Advance version

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

19-23 February, 2024

Tokyo, Japan

Abbreviations

ABMT	Area-based management tool[1]
AIST	National Institute of Advanced Industrial Science and Technology, Japan
APEI	Area of particular environmental interest
BPHDC	Beijing Pioneer Hi-Tech Development Corporation, China
CCZ	Clarion-Clipperton Zone
CFC	Cobalt rich ferromanganese crust
COMRA	China Ocean Mineral Resources Research and Development Association
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
CTD	Conductivity, temperature, and depth
DORD	Deep Ocean Resources Development Co.,Ltd., Japan
EEZ	Exclusive Economic Zone
EMP	Environmental management plan
ISA	International Seabed Authority
JOGMEC	Japan Organization for Metals and Energy Security
KDE	Kernel Density Estimate KDE
KIOST	Korean Institute of Science and Technology
LTC	Legal and Technical Commission, ISA
nMAR	northern Mid-Atlantic Ridge
MNRE	Ministry of Natural Resources and Environment, Russian Federation
NWP	Northwest Pacific
NPIB	North Pacific inter-seamount basin
OEMMR	Office of Environmental Management and Mineral Resources, ISA
OMZ	Oxygen minimum zone
PMN	Polymetallic nodule
POC	Particulate organic carbon
POM	Particulate organic matter
REA	Regional environmental assessment
REMP	Regional environmental management plan

1 In this report, area-based management tools (ABMTs) include areas of particular environmental interest (APEIs) and sites of particular environmental interest (SPEIs) as explained in Section IV of the Recommendations on technical guidance for the development of Regional Environmental Management Plans in support of the Standardized Procedure and Template (ISBA/29/LTC/8).

RFMO	Regional Fisheries Management Organization
SPEI	Site of particular environmental interest
UNCLOS	United Nations Convention on the Law of the Sea

Contents

Figures and tables

INTRODUCTION

1. In accordance with the United Nations Convention on the Law of the Sea (UNCLOS) and 1994 Agreement relating to the implementation of Part XI of the Convention, the mandate of the International Seabed Authority (ISA) is to administer the mineral resources in the Area on behalf of the States Parties to UNCLOS, and to control and organize mineral resource-related activities in the Area for the benefit of humankind as a whole. ISA's mandate also includes taking necessary measures with respect to activities in the Area to ensure effective protection of the marine environment from harmful effects which may arise from such activities. To this end, ISA is required to adopt appropriate rules, regulations and procedures for, *inter alia*, the prevention, reduction and control of pollution and other hazards to the marine environment, the protection and conservation of the natural resources of the Area, and the prevention of damage to the flora and fauna of the marine environment.[2]

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 (LTC), approved an Environmental Management Plan (EMP) for the Clarion-Clipperton Zone (CCZ).[3] This included the designation of a network of nine "Areas of Particular Environmental Interest" (APEIs). In 2021, following a comprehensive review of the implementation of the environmental management plan for the CCZ, the LTC recommended further actions to advance the implementation of the plan. These included the establishment of four additional APEIs to enhance the effectiveness of the overall network. The Council endorsed this recommendation in December 2021.[4] As a result, the network of APEIs in the CCZ now comprises 13 APEIs covering a total area of 1.97 million km^2 of seabed.

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 of the Area where there were contracts for exploration.[5] The Council agreed with the priority areas that had been identified on a preliminary basis as the northern Mid-Atlantic Ridge (nMAR), the Indian Ocean triple junction ridge and nodule-bearing province, as well as the North-West Pacific (NWP) and South Atlantic for seamounts.[6] The strategy was later reflected in the Authority's strategic plan and its high-level action plan for the period 2019–2025.

4. The Council also noted that the 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 UNCLOS and the Agreement relating to the implementation of Part XI of the Convention.[7]

5. As requested by the Council, the LTC is developing a standardized procedure for the development, establishment and review of REMPs, and has outlined the technical approaches to the development and review of REMPs in its recommendations.[8]

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

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

4 ISBA/26/C/58

5 See ISBA/24/C/3.

6 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.

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

8 ISBA/29/LTC/8.

6. In line with the above, since 2018, six expert workshops have been convened by ISA in collaboration with various partner organizations to support the development of REMPs in priority areas including the CCZ, nMAR, the Indian Ocean triple junction ridge and nodule-bearing province and NWP Ocean.

7. With the above background, the ISA, in collaboration with the Ministry of Economy, Trade and Industry (METI) and Japan Organization for Metals and Energy Security (JOGMEC) as well as Deep Ocean Resources Development (DORD) and the National Institute of Advanced Industrial Science and Technology (AIST) of Japan, convened the workshop on the development of a REMP for the Area of the NWP Ocean.

8. The workshop aimed to:

- review and synthesize newly available scientific data and information related to the biological, oceanographical and geological aspects of the marine environment in the NWP Ocean;
- validate and refine the design of potential area-based management tools (ABMTs) identified in the previous online workshop, and review and further improve the scientific rationale for the identification of such potential ABMTs based on agreed scientific criteria;
- drawing on the results from the quantitative modeling of cumulative impacts from the previous online workshop, determine ecosystem components, which may be at a high risk from future potential exploitation activities, including cumulative impacts of activities, and on this basis, appropriate management approaches for addressing such impacts, including non-spatial measures; and
- discuss priorities for future, regional-scale monitoring and research.

9. The results of this workshop will provide scientific inputs to additional workshops in this region, and together the results from these workshops will provide the core elements for the LTC to formulate a draft REMP for the Area of the NWP Ocean.

