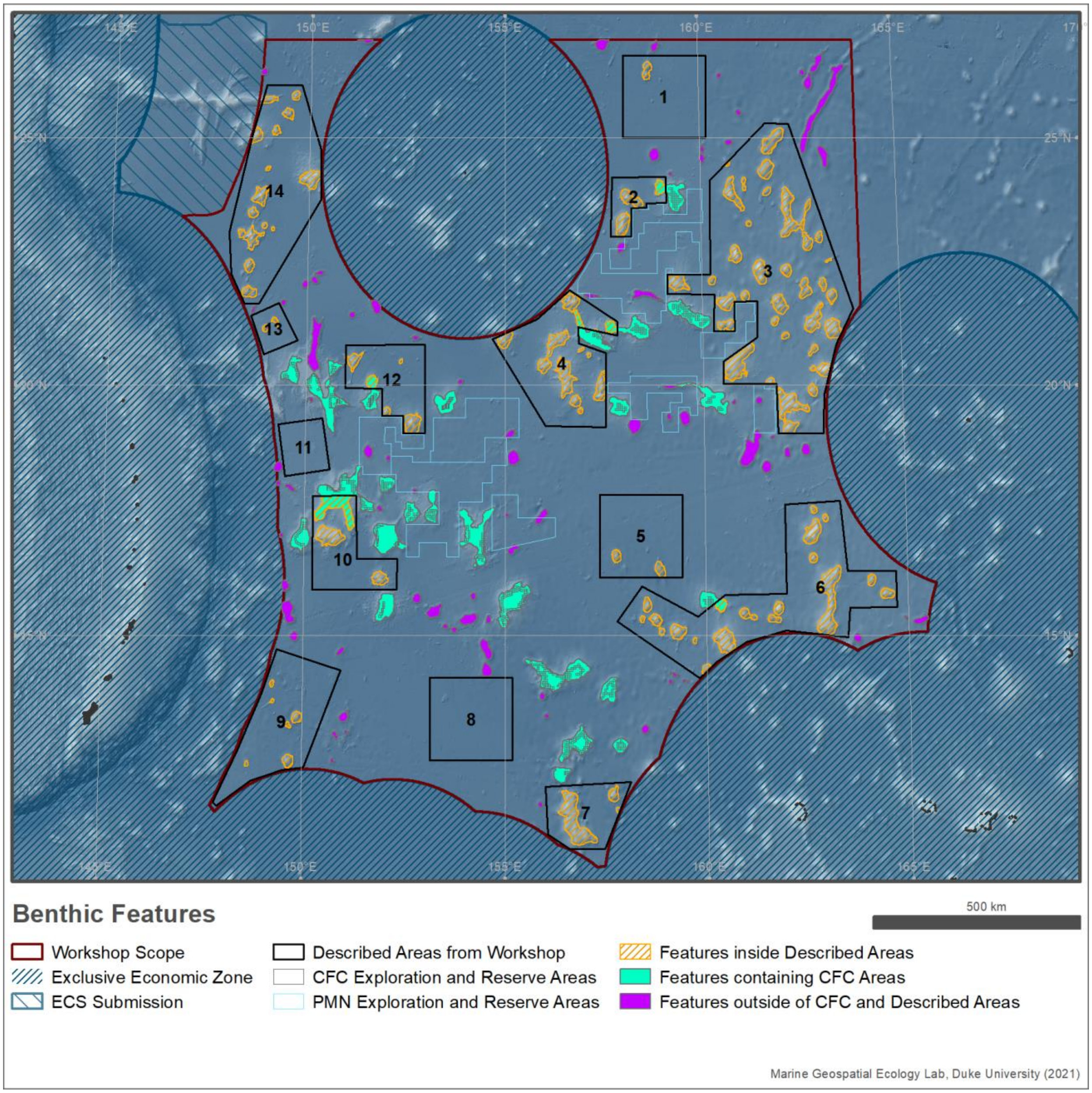


Figure 2. Map of large benthic features (seamounts and guyots) in the workshop area. For GIS methods used to identify the large benthic features, please refer to section III of this Annex.

Table 3. The coverage of each depth zone of the seafloor in the potential AINPs and in seamounts with CFC contract and reserved areas.

Depth Zone (m)	Depth Zone in Workshop area (km^2)	Depth Zone in potential AINPs (km^2)	Percentage in potential AINPs	Depth Zone in seamounts with CFC contract areas (km^2)	Percentage in seamounts with CFC contract and reserved areas
0-500	1074.6	655.7	61.0	418.9	39.0
500-1000	1214.4	477.5	39.3	737.0	60.7
1000-1500	17843.1	6008.8	33.7	12059.3	67.6
1500-2000	21548.5	9777.6	45.4	12502.9	58.0
2000-2500	20604.6	10884.1	52.8	9546.4	46.3
2500-3000	26855.5	13142.8	48.9	10639.7	39.6
3000-3500	37272.4	18386.6	49.3	11692.2	31.4
3500-4000	51440.0	27591.3	53.6	8851.2	17.2
4000-4500	77582.2	39606.3	51.1	3480.0	4.5
4500-5000	144250.0	73203.4	50.7	788.6	0.5
5000-5500	425737.1	172124.7	40.4	39.4	<0.01
5500-6000	1093046.6	284089.0	26.0	0	0
6000-6500	199143.1	54236.6	27.2	0	0

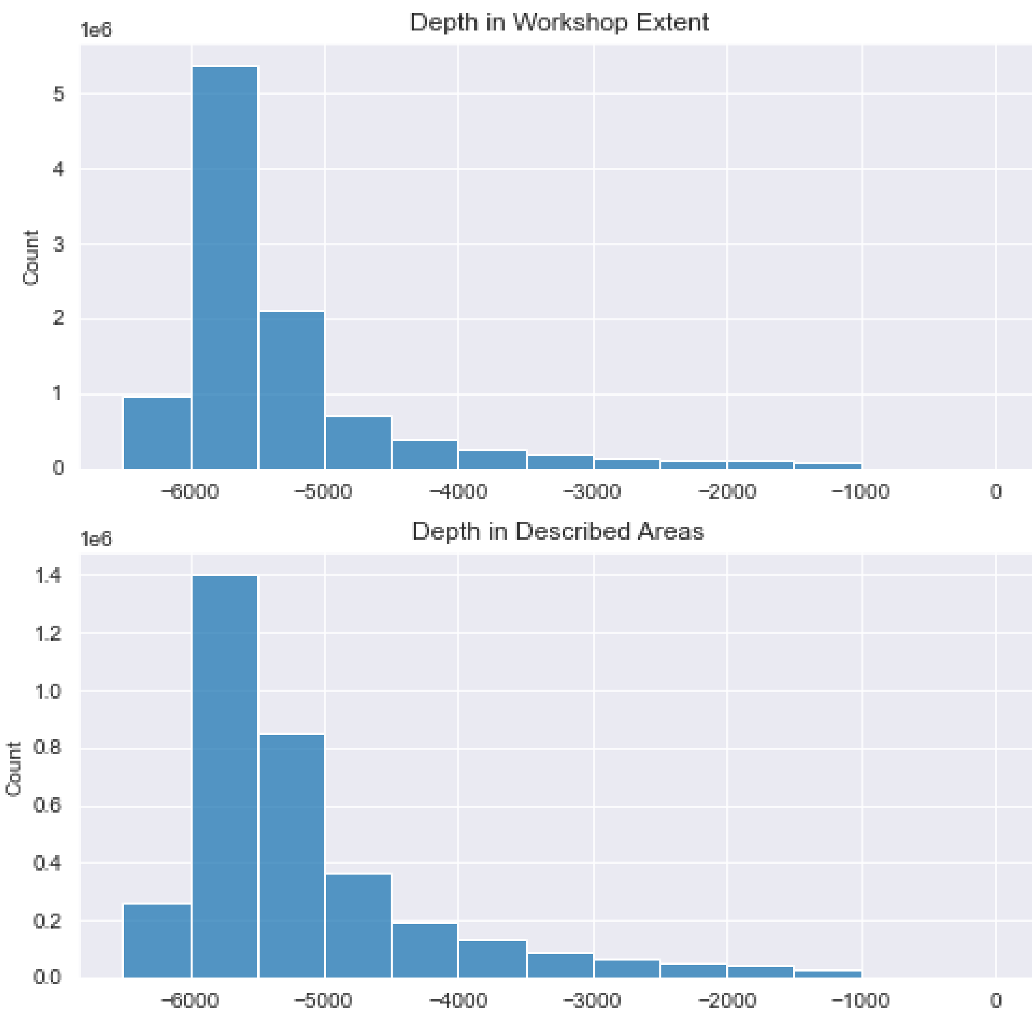


Figure 3. Coverage of different depth zones in the geographical region considered in the workshop (top) and the potential AINPs (bottom).

B. Proposed modifications to the potential AINPs

16. Several potential AINPs have an irregular shape which might increase the difficulty for management. The irregular shape was driven by the heterogeneous geophysical structure in this area and by design of polygons that combine the shallower seamounts with the lower slope and the adjacent abyssal plain areas.

17. Suggestions were also made to look into splitting large, irregular shaped AINPs into smaller and regular-shaped areas with straight-line boundaries. It was suggested that as the boundary and shapes of the

AINPs may have management implications, this issue would need to be discussed further in the next REMP workshop.

C. Discussions on other approaches

18. **Information on vulnerable habitats within three potential AINPs (AINP3, AINP 9 and AINP13).** Environmental information on 3 seamounts and surrounding areas was submitted (see Appendix2), supporting the designation of potential AINPs in these areas. All 3 sites are located outside contract areas and survey results from COMRA cruises, during which a total of 7 sites were surveyed indicated the existence of vulnerable habitats such as corals and sponges. All 3 sites are located in the described AINPs, and data and information provided in the submission was used to support the description of potential AINP3, AINP 9 and AINP13 as documented in Appendix 1.

19. **Approaches for areas in need of precaution**. No consensus was reached at the workshop regarding the application of areas in need of precaution. Some workshop participants suggested that information indicating the location of all seamounts not in AINPs or contract areas, along with habitat suitability modeling results and knowledge of VME species, could be used to help identify areas of increased precaution.

20. Based on the BTM model, there are 81 large benthic features which were not included in the contract and reserved areas or the potential AINPs (see Tables 14-16 in Appendix 1), ranging from 1200-5300m depth.

21. Various suggestions were made about aspects that could be considered in identifying potential areas in need of precautions:

- Consideration of areas of high potential cold-water coral habitat suitability;
- When new seamounts or cold-water coral or sponge habitats are discovered, the information could be used to identify areas in need of precaution; and
- When or if contract or reserved areas are relinquished, consideration could be given to include them within the areas in need of precaution.

III. Summary of break-out group discussion on analytical methods

22. During the workshop, a benthic terrain characterization was performed to help workshop participants assess the coverage of large benthic features, such as seamounts and guyots, within exploration areas, potential AINPs, and the broader workshop region. This analysis was performed using the ESRI Benthic Terrain Modeler (BTM, Walbridge et al. 2018). The terrain forms from the BTM analysis were aggregated at two levels for workshop participants to review: a broad aggregation included the crest, upper-slope, mid-slope and lower-slope terrain forms; and a narrow aggregation included the crest and upper-slope terrain forms. Participants reviewed both the broad aggregation and the narrow aggregation during the description of areas. The statistics summarized in Table 3 are calculated for the narrow aggregation of benthic terrain forms. These results from the BTM tool were filtered to focus on large features with areas greater than $50km^2$.

23. Subsequent GIS geoprocessing was used to summarize the identified features within several zones of interest. Three levels of spatial overlap were mapped and summarized (Tables 14-16 in Appendix 1):

- Large benthic features within potential AINPs
- Large benthic features within CFC contract and reserved areas; and
- Large benthic features that do not overlap with CFC contract/reserved areas or potential AINPs.

24. An additional analysis of depth zone representation within CFC contract and reserved areas, potential AINPs, and the broader workshop region was undertaken. Depth was calculated using the GEBCO 2019 bathymetry dataset (GEBCO Compilation Group 2019). For this analysis, area calculations were performed using the Mollweide projection, with the central meridian set to 155 E longitude. Area calculations were made using 2D GIS features.

25. The BTM model identified a total of 211 large benthic features in the area considered. A total of 103 of such features are located within the 14 potential AINPs, 27 were found within the CFC contract and reserved areas, and 81 outside the potential AINPs or existing CFC contract or reserved areas. A summary of depth statistics for each large benthic feature can be found in Tables 14-16 in Appendix 1.

26. The following results in particular influenced the choices of location of the potential AINPs:

- Depth band analysis. The potential AINPs were suggested by some participants (but not universally agreed) as needing to cover 30%-50%of each depth class;
- The percentage of the depth bands from 500 to 1500m found in seamounts with CFC contract and reserved areas is between 60 to 67 %;
- There is a low percentage of seafloor shallower than 3,000m, which occurs mostly on seamounts; and
- Around 14% of the seamount-adjacent abyssal plain area which roughly corresponds to the depth band from 5000- 5500m is within contract areas for the exploration of polymetallic nodules.

27. As highlighted in the “data issues and assumptions” section, a limitation of this depth-class approach is that relatively low-resolution bathymetric data was used to define classes. To apply the network criteria, different seamount classification systems were discussed (Yessen et al. 2011, Yessen et al. 2020, Keel and Wessel, and Clark et al. 2010). Each of these classifications have strengths and weaknesses. Models (points and polygons) identify peaks, not individual seamounts, therefore providing an exaggerated number of features if interpreted to represent individual seamounts. The technical team performed a BPI analyses to identify and mark boundaries of individual seamounts.

28. The application of the precautionary approach in the selection of AINPs was highlighted, particularly since the general location of seamount areas that are targeted for exploration (i.e., upper slopes with hard bottom habitats) are known to host dense and diverse communities throughout the North Pacific.

29. Other spatial factors, such as the complex geometry of the Northwest Pacific region, the distribution of existing contract and reserved areas, and the EEZ boundaries bordering this region have a number of spatial implications for the configuration of potential AINPs:

- Buffer zones spanning 100km distance, similar to those applied in the CCZ APEIs, cannot be applied in most AINPs near seamount areas due to space constrained by contract/reserved areas and EEZ boundaries.
- The coverage of some depth classes in potential AINPs is summarized in Table 3. There are already CFC contract and reserved areas on all “shallow” guyots within the Area, with only conical seamounts remaining. A relatively high percentage of the 500-2,500m depth zones are on guyots and seamounts with contract areas. There was an attempt to protect a high percentage of remaining depth classes.
- In addition to likely supporting cold-water coral and sponge and other benthic habitats, “shallow” seamounts (<3,000 m depth) were regarded as more important for pelagic species (e.g., for aggregating transient species such as whales, sharks, sea turtles, sea birds, commercially important fish, etc.; see draft REA report for details).

- It was also suggested that specific habitats under-represented in the potential AINPs can be highlighted for consideration in the future relinquishment process, such as a single seamount in the southern areas that include almost 25% of the band between 500 and 1000m of the entire region.

Additional seamount group comments

30. Spatial variability of biological communities (beta biodiversity) within seamounts was noted. A case in Hawaii showed that there are dissimilarities up to 93% within 25 to 50 meters of depth scale in coral assemblages and that this was reflected with the same distribution trend in macrofauna and fishes. Therefore, the applicability of within-seamount management could be considered, as well as definition of the entire seamount as a unit.

31. At present, many deep-sea species found on seamounts are only known from a single location, which may be due to the small sample size, or reflect localized distributions within a seamount.

32. Several workshop participants noted seamounts should in general be considered areas of need of precaution, while some argued for the need for validation of the habitat models predicting widespread coral distribution (and abundance).

Additional abyssal plain group comments

33. There was general consensus that in data-poor environments such as the abyssal plain, a common approach is to use basic information about the physical environment as a proxy for selecting areas that could represent potential habitat types.

34. Participants noted that the abyssal plain areas inside the contract areas was mostly characterized by the inner-mountain basin and the areas in proximity to the base of the seamounts, therefore a similar environment needed to be replicated in potential ABMTs. It was further noted that the abyssal plain areas outside contract areas were ocean basins at a greater depth than the contract areas.

35. The importance of this region to migratory species, such as cetaceans, leatherback turtles and migratory birds, was also considered. It was noted that the entire region of Northwest Pacific was used by different species such as leatherback turtles as transit routes, when they migrate across the Pacific. There was, however, no single pathway.

IV. Data issues and assumptions

36. Participants examined the data layers that would help characterize the physical and oceanographical environment and identification of any biogeographical units in this region, including:

- ISA DeepData portal sampling points
- Bathymetric data
- Identify the depth range of seamounts within the contract areas
- Occurrence of VME taxa, as well as modelled data for these taxa
- The seamount footprint layer in Harris et al. (2014)
- Sponge distribution including Hexactinellid and others
- Bottom fisheries data
- Current data
- Oceanographical data including dissolved oxygen, net primary productivity, POC flux,
- Habitat suitability models for the CFC and PNM exploration and reserve area, and
- 500 m depth zones.

37. The workshop discussion stressed that this region contains numerous data gaps. Biological data in general and data available outside the contract areas in this region are very minimal. Several workshop participants noted that this highlights the need to use a precautionary approach. Other observation included the importance of circulation and physical oceanographic characteristics such as downstream and upstream currents around seamounts, of tidal movements, of stable mesoscale surface eddies (from satellite images) which could form Taylor columns above or in proximity of seamounts, of directionality and ocean current transport which can all be a drive for larval dispersion and connectivity within and between seamounts. The HYCOM global circulation model was presented for this region, but it was noted that the bottom layer circulation, including the bottom features may not sufficiently represent important circulation patterns.

38. It was noted that data on connectivity and dispersal distance are especially important for deciding how to cluster sites and future research in this aspect is necessary. The analysis of the regional flow and current velocity provide a basis for estimating connectivity but need to be better developed in this region. Classification of seamounts and identification of replicate areas will require these biologically important dispersal and connectivity information. These future studies will need to cover both surface and deep water circulation because larvae behave differently depending on the species.

39. Acquisition of seasonal variation of POC flux was suggested to better understand temporal variation. It was noted that the area is influenced by typhoons, which can have a seasonal influence on biological communities.

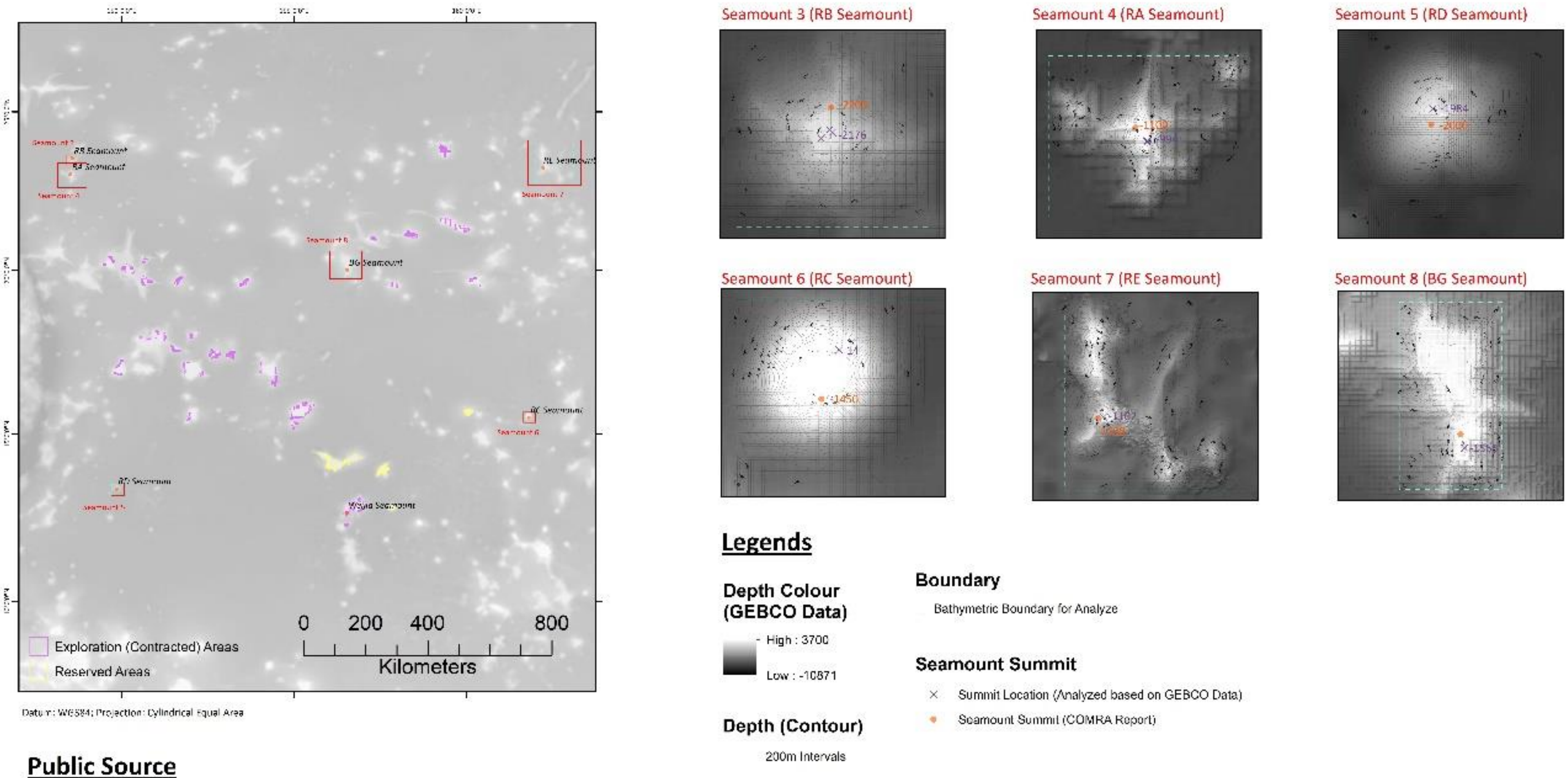
40. Chlorophyll A climatology derived from remote sensing imagery were presented as well as an index of POC flux. These products exhibited a latitudinal gradient. Further studies are needed to ground truth these remote sensing and model results.

Bathymetry

41. The bathymetric resolution of the GEBCO database used for defining ABMT boundaries is derived mostly from satellite altimetry, since publicly-available multibeam bathymetry coverage in this region is extremely low. Some benthic features that lack acoustic soundings may have significant uncertainty in the slope or depth that was used to describe and classify the feature. For example, there may be discrepancies of several hundred meters between satellite and multibeam data (e.g. Watts et al. 2020).

42. There is limited publicly available high resolution multibeam bathymetric data in the region, but where available, these data were used to spot check the feature boundaries determined based on GEBCO data. According to ISA exploration regulations, bathymetric data submitted by contractors in contract areas is confidential and not made available for public access. The ISA exploration regulations also state that confidential data and information may be used by the Secretary-General and staff of the Secretariat, as authorized by the Secretary-General, and by the members of the Legal and Technical Commission as necessary for and relevant to the effective exercise of their powers and functions. In line with these regulations, the secretariat, in discussion with co-chairs, performed a spot check of GEBCO bathymetry data using the data available in DeepData, as well as with bathymetry data on surveyed sites in the submission by COMRA. The results are summarized and the water depth on the top of the seamounts were illustrated below for comparison between GEBCO and multibeam data. Due to confidentiality of bathymetry data from DeepData, this spot checking was not discussed during the workshop.

Location	Water Depth Top [m] Multibeam	Water Depth Top [m] GEBCO	Water Depth Base [m] Multibeam
COMRA submission			
Seamount 3	2,200	2,176	4,600
Seamount 4	1,100	994	5,800
Seamount 5	2,000	1,984	5,800
Seamount 6	1,450	No reading	5,200
Seamount 7	1,100	1,102	4,800
Seamount 8	No reading	1,565	4,000
DeepData			
Seamount D1	1,183	1,176	4,800
Seamount D2	1,060	1,148	4,500
Seamount D3.1	1,145	1,178	4,000
Seamount D3.2	1,231	1,217	4,000
Seamount D4	1,720	1,747	3,200
Seamount D5	1,298	1,298	4,000
Seamount D6	1,412	1,190	5,000



Public Source

GEBCO 2019 Grid (https://www.gebco.net/data_and_products/gridded_bathymetry_data/gebco_2019/gebco_2019_info.html)

Area of focus and management units

43. The focus of the protection in this region should go from 500 meters to 2500 meters depth for seamounts to cover the depth of contract and reserved areas for the CFC resource, which are driven by location of higher quality crusts due to lower sediment cover on exposed rocks.

44. A seamount as a unit of management is a precautionary measure to reduce the potential risk of impacts from any exploitation operation/activity on that seamount affecting other parts of the seamount, even if not being actively mined. These can be amalgamated in clusters based on proximity to enhance possible connectivity between seamounts and increase the variety of environmental characteristics protected that are associated with each seamount (e.g., depth, size, slope etc). It was felt by some participants that portions of larger seamounts may be included within a management unit to increase target depths in the AINPs where these were not sufficiently included in whole-seamount areas.

45. Low slope intra-mountain space is considered important as a representative habitat for abyssal plains since many contract areas are located on similar areas. They may also differ in their substrate characteristics due to deep bottom currents that are believed to move northwards and northeastwards from abyssal basins through the seamount chains.

46. Abyssal plan management units need to be spaced across the management area to reflect any gradients e.g. in POC flux, and to enhance the potential for connectivity. They should also be sufficiently large to ensure against any impacts from plumes which may travel long distances during nodule exploitation. The effect of POC flux at the values modelled across the region is unknown. The gradient is much less than what was used in the CCZ to structure the distribution of APEIs.

47. Abyssal plain management units should be allocated into bottom types defined by depth, slope and terrain roughness so that representative habitats are included in potential AINPs. Where possible and practical abyssal plain management units should be connected to seamount management units to protect representative features of the ecosystem.

48. Participants also noted that the ABMT tasks were challenging without a preexisting inventory of seamounts for the region (i.e., name/ID, location, boundary, etc.). Representativity of habitats within and outside of contract areas would have benefited from this inventory prior to the establishment of exploration areas (e.g., the majority of several depth-defined habitats in the region exist on seamounts with contract areas). The need for including representative habitats was suggested to be considered when seamount areas are relinquished in the future (see paragraph 29).

49. There were some suggestions in the literature for the percent of habitat under protection to reach the level of 30-50%. However, these values are based on models for shallow water and generally for coastal habitats. Workshop participants discussed but did not reach consensus on this target.

Biodiversity

50. Beta diversity has been observed to be extremely high within single seamounts and among seamounts (Long and Baco 2014, Schlacher et al. 2014, Morgan et al. 2019, Mejia-Mercado et al. 2019). The current ABMT exercise was unable to assess this factor because of biological data limitations in the region. This lack of biological data was a key limitation in the ABMT planning.