10. The workshop was co-chaired by Dr. Malcolm Clark and Dr. Tomohiko Fukushima, members of the LTC of ISA. It was attended by 34 participants in their individual expert capacities. The full list of workshop participants is provided in Annex I to this report.

ITEM 1. OPENING OF THE WORKSHOP

11. H.E. Mr. Michael W. Lodge, Secretary-General of ISA opened the workshop at 9 a.m. (Japan; GMT+9:00) on Monday, 19 February, 2024. He welcomed the participants and thanked the METI, JOGMEC, DORD and AIST, for hosting and supporting the workshop.

12. Mr. Ichiro Takahara, Chairman & CEO of JOGMEC delivered his welcome remarks. He expressed his gratitude to all the participants and emphasized the importance of managing the marine environment through effective international cooperation for achieving sustainable mineral resource development. He highlighted JOGMEC's expanding efforts in this field, particularly in the exploration for and environmental surveys of pollymetallic sulphides and cobalt-rich ferromanganese crusts (CFC). While acknowledging concerns about the potential impact of seabed mineral resource development on the marine environment, he stressed the importance of striving for a balance between the protection of the marine environment and equitable sharing of benefits deriving from the activities in the Area.

13. Mr. Hiromasa Oba, President of DORD, delivered his welcome remark. He expressed gratitude to H.E. Mr. Michael W. Lodge, Secretary-General of ISA and his team for organizing the workshop, as

well as participants for attending the workshop. He introduced DORD and its collaboration with private companies and JOGMEC on exploration of polymetallic nodules in the CCZ. He highlighted that the nodules contain essential elements for a decarbonized society and are attracting interests worldwide. He also presented DORD's contribution to environmental conservation efforts, development of new technologies, and long-term monitoring of seabed disturbance globally, as well as its participation in discussions on the formulation of exploitation regulations under ISA. Finally, he reaffirmed DORD's continued support and willingness to contribute to the development of a REMP in the NWP Ocean.

14. Mr. Yuki Sadamitsu, Director-General, Natural Resources and Fuel Department, Agency for Natural Resources and Energy, METI, delivered his welcome remarks. He expressed his pleasure in hosting a workshop in Japan on the development of a REMP for the NWP Ocean. He acknowledged the importance of seabed mineral resources, especially towards achieving carbon neutrality by 2050 and for improving Japan's self-sufficiency in meeting the growing demands of mineral resources. He highlighted the importance of developing an effective regulatory framework, taking into consideration potential environmental impacts of extracting seabed mineral resources. The results of this workshop will provide an important basis to developing an effective REMP that is based on the best available science.

15. Prof. Yoshihisa Shirayama, Professor Emeritus of Kyoto University and Advisor of Japan Agency for Marine-Earth Science and Technology (JAMSTEC), delivered a keynote presentation on the importance of developing a REMP for the Area of the NWP Ocean in ensuring the effective protection of the marine environment from potential harmful effects that may arise from activities in the Area of this region. He highlighted ISA's duty assigned by UNCLOS to adopt and implement appropriate measures to organize, conduct, and control activities in the Area and ensure effective protection of its marine environment. He also emphasized the importance of increasing scientific knowledge, advancing technologies, and promoting effective development of REMPs, including area-based management tools, in ensuring sustainable management of activities in the Area for the protection and sustainable use of the Area.

ITEM 2. INTRODUCTION TO THE WORKSHOP

16. Under this item, the workshop co-chairs introduced the agenda, and Jose Dallo (ISA Secretariat) delivered a presentation on the introduction to REMPs in the Area, and the objectives and expected outcomes of the workshop.

17. Next, Malcolm Clark and Se-Jong Ju, members of the LTC of ISA delivered a presentation on scientific approaches to the development of REMPs, and the outcomes of the previous workshops for the Area of the NWP Ocean held in 2018 and 2020.

18. Participants were then invited to ask questions and share insights on the presentations above.

19. Summaries of the above presentations are provided in Annex II to this report.

ITEM 3. REVIEW, ANALYSIS AND SYNTHESIS OF RELEVANT SCIENTIFIC DATA/INFORMATION/MAPS RELATING TO BIODIVERSITY AND ECOSYSTEM PATTERNS IN THE NORTHWEST PACIFIC OCEAN

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

a. Draft Data Report compiling environmental and biological information, biogeographic classification, and other geo-spatial information in GIS layers, prepared by Duke University in support of the workshop objectives, and
b. The Regional Environmental Assessment (REA) prepared for the previous workshop for this region in 2020.
c. Submissions of information to update the REA.
d. Submissions of relevant information to support the workshop objectives.

21. Sarah DeLand (Duke University, United States) provided a presentation on the draft Data Report, followed by a presentation by Luciana Genio and Kioshi Mishiro (ISA Secretariat) on extracts from ISA DeepData.

22. Then, the following representatives of the ISA contractors delivered presentations on their environmental baseline studies conducted in the NWP Ocean:

a. Hiroko Kamoshida and Hikari Hino (JOGMEC, Japan);
b. Dongsheng Zhang (China Ocean Mineral Resource Research and Development Association-(COMRA), China)-;
c. Livia Ermakova (Ministry of Natural Resources and Environment (MNRE), Russian Federation);
d. Jaewoo Jung (Government of the Republic of Korea); and
e. Jingtao Gao (Beijing Pioneer Hi-Tech Development Corporation (BPHDC), China).