51. Depth range, substrate type, temperature, POC flux, chlorophyll, currents velocity and directions are all proxies that can influence the biological zonation on seamounts and on abyssal plains. Substrate composition and characteristics are key for benthic fauna, but such data are not available at a regional scale.

52. In the region there are substantial data gaps that create significant challenges for most steps of the ABMT process. In addition, data generated by contractors was not used for this discussion. Templates describing 3 sites in need of protection were based on a single ROV dive on each seamount.

53. Publicly available video data is only available from a single seamount and a single remotely operated vehicle (ROV) dive survey from the Area in the Northwest Pacific (NOAA 2016), despite the fact that this area includes over 165 seamounts. Video footages of benthic fauna in 7 seamounts from COMRA cruises were shared with participants.

54. The workshop participants observed that there was not an adequate understanding of the physical properties of the seamounts of the region, nor of the ecology of seamounts in general to answer most of the questions in the ABMT design process, particularly in regard to the distributions of the fauna in the region, the taxa that occur in the region, how to capture representativity, the scales of connectivity on seamounts in general, the scales of connectivity on these seamounts in particular, etc. In addition, biodiversity data provided by different contractors at lowest taxonomic level need to be calibrated.

55. In general, megafauna are usually located on the upper slopes and crest of the conical seamounts and on the unsedimented edges of the summit of guyot. There can be rich communities on the slopes of seamounts as well, especially in areas with significant ridges, pinnacles or other types of abrupt topography. Vertical walls, edges of terraces and other forms of topography with enchanted hydrology may be inhabited by hard-sediment filter-feeders and associated fauna (Johnson et al., 2013; Ropert et al., 2020; Moskalev and Galkin, 1986; REA p.141; Genin et al., 1986).

56. Seamounts that extend to shallower water depths have a higher range of habitats and therefore a higher biodiversity. There are also fewer shallow seamounts so these habitats are relatively rare and less well connected than deeper areas.

57. Habitats shallower than 1500m are known to host the majority of biodiversity, however that is biased by the focus of research also being at shallower depths on seamounts. Seamount VME indicator taxa have been observed at depths greater than 5000m.

58. The variation of temperature and water masses stratification are important for the distribution of species (Puerta et al., 2020; Serrano et al., 2017).

Connectivity

59. In the deep-sea there tends to be broader connectivity along depth bands rather than across depth bands. Therefore distances among seamounts within a given depth range are a critical consideration for connectivity. Similarly, currents within a given depth range and the eddies generated will also be key in determining connectivity among populations (Bracco et al., 2019; Gary et al., 2020)

60. A recent synthesis of dispersal distances of deep-sea taxa indicates a geometric mean of dispersal distances of 33km (Baco et al 2016). Therefore, 33km was used as a starting point for distances between seamounts to determine which ones might have connectivity. However, some workshop participants noted that using this mean distance would be inappropriate for 50% of studied species. This synthesis was for the general deep-sea with only a few seamount taxa represented. Genetic studies of seamounts have shown populations on a given seamount may be largely self-recruiting and life history studies show a seamount may have a higher proportion of species that have short distance dispersal abilities. Therefore, dispersal distances may be shorter for seamounts than the general deep sea patterns. However only a small number of seamounts in the target area are within this short range (33km) from each other, so this suggestion had to be ignored in the design of areas in need of protection.

61. Several recent studies were identified that may be relevant to connectivity in the REMP region. Na et al., 2020 pursued a study on the connectivity of the ophiuroid *Ophioplinthaca defensor*. All the samples were collected in seamounts in the Northwest Pacific. The molecular analysis revealed 20 haplotypes from 32 COI gene sequences, and eight haplotypes from 37 16S, both mitochondrial gene makers (COI gene and 16S gene). The results of the analysis suggest that there was no significant population structure between or within seamounts, therefore a valid hypothesis is that *O. defensor* may have long-distance dispersal capability (Na et al. 2020 in press). Iguchi et al. (2020) analysed genetic sequences of 37 amphipods collected from different water depths (1300 m – 3800 m) on Xufu Guyot near Minami-Torishima Island. From these 18 were clustered in a single clade belonging to Abyssorchomene, which has also been reported from the New Hebrides Trench in the South Pacific.

Cultural values

62. Participants discussed that in defining the location of the potential AINPs, the cultural value of the deepest point on earth (the Challenger Deep) needs to be considered in regards to the heritage of humankind, which is on the west side of the area defined as the scope of this workshop and is a National Monument. The trench habitat is dependent on organic matter (Danovaro et al 2003, Luo et al 2017), and it was suggested that the habitat should be protected from the potential impacts from future exploitation activities in the region. The accumulation of plastic in the Trench is evidence of its capacity to collect and retain settling particles (Peng et al. 2020).

63. Pacific Island nation societies of the surrounding region have spiritual and cultural connections to marine species in this region, including to migratory species such as whales, sea turtles, sharks, and tuna that range between coastal waters and the high seas. In many Polynesian cultures all natural resources are considered cultural resources. Several such societies (including Carolinians/Refaluwasch in the Marianas Islands and the Remathau of the outer islands of Yap and Chuuk in the Federated States of Micronesia) also regularly engage in instrument-free traditional navigation over the open Ocean (including the area of the Northwest Pacific) that relies in part on expert traditional knowledge of marine species and ocean processes encountered during such voyaging (Metzgar 2006). A general appreciation of the cultural significance of all such species and processes and the potential impacts on them from exploitation activities in the area of the Northwest Pacific should be assumed (Vierros et al., 2020).

64. Some participants addressed that the current literature on the relevant traditional knowledge of indigenous peoples and local communities and associated cultural values is not as robust as the scientific literature for the area of the Northwest Pacific, in part because of the challenges involved in generating, accessing, documenting, and applying such knowledge, including in a manner that respects relevant cultural protocols involving the holders of such knowledge and complements scientific methods (Vierros et al., 2020). Some participants raised that the draft implementation plan of the United Nations Decade of Ocean Science for Sustainable Development (the "Decade") recognizes, respects and embraces local and indigenous knowledge[24] which can be particularly applicable to the area of the Northwest Pacific, given the associated cultural values of the marine spaces of the region and available relevant traditional knowledge of the indigenous peoples and local communities in the area.

65. Several workshop participants suggested that further efforts need to be made to actively engage Pacific member States in the future planning process for this process, while noting all of them were invited to submit nominations of experts to attend this workshop. Some participants also suggested that as the Northwest Pacific is known to host a high number of culturally important shipwrecks and other submerged

[24] Please see full version of the implementation plan at https://www.oceandecade.org/resource/108/Version-20-of-the-Ocean-Decade-Implementation-Plan-.

archaeological resources, the future workshop can benefit from the expertise of maritime archaeology. Such cultural issues were not explicitly evaluated during this workshop.

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Appendix 1 to Annex V

Compilation of scientific information to describe potential AINPs

Editor's notes

This Appendix does not include all information and views, rather, it aims for providing a synthesis of key results and factual information as inputs to the next workshop planned to progress the REMP process for this region.

This appendix provides a description of potential AINPs that were discussed during the workshop through an interactive mapping exercise. A total of 14 potential AINPs were discussed by participants, covering 34 % of the seafloor in the Northwest Pacific region. The maps of the potential AINPs, as well as coverage of potential AINPs for different depth bands are provided in Figures 1 and 2 and Table 1 below.

Table 1. Description of generic characteristics of seamounts against relevant scientific criteria for ABMTs.

Relevant Criteria	Description
Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.

Commentary: Seamount habitats are distinct from the surrounding abyssal plains. They provide relatively shallow benthic habitats, hard substrate, altered oceanographic conditions, enhanced currents, as well as various other ecosystem functions. Within the area considered by this workshop, "shallow-water" seafloor is considered relatively rare. Only 5% of the seafloor occurs between the surface and 3,000 m depth, with 0.05 to 1.4% within each 500 m depth zone (See Table below). The remaining 95% of the seafloor occurs between 3,000 and ~6,000 m depth.

Similarly, seamount and inter-mountain basin habitats similar to the habitats within CFC and PMN contract and reserved areas are limited (based on seafloor depth, slope and a benthic position index: 1846±606m, 10.23±7.7°, 24±62 and 5428±319m, 1.77±2.63°, 0±22, respectively).

Roughly 40 to 70% of the shallow depth habitats (<3,000 m depth) are located on seamounts with existing exploration contracts or reserved areas, with a substantial proportion located inside contract blocks (6 to 30%) (data provided below).

Depth Zone (m)	Depth zone in workshop area (km^2)	Depth zone in potential AINPs (km^2)	Percentage in potential AINPs	Depth zone on Seamounts with CFC contract and reserved areas (km^2)	Percentage on Seamounts with CFC contract and reserved areas
0-500	1074.6	655.7	61.0	418.9	39.0
500-1000	1214.4	477.5	39.3	737.0	60.7
1000-1500	17843.1	6008.8	33.7	12059.3	67.6
1500-2000	21548.5	9777.6	45.4	12502.9	58.0
2000-2500	20604.6	10884.1	52.8	9546.4	46.3
2500-3000	26855.5	13142.8	48.9	10639.7	39.6
3000-3500	37272.4	18386.6	49.3	11692.2	31.4
3500-4000	51440.0	27591.3	53.6	8851.2	17.2
4000-4500	77582.2	39606.3	51.1	3480.0	4.5
4500-5000	144250.0	73203.4	50.7	788.6	0.5
5000-5500	425737.1	172124.7	40.4	39.4	<0.01
5500-6000	1093046.6	284089.0	26.0	0	0
6000-6500	199143.1	54236.6	27.2	0	0

Special importance for connectivity	Areas that are required for a population to survive and thrive.
Commentary: Connectivity is poorly understood in the deep-sea, but a recent synthesis indicates that dispersal distances of deep-sea invertebrates are comparable to those of shallow-water taxa, with a geometric mean of ~33km (Baco et al 2016). Seamounts in this area are generally spaced at greater distances than this mean, and thus many seamount populations could be largely self-recruiting with only occasional input from external sites.	
Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.
Commentary: Many pelagic and air-breathing megafauna migrate through and directly adjacent to the Area and are known to gather around or benefit from seamounts. These species are often culturally important and species of conservation concern--many are declining pelagic fish species that are commercially important. Lists of whales, seabirds, sea turtles, fish, sharks etc. known to occur within the area considered by this workshop are provided in the Regional Environmental Assessment, along with their conservation status. The IUCN Red List, the comprehensive dataset on the spatial distribution of threatened and endangered species (IUCN 2020), shows that the Area of the Northwest Pacific provides habitat for a multitude of threatened and endangered species.	
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.
Commentary: Seamount hard substrate benthic megafauna can be dominated by habitat-forming foundation species including octocorals, sponges, antipatharians and scleractinians Many can be long-lived and slow growing, that make them fragile, vulnerable to impacts, and slow to recover. They are considered VME indicator taxa . Most seamounts that have been surveyed in Alaska, the Hawaiian Archipelago, Emperor Seamount Chain and wider central Pacific have such VME indicator taxa present. Therefore, the probability of unexplored seamounts in the Northwest Pacific harboring VME taxa is also high. A high diversity of invertebrate fauna and fishes are also associated with these deep-sea corals and sponges as indicated in diversity section below.	

Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.
Commentary: Sea surface chlorophyll concentration and particulate organic carbon flux showed a latitudinal pattern that is stronger in higher latitudes in the Pacific (Lutz et al., 2007), suggesting productivity in the north part of the area considered in this workshop may be higher than that in the south part. Some seamounts can have high biological productivity, but this is not a generalization applicable to all seamounts. There are complex patterns of both spatial and temporal biological community composition and abundance on seamounts.	
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.
Commentary: A high diversity of invertebrate fauna is associated with deep-sea corals and sponges Fishes can also use corals as nursery habitat for their eggs, likely shelter, and as a source of food.	
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.
Commentary: A survey of the available AIS data in the Global Fish Watch database available online (Kroodsma et al 2018) indicates very little trawling effort is present in this area. The Area of the Northwest Pacific is also far removed from human population centers, and as a result, is isolated from many anthropogenic stressors that impact nearshore areas, such as runoff and chemical pollution. Therefore this area is relatively unimpacted compared to many areas of the Pacific and can be considered to have a high degree of naturalness.	

References

Baco, A.R., Etter, R.J., Ribeiro, P.A., Von der Heyden, S., Beerli, P. and Kinlan, B.P., 2016. A synthesis of genetic connectivity in deep-sea fauna and implications for marine reserve design. Molecular Ecology, 25(14), pp.3276-3298.

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Kroodsma, D. A,. Mayorga, J., Hochberg, T., Miller, N. A., Boerder, K., Ferretti, F., Wilson, A., Bergman, B., White, T. D., Block, B. A., Woods, P., Sullivan, B., Costello, C., and Worm, B. 2018. Tracking the global footprint of fisheries. *Science* **359**, 904–908.

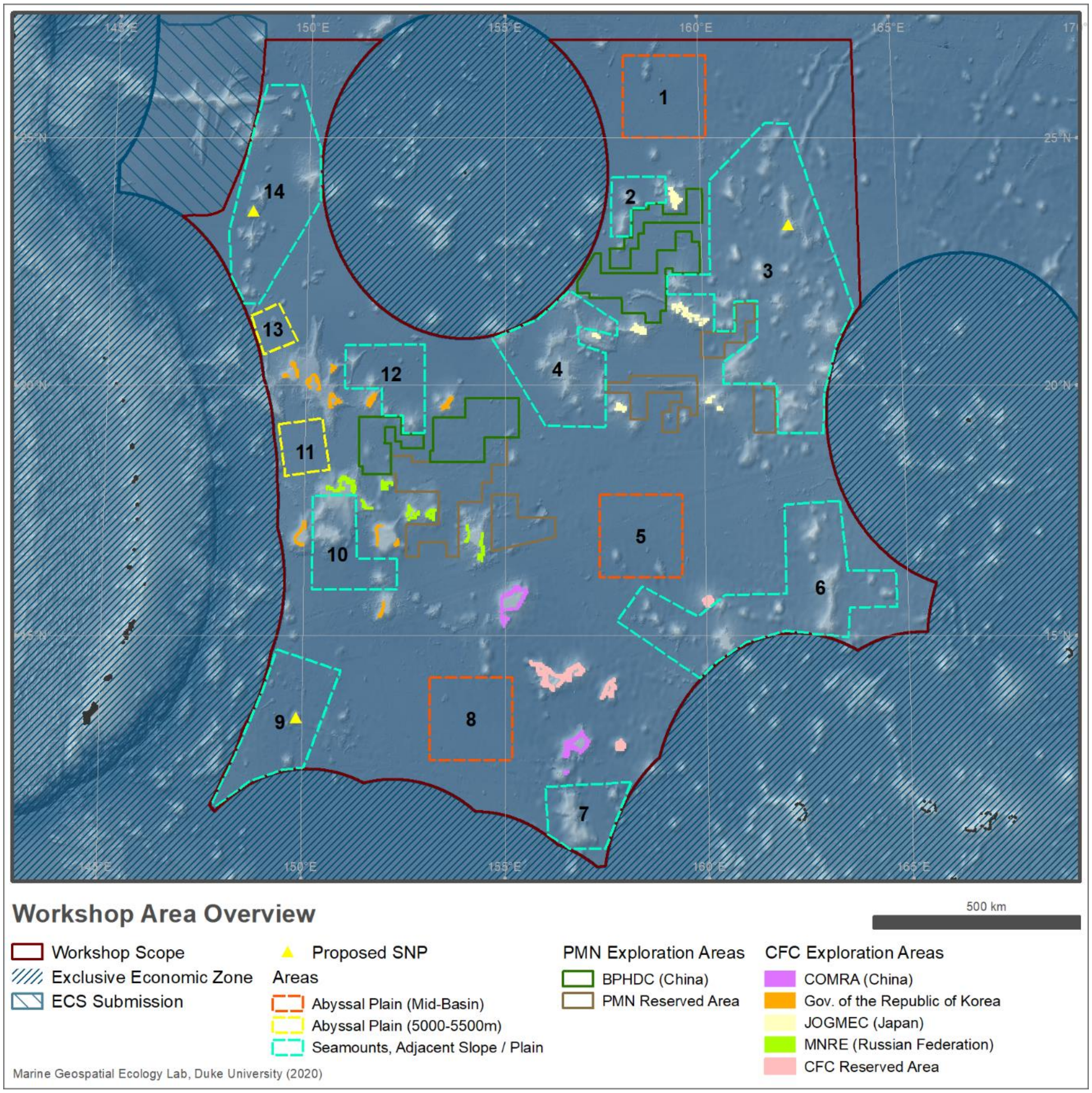

Figure 1. Overview of potential AINPs described in this section.

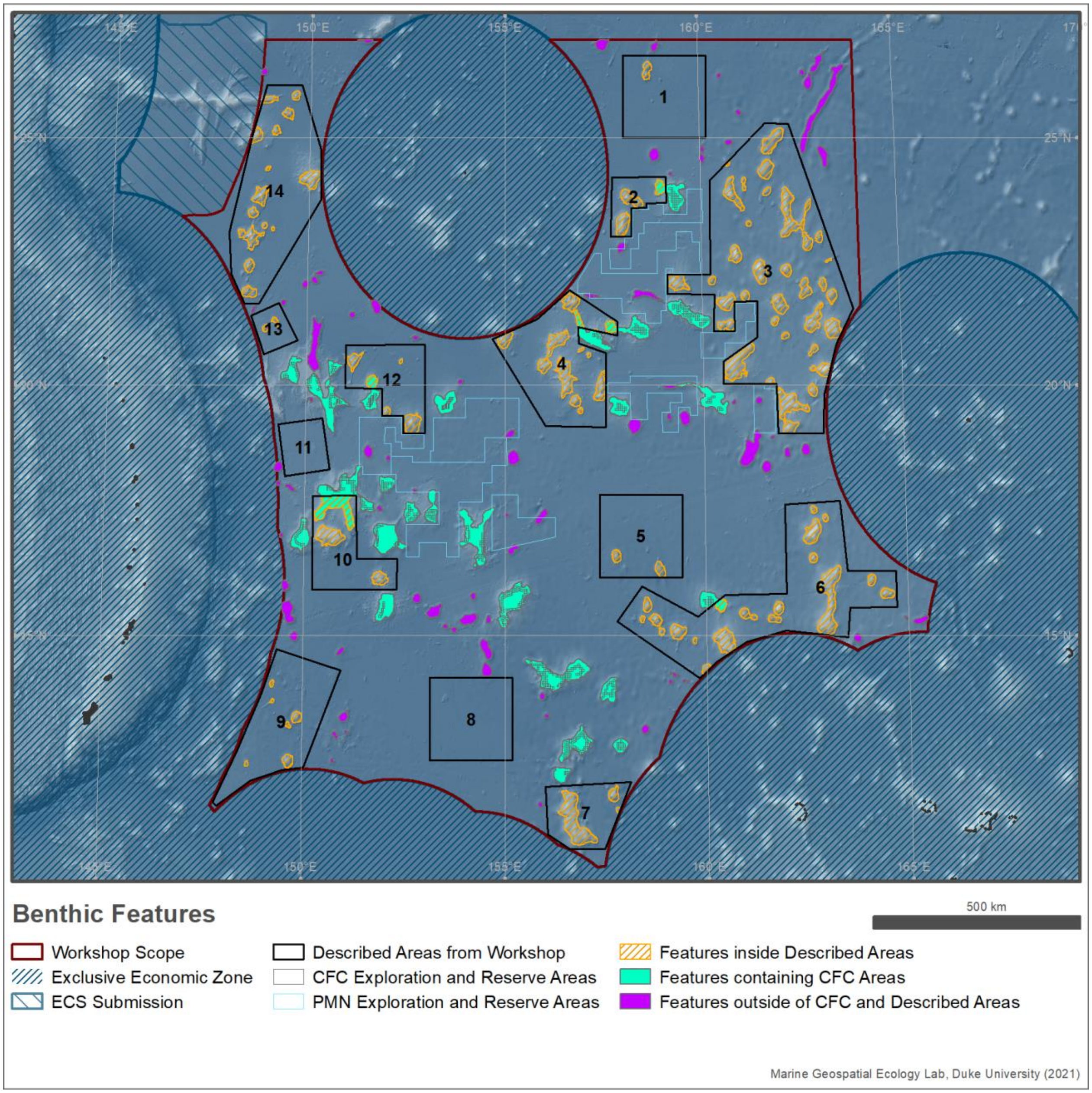

Figure 2. Large Benthic Feature Summary Map

Potential AINP No.1 (abyssal plain environment)

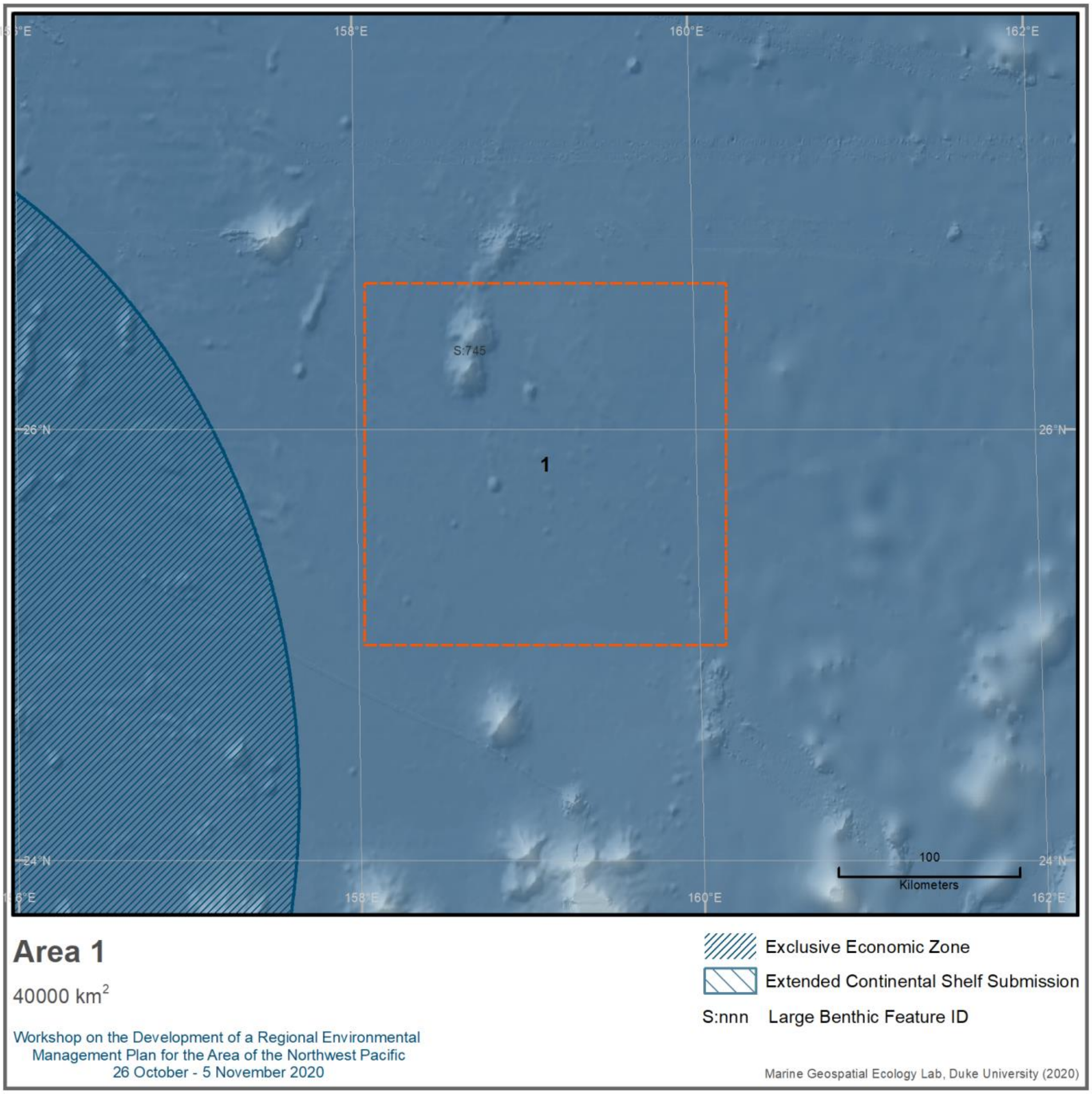

Figure 3. Map of potential AINP 1.

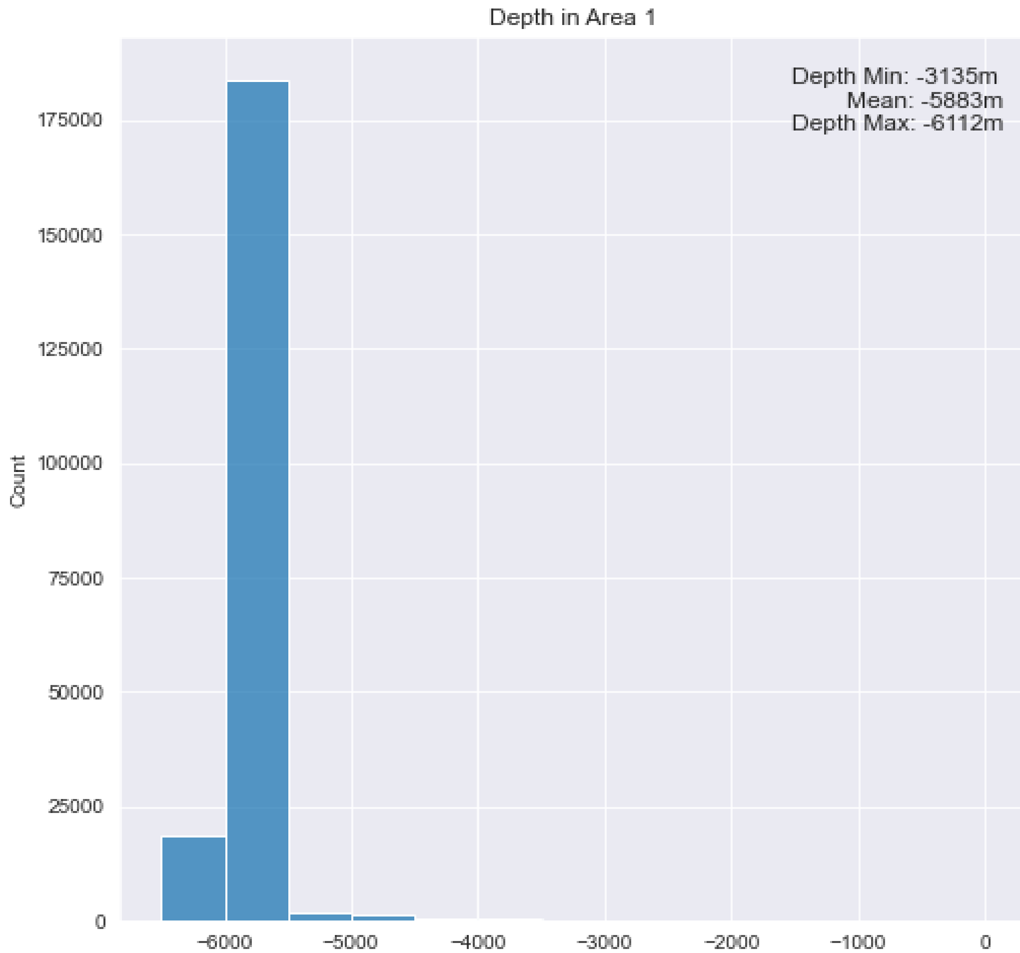

Figure 4. Depth profile in potential AINP 1.

Table 2. Large benthic features in potential AINP1.

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
745	668	-3135	-5391	-4643

1. Introduction

This represents the northernmost of four potential AINPs to cover biophysical gradients that run from north to south across the area. Scientific information is scarce in the area but available data on POC flux suggest a weak gradient with increase towards the north. Given that the distance from the northern to the southern limit, it was suggested that four proposed sites could be appropriate, all located on the abyssal plain. Over such long distance there could be faunal changes and connectivity issues that are not currently apparent due to lack of scientific information. The distance between AINP1 and 5 which is the next potential abyssal plain AINP to the south is a considerable distance. These two potential AINPs are separated by the Marcus-Wake seamounts, within which there are some areas of abyssal plain, but some of this area is occupied by contract blocks.

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 2.

The size of these potential abyssal plain AINP is 200x200 km in line with APEIs established in the CCZ. As in the CCZ macrofaunal and meiofaunal invertebrates are likely to constitute the vast majority of biodiversity and almost certainly include species with the most limited dispersal capabilities and biogeographic ranges. Arguments for this size of AINPs were given in Wedding et al., (2013) and could apply equally to this region of abyssal plain. This size should enable maintenance of sustainable, intact and healthy marine populations, maintain minimum viable population sizes for species potentially restricted to a subregion and protect a full range of habitat types found within each subregion.

A 100 km buffer zone was not included but the boundaries of these areas are at least 100 km away from contract areas.

3. Description of the potential AINP against relevant scientific criteria

Representativity: The abyssal plain represents a large proportion of the area considered in this workshop which includes seamount chains and individual seamounts. Contract areas and reserved areas cover about 148,000 km^2 of the abyssal plain. To maintain representativity and connectivity for abyssal plain faunas across the management area 4 sites have been chosen including this one.

There was little to no biological information available for this area. The criteria used for inclusion as an AINP was its bathymetric characteristics indicating that it was part of an under-represented depth range when compared to the depth ranges for the overall region. This AINP was also included to provide replication of the types of seafloor bathymetric characteristics that were found within the contract areas. In addition, this area was the northernmost site and combined with AINP 5 and 8 was meant to represent north to south gradients in POC (productivity). This site was also included to provide replication of the types of seafloor bathymetric conditions that were found within the contract areas.

4. Reference

Wedding LM, Friedlander AM, Kittinger JN, Watling L, Gaines SD, Bennett M, Hardy SM, Smith CR. 2013 From principles to practice: a spatial approach to systematic conservation planning in the deep sea. Proc R Soc B 280: 20131684. http://dx.doi.org/10.1098/rspb.2013.1684

Potencial AINP No.2 (Seamount complex & intra-seamount basin**)**

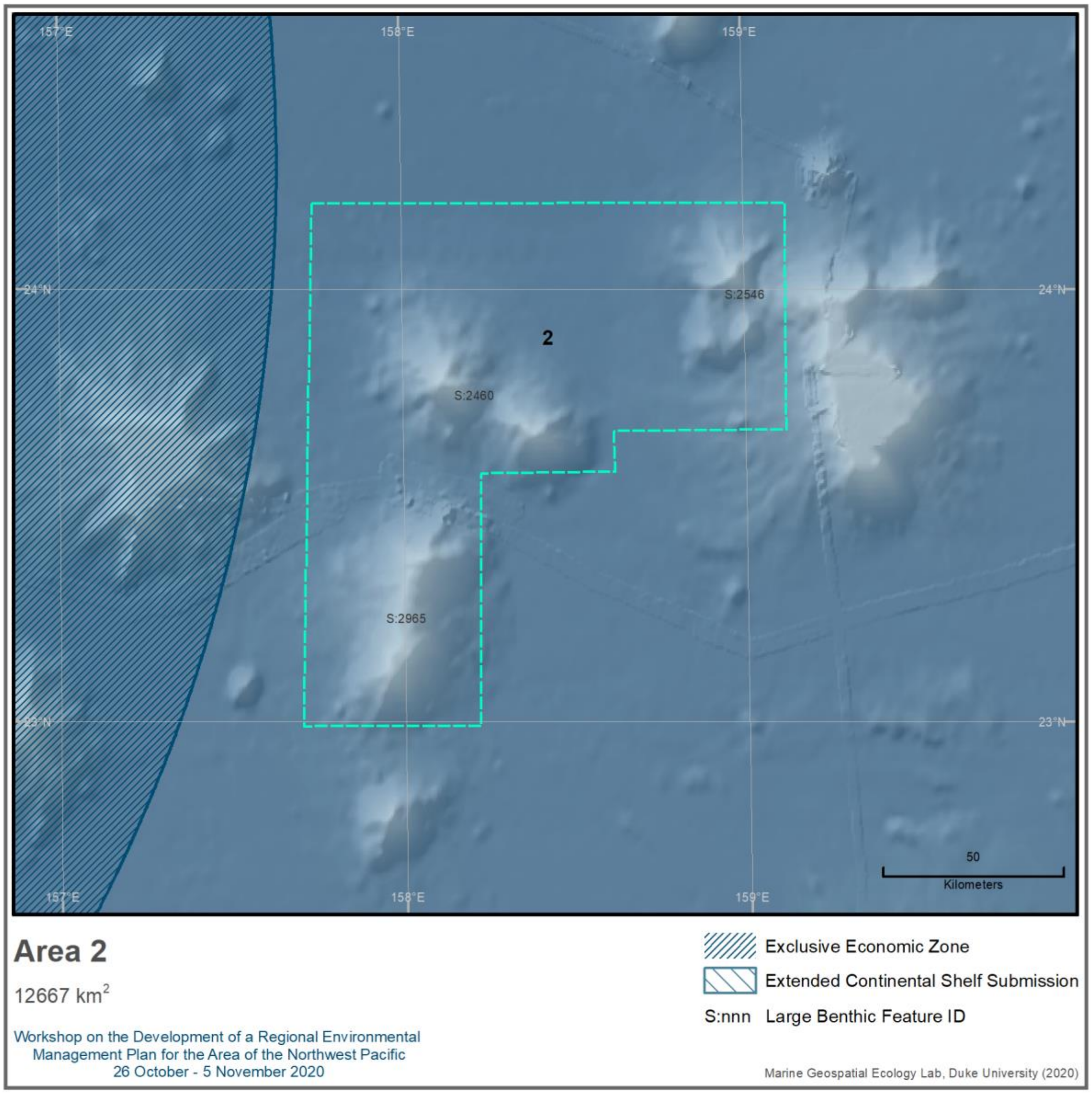

Figure 5. Map of potential AINP 2.

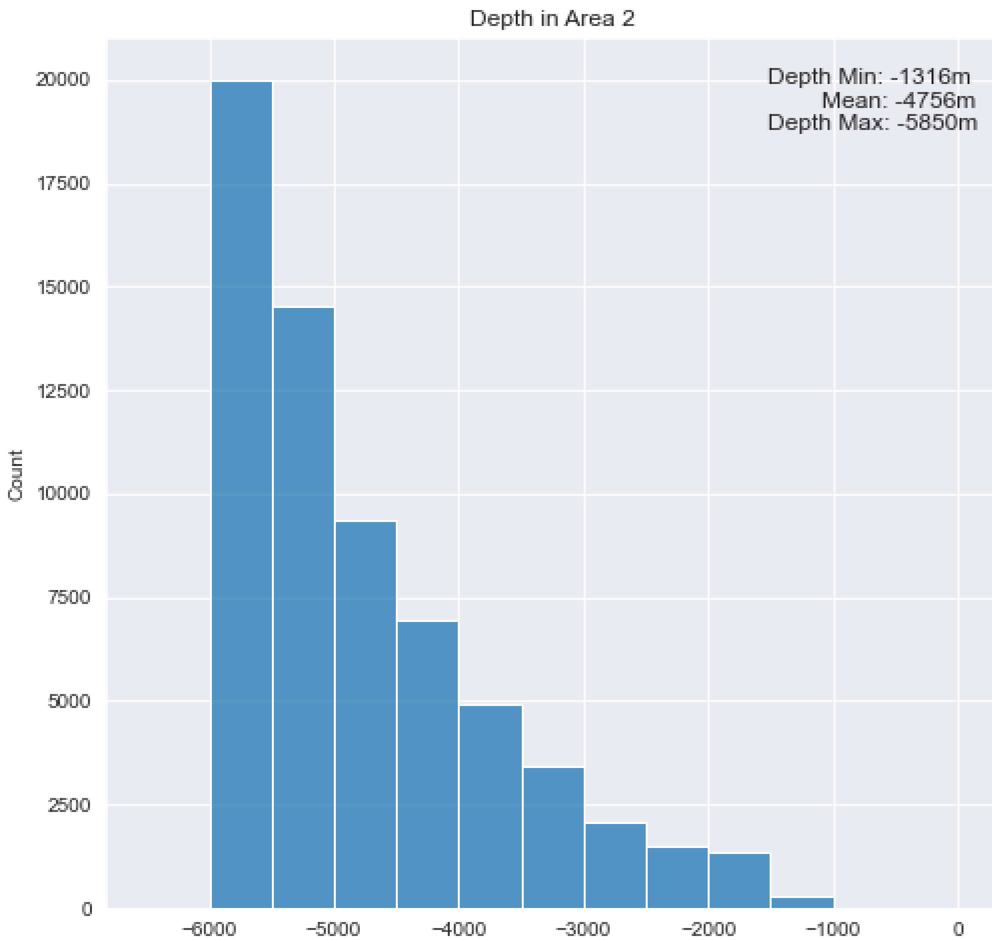

Figure 6. Depth profile in potential AINP 2.

Table 3. Large benthic features in potential AINP 2

Id	**Area (km^2)**	**Depth Min (m)**	**Depth Max (m)**	**Depth Mean (m)**
2965	1388	-1316	-4204	-2974
2546	651	-1509	-4595	-3471
2460	1270	-1337	-4816	-3593

1. Introduction

This relatively small area of 12,667 km^2 contains three close-proximity Marcus-Wake seamounts. The seamounts rise from approximately 6,000 m to below 1000 m depth. Although the seamounts are much narrower than those with exploration and reserved areas on them, the area is predominately habitat similar to the habitat within CFC and PNM contract areas (although there is no data currently available to confirm the presence of nodules).

2. **Description of features and habitat type(s), including depth range and terrain classes**: see Table 3.

3. **Description of the potential AINP against relevant scientific criteria**

For details on how seamounts in general meet the criteria, please refer to Table 1.

4. **Reference (if any)**

Potential AINP No.3 (Seamount complex & intra-seamount basin)

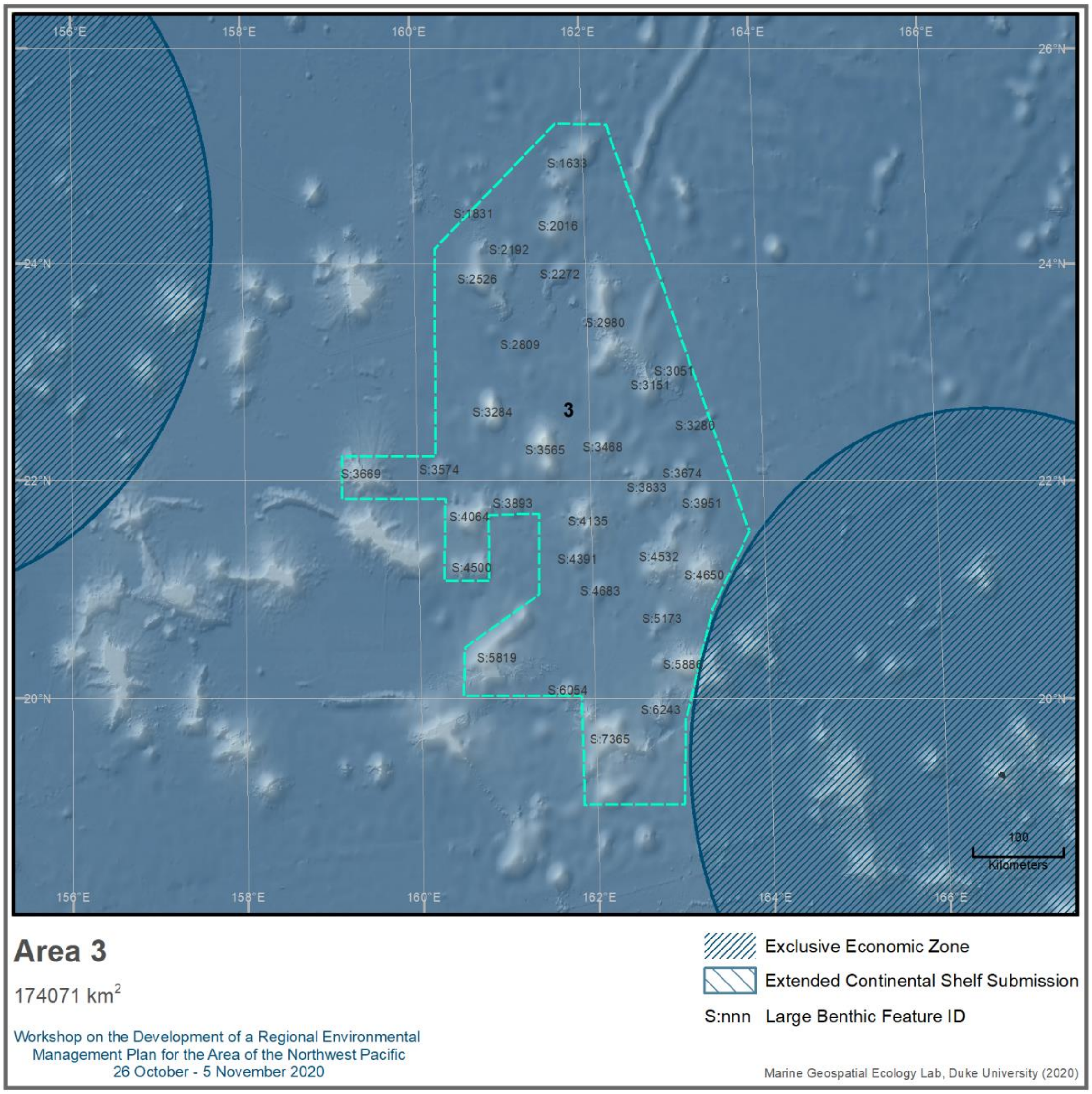

Figure 7. Map of potential AINP 3.

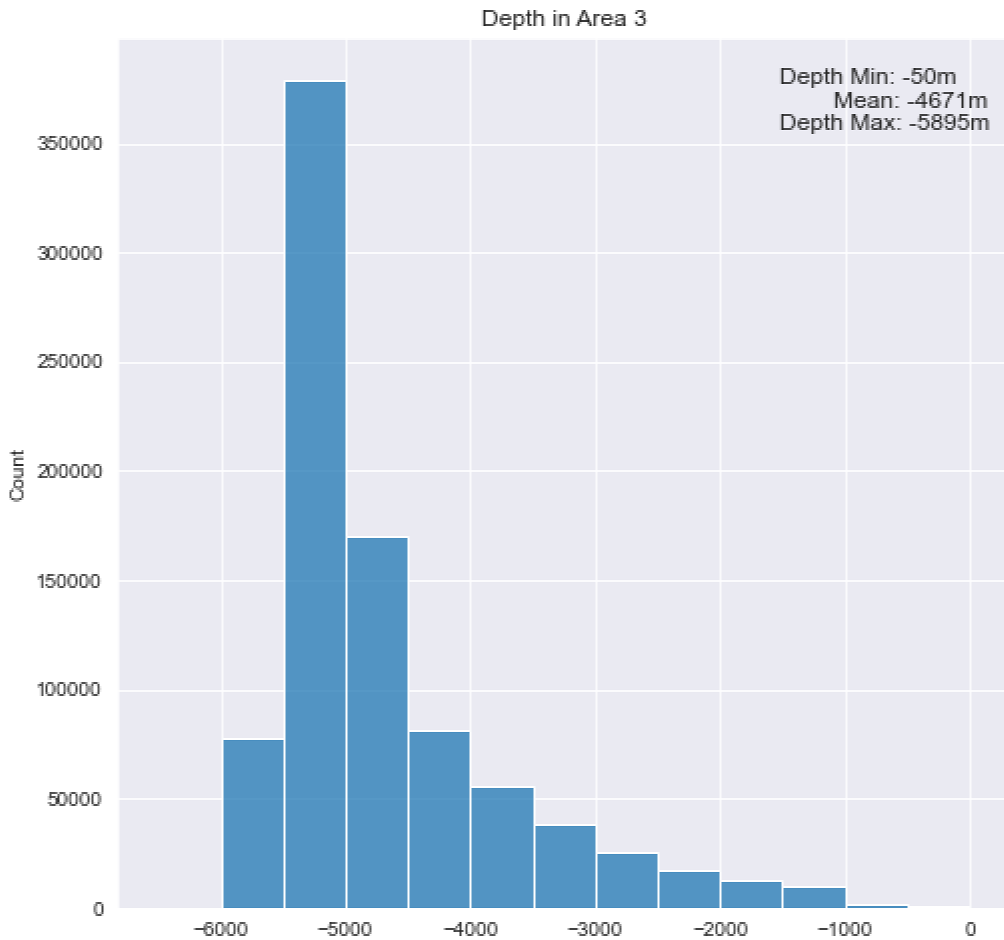

Figure 8. Depth profile of potential AINP3.

Table 4. Large benthic features in potential AINP 3

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
4650	1491	-1253	-3791	-2365
5886	952	Out of Range	-3887	-1984
7365	3319	-1083	-3914	-2403
6243	470	-1993	-3946	-2990
4064	1213	-885	-4030	-2625
4135	1222	-1181	-4081	-2988
4532	1484	-1842	-4138	-2951
3669	1390	-1268	-4140	-2770
3565	1453	Out of Range	-4143	-2515

5819	2999	-1197	-4263	-2574
4500	827	-1435	-4283	-3190
5173	304	-2758	-4308	-3678
4391	271	-2061	-4345	-3450
6054	230	-1457	-4376	-3255
3833	899	-2814	-4396	-3929
3893	379	-2027	-4423	-3406
3468	573	-1085	-4444	-3286
3151	726	-2057	-4456	-3417
3951	596	-2404	-4492	-3572
3284	931	Out of Range	-4508	-2691
2016	1197	-2464	-4548	-3567
3674	394	-3661	-4569	-4021
4683	221	-3663	-4614	-4145
2192	202	-3600	-4687	-4136
3051	351	-2915	-4694	-3984
2526	1549	-859	-4740	-3359
2980	3093	-1103	-4754	-3072
3574	277	-2939	-4834	-4045
2272	257	-3600	-4866	-4223
1831	85	-4278	-4921	-4622
1633	1754	-2373	-4922	-3924
3280	58	-4731	-4968	-4857
2809	127	-4608	-4974	-4795

1. Introduction

The area covers 174,071 km^2 of the Marcus-Wake seamount chain and contains a large, dense network of shallow, conical seamounts and their inter-mountain basins (approximately 20 seamount or seamount-like features). The seafloor rises from approximately 6,000 m to above 500 m depth. It contains over 35% of the seafloor above 500 m in the Area, a relatively high proportion considering it represents only 8% of the surface area. Although the seamounts are much narrower than those within exploration and reserved areas, this area contains the most habitat similar to the habitat within CFC and PNM contract areas (although there is no data currently available to confirm the presence of nodules).

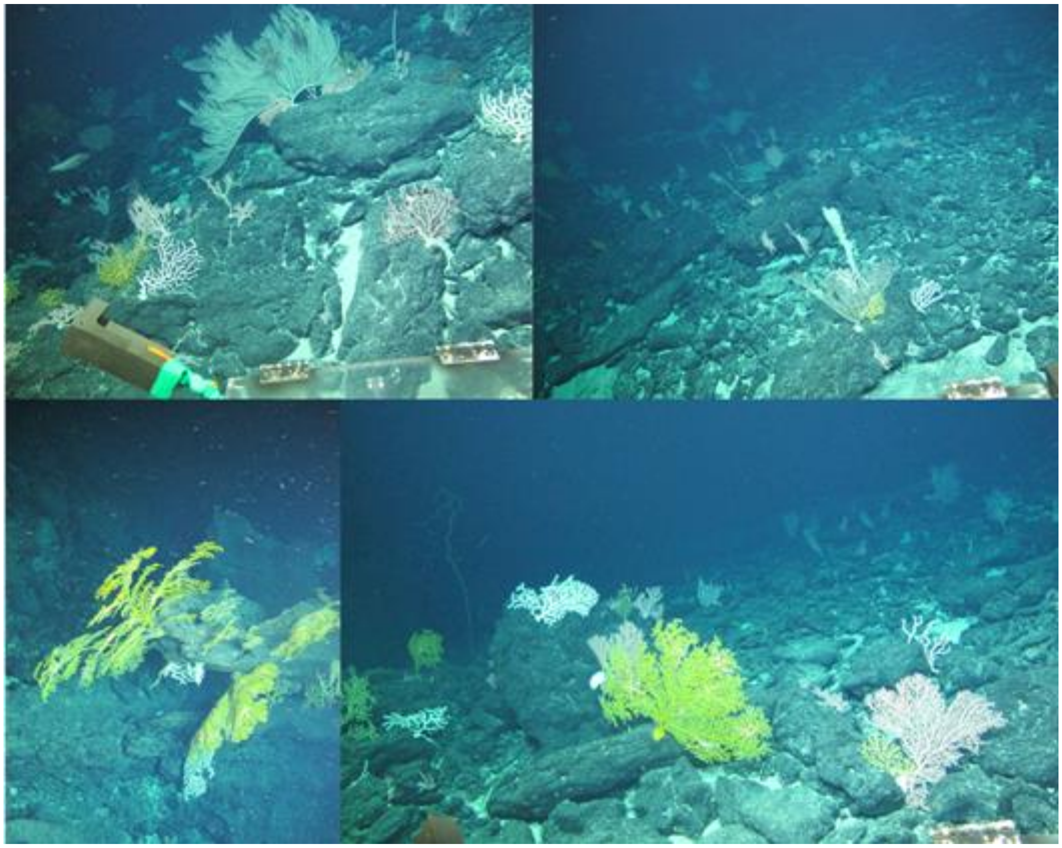

Figure 9. Cold-water corals from ROV images taken during COMRA cruise.

Description of features and habitat type(s), including depth range and terrain classes: see Table 4.

2. Description of the AINP against relevant scientific criteria

Please refer to the description of RE seamount in Appendix 2.

3. Reference

1. COMRA Cruise Report (2020).

2. Lutz M J, Caldeira K, Dunbar R B, et al. Seasonal rhythms of net primary production and particulate organic carbon flux to depth describe the efficiency of biological pump in the global ocean. JGR Oceans, 2007, 112, dor.org/10.1029/2006JC003706

3. Roark E B, Guilderson T P, Dunbar R B , et al. Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. Marine Ecology Progress Series, 2006, 327(Dec):1-14.

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5. Woolley S N C, Tittensor D P, Dunstan P K, et al. Deep-Sea diversity patterns are shaped by energy availability. Nature, 2016, 533, 393-396.

Potential AINP 4 (Seamount complex & intra-seamount basin)

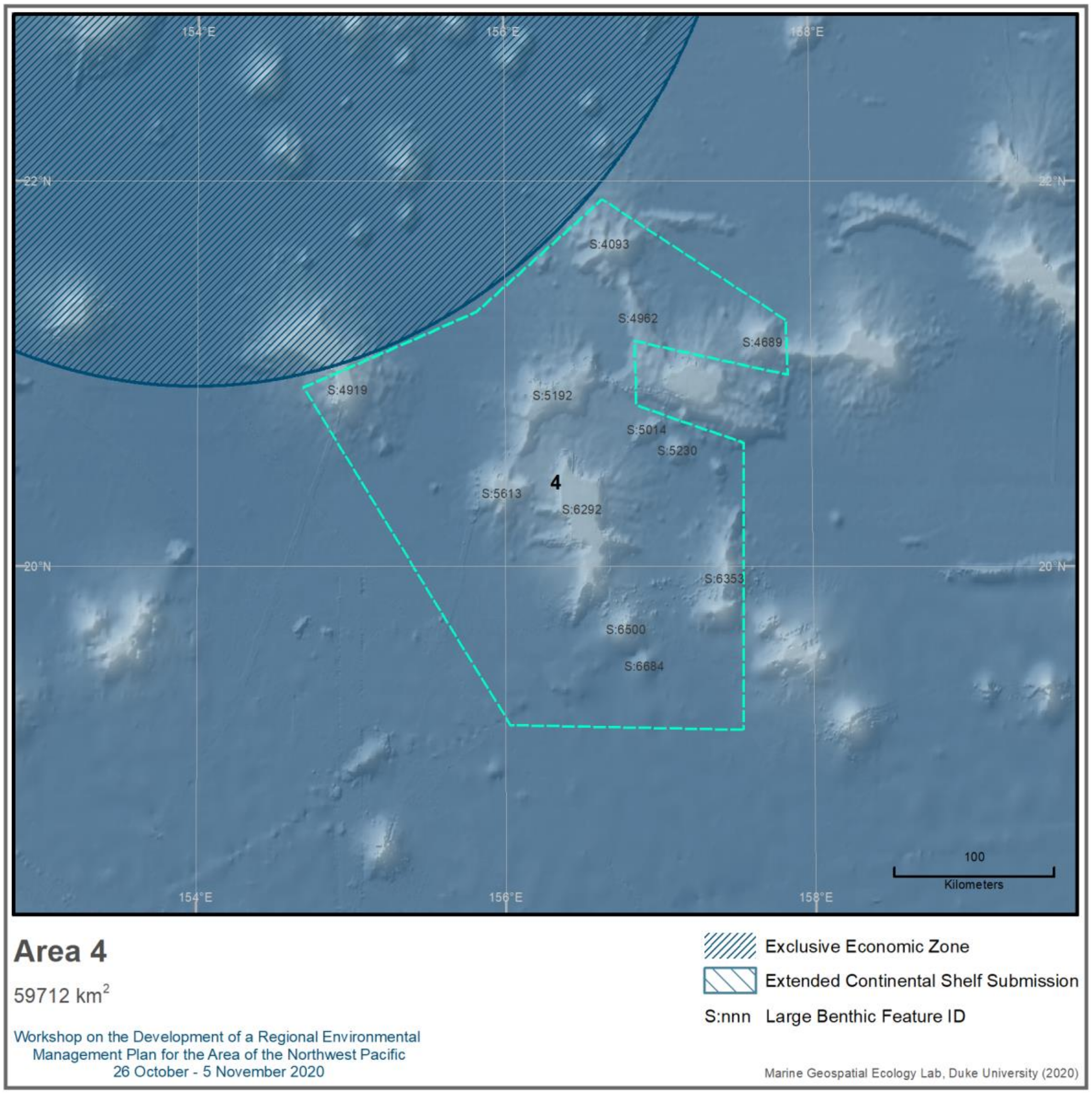


Figure 10. Map of potential AINP 4.