23. Summaries of the presentations above are provided in Annex II to this report.

24. Following on from the presentations above, participants exchanged their views, insights, and suggestions on the current state of knowledge on the marine environment in the region and the potential for a regional-scale synthesis.

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

25. Following on from 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.

26. On the topic of area-based management, Jesse Cleary and Sarah DeLand (Duke University) were invited as facilitators to moderate the discussion, together with the workshop co-chairs. The facilitators introduced suggested approaches to considering and producing outputs on:

a. An overall network of ABMTs (e.g. representativity, replication and adequacy)
b. Individual ABMTs (e.g. size, placement, and buffer zones)

27. Then, participants were divided into break-out groups to undertake focused discussions on area-based management:

- Group 1: Geology, geophysics, and technology.
  - Moderated by Sissel Eriksen (member of the LTC, ISA).
- Group 2: Biology and oceanography.
  - Moderated by Jesse Cleary and Sarah DeLand (Duke University).

28. Following the break-out group discussions, participants gathered in plenary to present results of the discussions, exchange views, and share further input.

29. On the topic of cumulative impacts assessment, Jeffery Dambacher and Piers Dunstan (CSIRO) were invited as facilitators to moderate the discussion, together with the workshop co-chairs. The facilitators introduced suggested approaches to producing outputs and presented an overview of results from the previous workshop in 2020.

30. Next, participants were divided into break-out groups to undertake focused discussions on cumulative impacts assessment:

- Group 1: Pelagic ecosystems
  - Moderated by Piers Dunstan (CSIRO)
- Group 2: Implications for management and monitoring.
  - Moderated by Jeffery Dambacher (CSIRO).

31. Following the break-out group discussions, participants gathered in plenary to present results of the discussions, exchange views, and share further input.

32. The results of the discussions under this agenda item are summarized in Annex IV (area-based management) and Annex V (cumulative impact assessment) of this report.

ITEM 5. REVIEW OF THE DRAFT WORKSHOP REPORT

33. The ISA Secretariat informed the workshop participants that a draft workshop report would be completed after the workshop and shared with the participants for their inputs and comments. The background documents (draft Data Report and REA) will also be updated after the workshop based on the comments and inputs received from the participants, and the final versions will be made available on the ISA website.

ITEM 6. CLOSURE OF THE WORKSHOP

34. The workshop was closed at 5 p.m. (Japan; GMT+9:00) on Friday, 23 February, 2024.

Annex I

LIST OF PARTICIPANTS

1. Mr. Malcolm Clark
   Member of LTC, ISA
   Principal Scientist (Fisheries)
   National Institute of Water and Atmospheric Research (NIWA)
   New Zealand
   Email: malcolm.clark@niwa.co.nz

2. Ms. Ana Colaco
   Senior Scientist
   University of Azores
   Nominated by the Deep-Ocean Stewardship Initiative (DOSI)[9]
   Portugal
   Email: maria.aa.colaco@uac.pt

3. Mr. Liang Du
   Project Manager
   BPHTDC, China
   China
   Email: duliang_kit@163.com

4. Ms. Cherisse Du Preez
   Head of the Deep-Sea Ecology Program & Head of the Northeast Pacific Deep-sea Exploration Project
   Institute of Ocean Sciences, Department of Fisheries and Oceans
   Canada
   Email: cherisse.dupreez@dfo-mpo.gc.ca

5. Mr. Robert Day
   Executive Secretary
   North Pacific Fisheries Commission
   Japan
   Emai: rday@npfc.int

6. Ms. Sissel Eriksen
   Vice Chair of LTC, ISA
   Senior Geologist
   The Norwegian Petroleum Directorate
   Norway

[9] The nominating entity is the same as the affiliation, unless otherwise indicated. Members of the LTC do not require a nomination.

Email: Sissel.Eriksen@npd.no

7. Ms. Livia Ermakova
   Researcher
   Academician I.S. Gramberg All-Russia Research Institute for Geology and Mineral Resources of the World Ocean
   Nominated by the JSC Yuzhmorgeologiya
   Russian Federation
   Email: livia77@inbox.ru

8. Mr. Tomohiko Fukushima
   Member of LTC, ISA
   Deputy Director General, Seafloor Mineral Resources
   JOGMEC
   Japan
   Email: fukushima-tomohiko@jogmec.go.jp

9. Mr. Jiangtao Guo
   Geologist/GIS Engineer
   BPHTDC
   China
   Email: 303196911@qq.com

10. Mr. Hikari Hino
    Geologist
    JOGMEC
    Japan
    Email: hino-hikari@jogmec.go.jp

11. Ms. Becky Hitchin
    Member of LTC, ISA
    Principal Consultant
    United Kingdom
    Email: elegaer@gmail.com

12. Mr. Se-Jong Ju
    Member of LTC, ISA
    Senior Director of Management Division
    KIOST
    Republic of Korea
    Email: sjju@kiost.ac.kr

13. Mr. Jaewoo Jung
    Senior Research Scientist
    KIOST
    Republic of Korea
    Email: jaewoo@kiost.ac.kr

14. Ms. Hiroko Kamoshida
Technical Researcher
JOGMEC
Japan
Email: kamoshida-hiroko@jogmec.go.jp

15. Mr. Hiroki Kise
JSPS Postdoctoral Fellow
AIST
Nominated by JOGMEC
Japan
Email: h.kise@aist.go.jp

16. Mr. Tomo Kitahashi
Leader, Technical Group
KANSO Technos Co., LTD
Nominated by JOGMEC
Japan
Email: kitahashi_tomo@kanso.co.jp