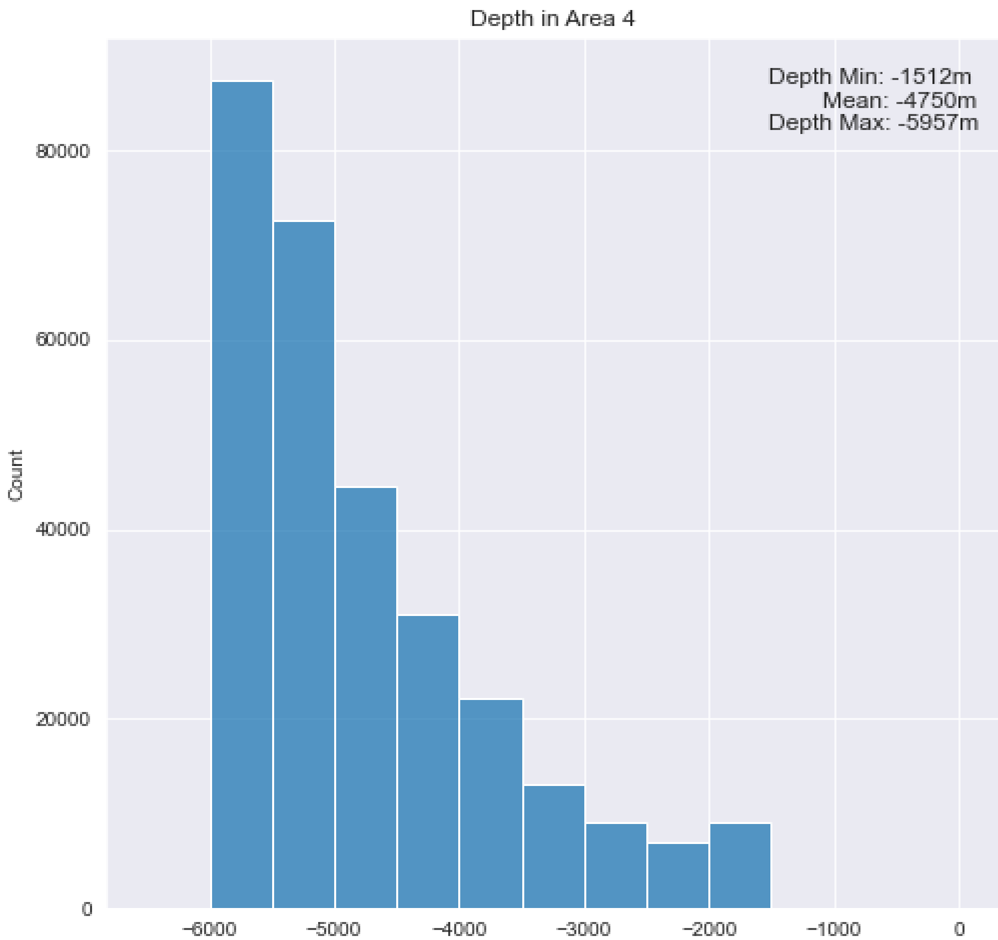


Figure 11. Depth profile in potential AINP 4.

Table 5. Large benthic features in potential AINP 4

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
5014	74	-3036	-3889	-3546
4962	439	-2932	-3971	-3446
5192	1477	-1909	-4084	-2795
6292	2299	-1566	-4124	-2311
4689	606	-1747	-4143	-2993
5230	68	-3000	-4228	-3645
4093	1290	-1701	-4239	-3214
4919	1007	-1512	-4247	-2831
5613	814	-1590	-4549	-2904

6500	531	-1591	-4576	-3522
6353	1347	-1570	-4733	-3303
6684	136	-3641	-4822	-4393

1. **Introduction**

The area covers 59,712 km^2 of the Marcus-Wake seamount chain and contains a dense complex of deep seamounts and guyots (>1500 m summits). The flat-topped geomorphology of the features represents relatively large areas of seamounts habitats above 3,000 m depth (in comparison to the colonial seamounts located to the east). As a result, the area contains similar habitat to that found within CFC and PNM blocks (although there is no data currently available to confirm the presence of nodules).

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 5

Located in the northern half of the Area, the area has a higher concentration of surface chlorophyll and modelled POC export than the southern region—owing to the latitudinal-gradient.

The area boarders the southern side of the Japanese EEZ and is the most central potential AINP, potentially representing an important pathway for connectivity among seamounts. There is evidence that the pelagic and benthic communities associated with these seamounts include ecologically, commercially, and culturally important species, as well as species of conservation concern (see table1).

3. **Description of the potential AINP against relevant scientific criteria**

For details on the criteria used for evaluating seamounts, please refer to Table 1.

4. **Reference**

Potential AINP No. 5 (abyssal plain environment)

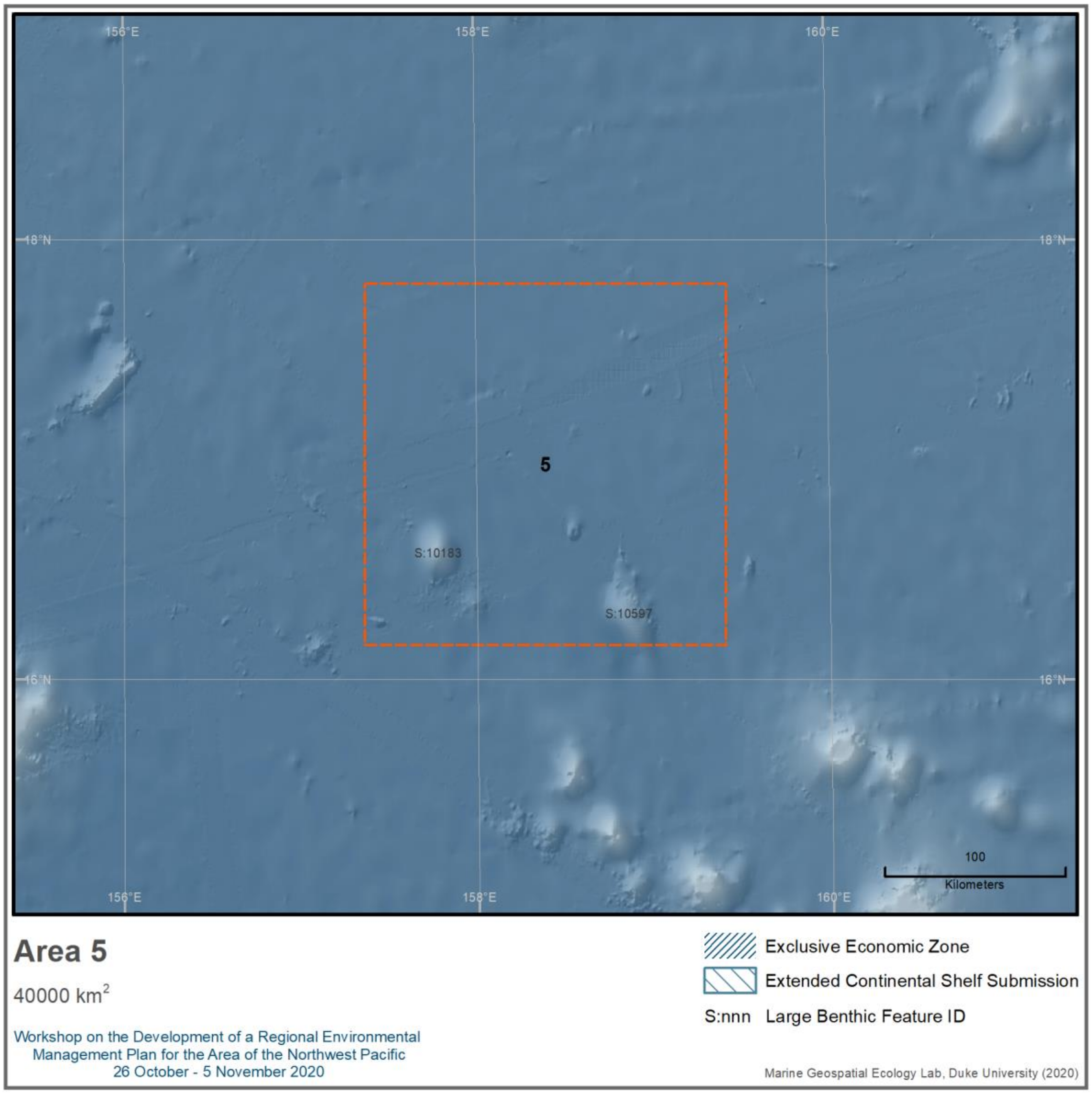


Figure 12. Map of potential AINP 5.

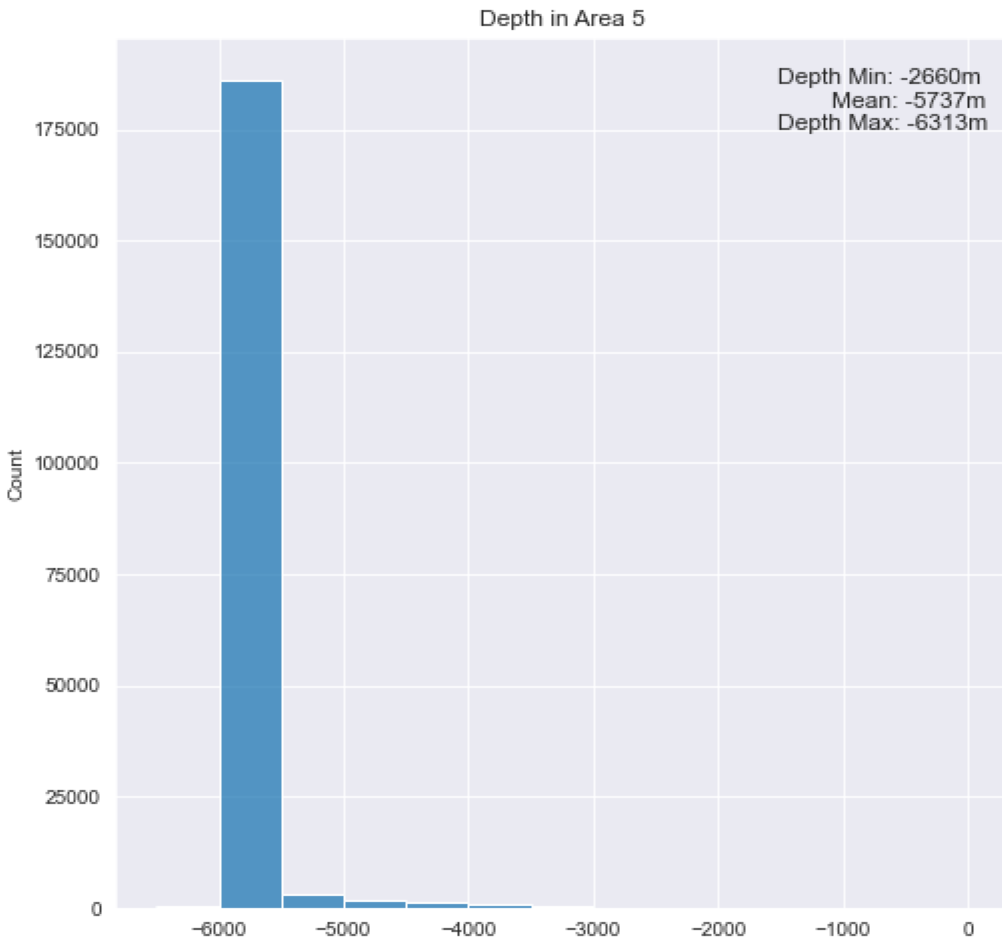


Figure 13. Depth profile in potential AINP 5.

Table 6. Large benthic features in potential AINP5

Id	**Area (km^2)**	**Depth Min (m)**	**Depth Max (m)**	**Depth Mean (m)**
10183	522	-2660	-5263	-4274
10597	651	-3460	-5314	-4469

1. Introduction

This site represents the second of four potential AINPs to cover biophysical gradients that run from north to south across the area. Scientific information is scarce in the area but available data on POC flux suggest a weak gradient with increase towards the north. Given the distance from the northern to the southern limit, it was suggested that four potential AINPs could be appropriate, all located on the abyssal plain. Over such long distance there could be faunal changes and connectivity issues that are not currently apparent due to lack of scientific information. AINP5 lies in the Pigafetta Basin. It is separated from AINP 8 to the south by the Magellan Seamounts, through which there are some connections at abyssal plain depth.

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 6.

The size of these potential abyssal plain AINP is 200x200 km in line with APEIs established in the CCZ. As in the CCZ macrofaunal and meiofaunal invertebrates are likely to constitute the vast majority of biodiversity and almost certainly include species with limited dispersal capabilities and biogeographic ranges. Arguments for this size of AINPs were given in Wedding et al., (2013) and could apply equally to this region of abyssal plain. This size should enable maintenance of sustainable, intact and healthy marine populations, maintain minimum viable population sizes for species potentially restricted to a subregion and protect a full range of habitat types found within each subregion.

A 100 km buffer zone was not included but the boundaries of these areas are at least 100 km away from contract areas.

3. Description of the potential AINP against relevant scientific criteria

Representativity: The abyssal plain represents a large proportion of the area considered in the workshop which includes seamount chains and individual seamounts. Contract areas and reserved areas cover about 148,000 km^2 of the abyssal plain. To maintain representativity and connectivity for abyssal plain faunas across the management area 4 sites have been chosen including this one.

There was little to no biological information available for this area. The criteria used for inclusion as an AINP was its bathymetric characteristics indicating that it was part of an under-represented depth range when compared to the depth ranges for the overall region. This site was also included to provide replication of the types of seafloor bathymetric characteristics that were found within the contract areas. In addition, this area was the northernmost site and combined with sites 1 and 8 was meant to represent north to south gradients in POC (productivity). This site was also included to provide replication of the types of seafloor bathymetric conditions that were found within the contract areas, as well as to represent the only abyssal plain area contiguous within the Pigafetta Basin.

4. Reference

Wedding LM, Friedlander AM, Kittinger JN, Watling L, Gaines SD, Bennett M, Hardy SM, Smith CR. 2013 From principles to practice: a spatial approach to systematic conservation planning in the deep sea. Proc R Soc B 280: 20131684. http://dx.doi.org/10.1098/rspb.2013.1684

Potential AINP No.6 (Seamount complex & intra-seamount basin)

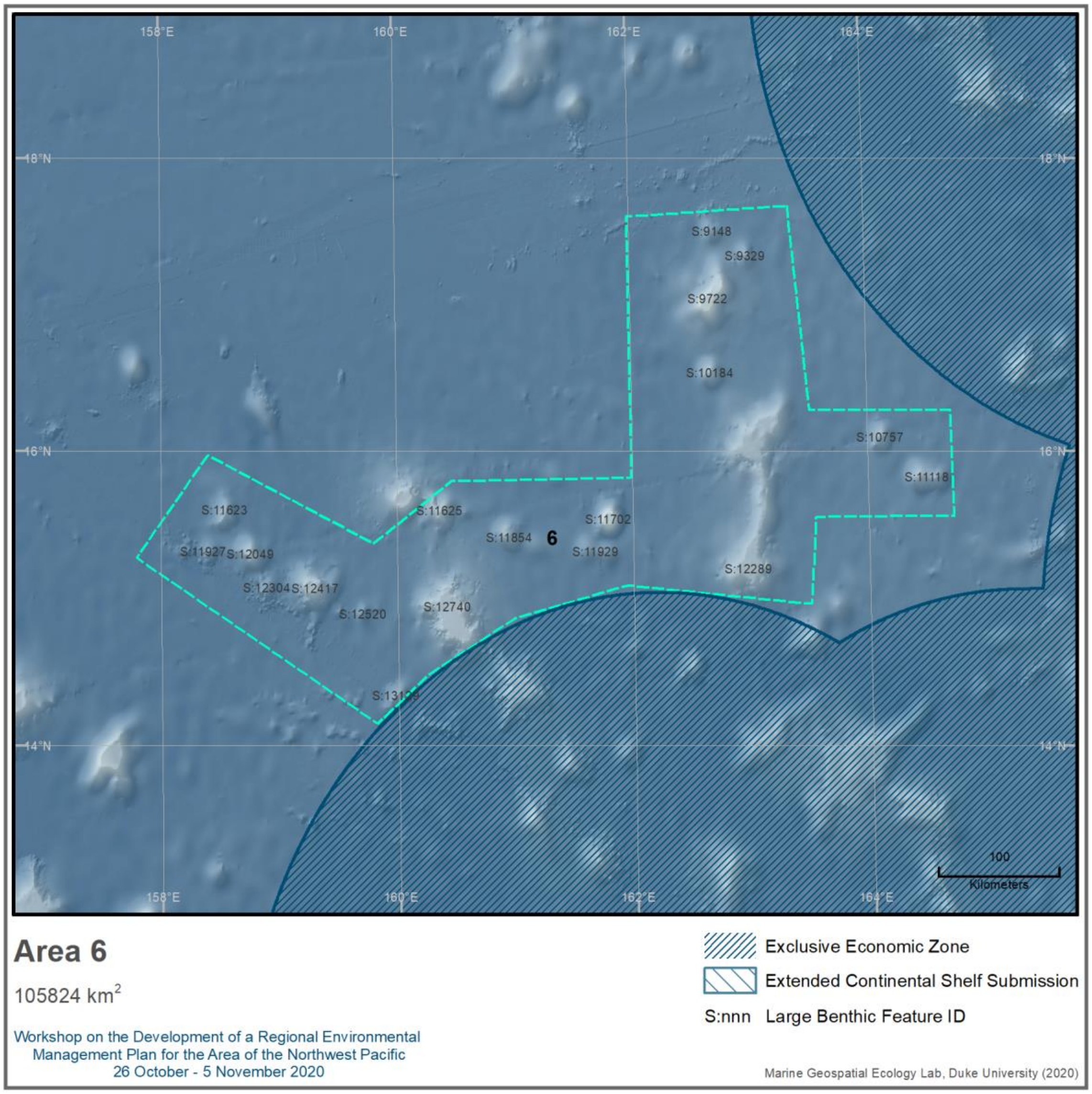


Figure 14. Map of potential AINP 6.

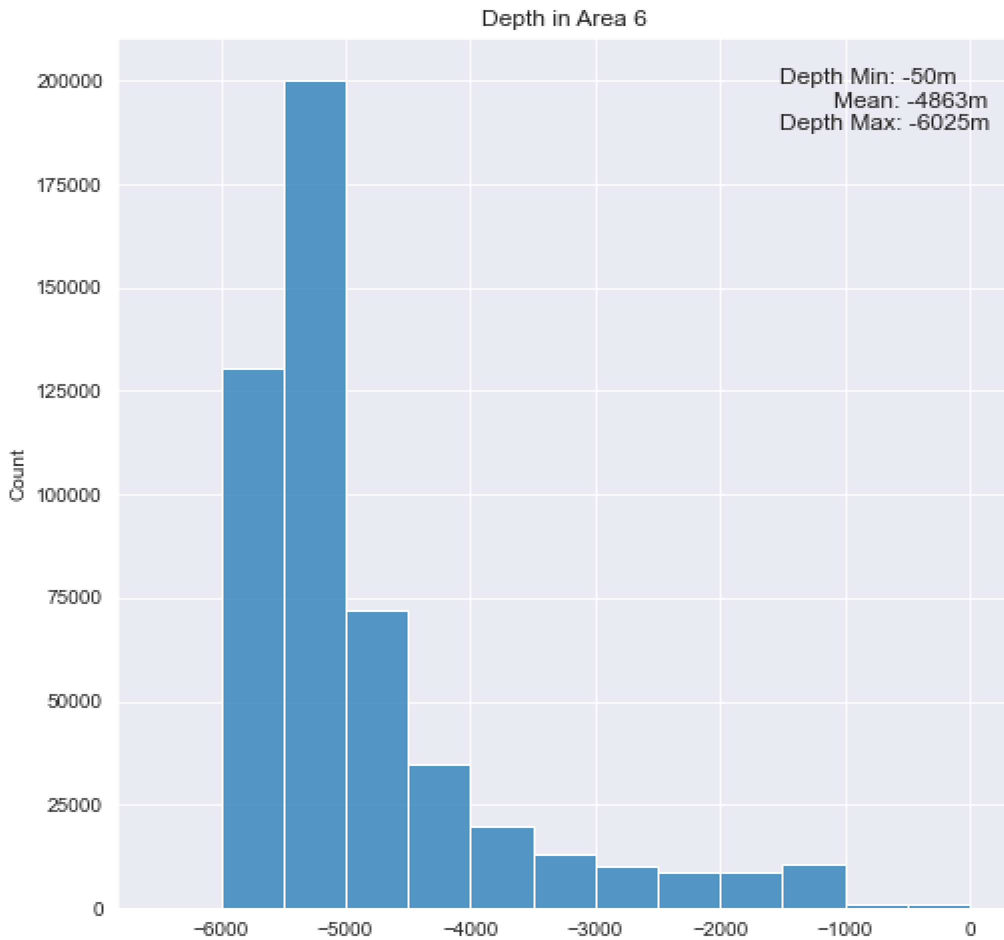


Figure 15. Depth profile of potential AINP 6.

Table 7. Large benthic features in potential AINP 6.

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
12740	2213	-994	-3825	-2024
9722	1607	Out of Range	-4061	-2300
12289	4759	-1051	-4085	-2282
11625	606	-1259	-4229	-2914
9329	182	-2513	-4263	-3606
10184	366	-1571	-4484	-3223
9148	201	-3094	-4580	-3864
11929	415	-3721	-4627	-4238

11118	659	-1804	-4644	-3441
11702	577	Out of Range	-4681	-2512
12417	1058	-1108	-4690	-3231
10757	427	-2070	-4696	-3629
11854	652	-2038	-4763	-3891
12304	174	-3789	-4792	-4256
12049	596	-1301	-4801	-3588
12520	107	-3702	-4965	-4523
11927	145	-4068	-4984	-4552
13129	305	-2954	-5004	-4174
11623	543	-1997	-5091	-3988

1. Introduction

The area covers 105,824 km^2 and contains a mix of several large, flat-topped guyots and small conical seamounts, as well as their broad inter-mountain basins. This is the only area that contains features from the Marshall seamount chain. This is the seafloor rises dramatically within this area, from roughly 6,500 m to above 500 m depth. Although the seamounts are much narrower than those with exploration and reserve areas on them, this area contains the largest area most similar to the habitat within CFC and PNM blocks (although there is no data currently available to confirm the presence of nodules).

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 7

Located in the southwest corner of the Area, the area has a lower concentration of surface chlorophyll and modelled POC export than the northern regions—owing to the latitudinal-gradient (representing a different class of seamount; cf. Clark et al. 2011).

The area boarders the northern side of the Marshall Island EEZ and directly west of the Wake Island Marine National Monument (sources of nearby seamount benthic survey data, Kelley et al., 2016). Owing to its distance from any CFC or PNM contract areas, the prevailing east-to-west surface currents, and its location in the southeast corner of the Area, the seamount and abyssal plain habitats within may be relatively remote from future exploitation activities.

There is evidence that the pelagic and benthic communities associated with these seamounts include ecologically, commercially, and culturally important species, as well as species of conservation concern.

3. Description of the AINP against relevant scientific criteria

For details on how seamounts in general meet the criteria, please refer to Table 1.

4. Reference

Potential AINP No.7 (Seamount complex & intra-seamount basin)

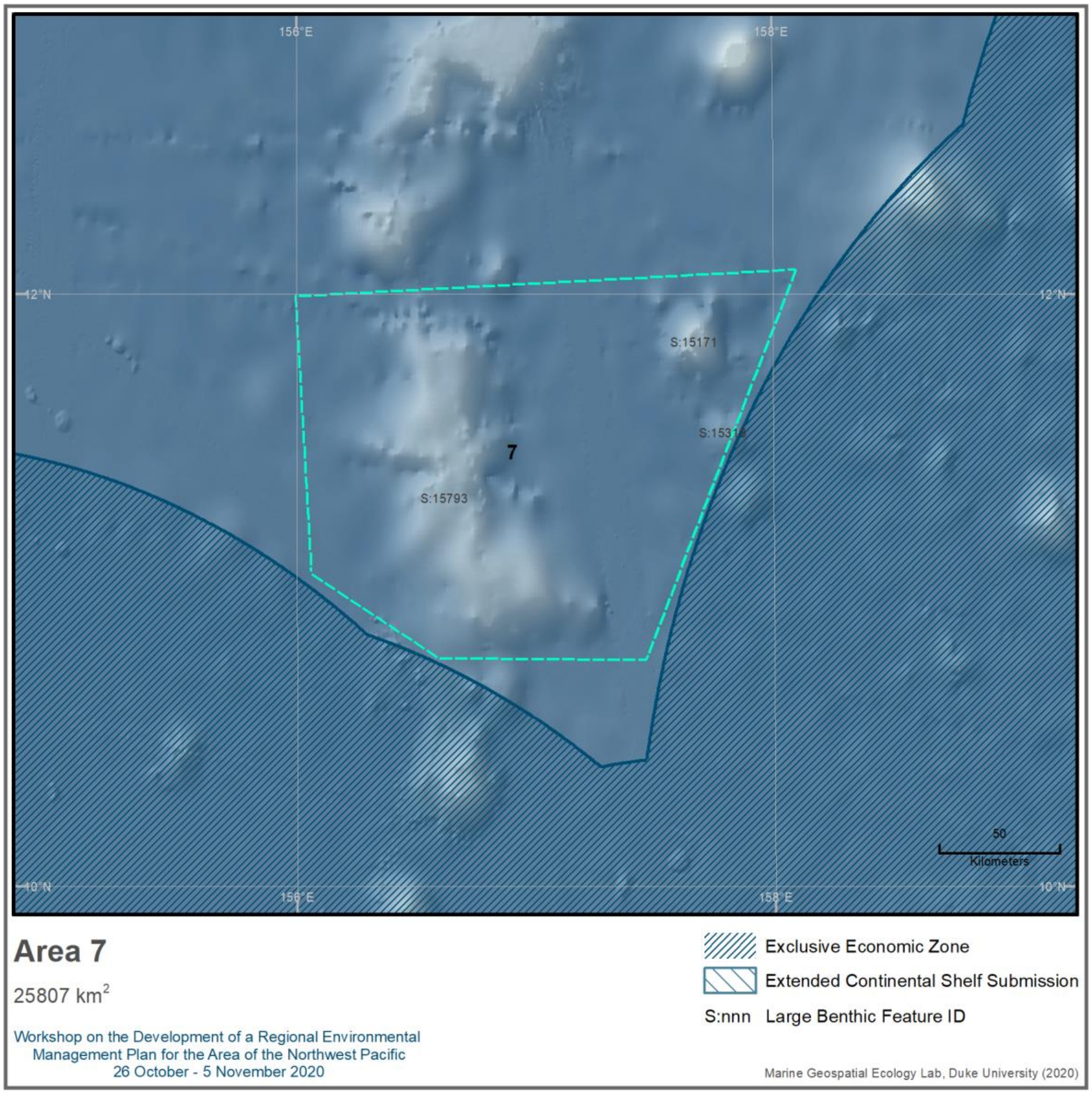


Figure 16. Map of potential AINP 7.

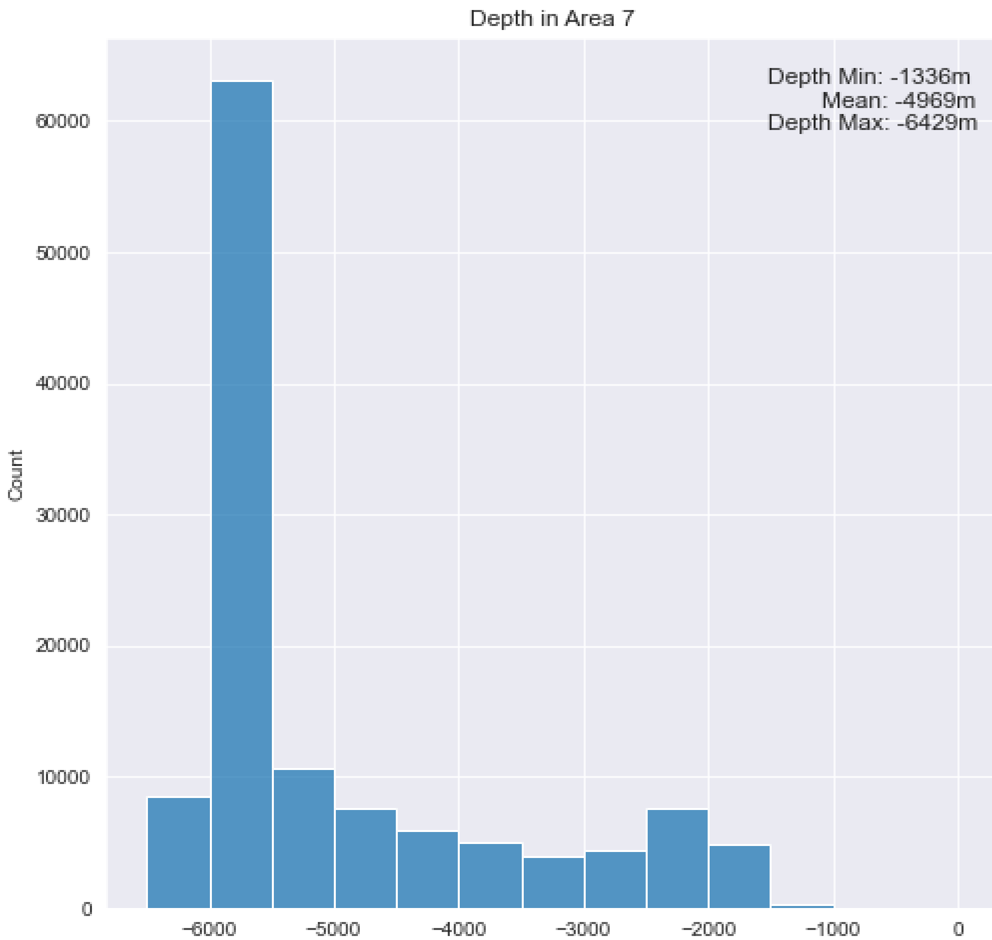


Figure 17. Depth profile of potential AINP 7.

Table 8. Large benthic features in potential AINP 7

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
15793	5022	-1391	-4760	-2655
15318	90	-4349	-5173	-4735
15171	666	-1336	-5231	-3737

1. Introduction

This relatively small area of 25,807 km^2 contains only two Magellan seamounts—the single largest guyot without an existing CFC or PNM contract area on it and a smaller, neighboring feature. For its size, this area contains the highest proportion of seamount habitat above 3,000 m. Remarkably, the seafloor also descends to approximately 6,500 m within the area. As a result, the small area likely supports high species turnover (high beta-diversity). There is evidence that the pelagic and benthic communities associated with these seamounts include ecologically, commercially, and culturally important species, as well as species of conservation concern (see table 1).

The area also contains habitat similar to the habitat within CFC and PNM contract areas (although there is no data currently available to confirm the presence of nodules).

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 8.

The area is the most southern proposed AINP in the Area and therefore has a lower concentration of surface chlorophyll and modelled POC export than the northern region—owing to the latitudinal-gradient.

The area boarders the northern side of the Marshall Island and Micronesia EEZs. Owing to its distance from any CFC or PNM contract areas, the prevailing east-to-west surface currents, and its location in the south-central, the seamount and abyssal plain habitats within may be relatively remote from future exploitation activities.

3. Description of potential AINP against relevant scientific criteria

For details on how seamounts in general meet the criteria, please refer to Table 1.

4. Reference

Potential AINP No.8 (abyssal plain environment)

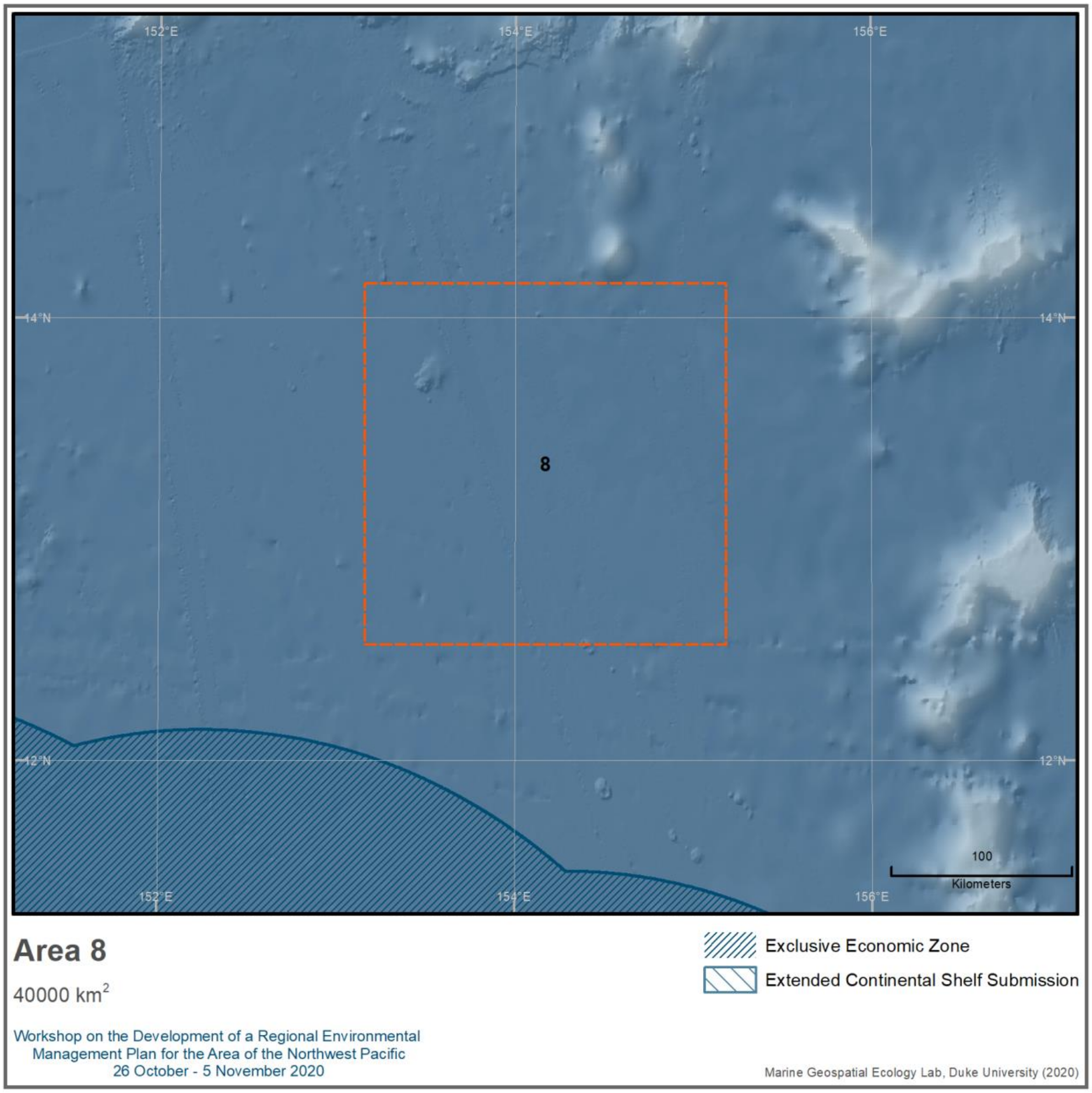


Figure 18. Map of potential AINP 8.

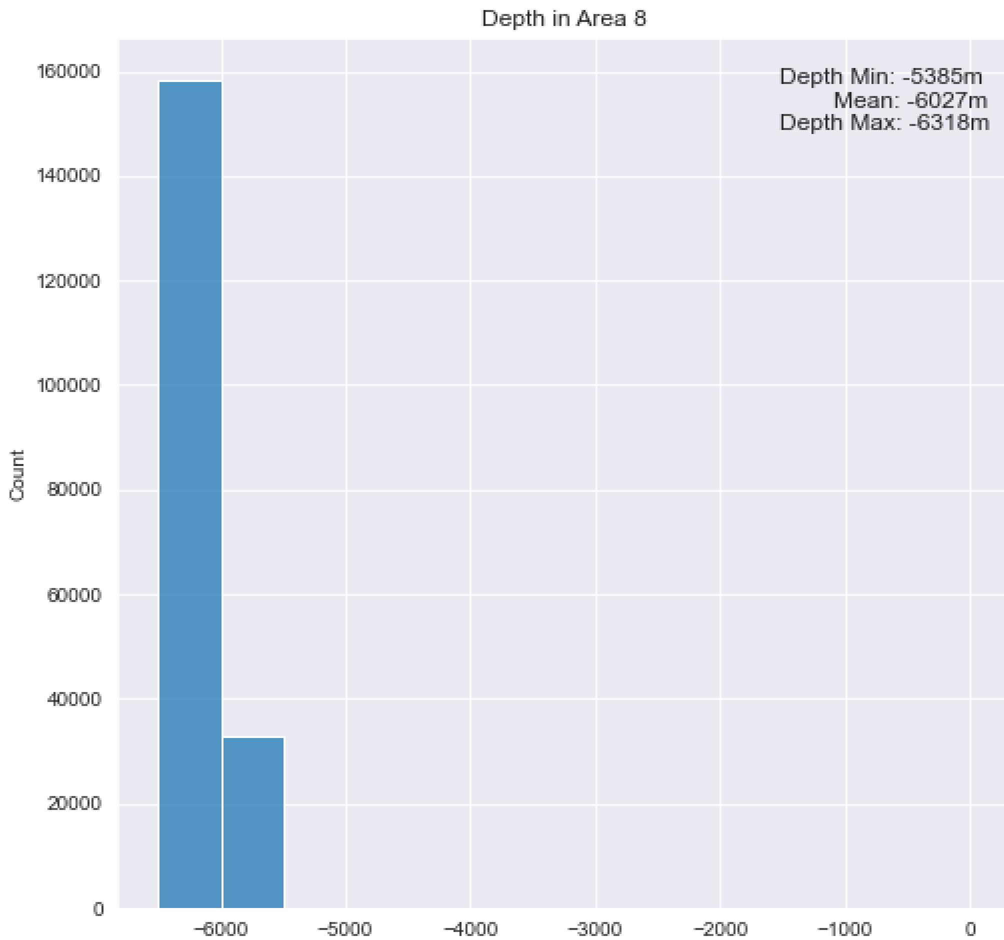


Figure 19. Depth profile in potential AINP 8.

1. Introduction

This site represents the third of four potential AINPs to cover biophysical gradients that run from north to south across the area. Scientific information is scarce in the area but available data on POC flux suggest a weak gradient with increase towards the north. Given the distance from the northern most limit to the southern limit, it was suggested that four potential AINPs could be appropriate, all located on the abyssal plain. Over such long distance there could be faunal changes and connectivity issues that are not currently apparent due to lack of scientific information. AINP 8 lies in the East Mariana Basin and is separated from AINP 9 to the west. AINPs 8 and 9 lie in the same deep East Mariana Basin.

The size of these proposed abyssal plain AINP is 200x200 km in line with those established in the CCZ. As in the CCZ macrofaunal and meiofaunal invertebrates are likely to constitute the vast majority of biodiversity and almost certainly include species with the most limited dispersal capabilities and biogeographic ranges. Arguments for this size of AINP were given in Wedding et al., (2013) and could apply equally to this region of abyssal plain. This size should enable maintenance of sustainable, intact and healthy marine populations, maintain minimum viable population sizes for species potentially restricted to a subregion and protect a full range of habitat types found within each subregion.

A 100 km buffer zone was not considered needed as the boundaries of these areas are at least 100 km away from contract areas.

2. Description of features and habitat type(s), including depth range and terrain classes

No large benthic features present in this AINP, based on workshop analysis.

3. Description of the potential AINP against relevant scientific criteria

Representativity: The abyssal plain represents a large proportion of the area considered by the workshop which includes seamount chains and individual seamounts. Contract areas and reserved areas cover about 148,000 km^2 of the abyssal plain. To maintain representativity and connectivity for abyssal plain faunas across the management area 4 sites have been chosen including this potential AINP.

There was little to no biological information available for this area. The criteria used for inclusion as an AINP was its bathymetric characteristics indicating that it was part of an under-represented depth range when compared to the depth ranges for the overall region. This site was also included to provide replication of the types of seafloor bathymetric characteristics that were found within the contract areas. In addition, this area was the northernmost site and combined with sites 1 and 5 was meant to represent north to south gradients in POC (productivity). This site was also included to provide replication of the types of seafloor bathymetric conditions that were found within the contract areas.

4. Reference

Potential AINP No.9 (Seamount complex & intra-seamount basin)

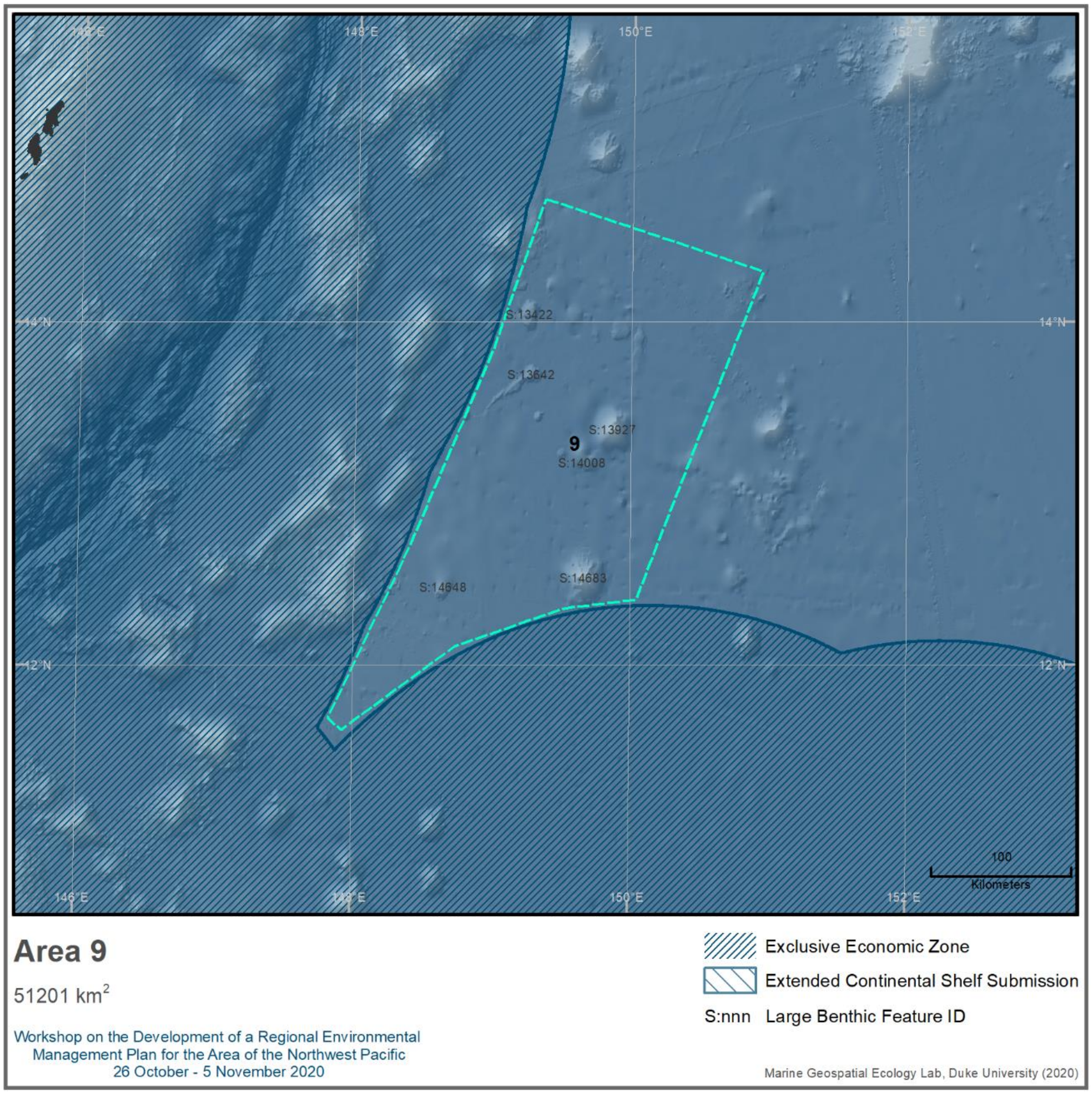


Figure 19. Map of potential AINP 9.

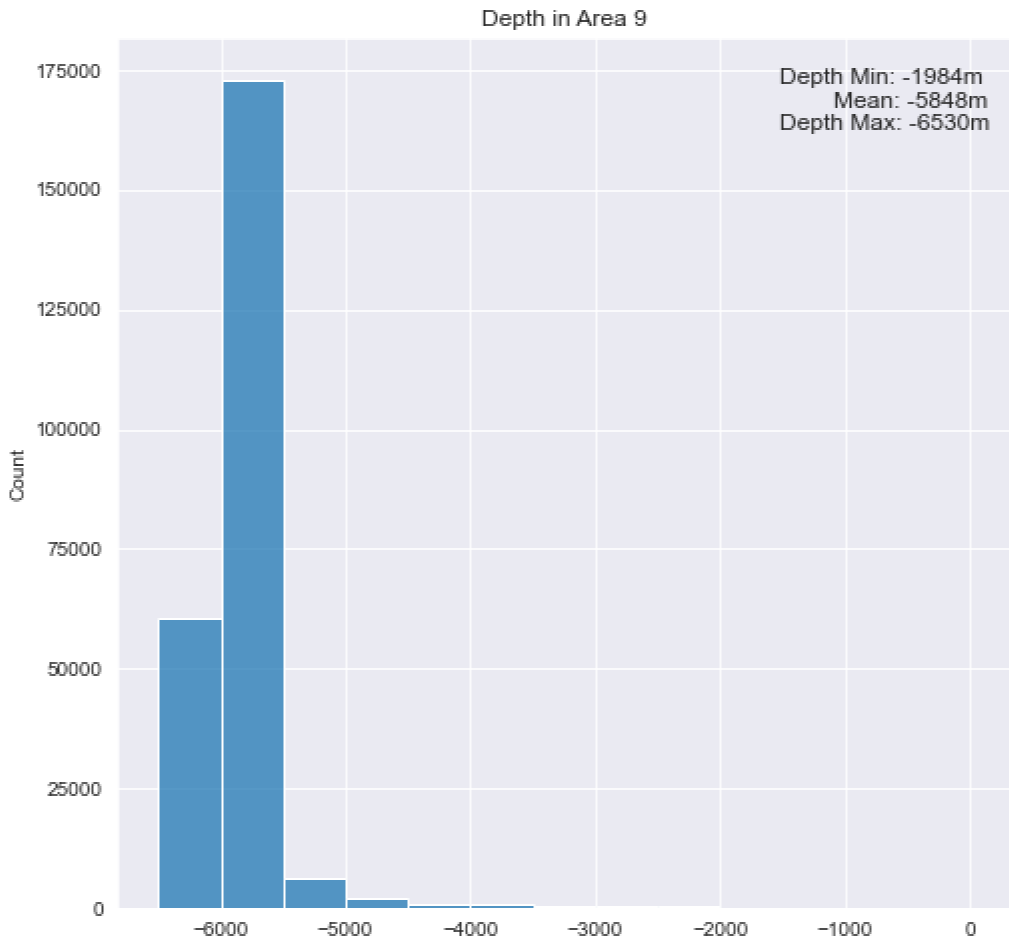


Figure 20. Depth profile in potential AINP 9.

Table 9. Large benthic features in potential AINP 9

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
14648	88	-4568	-5277	-4952
14683	630	-2118	-5370	-4299
13422	119	-4339	-5398	-4871
14008	113	-4777	-5400	-5165
13927	502	-1984	-5413	-4119
13642	60	-4753	-5478	-5066

1. **Introduction**
This site includes seamount complex and intra-seamount basin, as well as abyssal plain areas. It represents the one of the four potential AINPs to cover biophysical gradients that run from north to south across the area. Scientific information is scarce in the area but available data on POC flux suggest a weak gradient with increase towards the north. It was suggested that four potential AINPs could be appropriate. Over the long distance from north to the south, there could be faunal changes and connectivity issues that are not currently apparent due to lack of scientific information. AINP 9 lies in the deep basin East Mariana Basin, east of the Mariana Trench providing potentially important connectivity links.

The size of these proposed abyssal plain AINP is 200x200 km in line with those established in the CCZ. As in the CCZ macrofaunal and meiofaunal invertebrates are likely to constitute the vast majority of biodiversity and almost certainly include species with the most limited dispersal capabilities and biogeographic ranges. Arguments for this size were given in Wedding et al., (2013) and could apply equally to this region of abyssal plain. This size should enable maintenance of sustainable, intact and healthy marine populations, maintain minimum viable population sizes for species potentially restricted to a subregion and protect a full range of habitat types found within each subregion.

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 9.

This proposed area is in the southwest corner of the Area under consideration where it abuts the EEZs of the USA and Micronesia. The seafloor is mostly deep abyssal plain at 6,000 to 6,500m depth with a few seamounts projecting many thousands of metres above the base. The location is notable for its proximity to the Mariana Trench. The area lies about 250km from the Nero Deep and northeast of the Sirena and Challenger Deeps - three of the deepest places of the Earth's ocean (Fryer et al, 2003).

One of the seamounts within this potential APIN was surveyed during COMRA cruises (see description of RD seamount in Appendix 2). A mound (300 m across) of sponge and coral fields was discovered. Crinoids are dominant benthos taxon which always live on sponge (mostly dead) along this area. Sponges and corals such as Primnoidae, Chrysogorgiidae are also dominant, which are often tall and have good variety. Ophiuroids living on big Primnoidae coral are also found.

3. **Description of the potential AINP against relevant scientific criteria**

This potential AINP was identified taking into consideration the criteria relating to scientific and to cultural significance, and its lose proximity to the deepest place on Earth. Culturally, the concept of the Deep is a globally recognized phenomenon that holds particular interest in the human psyche - as evidenced by creative works of many types featuring the Challenger Deep. Recognition of its unique nature is entrenched in the designation bestowed as a National Marine Monument by the USA (https://www.fisheries.noaa.gov/pacific-islands/habitat-conservation/marianas-trench-marine-national-monument). The science rationale is to ensure that no plumes from exploitation drift westward to the Trench. Trenches are known to be 'collectors' of sediment and debris (Danovaro et a. 2003), but the extreme pressures mean only a few organism types can live as scavengers at these depths (Gallo et al., 2015). Dilution by excess sediment of the small fraction of organic material that arrives at these extreme depths would likely have notable consequences for the unique fauna.

Representativity: The abyssal plain represents a large proportion of the management area. Contract areas and reserved areas cover about 148,000 km^2 of the abyssal plain. To maintain representativity and connectivity for abyssal plain faunas across the management area 4 potential AINPs have been chosen including this one.

There are little to no biological information available for this area, with the exception of the information provided by COMRA on RD seamount. The criteria used for inclusion was its connectivity among a collection of seamounts and its replication of the types of seafloor bathymetric characteristics that were found within the contract areas. This area included important inter-seamount valleys, hills and slopes that potentially provide connectivity among seamounts potentially preserving both connectivity and whole ecosystems. It’s nearness to the Challenger Deep and its position as upstream (for the dominant surface current) to the Challenger Deep were also strong arguments for its inclusion, as the Challenger Deep is a significant and important area as the deepest known point on Earth.

4. Reference

1. COMRA Cruise Report (2019).

2. Sherwood O A, Edinger E N. Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences, 2009, 66(1):142-152.

3. Roark E B , Guilderson T P , Dunbar R B , et al. Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. Marine Ecology Progress Series, 2006, 327(Dec):1-14.

4. Fryer, P., Becker, N., Appelgate, B., Martinez, F., Edwards, M. and Fryer, G., 2003. Why is the Challenger Deep so deep?. Earth and Planetary Science Letters, 211(3-4), pp.259-269.

5. Danovaro, R., Della Croce, N., Dell’Anno, A. and Pusceddu, A., 2003. A depocenter of organic matter at 7800 m depth in the SE Pacific Ocean. Deep Sea Research Part I: Oceanographic Research Papers, 50(12), pp.1411-1420.