17. Mr. Youngtak Ko
Director, Principal Research Scientist
KIOST
Republic of Korea
Email: ytko@kiost.ac.kr

18. Ms. Maria Krugliakova
Director of Subdivision
JSC Yuzhmorgeologiya
Russian Federation
Email: kruglyakovamari@gmail.com

19. Mr. Ole Larsen
Project Director & Principal Scientist
DHI
Denmark
Email: OLA@dhigroup.com

20. Mr. Gary Lee
Geotechnical Adviser
The Pacific Community
Fiji
Email: garyl@spc.int

21. Mr. Nobuyuki Okamoto
General Manager, Overseas Business Department
DORD
Japan

Email: okamoto@dord.co.jp

22. Ms. Irina Ponomareva
Deputy Chief Geologist
JSC Yuzhmorgeologiya
Russian Federation
Email: irinap875@mail.ru

23. Mr. Bazlar Rashid
Deputy Director (Geology)
Geological Survey of Bangladesh
Bangladesh
Email: bazlarrashid@ymail.com

24. Mr. Naoki Saito
Researcher
AIST
Nominated by JOGMEC
Japan
Email: n.saito@aist.go.jp

25. Ms. Nurashiqin Binti Salih Udin
Senior Fisheries Officer
Conservation and Fisheries Protection Division
Department of Fisheries, Ministry of Agriculture and Food Security Malaysia
Malaysia
Email: nurashiqin@dof.gov.my

26. Ms. Chengcheng Shen
Assistant Professor
Second Institute of Oceanography, Ministry of Natural Resources
China
Email: shencc@sio.org.cn

27. Mr. Katsuhiko Suzuki
Director / Principal Scientist
JAMSTEC
Nominated by JOGMEC
Japan
Email: katz@jamstec.go.jp

28. Ms. Verena Tunnicliffe
Professor Emerita
University of Victoria
Nominated by the Government of Canada
Canada
Email: verenat@uvic.ca

29. Mr. Travis Washburn
    Fish & Wildlife Biologist
    Washington Department, United States of America
    Nominated by JOGMEC
    Japan
    Email: twwashburn@outlook.com

30. Mr. Kuidong Xu
    Professor
    Chinese Academy of Sciences
    Nominated by the North Pacific Marine Science Organization
    Email: kxu@qdio.ac.cn

31. Mr. Xue-Wei Xu
    Deputy Director
    National Deep Sea Center, Ministry of Natural Resources
    Nominated by COMRA
    China
    Email: xuxw@ndsc.org.cn

32. Ms. Kyoko Yamaoka
    Senior Researcher
    AIST
    Nominated by JOGMEC
    Japan
    Email: k.yamaoka@aist.go.jp

33. Mr. Dongsheng Zhang
    Professor
    Second Institute of Oceanography, Ministry of Natural Resources
    China
    Email: dszhang@sio.org.cn

Technical Support

34. Mr. Jesse Cleary
    Research Associate
    Duke University Marine Geospatial Ecology Lab
    United States of America
    Email: jesse.cleary@duke.edu

35. Mr. Jeffrey Dambacher
    Senior Research Scientist
    CSIRO
    Australia
    Email: Jeffrey.Dambacher@csiro.au

36. Ms. Sarah DeLand
    Research Associate
    Duke University Marine Geospatial Ecology Lab
    United States of America
    Email: sarah.deland@duke.edu

37. Mr. Piers Dunstan
    Biodiversity Domain Lead
    Team Leader, Marine Biodiversity Risk & Management, Oceans and Atmosphere
    CSIRO
    Australia
    Email: Piers.Dunstan@csiro.au

38. Ms. Elisabetta Menini
    PhD Candidate in Marine Science and Conservation
    Nicholas School of the Environment
    Duke University Marine Geospatial Ecology Lab
    United States of America
    Email: elisabetta.menini@duke.edu

Secretariat

39. Mr. Jose Dallo Moros
    Director
    OEMMR, ISA
    Email: jdallo@isa.org.jm

40. Ms. Wanfei Qiu
    Programme Manager (Marine Environment)
    OEMMR, ISA
    Email: wqiu@isa.org.jm

41. Ms. Luciana Genio
    Environmental Coordinator
    OEMMR, ISA
    Email: lgenio@isa.org.jm

42. Mr. Kioshi Mishiro
    GIS Officer
    OEMMR, ISA
    Email: kmishiro@isa.org.jm

43. Mr. Changsung Lim
    Associate Programme Management Officer
    OEMMR, ISA

Email: clim@isa.org.jm

44. Ms. Tomoko Tauchi
Consultant
OEMMR, ISA
Email: ttauchi@isa.org.jm

Annex II

Summary of Presentations

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

Introduction to regional environmental management plans (REMPs) in the Area, and objectives and expected outcomes of the workshop

By Jose Dallo (ISA Secretariat)

Mr. Jose Dallo, the Director of OEMMR at the ISA Secretariat, presented an overview of the objectives and expected outcomes of the workshop. Mr. Dallo outlined that the workshop aimed to (i) review and synthesize newly available scientific data and information related to the biological, oceanographical and geological aspects of the marine environment in the Northwest Pacific Ocean; (ii) validate and refine the design of potential ABMTs identified in the previous online workshop, and review and further improve the scientific rationale for the identification of such potential ABMTs based on agreed scientific criteria; (iii) drawing on the results from the quantitative modeling of cumulative impacts from the previous online workshop, determine ecosystem components, which may be at a high risk from future potential exploitation activities and cumulative impacts, and on this basis, appropriate management approaches for addressing such impacts, including spatial and non-spatial measures; and (iv) discuss priorities for future, regional-scale monitoring and research. The workshop outcomes will be summarized in the workshop report, and the draft data report and regional environmental assessment report will be finalized after the workshop. The expected outputs presented in the workshop report will be (i) a scientific proposal for potential ABMTs; (ii) suggested management approaches for addressing cumulative impacts; and (iii) proposed priorities for future monitoring and research at the regional scale. Ultimately, this work will contribute towards a shared understanding of the current scientific knowledge to inform the development of the REMP in this region.