6. Gallo, N.D., Cameron, J., Hardy, K., Fryer, P., Bartlett, D.H. and Levin, L.A., 2015. Submersible- and lander-observed community patterns in the Mariana and New Britain trenches: influence of productivity and depth on epibenthic and scavenging communities. Deep Sea Research Part I: Oceanographic Research Papers, 99, pp.119-133.

Potential AINP No.10 (Seamount complex & intra-seamount basin)

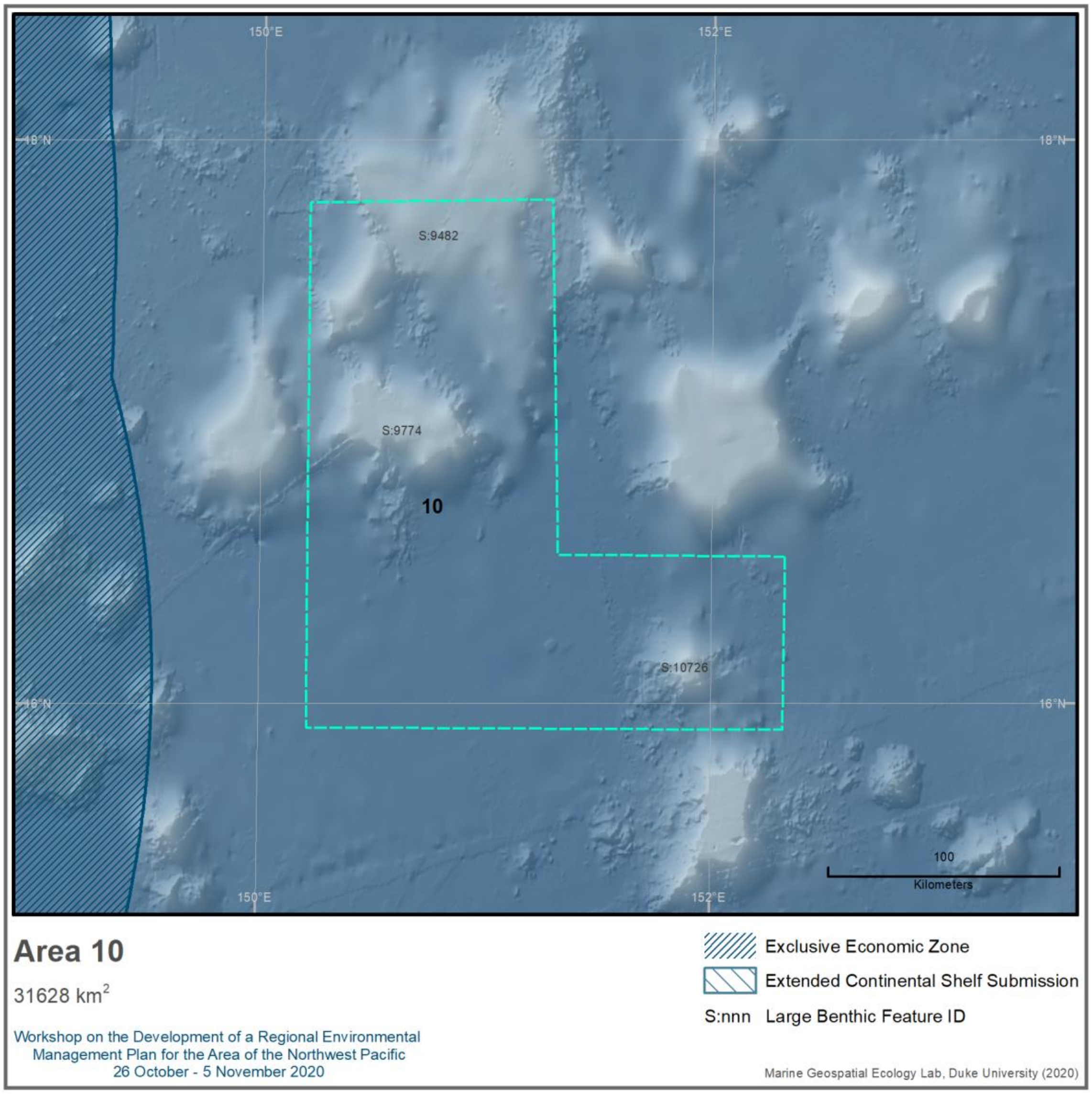


Figure 22. Map of potential AINP 10.

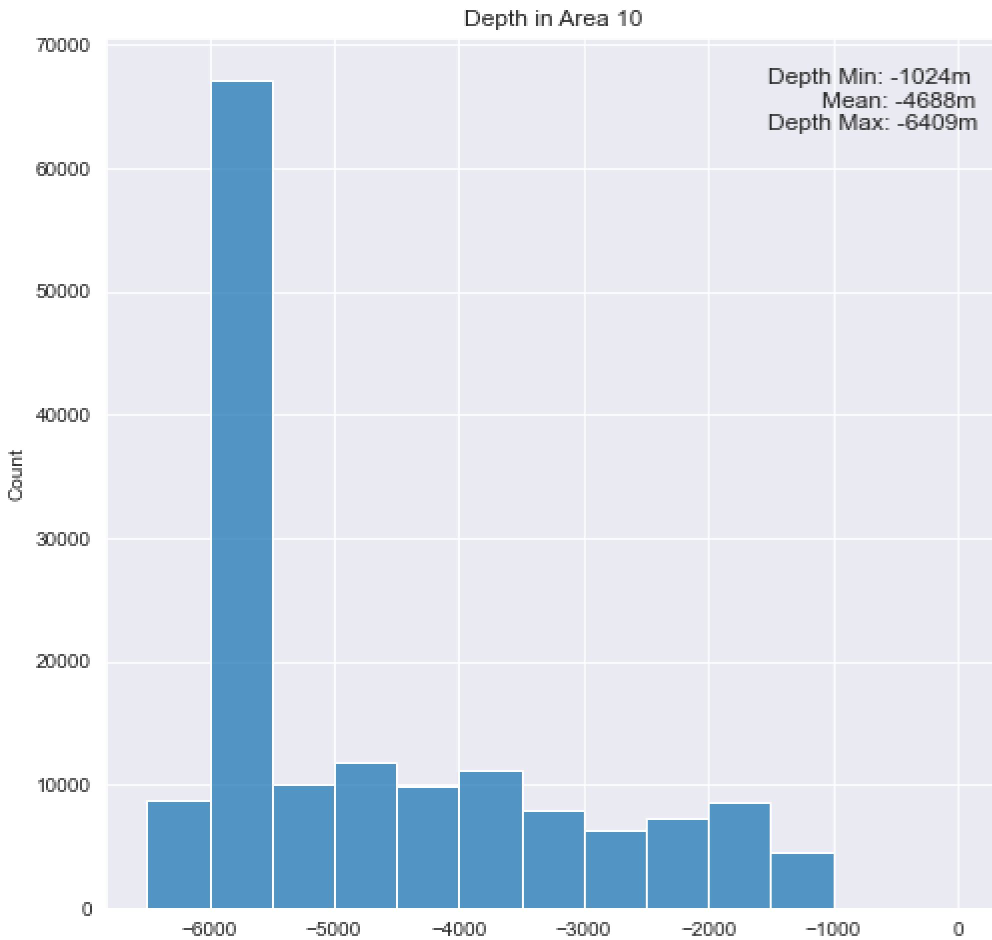


Figure 23. Depth profile in potential AINP 10.

Table 10. Large benthic features in potential AINP 10

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
9774	2165	-1024	-4197	-2090
9482	3459	-1042	-4271	-2296
10726	921	-1170	-4938	-3415

1. Introduction

This relatively small area of 31,628 km^2 contains three close-proximity Magellan seamounts. In the southeast corner of the area, the seafloor rises dramatically from approximately 6,500 m to below 500 m depth at the summit of a narrow conical seamount. The majority of the area covers the southern portion of a large guyot. The feature is over 250 km long and has existing CFC contract areas on its western and northern sides. As would be expected, the area captures a lot of habitat similar to the habitat within CFC blocks. While the area is in relatively close proximity to potential exploitation sites, the large guyot contributes a significant proportion of rare depth-defined seamount habitats to the potential AINP portfolio (e.g., approximately 15 to 18% of the habitat between 1,000-1,500 and 1,500-2,000 m depth, respectively).

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 10

Located on the central-east side of the Area, the area has an average concentration of surface chlorophyll and modelled POC export in comparison to the other southern regions—owing to the latitudinal-gradient.

The area is located directly east of the U.S.A. EEZ around the Northern Marina Islands.

There is evidence that the pelagic and benthic communities associated with these seamounts include ecologically, commercially, and culturally important species, as well as species of conservation concern (see table 1).

3. Description of the potential AINP against relevant scientific criteria

For details on how seamounts in general meet the criteria, please refer to Table 1.

4. Reference (if any)

Potential AINP No.11 (abyssal plain environment)

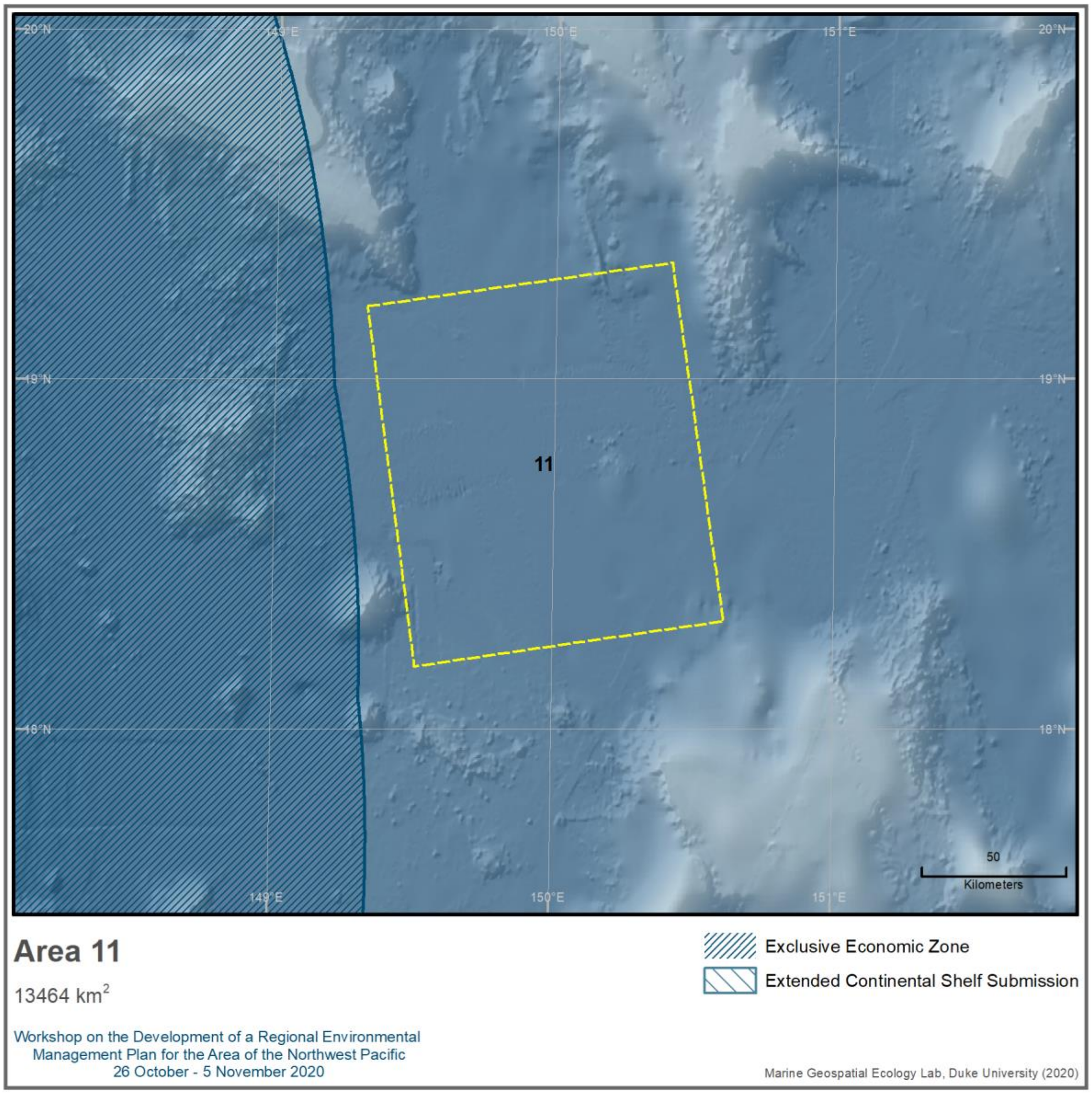


Figure 24. Map of potential AINP 11.

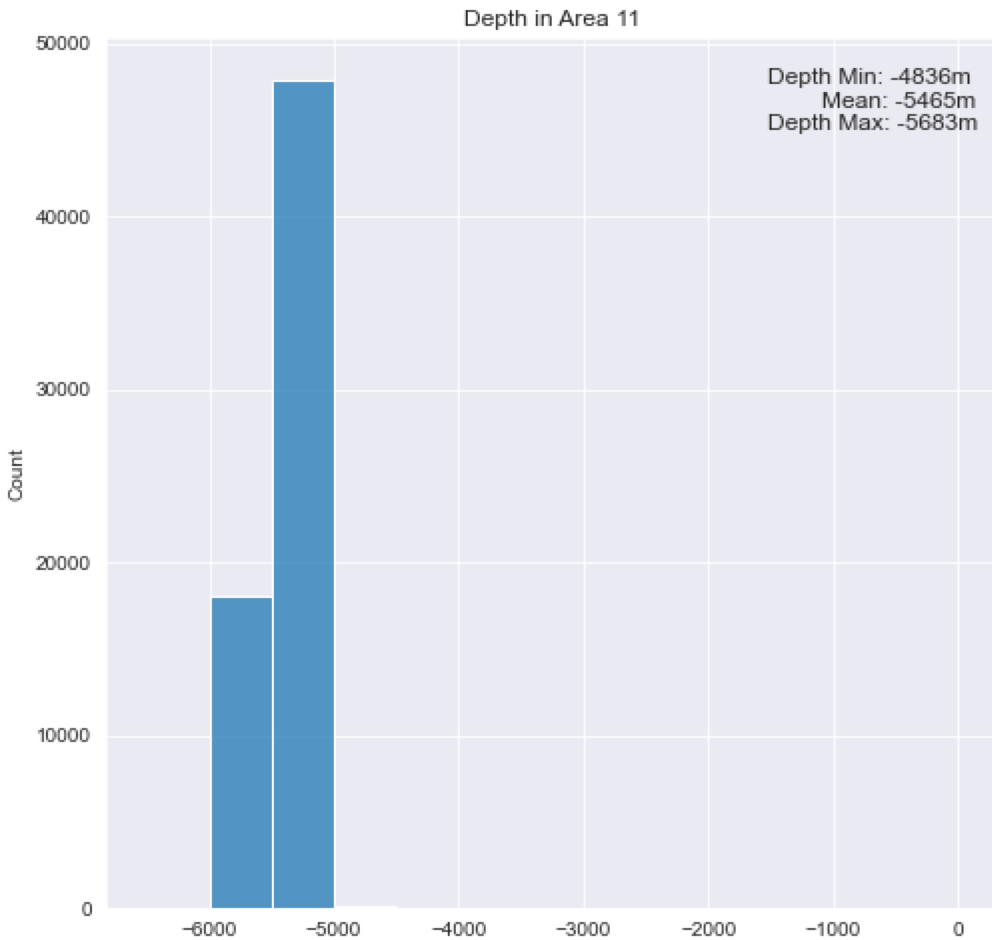


Figure 25. Depth profile in potential AINP 11.

1. Introduction

The area of abyssal plain is located between the 5000m and 5500m contours within the overall management area. to maintain representativity for animals living within this depth range two areas were identified as potential AINPs (AINPs 11 and 13).

AINP 11 lies between the northern end of the Magellan Seamounts and the Mariana Trench.

2. Description of features and habitat type(s), including depth range and terrain classes

No large benthic features present in this AINP, based on workshop analysis.

3. Description of the potential AINP against relevant scientific criteria

Representativity: The depth interval from 5000 to 5500 m is not well represented in other potential AINPs, but it is an interval that contains a number of contract areas for manganese nodules. To maintain representativity of organisms in this depth interval additional areas need to be located. Area 11 is one of the largest available areas within the overall management area.

There was little to no biological information available for this area. The criteria used for inclusion as an AINP was its bathymetric characteristics indicating that it was part of an under-represented depth range when compared to the depth ranges for the overall region. This site was also included to provide replication of the types of seafloor bathymetric characteristics that were found within the contract areas. In addition, this area combined with potential AINP 13 provided some additional east to west balance in the AINP for the abyssal plain.

4. Reference

Potential Area No.12 (Seamount complex & intra-seamount basin)

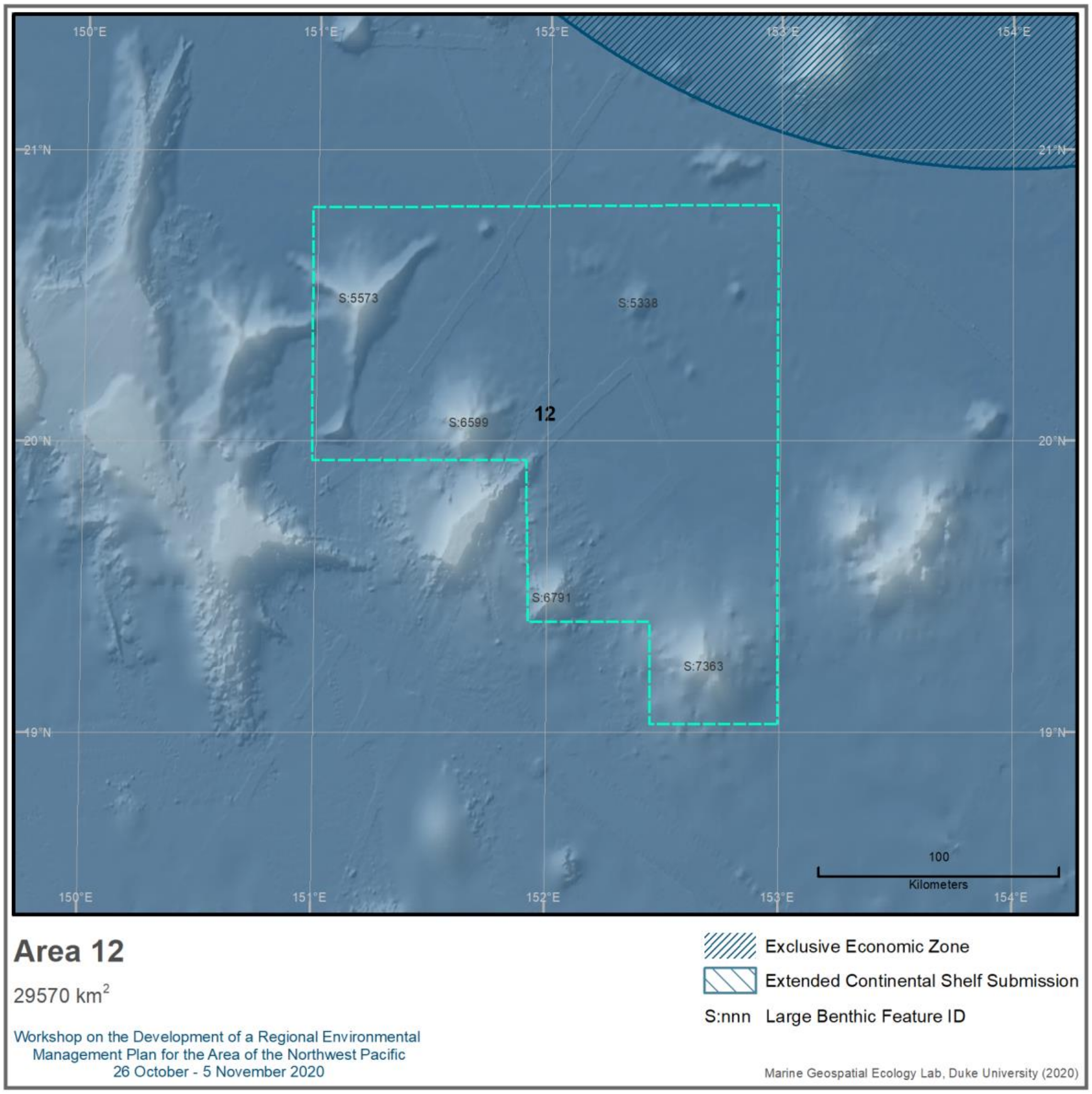


Figure 26. Map of potential AINP 12.

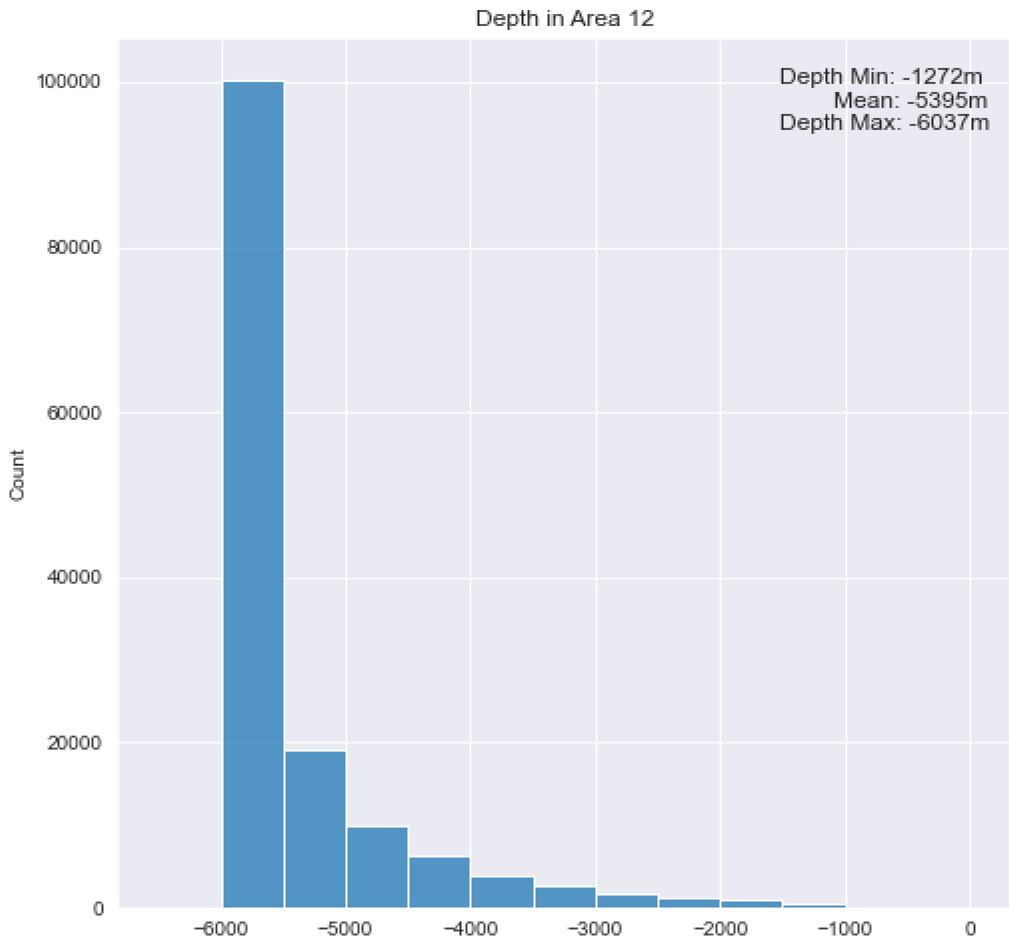


Figure 27. Depth profile in potential AINP 12.

Table 11. Large benthic features in potential AINP 12

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
7363	1564	-1304	-4496	-3528
6791	349	-1624	-4562	-3482
6599	644	-1272	-4688	-3176
5573	856	-1291	-5105	-3768
5338	67	-4769	-5409	-5166

1. **Introduction**

This relatively small area of 29,570 km^2 contains four close-proximity Magellan seamounts. The seamounts rise from approximately 6,000 m to below 1000 m depth. Although the seamounts are much narrower than those with exploration and reserved areas on them, the area contains habitat similar to the habitat within CFC and PNM blocks (although there is no data currently available to confirm the presence of nodules).

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 11.

Located in the northwest corner of the Area, the area has a higher concentration of surface chlorophyll and modelled POC export than the southern region—owing to the latitudinal-gradient.

The area is located between the Japanese EEZ and the U.S.A. EEZ around the Northern Marina Islands.

There is evidence that the pelagic and benthic communities associated with these seamounts include ecologically, commercially, and culturally important species, as well as species of conservation concern (see table1).

3. **Description of the potential AINP against relevant scientific criteria**

For details on how seamounts in general meet the criteria, please refer to Table 1.

4. **Reference**

Potential AINP No.13 (abyssal plain environment)

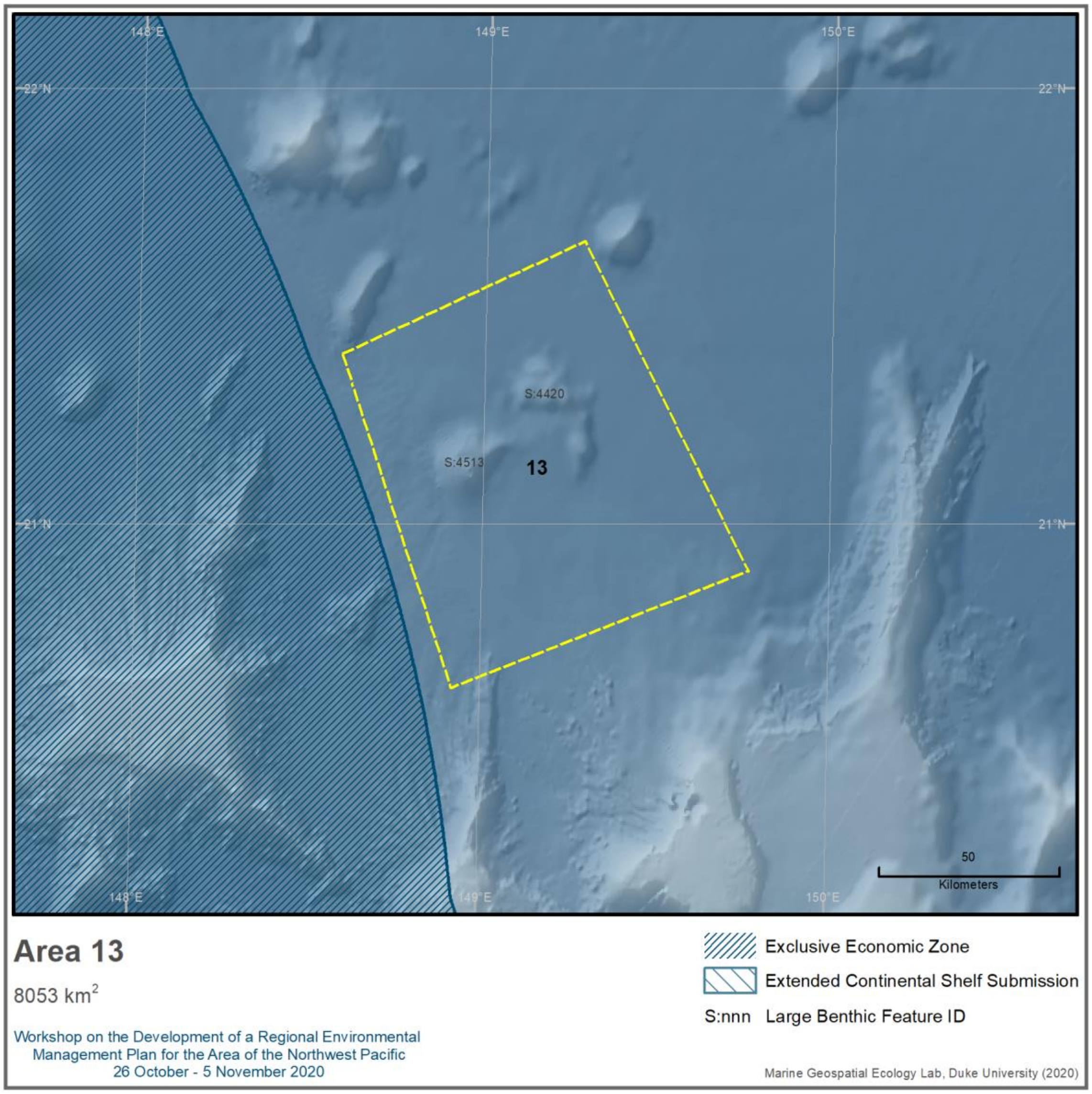


Figure 28. Map of potential AINP 13.

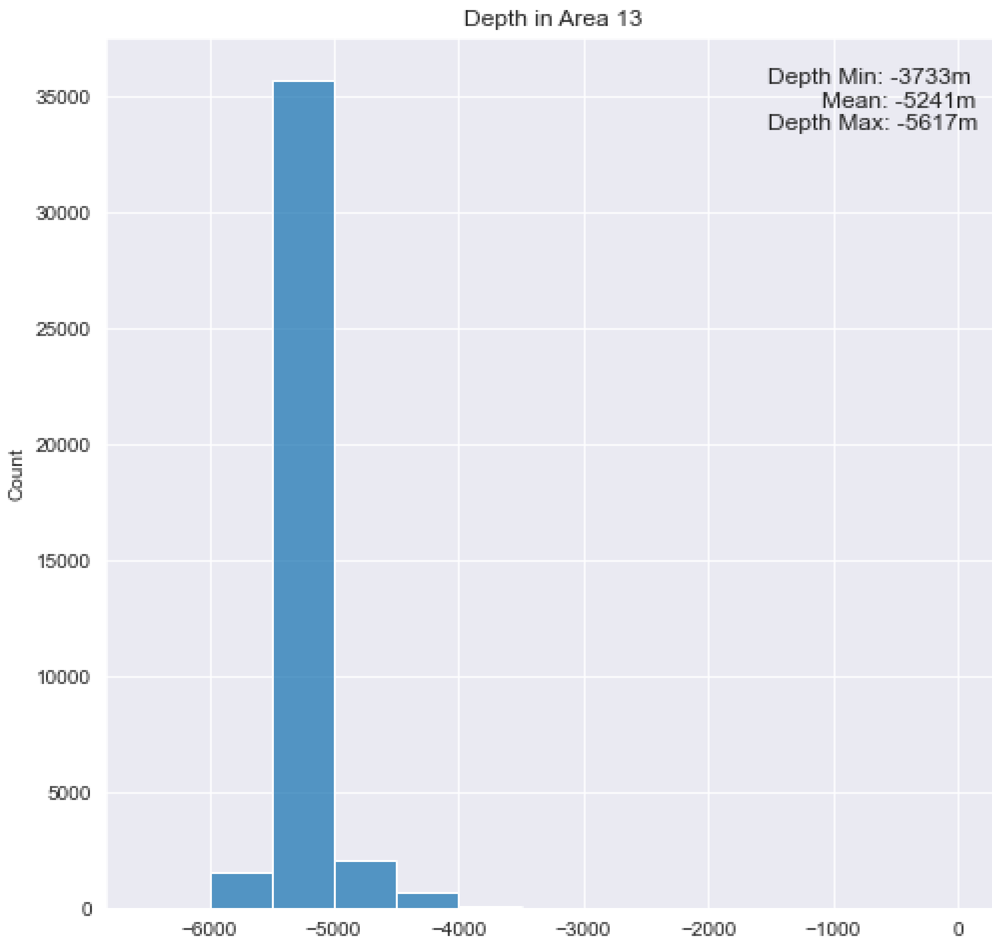


Figure 29. Depth profile of potential AINP 13.

Table 12. Large Benthic Features in potential AINP 13

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
4513	198	-3733	-4799	-4346
4420	186	-4302	-4903	-4672

1. Introduction

The area of abyssal plain seafloor located between the 5000m and 5500m contours within the overall management area. To maintain representativity for animals living within this depth range two areas were identified as potential management units (potential AINP11 and 13).

Area 13 lies just north the north-west end of the Magellan Seamounts and close to the Mariana Trench.

2. Description of features and habitat type(s), including depth range and terrain classes:
see Table 12.

3. Assessment of the AINP against relevant scientific criteria

Representativity; The depth interval from 5000 to 5500 m is not well represented in other proposed management areas, but it is an interval that contains a number of contract areas for manganese nodules. To maintain representativity of organisms in this depth interval additional areas need to be located. After AINP 11, AINP 13 is one of the largest available areas within the overall management area.

There was little to no biological information available for this area. The criteria used for inclusion as an AINP was its bathymetric characteristics indicating that it was part of an under-represented depth range when compared to the depth ranges for the overall region. This site was also included to provide replication of the types of seafloor bathymetric characteristics that were found within the contract areas. In addition, this area combined with AINP 11 provided some additional east to west balance in the potential AINPs for the abyssal plain. This site was also included to provide replication of the types of seafloor bathymetric conditions that were found within the contract areas.

4. Reference

Potential AINP No.14 (Seamount complex & intra-seamount basin)

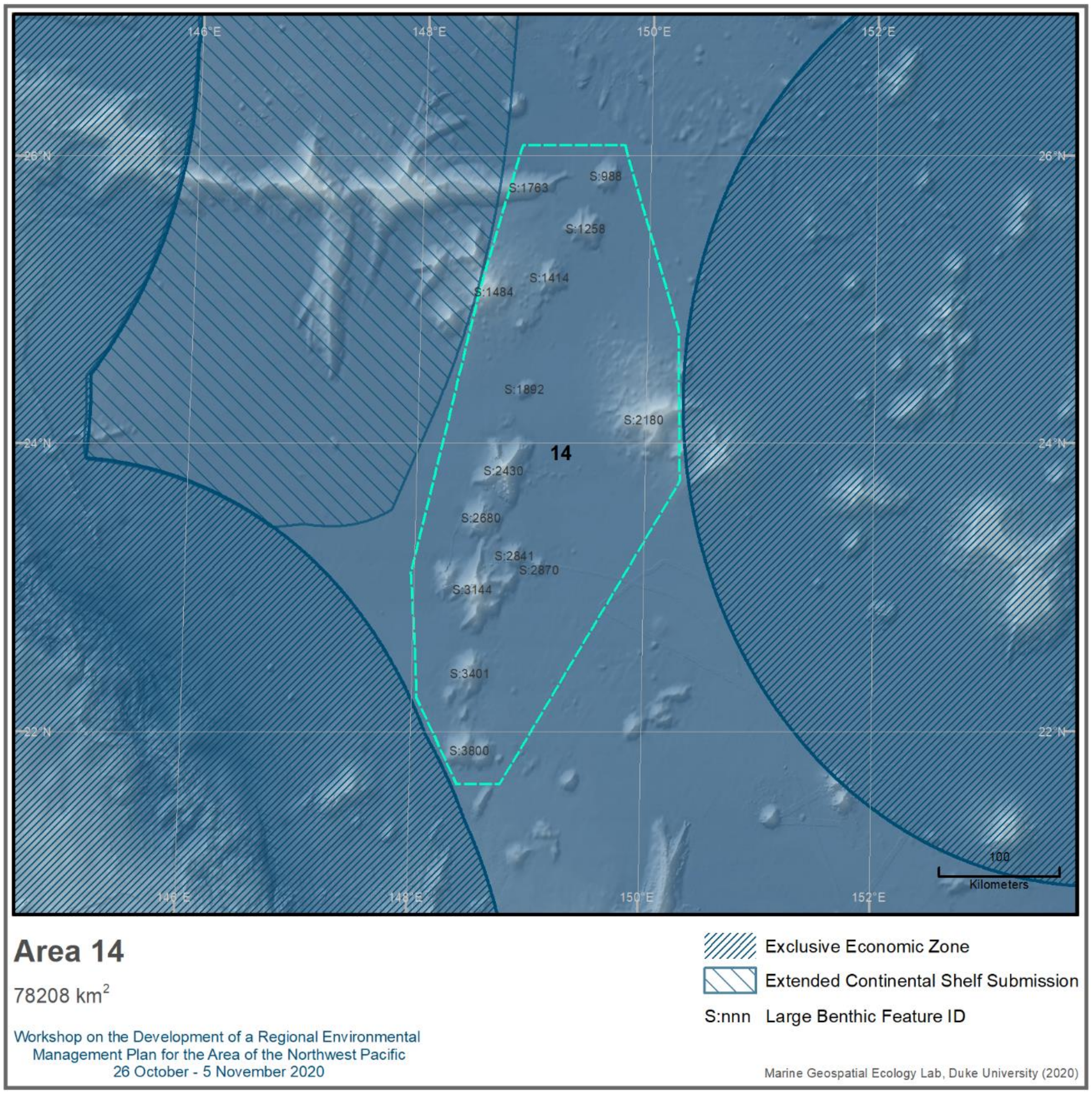


Figure 30. Map of potential AINP 14.

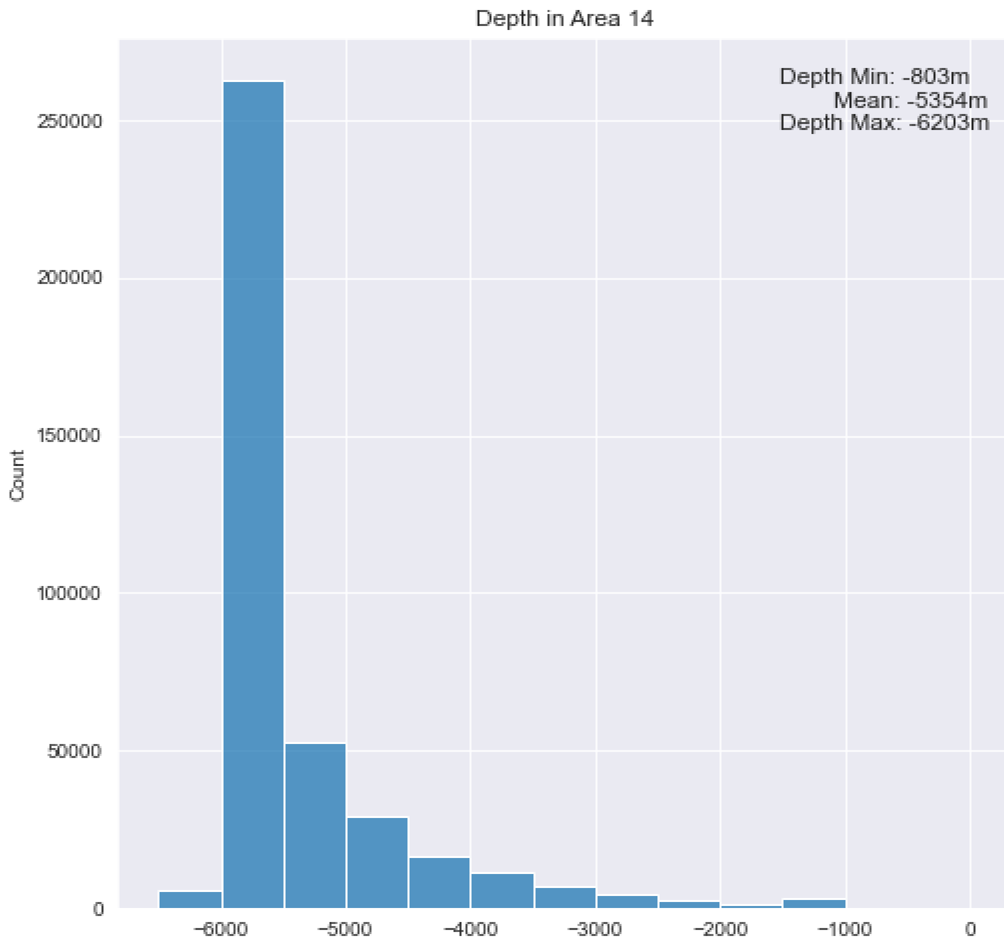


Figure 31. Depth profile in potential AINP 14.

Table 13. Large benthic features in potential AINP14

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
1484	751	-1077	-4155	-2796
2180	1559	-803	-4268	-2463
3800	756	-2041	-4838	-3843
2680	424	-2176	-4846	-3801
3144	1475	-994	-4924	-3472
2430	1102	-963	-4935	-3604
2841	136	-2691	-4986	-4102
3401	548	-2151	-5004	-3921
1414	329	-2009	-5023	-3999

1258	499	-2404	-5213	-4086
1763	497	-2854	-5217	-3977
2870	52	-4071	-5235	-4854
1892	86	-4393	-5298	-4953
988	314	-2658	-5404	-4405

1. Introduction

The area covers 78,207 km^2 and contains a mix of several large, flat-topped guyots and small conical seamounts, as well as their broad inter-mountain basins (outside of the three seamount chains). The area is north of any exploration and reserved areas on them but it may still contain habitat with similar characteristics to the habitat within CFC and PNM blocks.

There was little biological information available for this area with the exception of the information provided by COMRA on the RB seamount. The criteria used for inclusion as an AINP was its connectivity with a potential AINP covering a collection of seamounts and its replication of the types of seafloor bathymetric characteristics that were found within the contract areas. This area included important inter-seamount valleys, hills and slopes that potentially provide connectivity among seamounts potentially preserving both connectivity and whole ecosystems. This potential AINP included an intact range of seamounts stretching from South to North along a latitudinal gradient.

2. **Description of features and habitat type(s), including depth range and terrain classes:** see Table 13.

Located in the northwest corner of the Area, the area has a higher concentration of surface chlorophyll and modelled POC export than the southern region—owing to the latitudinal-gradient.

The area overlaps with a region recently identified as a ABNJ priority area for protection, based on a new data-driven approach (included species-specific data, bathymetry data, biodiversity data, etc.) (Visalli et al., 2020). This area overlaps with a COMRA surveyed seamount and borders the northeast side of the U.S.A. EEZ around the around the Northern Marina Islands and southwest side of the Japanese EEZ.

RB seamount lies at the middle of a short seamount chain between the two large seamount chains, the Magellan Seamount Chain and the Marcus-wake Seamount Chain, at the northwest part of the cobalt-rich seamounts area. The depth range of RB seamount is between 2183 m - 5805 m. For detailed information on the RB seamount please refer to Appendix 2.

3. Assessment of the AINP against relevant scientific criteria

Details can be found in Appendix 2.

4. Reference

1. COMRA Cruise Report (2020).

2. Lutz M J, Caldeira K, Dunbar R B, et al. Seasonal rhythms of net primary production and particulate organic carbon flux to depth describe the efficiency of biological pump in the global ocean. JGR Oceans, 2007, 112, dor.org/10.1029/2006JC003706

3. Roark E B , Guilderson T P , Dunbar R B , et al. Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. Marine Ecology Progress Series, 2006, 327(Dec):1-14.

4. Sherwood O A , Edinger E N . Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences, 2009, 66(1):142-152.

5. Woolley S N C, Tittensor D P, Dunstan P K, et al. Deep-Sea diversity patterns are shaped by energy availability. Nature, 2016, 533, 393-396.

Table 14: Large benthic features in the potential AINPs

This table contains summary statistics for the 103 large benthic features from the BTM analysis that were found within the 14 potential AINPs. These statistics are for the portions of these features falling within the 14 potential AINPs. These features cover 88351 km^2 and depth ranges from 800m – 5500m.

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
4650	1491	-1253	-3791	-2365
12740	2213	-994	-3825	-2024
5886	952	Out of Range	-3887	-1984
5014	74	-3036	-3889	-3546
7365	3319	-1083	-3914	-2403
6243	470	-1993	-3946	-2990
4962	439	-2932	-3971	-3446
4064	1213	-885	-4030	-2625
9722	1607	Out of Range	-4061	-2300
4135	1222	-1181	-4081	-2988
5192	1477	-1909	-4084	-2795
12289	4759	-1051	-4085	-2282
6292	2299	-1566	-4124	-2311
4532	1484	-1842	-4138	-2951
3669	1390	-1268	-4140	-2770
3565	1453	Out of Range	-4143	-2515
4689	606	-1747	-4143	-2993
1484	751	-1077	-4155	-2796
9774	2165	-1024	-4197	-2090
2965	1388	-1316	-4204	-2974
5230	68	-3000	-4228	-3645
11625	606	-1259	-4229	-2914
4093	1290	-1701	-4239	-3214
4919	1007	-1512	-4247	-2831
5819	2999	-1197	-4263	-2574
9329	182	-2513	-4263	-3606
2180	1559	-803	-4268	-2463
9482	3459	-1042	-4271	-2296
4500	827	-1435	-4283	-3190

5173	304	-2758	-4308	-3678
4391	271	-2061	-4345	-3450
6054	230	-1457	-4376	-3255
3833	899	-2814	-4396	-3929
3893	379	-2027	-4423	-3406
3468	573	-1085	-4444	-3286
3151	726	-2057	-4456	-3417
10184	366	-1571	-4484	-3223
3951	596	-2404	-4492	-3572
7363	1564	-1304	-4496	-3528
3284	931	Out of Range	-4508	-2691
2016	1197	-2464	-4548	-3567
5613	814	-1590	-4549	-2904
6791	349	-1624	-4562	-3482
3674	394	-3661	-4569	-4021
6500	531	-1591	-4576	-3522
9148	201	-3094	-4580	-3864
2546	651	-1509	-4595	-3471
4683	221	-3663	-4614	-4145
11929	415	-3721	-4627	-4238
11118	659	-1804	-4644	-3441
11702	577	Out of Range	-4681	-2512
2192	202	-3600	-4687	-4136
6599	644	-1272	-4688	-3176
12417	1058	-1108	-4690	-3231
3051	351	-2915	-4694	-3984
10757	427	-2070	-4696	-3629
6353	1347	-1570	-4733	-3303
2526	1549	-859	-4740	-3359
2980	3093	-1103	-4754	-3072
15793	5022	-1391	-4760	-2655
11854	652	-2038	-4763	-3891
12304	174	-3789	-4792	-4256
4513	198	-3733	-4799	-4346
12049	596	-1301	-4801	-3588
2460	1270	-1337	-4816	-3593
6684	136	-3641	-4822	-4393
3574	277	-2939	-4834	-4045
3800	756	-2041	-4838	-3843
2680	424	-2176	-4846	-3801
2272	257	-3600	-4866	-4223
4420	186	-4302	-4903	-4672
1831	85	-4278	-4921	-4622
1633	1754	-2373	-4922	-3924
3144	1475	-994	-4924	-3472
2430	1102	-963	-4935	-3604
10726	921	-1170	-4938	-3415

12520	107	-3702	-4965	-4523
3280	58	-4731	-4968	-4857
2809	127	-4608	-4974	-4795
11927	145	-4068	-4984	-4552
2841	136	-2691	-4986	-4102
3401	548	-2151	-5004	-3921
13129	305	-2954	-5004	-4174
1414	329	-2009	-5023	-3999
11623	543	-1997	-5091	-3988
5573	856	-1291	-5105	-3768
15318	90	-4349	-5173	-4735
1258	499	-2404	-5213	-4086
1763	497	-2854	-5217	-3977
15171	666	-1336	-5231	-3737
2870	52	-4071	-5235	-4854
10183	522	-2660	-5263	-4274
14648	88	-4568	-5277	-4952
1892	86	-4393	-5298	-4953
10597	651	-3460	-5314	-4469
14683	630	-2118	-5370	-4299
745	668	-3135	-5391	-4643
13422	119	-4339	-5398	-4871
14008	113	-4777	-5400	-5165
988	314	-2658	-5404	-4405
5338	67	-4769	-5409	-5166
13927	502	-1984	-5413	-4119
13642	60	-4753	-5478	-5066

Table 15: Large benthic features in CFC Exploration and Reserved Areas

This table contains summary statistics for the 27 large benthic features from the BTM analysis that were found within the existing CFC Exploration and Reserved areas. These statistics are for complete features with spatial overlap with CFC exploration and reserved areas. These features cover 70757 km^2 and depth ranges from 70m – 5300m.

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
5933	1768	-1441	-3620	-2187
9350	1320	-207	-3920	-2228
6745	1715	-1217	-4014	-2717
4458	3332	-1215	-4032	-2186
9110	817	-796	-4083	-2666
9948	2173	-1118	-4109	-2201
4689	2876	-1358	-4143	-2759
11625	1982	-876	-4295	-2949
6692	2055	-952	-4363	-2797
12099	4310	-1234	-4407	-2103

9482	6827	-1042	-4490	-2314
4962	2655	-1747	-4496	-2980
8672	1146	-1086	-4529	-3151
14598	3147	-1191	-4563	-2486
9351	1541	-403	-4577	-3000
2546	2924	-1177	-4595	-2598
5680	749	-1681	-4638	-3274
13639	1792	-73	-4646	-2541
11896	2192	-1256	-4668	-2487
10009	3721	-1090	-4683	-1977
6599	2110	-1257	-4688	-2860
7272	4433	-1452	-4759	-2574
14922	1109	-1299	-4775	-3202
10276	4661	-827	-4867	-2635
6712	3111	-1148	-5013	-2730
14427	977	Out of Range	-5053	-2942
13496	5314	-477	-5271	-2412

Table 16: Large benthic features not in CFC Exploration and Reserved Areas or potential AINPs.

This table contains summary statistics on the 81 large benthic features from the BTM analysis that were not in either CFC Exploration and Reserved Areas or potential AINPs. These features cover 30877 km^2 and depth ranges from 1200m – 5700m.

Id	Area (km^2)	Depth Min (m)	Depth Max (m)	Depth Mean (m)
6379	79	-3057	-3712	-3369
6440	76	-3712	-4022	-3830
9090	125	-3278	-4152	-3736
7474	57	-4288	-4435	-4348
8698	86	-3105	-4436	-3840
1942	57	-3039	-4519	-3959
12484	296	-3220	-4592	-4066
8083	2202	-2006	-4625	-3411
6416	191	-4010	-4630	-4320
11943	166	-3250	-4669	-4106
7854	449	-2299	-4696	-3739
9610	71	-3227	-4715	-4102
7904	278	-2834	-4718	-4025
3180	351	-2142	-4739	-3824
7300	824	-1179	-4742	-3395
11964	427	-3432	-4748	-4345
8241	517	-1619	-4755	-3542
11855	52	-4715	-4773	-4743
3898	810	-3063	-4775	-4106
8661	220	-4069	-4783	-4557
4112	98	-3962	-4825	-4453

11930	1131	-1723	-4835	-3821
3829	235	-3853	-4898	-4468
7056	661	-1231	-4915	-3759
7921	490	-3723	-4917	-4413
10889	353	-2630	-4919	-4170
8542	102	-3304	-4928	-4295
13611	170	-3312	-4979	-4198
12841	849	-2251	-4994	-4006
12013	823	-3949	-5006	-4573
8065	767	-1427	-5006	-3900
1848	740	-1964	-5021	-4133
7965	103	-4034	-5028	-4659
8191	378	-2089	-5051	-3940
13323	70	-4725	-5091	-4940
1762	188	-3879	-5098	-4670
6854	122	-3512	-5106	-4573
6046	193	-4047	-5118	-4696
11151	165	-3985	-5130	-4720
3968	129	-3368	-5141	-4484
5569	2253	-2375	-5147	-3440
4126	570	-2152	-5159	-4205
7483	307	-3808	-5163	-4670
9224	53	-4565	-5171	-4914
3616	215	-3253	-5172	-4409
3548	199	-3998	-5180	-4713
13208	118	-4888	-5182	-5077
1503	175	-4644	-5185	-5005
664	135	-4523	-5186	-4874
1735	589	-1303	-5186	-4064
1614	117	-4781	-5187	-4992
13354	74	-4689	-5188	-4954
874	506	-2981	-5190	-4370
14128	307	-4000	-5201	-4724
5918	104	-3912	-5202	-4635
11816	776	-2436	-5210	-4181
12112	126	-4396	-5211	-4883
11254	350	-3005	-5220	-4304
3431	154	-4123	-5221	-4806
12227	136	-4382	-5226	-4864
47	195	-2820	-5240	-4380
4706	129	-4356	-5258	-4863
12448	345	-2374	-5270	-4292
13192	605	-1912	-5278	-4046
1619	3018	-2902	-5289	-4552
9375	574	-3070	-5289	-4426
14214	153	-4732	-5318	-5056
10016	359	-4181	-5335	-4887

590	610	-4287	-5342	-4841
4221	185	-2827	-5375	-4397
14126	58	-5063	-5393	-5207
241	302	-4108	-5394	-4954
1203	132	-5042	-5412	-5235
221	646	-1539	-5420	-4173
13912	413	-2394	-5425	-4504
706	91	-5087	-5454	-5335
14603	75	-5151	-5461	-5313
15244	106	-5257	-5477	-5359
12745	209	-5135	-5568	-5406
13863	99	-5058	-5613	-5390
649	208	-2870	-5693	-4630

Appendix 2 to Annex V

Compilation of scientific information on several sites within the potential AINPs

Based on results from COMRA cruises

In 2019 and 2020, scientists onboard COMRA cruises investigated 6 seamounts, indicated as RA (2019), RB (2019 and 2020), RC (2019), RD (2019), BG (2019) and RE (2020) seamounts (Figure 1). The sampling methodology included:

- Obtain topography data by multibeam;
- Draw topographic map;
- Describe megafauna by Remotely Operated Vehicle (ROV);
- Collect seawater samples by CTD (not all stations) and analyze nutrients.