Scientific approaches to the development of REMPs, and the outcomes of the previous workshops for the region of the northwest Pacific Ocean held in 2018 and 2020

By Malcolm Clark and Se-Jong Ju (members of the LTC, ISA)

Mr. Malcolm Clark and Mr. Se-Jong Ju, members of the LTC, provided an overview of scientific approaches to the development of REMPs under the auspices of ISA. The presentation covered progress in developing and implementing REMPs in the CCZ, nMAR, and NWP Ocean. The progressive development of the environmental management plan for the CCZ was described, including reviews by the LTC of the plan in 2016 and 2021, and a scientific synthesis workshop in 2019. This latter workshop included the development of habitat classification models to assess the representativity of the network of APEIs, and identify gaps in representativity. This work was important in the establishment of 4 new APEIs to address issues of connectivity and protection of environmental gradients (i.e., topography, particulate organic carbon (POC) flux and nodule abundance). The draft REMP for the nMAR was also introduced, including the identification of ABMTs based on a different set of criteria, and non-spatial management measures. The experiences with the CCZ EMP and the draft nMAR REMP is that given differences in environmental and resource characteristics, the methods applied and derivation of management options within REMPs may vary in different regions while maintaining a level of consistency in the overarching environmental goals and objectives, design principles and criteria in developing approaches to management and conservation. The need for regional environmental monitoring was identified as an important addition to existing REMP processes.

The presentation included a summary of the progress made on a REMP for the NWP. Key results were described from the previous workshops held in Qingdao, China in 2018, and an online workshop in 2020 supported by the Government of the Republic of Korea. It was recalled that 14 potential ABMTs were identified as potential candidates for protection but no consensus was reached during the last workshop. It was emphasized that one of the key tasks for this workshop was to revisit the previous workshop discussions, and to validate and refine the scientific approaches where appropriate, without re-inventing the wheel.

Presentations delivered under agenda item 3

Updates to the Data Report

By Sarah DeLand (Duke University)

Ms. Sarah DeLand 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 Ocean*. She 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 Ocean region. About 90 data layers were collated and prepared for this workshop, building on the data report developed for the previous REMP workshop for this region held in 2020. In addition to data layers, the report identifies several published scientific papers that list additional data resources. The presentation covered five 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 environmental data layers included bathymetric and physical substrate data, oceanographic features, and remotely sensed data. The biological data portion of the draft report covered a variety of data sources to include data and statistical indices compiled by the Ocean Biodiversity Information System (OBIS), habitat suitability models, and important bird areas. Biological data records and CTD sampling station records from the ISA DeepData database for this region were also included. The biogeographic data focused on major biogeographic classification systems. The human uses section of the report covers fishing efforts, shipping densities, mining exploration areas, and the cumulative human impacts on the world’s oceans. Areas defined for management and/or conservation objectives include marine protected areas and ecologically or biologically significant marine areas (EBSAs) of the Convention on Biological Diversity. The report also identified a few published scientific papers that listed additional data resources. It was explained that the draft data report will be finalized after the workshop to include additional datasets suggested by participants and will be updated in the future as a living document.

Extract from ISA's DeepData

By Luciana Genio and Kioshi Mishiro (ISA Secretariat)

Ms. Luciana Genio (ISA Secretariat) presented on data compiled from ISA DeepData[10] database to support the development of the REMP for the Area of NWP Ocean. She began with a brief introduction to DeepData, highlighting its current main role as the global repository of data and information collected by ISA contractors during mineral exploration activities. Launched in 2019, DeepData is a georeferenced web platform that contains information on mineral resource assessment and environmental data, including physical and chemical oceanographic information, geological and biological data collected from the ocean surface to the seabed. Both structured data submitted through digital templates and unstructured data, including images, maps and raw data files are available for downloading on the web platform. Ms Genio outlined several ongoing efforts and next steps for improving data quantity and quality in DeepData, as part of ISA data management strategy roadmap, including quality control and quality assurance procedures to improve data standardization and capacity development opportunities for ISA stakeholders. Other initiatives launched by the ISA were presented, such as the Sustainable Seabed Knowledge Initiative[11] and Area 2030[12]. These initiatives aim to enhance access to data collected in the Area, by establishing interoperable links with external databases, and to strengthen collaboration among ISA contractors and the scientific community. Ms Genio and Mr Mishiro presented a summary of biological and physical oceanographic data (currents, temperature, salinity) that are available for the NWP region since the first contract was signed in 2014 for exploration for CFC. These data were made available to participants to support workshop deliberations.

Overview of exploration activities, with a focus on environmental baseline studies conducted by ISA contractors in the Northwest Pacific Ocean

By Hikari Hino and Hiroko Kamoshida (JOGMEC)

JOGMEC has data and information collected from a 15-year exploration contract with ISA in six seamounts in the Northwest Pacific Ocean, starting in January 2014. The distance between the most distant seamounts in the contract area from north to south is approximately 500 km. The seamount flat-tops are mainly covered by cobalt-rich ferromanganese crust and foraminiferal ooze. The surface area of these flat-tops varies from 260 to 1,740 km², depending on the seamount. Within the flat-tops are pinnacles, terraces, depressions, etc., and the environmental characteristics of each seamount are diverse. Environmental surveys have been conducted on these seamounts since 2014. Main results were summarized from the geophysical, chemical, and biological surveys on the seamounts. As for the geophysical surveys, currents were observed in five seamounts. Current simulations were conducted for JA17, and it was predicted that current velocities within the flat-top was not uniform. From the chemical surveys, Nutrient and DO analyses were conducted to characterize the water column in the area. Nutrient concentrations in the surface layer were almost depleted, but increased with depth, with no significant changes at depths below 1000 m. DO concentrations showed a minimum layer at around 1000 m and increased at greater depths. The results of these analyses showed the general characteristics of the water column in tropical and subtropical waters. In the survey on organisms, we efficiently collected video data using FDC, ROV, and Edokko-1, and confirmed that there

10 https://www.isa.org.jm/deepdata-database/

11 https://www.isa.org.jm/sski/

12 https://www.isa.org.jm/area-2030/

were concentrated areas of organisms on the flat tops of several seamounts. In addition, genetic analysis of the collected amphipods in five seamounts confirmed the possibility of genetic linkage among seamounts.

By Dongsheng Zhang (COMRA)

COMRA signed the contract of Cobalt-rich crust with ISA in 2014. The contract area was located at two seamounts in the south of the Magellan seamount chain. During several cruises between 2014-2023, environmental baseline data including physical, chemical, geological and biological baseline data were collected. Temperature, salinity, dissolved oxygen, nutrient profiles of the water column are consistent with the typical oceanography features of oligotrophic open ocean in the west Pacific. The mooring system observations show an anticyclonic circulation structure for the near-bottom current, which is stronger at the summit than that at the slope and foot. POC flux was higher at the northern seamount than that at the southern seamount, but no obvious seasonal variation was observed. Vertical distribution pattern of zooplankton biomass along the water depth was found, furthermore, an interannual and seasonal variation of zooplankton biomass were also recovered. The megafaunal community of the two seamounts was described based on video data from HOV/ROV. A total of 94 morph-species were identified from more than 6000 megabenthic animals recorded. Echinoderms, sponges and cnidarians were dominant taxa. Richness and abundance are similar between the two seamounts, but species compositions are different. BPI, slope, velocity, depth and substrate types are key environmental factors shaping community structure. Diversity of brittle star from 9 seamounts in this region were studied and evaluated. Genetic population analysis suggested that the connectivity maybe high in this area. Additionally, habitat classification was conducted and 12 types of habitats were identified. According to the habitat classification results, a plan for spatial management was proposed.

By Livia Ermakova (MNRE, Russian Federation)

Results of environmental baseline studies carried out at the Alba Guyot and the Kocebu Guyot during the period of 2020-2023 are presented. Currents are strongly impacted of tidal and other long waves, presence of seamounts and local bottom topography. The seasonal variations are also existing. Velocities measured near bottom vary up to 27 cm/s (at two mooring stations – up to 10 cm/s), mainly from 9 to 21 cm/s. Analysis of the LADCP data on vertical distribution of currents (at the Kocebu, Govorov and Vulkanolog guyots) shows maximum velocities at the upper 400 meters of the water column. The north-west direction prevails here. Currents turn clockwise with depth, and eastward direction dominates at depth between 500-1200 m. The minimum velocities are measured at the layer of 2200-3000 m. Vertical distribution of the most physical and chemical characteristic of the water column is very similar for both of guyots in terms of their profiles form and values (but there are differences in values of salinity and oxygen). The depths of water layers with equal values of parameters are different between these two guyots. In ferromanganese crusts, the concentrations of copper and lead are several dozen times higher than the Clarke values, zinc - seven times higher, cadmium varies from 2.1 to 6.46 mg/kg (comparable with the Clarke values). In magmatic and sedimentary rocks, the concentrations of trace metals are much lower (copper: 15 - 660 mg/kg; zinc: 29 - 597 mg/kg; lead - 1.9 to 263 mg/kg; cadmium: no more than 3.52 mg/kg). The content of trace metals in bottom sediments is on average below the Clarke values (copper: 8.1 - 48.0 mg/kg; zinc: 1-112 mg/kg; lead: 2 - 263 mg/kg; cadmium: no more than 1.9 mg/kg). Average concentrations of copper and zinc in the water are comparable to natural levels, concentrations of cadmium and lead are slightly higher. Content of copper and lead in marine organisms (corals and brittle stars) is generally comparable to their content in sediments, concentrations of zinc and cadmium are up to 198.5 and 50.9 mg/kg, respectively. The composition and distribution of megafauna, macrofauna, meiofauna, bacterioplankton, phytoplankton and zooplankton at the Kocebu and the Alba guyots have been studied. At the Alba guyot, Crinoidea are the most numerous group of megafauna (59 % of the total number of megafauna). Coral polyps (Anthozoa) are the second (21.7 %) and glass sponges (Hexactinellida) are the third (about 8 %). At the Kocebu Guyot, coral polyps are the most abundant (about 42%), and the higher crustaceans (Malacostraca) are the second by the quantity. Polychaetes are the most numerous representatives of macrofauna at the Kocebu Guyot. Nematodes are the most abundant among meiofauna in the layer of sediments from 0 to 5 cm (about 82%), and small crustaceans (order Harpacticoida) are the second (16%).