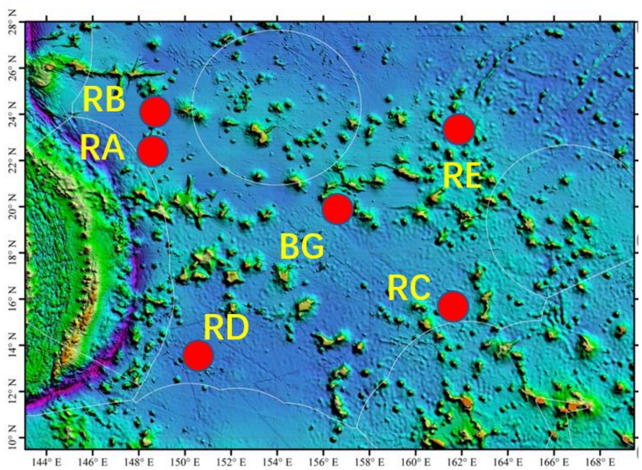


Figure 1 Map for survey stations

The processing of samples and analysis of data are still ongoing. Some preliminary results are described below. Based on these results, three sites meeting the criteria for Sites in need of Protection were identified. All sites are located within potential AINPs as described in Appendix 1. For RD seamount, high-abundance nodule areas were discovered near the base of the seamount, supporting a large potential AINP combining both seamount and abyssal plain habitats can be considered.

RE seamount (within potential AINP3)

Introduction

(To include: feature type(s) presented, geographic description, depth range, oceanography, general information data reported, availability of models)

Deposit type：Basalt and crust

Depth of summit: 1100 m

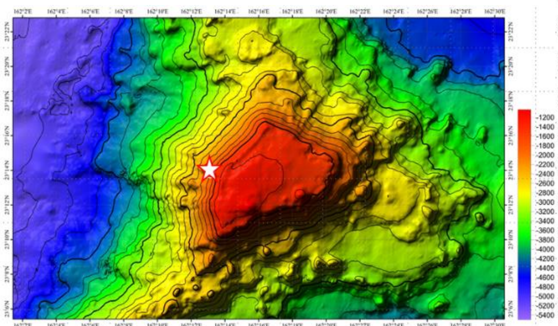
Depth range: 1100 – 1300 m

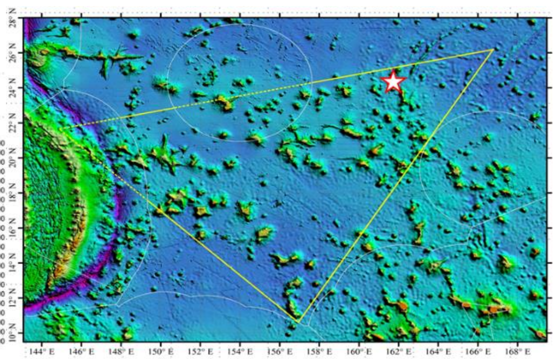
Area: 800 m long vertical transect

Location

Latitude: 23.221° N

Longitude: 162.220° E



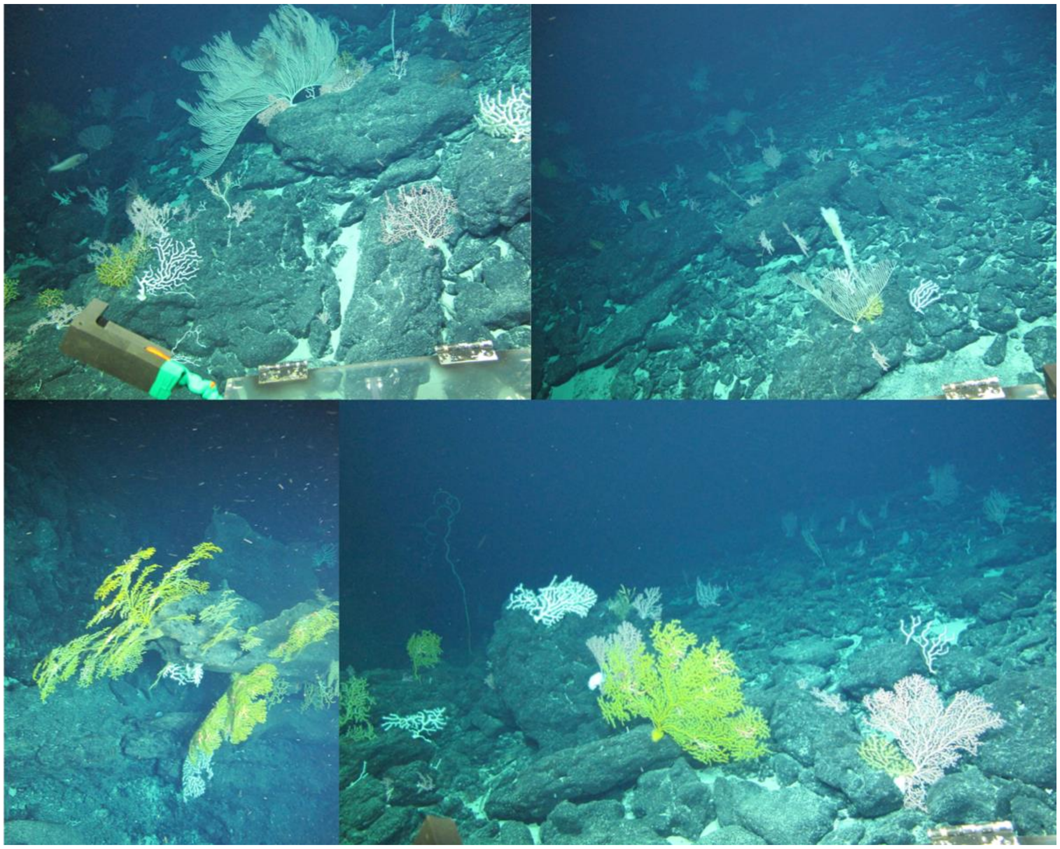


Feature description

(This should include information about the characteristics of the area/ecosystem features, e.g. in terms of physical description (water column feature, benthic feature, or both), biological communities, role in ecosystem function, including data/information sources.)

RE Seamount locates in the northeast part of the cobalt-rich seamounts area in the northwest Pacific Ocean. SINP-RE-01 was discovered by a ROV survey, lies on the west flank of the RE seamount, close to the summit, with water depth ranged from 1100 to 1300 m, with the distance of approx. 800 meters. The substrate is dominated by rock. Temperature and salinity showed a gradually change pattern, increase and decrease with water depth, respectively, along the ROV survey line. However, at the SINP, the temperature and salinity keep stable though water depth varied from 1300 m to 1100 m, suggesting a vertical mix of water mass here.

Extremely high abundance of deep-sea coral was observed here forming a ‘coral garden’. The coral fauna is dominated by gorgonians. The dominant species belongs to yellow green sea fan. Precious coral belonged to *Hemicorallium* genus is also commonly found. Besides, Primnoid, Isidid, Chrysogorgid and Victrogorgid were frequently distributed. Ophiuroids commensal with gorgonians are also found.



Assessment of the area against relevant scientific criteria

(Discuss the area in relation to each of the relevant scientific criteria and relate the best available science. The description of the area can be provided on the basis of one of more of the criteria, and the polygons of the area can be defined without exact precision. Information on modeling can also be used for the description of the area, including the presence of relevant ecological attributes. Please note where there are significant information gaps.)

The following ranking can be used for describing the relevance in terms of respective scientific criteria.

High: *Well documented evidence supporting criteria: multiple publications, including peer-reviewed articles, scientific papers, reports; expert knowledge based on direct observations and scientific rationale.*

Medium: *Less well documented evidence: few publications; expert knowledge based on models, indirect observations.*

Low: *Very limited evidence from publications or expert knowledge.*

No information: *No data/information is available.*

Relevant Criteria	**Description**	**Ranking of criterion relevance** (please mark one column with an X)

		No information	Low	Medium	High
Uniqueness or rarity	Area contains either (i) unique (“the only one of its kind”), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.				X

Explanation for ranking

A coral garden was discovered at the west flank of the RE Seamount, containing high abundance of cold-water corals, such as *Scleraxonia*, *Holaxonia* and *Calcaxonia* (COMRA Cruise Report). As far as we know, this kind of ‘coral garden’ has not been reported in the cobalt-rich seamount located in the northwest Pacific.

		No information	Low	Medium	High
Special importance for connectivity	Areas that are required for a population to survive and thrive.			X	
Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.			X	

Explanation for ranking

An 800 m-long coral assemblage was observed by ROV, a half of the line is covered by high population density (> 1.0 ind./m^2). Importantly, there are a lot of seamounts without contract around the RE Seamount. The coral garden discovered at the RE seamount may be considered as species pool of cold water corals, as well as other megafauna species inhabiting the coral garden. the site at the RE seamount may play important role for protecting megafauna, especially cold water corals for the cobalt-rich seamount area.

		No information	Low	Medium	High
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				X

<table>
<tr><td></td><td>degradation or depletion by human activity or by natural events) or with slow recovery.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">Explanation for ranking

RE has a large area of coral garden. High density of cold water corals is distributed. Cold water coral such as Primnoidae, Isididae, Coralliidae and Antipatharia were found. They could be considered as indicator species, due to slow growth rate and relatively high longevity (Sherwood et al., 2009; Roark et al., 2006). It is probably vulnerable to degradation or depletion and with slow recovery while damaged.</td></tr>
<tr><td>Biological productivity</td><td>Area containing species, populations or communities with comparatively higher natural biological productivity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Explanation for ranking

The particulate organic carbon flux showed a latitudinal pattern that stronger in higher latitudes in Pacific (Lutz et al., 2007), suggesting productivity in the north part of the Triangle Area may be higher than that in the south part.</td></tr>
<tr><td>Biological diversity</td><td>Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Explanation for ranking

A globally latitudinal pattern of species richness suggested that deep water diversity at high latitudes was higher than that at low latitude (Woolley et al., 2016). RE Seamount locates at the north boundary of the cobalt-rich seamounts area in the Northwest Pacific Ocean, with more than 90 morph-species identified from video data (data no show).</td></tr>
<tr><td>Naturalness</td><td>Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.</td><td></td><td></td><td></td><td>X</td></tr>
<tr><td colspan="6">Explanation for ranking

No traces of human activities have been found in this area, including exploration and exploitation, bottom trawl fishery or submarine cable during investigation.</td></tr>
</table>

References

1. COMRA Cruise Report (2020).
2. Lutz M J, Caldeira K, Dunbar R B, et al. Seasonal rhythms of net primary production and particulate organic carbon flux to depth describe the efficiency of biological pump in the global ocean. JGR Oceans, 2007, 112, dor.org/10.1029/2006JC003706
3. Roark E B, Guilderson T P, Dunbar R B , et al. Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. Marine Ecology Progress Series, 2006, 327(Dec):1-14.
4. Sherwood O A, Edinger E N. Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences, 2009, 66(1):142-152.
5. Woolley S N C, Tittensor D P, Dunstan P K, et al. Deep-Sea diversity patterns are shaped by energy availability. Nature, 2016, 533, 393-396.

RB seamount (with potential AINP 13)

Introduction

(To include: feature type(s) presented, geographic description, depth range, oceanography, general information data reported, availability of models)

Deposit type: Basalt and crust

Depth of summit: 2200 m

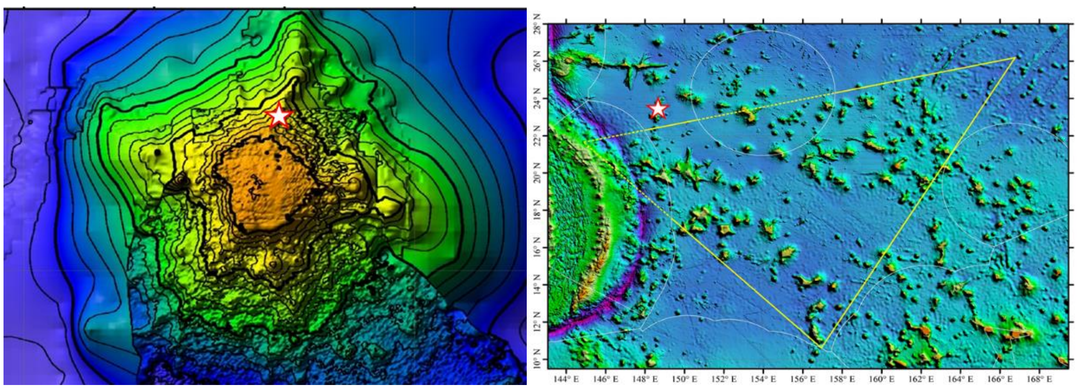
Depth range: 2700 m – 2800 m

Area: 300 m long vertical transect

Location

Latitude: 23.511 N

Longitude: 148.575 E

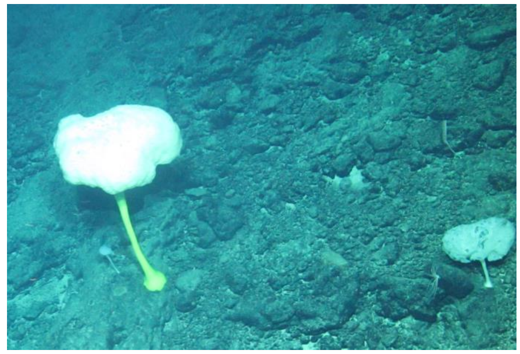
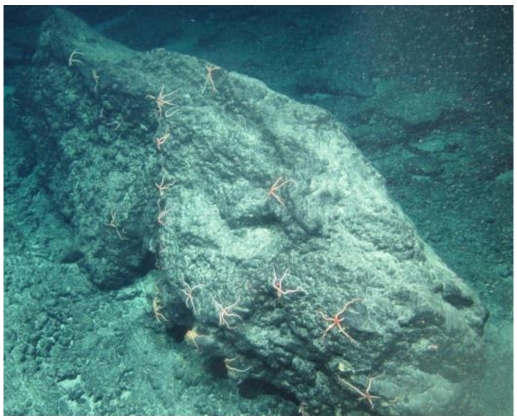


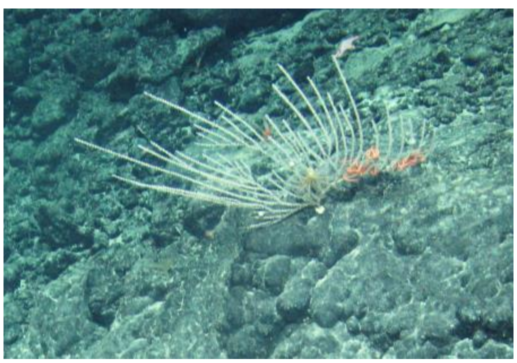
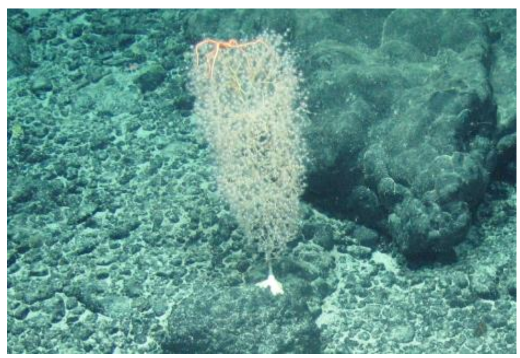
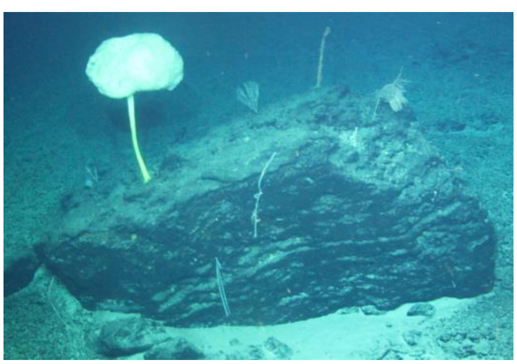
Feature description

(This should include information about the characteristics of the area/ecosystem features, e.g. in terms of physical description (water column feature, benthic feature, or both), biological communities, role in ecosystem function, including data/information sources.)

RB seamount lies at the middle of a short seamount chain between the two large seamount chains, the Magellan Seamount Chain and the Marcus-wake Seamount Chain, at the northwest part of the cobalt-rich seamounts area. The depth range of RB seamount is between 2183-5805m. SINP-RB-01 (transect line) lies on the north ridge of RB seamount at the depth of 2700-2800 m.

Totally, nine groups were observed, including Sponge, Coral, Sea anemone, Ophiuroidea, Asteroidean, Crinoidea, Holothuroidea, Crustacean and fish. The substrate is mainly composed of rock, which provides the substrate for benthic sessile organisms (sponge, coral, Crinoidea, etc). Sponge fauna is dominated by genus *Saccocalyx* and family Pheronematidae. Primnoidae is the dominant coral taxa. Another important group is Ophiuroidea, with high abundance observed frequently on large steep rock, contributing a high percentage of megafauna here.


Assessment of the area against relevant scientific criteria

(Discuss the area in relation to each of the relevant scientific criteria and relate the best available science. The description of the area can be provided on the basis of one of more of the criteria, and the polygons of the area can be defined without exact precision. Information on modeling can also be used for the description of the area, including the presence of relevant ecological attributes. Please note where there are significant information gaps.)

The following ranking can be used for describing the relevance in terms of respective scientific criteria.

High: *Well documented evidence supporting criteria: multiple publications, including peer-reviewed articles, scientific papers, reports; expert knowledge based on direct observations and scientific rationale.*

Medium: *Less well documented evidence: few publications; expert knowledge based on models, indirect observations.*

Low: *Very limited evidence from publications or expert knowledge.*

No information: *No data/information is available.*

Relevant Criteria	**Description**	**Ranking of criterion relevance** (please mark one column with an X)			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.			X	
Explanation for ranking High biodiversity and biomass were observed in the RB Seamount. Nine megafauna groups were found here, including sponge, coral, sea anemone, Ophiuroidea, Asteroidean, Crinoidea, Holothuroidea, Crustacean and fish. The seamount is dominated by hard substrate, which provides the habitat for sessiles, mainly constructed by sponge and coral. Another dominant taxon is ophiuroid with relative high abundance.					
Special importance for connectivity	Areas that are required for a population to survive and thrive.				X
Importance for threatened, endangered or	Area containing habitat for the survival and recovery of endangered, threatened, declining			X	

declining species and/or habitats	species or area with significant assemblages of such species.				
Explanation for ranking RB Seamount locates at the middle of a short latitudinal-ward seamount chain, which is situated between two large seamount chains, the Magellan Seamount Chain and the Marcus-wake Seamount Chain, possibly playing important role as stepping stones for benthic invertebrate dispersal between the two seamount chains. No molecular data of megafauna for connectivity is given at present.					
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.				X
Explanation for ranking The diversity and biomass of corals found in the RB seamount are relatively high. 7 species of coral were found, as well as several individuals that could not be identified. The dominant family is Primnoidae, which were often found on deep-sea rocks, usually small in size with high density. Besides, *Pleurocorallium*, *Hemicorallium,* and black corals were sometimes observed. RB seamount has a relatively abundant cold water corals such as Primnoidae, Isididae, with slow growth rate and relatively high longevity (Sherwood et al. 2009; Roark et al., 2006). They are probably vulnerable to degradation or depletion and with slow recovery while damaged.					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.				X
Explanation for ranking (must be accompanied by relevant sources of scientific articles, reports or documents) The particulate organic carbon flux showed a latitudinal pattern that stronger in higher latitudes in Pacific (Lutz et al., 2007), suggesting productivity in the north part of the cobalt-rich seamount area may be higher than that in the south part.					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.				X
Explanation for ranking Small scale of slope and ridge on summit of this seamount is very complex in topography, and is covered by coral and sponge assemblage. A globally latitudinal pattern of species richness was suggested that deep water biodiversity at high latitudes was higher than that at low latitude (Woolley et					

al., 2016). Compared with seamount in the south of the area, RB seamount has a relatively high 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.				X
Explanation for ranking No traces of human activities have been found in this area, including exploration and exploitation, bottom trawl fishery or submarine cable.					

References

1. COMRA Cruise Report (2020).
2. Lutz M J, Caldeira K, Dunbar R B, et al. Seasonal rhythms of net primary production and particulate organic carbon flux to depth describe the efficiency of biological pump in the global ocean. JGR Oceans, 2007, 112, dor.org/10.1029/2006JC003706
3. Roark E B , Guilderson T P , Dunbar R B , et al. Radiocarbon-based ages and growth rates of Hawaiian deep-sea corals. Marine Ecology Progress Series, 2006, 327(Dec):1-14.
4. Sherwood O A , Edinger E N . Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences, 2009, 66(1):142-152.
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RD seamount (within potential AINP9)

Introduction

(To include: feature type(s) presented, geographic description, depth range, oceanography, general information data reported, availability of models)

Bottom type: Basalt and crust

Depth of summit: 2000m

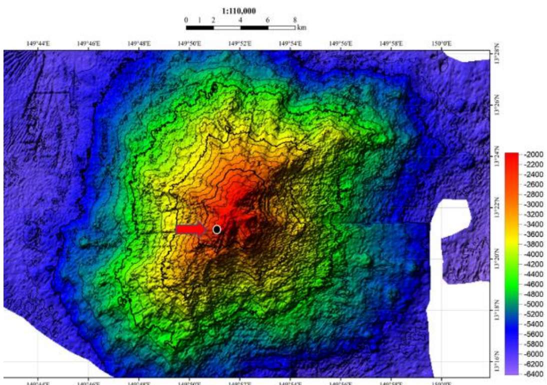
Depth range: 2072-1985

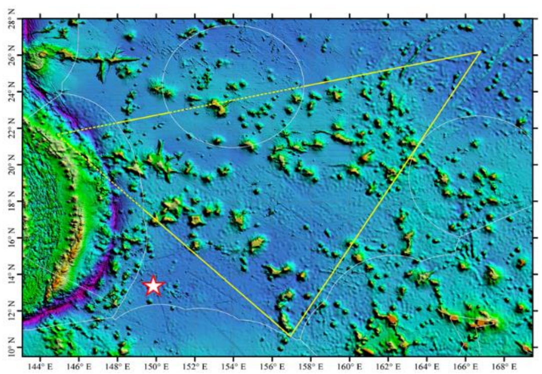
Area: 300m along transect

Location

Latitude: 13.355° N

Longitude: 149.854° E





RD seamount located on the East Mariana Basin, southwest to the Magellan seamount chain in the Northwest Pacific Ocean. Depth range 1966 m - 6417 m, relative relief 4400 m, 25 km width. Summit area is a small peak. This seamount lies on the WPWP (Western Pacific Warm Pool) area. Surface water mixing layer is stable all seasons, leading to a relatively low primary productivity at surface water. SINP-RD-01(transect line) lies near the summit of the RD seamount at the depth of 2072 m - 1985 m. Sea bottom is relatively flat at large scale covered by basalt and crust, but have many cliffs and protruding rocks. This area was observed in COMRA DY56 Cruise.

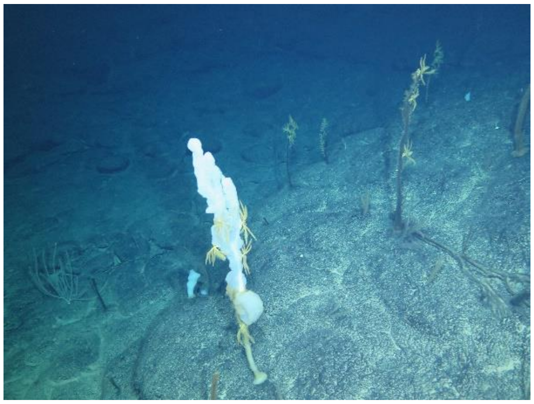
From the video footages, high-abundance nodule areas were discovered around the base of the seamount. Therefore this seamount and its surrounding abyssal plain areas can be considered as a large AINP.

A mound (300 m across) of sponge and coral fields were discovered. Crinoid are dominant benthos taxon which always live on sponge (mostly dead) along this area. Sponges and corals such as Primnoidae, Chrysogorgiidae are also dominant, which are often tall and have good variety. Ophiuroids living on big Primnoidae coral are also found.

Big Primnoidae with numerous ophiuroids and a crinoid living on it

Iridogorgia sp.

Community of sponges, *Chrysogorgia*, black corals and crinoids



Live and dead sponges with numerous crinoids living on them, gorgonians and black corals beside them

Assessment of the area against relevant scientific criteria

(Discuss the area in relation to each of the relevant scientific criteria and relate the best available science. The description of the area can be provided on the basis of one of more of the criteria, and the polygons of the area can be defined without exact precision. Information on modeling can also be used for the description of the area, including the presence of relevant ecological attributes. Please note where there are significant information gaps.)

The following ranking can be used for describing the relevance in terms of respective scientific criteria.

High: *Well documented evidence supporting criteria: multiple publications, including peer-reviewed articles, scientific papers, reports; expert knowledge based on direct observations and scientific rationale.*

Medium: *Less well documented evidence: few publications; expert knowledge based on models, indirect observations.*

Low: *Very limited evidence from publications or expert knowledge.*

No information: *No data/information is available.*

Relevant Criteria	Description	Ranking of criterion relevance (please mark one column with an X)			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.			X	
Explanation for ranking RD seamount is a deep seamount, with a depth of summit approx. 2000 meters. The water depths of many large seamount in the TA is approx. 1500 meters. The site covered by sponge with mutualists, mainly including Ophiuroidea and Crinoidea, was identified.					
Special importance for connectivity	Areas that are required for a population to survive and thrive.			X	
Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.				X
Explanation for ranking Assemblages of cold water coral found at this area.					
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.				X
Explanation for ranking Area of relatively high density of cold water corals are found in the RD Seamount. Cold water coral such as Primnoidae, Isididae and black coral found. They have slow growth rate and relatively high longevity					

(Sherwood et al. 2009; Roark et al. 2006). It is probably vulnerable to degradation or depletion and with slow recovery while damaged.					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.			X	
Explanation for ranking The productivity of this area is lower than that in the north part. However, the site has significantly higher biological density and biomass than the surrounding low-productivity deep sea basins.					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.			X	
Explanation for ranking At least 3 species of sponges, 4 species of gorgonians and 2 species of black corals are found. These combining with crinoids and ophiuroids commensal with gorgonians and sponges comprise a good biodiversity.					
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.				X
Explanation for ranking No traces of human activities have been found in this area, including exploration and exploitation, bottom trawl fishery or submarine cable.					

References

1. COMRA Cruise Report (2019).
2. Sherwood O A, Edinger E N. Ages and growth rates of some deep-sea gorgonian and antipatharian corals of Newfoundland and Labrador. Canadian Journal of Fisheries and Aquatic Sciences, 2009, 66(1):142-152.
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