By Jaewoo Jung (Government of the Republic of Korea)

Since signing an exploration contract for CFC with the ISA in 2018, extensive seafloor exploration has been undertaken to assess resource abundance, alongside the collection of environmental baseline data. As a major part of a R&D program for CFC exploration in the western Pacific, initiated in 2022, the scientific team at KIOST have conducted comprehensive resource and environmental assessments. Currently the second stage of the exploration contract is underway, with a focus on organizing the environmental research data. Our efforts have yielded valuable insights across various domains, including water column physics and chemistry, geological characteristics, and the biodiversity of mega- and macro- benthic organisms and plankton. Notably, cutting-edge environmental DNA (eDNA) techniques have been employed since 2022 to enhance biodiversity research. To fulfill the environmental data requirements outlined by ISA, our approach is systematic and staged, aligning with the progression of exploration activities. Plans are in place to delve into the realms of meso- and micro-fauna, food webs, ecosystem function, and related aspects beginning in 2026, with a strategic focus on sample collection and analysis. These collected environmental datasets will serve as foundations for the implementation of environmental management areas, slated for the third stage of the exploration contract.

By Jiangtao Guo (BPHDC, China)

The contract area of BPHDC is located in the NW Pacific. It consists of 4 blocks: C1, C2, M1, and M2, with a total area of 74,052 km^2. From 2020 to 2023, BPC have taken various methods to survey the environmental baseline in M1 and M2 blocks, including CTD stations, stations of submersible mooring system, box-corer sampling, multi-beam bathymetric surveys, deep-towed camera survey, multicorer sampling, vertical trawling etc. The M1 and M2 blocks are located in the Magellanic Sea Mountains in the NW Pacific. This area has developed numerous seamounts of different shapes. These seamounts are all flat-topped seamounts. The water depth at the top of the mountain is about 1500 m. Submarine fans formed by slope damage caused by gravity are generally developed around the seamounts. The water depth range of M1 and M2 blocks is mainly between 4,000 and 6,000m, accounting for 91.23% of the area. The time series vector data of currents show that the upper layer (~100 m) is affected by large-scale circulation while the bottom layer (>5000 m) is dominated by Antarctic bottom flow. The NW Pacific is an oligotrophic and low-productivity area with the water column primary productivity ranging from 15 to 40 mg C/m2·h in the true light layer of the contract area. The dissolved oxygen in the mixed layer is relatively uniform and decreases under the euphotic layer (~100 m) with a minimum at about 800 m depth which is often caused by oxidative decomposition of organic matter. Echinoderms, Porifera, Arthropods and Cnidaria are the top 4 dominant megafauna. The average density of macrofauna in the 39 survey stations was 13.44±15.69 ind/m2, mainly distributed in the 0-3cm layer. A total of 15 taxa of meiofauna were found in the work area, among them, nematodes are the main dominant group, accounting for more than 90% of the density, followed by water fleas (4.15%) and nauplii, and the remaining 12 groups account for less than 5% of the biological density. The microfauna community composition from the 72 seawater samples of 6 stations can be clearly divided into two major branches according to the results of sample hierarchical clustering tree analysis. The seawater samples taken below 135 m clustered together, while the samples above 135 m clustered into a large branch.

Presentations delivered under agenda item 4

Approaches for spatial planning

By Jesse Cleary (Duke University)

Mr. Cleary presented an overview of spatial planning approaches and described the relationship between spatial and complementary non-spatial approaches. The presenter began emphasizing the results of the previous REMP workshops. 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 is 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 their vulnerability to disruption or damage. In this regard, the differences between site-level and network-level criteria were presented. Next, the presenter described two approaches to applying ABMTs: a coarse-filter approach, which targets the representation of broad ecosystem features and gradients and 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 (SINPs). He also suggested that a purposefully configured mixed portfolio, combining large areas to protect and buffer intact gradients of habitats augmented with specific SINPs, 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. Finally, it was highlighted that defining the appropriate biogeographic spatial extent of a REMP is a fundamental step in the planning process. Defining tractable evaluation criteria for assessing different ABMT network configurations (size, spacing, placement) will also be key to REMP planning. Increased spatial precision will require increased data coverage and detail, which have implications for adaptive management. An adaptive management approach will likely be required to anticipate changes in data and knowledge, new technologies and contract area relinquishment.

Developing cumulative impact assessments

By Piers Dunstan (CSIRO)

Mr. Dunstan began his presentation by introducing the basis for adaptive management, which has three key components: (1) a clear understanding of the objectives and desired outcomes, (2) an assessment process that includes all potential positive and negative effects of development and (3) a monitoring programme that can test this assessment and ensure that the desired outcomes are achieved. The presenter 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 a multi-tiered 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. The presenter explained how the participants would construct conceptual models during the workshop. This process includes first identifying the 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. The presenter provided an example of previous work on developing qualitative models to assess the potential risks from future mining operations in the region of the nMAR. Mr. Dunstan 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 timescale) and identify the best indicator species/groups.

Annex III

Summary of discussion on review, analysis and synthesis of relevant scientific data/information/maps relating to the marine environment, biodiversity and ecosystem patterns in the NWP Ocean

1. Participants discussed the data and information that had been compiled in the draft data report and updated information submitted by ISA contractors prior to the workshop. The draft data report provides an overview of geo-referenced environmental data available for this region and new data sources were included in the revised version. Information submitted by the contractors will be used to update the REA.

2. Participants noted the oceanographic, biological and other types of environmental data collected by the contractors, which can be downloaded from ISA database DeepData[13]. While some data (e.g. CTD) is relatively standardized across the region, biological data is more difficult to compare or synthesize across different contractors. Metadata templates were introduced in recent years, and the lack of metadata in old data submissions can limit the potential for comparative analysis across different contractors.

3. Contractors' environmental baseline studies follow the guidance issued by the LTC, but are at different stages of development. A variety of geological, oceanographic and biological studies were presented during the workshop. These included studies comparing water characteristics, depth stratification and benthic fauna communities between different seamounts within a single contract area. The potential for synthesis across different contractors in biological studies is constrained by the relatively small sample size. Collaboration among contractors can help overcome such constraints, and was strongly recommended by workshop participants.

4. Surface productivity is in general very low in this region, however small spatial and temporal changes in POC fluxes were observed for different seamounts. Preliminary data suggested that POC levels might be influenced by currents in addition to surface productivity.

5. Participants also noted that while more data have become available since the last workshop held in 2020, data limitations mean it remains difficult to analyze regional or sub-regional patterns of biodiversity, or to identify with confidence the key drivers of biodiversity patterns. Oceanographic data collected by the contractors helps identify potential patterns of depth stratification through water layer distribution.

6. Species distribution and habitat classification modelling show promise, however, there is limited data to support validation of the models' biological application, which is based solely on presence and pseudo-absence data. The need for more abundance-based biological analyses was recognized.

7. Participants also discussed important knowledge gaps. There are few studies about pelagic biology and there are currently no detailed current circulation models in the region. Contractor collaboration will be needed to carry out further review and analysis of available environmental data in the region. Such collaborative data analyses should be aligned with the main scientific needs to support the REMP development.

8. There is potential for data sharing between ISA and regional fisheries bodies or regional fisheries management organizations (RFMOs), including confidential data. This can contribute to a more robust gap

13 DeepData Database - International Seabed Authority (isa.org.jm)

analysis and addressing knowledge gaps. Contractors are making huge investments on environmental studies and their data can also be helpful to RFMOs.

9. In this connection, participants noted that there were additional datasets available through RFMOs and other regional organizations or research programmes, which could contribute to the work on REMPs, such as the data on plankton in the North Pacific Ocean[14].

14 See https://www.dassh.ac.uk/lifeforms/ and https://doi.mba.ac.uk/data/3086

Annex IV

Main results of discussion on spatial planning and ABMTs[15]

A. Background

1. Discussions on ABMTs focused on the following objectives of the workshop:

- review and synthesize newly available scientific data and information related to the biological, oceanographical and geological aspects of the marine environment in the NWP Ocean; and
- validate and refine the design of potential ABMTs identified in the previous online workshop held in 2020, and review and further improve the scientific rationale for the identification of such potential ABMTs based on agreed scientific criteria.

2. Participants discussed the suitability of coarse- and fine-filter approaches. There was general agreement that a purposefully configured mixed portfolio combining large areas to protect and buffer intact gradients of habitats, augmented with specific sites, may best provide the flexibility needed to meet both mining and environmental interests.

3. Participants were reminded about the main results from the previous virtual workshop for this region, held in 2020. It was noted that a total of 14 potential ABMTs were identified, which includes 9 for seamounts and adjacent slopes, and 5 for abyssal plains (see Figure 1). The 14 potential ABMTs covered 34% of the seafloor in the region. For seamounts, a Benthic Terrain Model was applied which characterized the benthic environment and identified seamount-like structures using a benthic position index (BPI) method. An analysis was also conducted to characterize the depth of seafloor in this region, as a proxy for faunal community change with habitat variability. This analysis divided the seafloor into 500-meter intervals based on depth, resulting in13 depth zones. It was emphasized that the depth zone analysis was not a driver in the identification of potential areas, rather, it was used to assess how much habitat variability was captured by the network of potential ABMTs.

4. Participants agreed to apply the same geographical scope for the REMP as discussed during the 2020 workshop. The breakout group discussion focused on the application of the scientific criteria in designing the ABMT network in the region, based on available data and expert knowledge among workshop participants. In both geology, and biology and oceanography groups, the discussion aimed to understand the data that can be used to assess the main criteria, such as representativity, adequacy, connectivity and viability, as well as the criteria related to ecological significance or sensitivity of an area (uniqueness, rarity, function significance of the habitat, structure complexity. vulnerability and other site-based criteria). Participants agreed in general with the main assumptions and methodologies applied in 2020 to identify the 14 potential ABMTs, based on the available data and expert knowledge.

5. Ms. Becky Hitchin (member of ISA LTC) provided a presentation on environmental goals and objectives, as a context for the workshop deliberation. A hierarchy of goals, objectives, management actions, indicators and thresholds was introduced, and it was suggested that an overarching environmental

[15] ABMTs include areas of particular environmental interest (APEIs) and sites of particular environmental interest (SPEIs) as explained in Section IV of the Recommendations on technical guidance for the development of Regional Environmental Management Plans in support of the Standardised Procedure and Template (ISBA/29/LTC/8).

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. Participants noted that the future REMP, including the development of ABMTs, will contribute to the fulfillment of ISA's environmental goals and objectives.

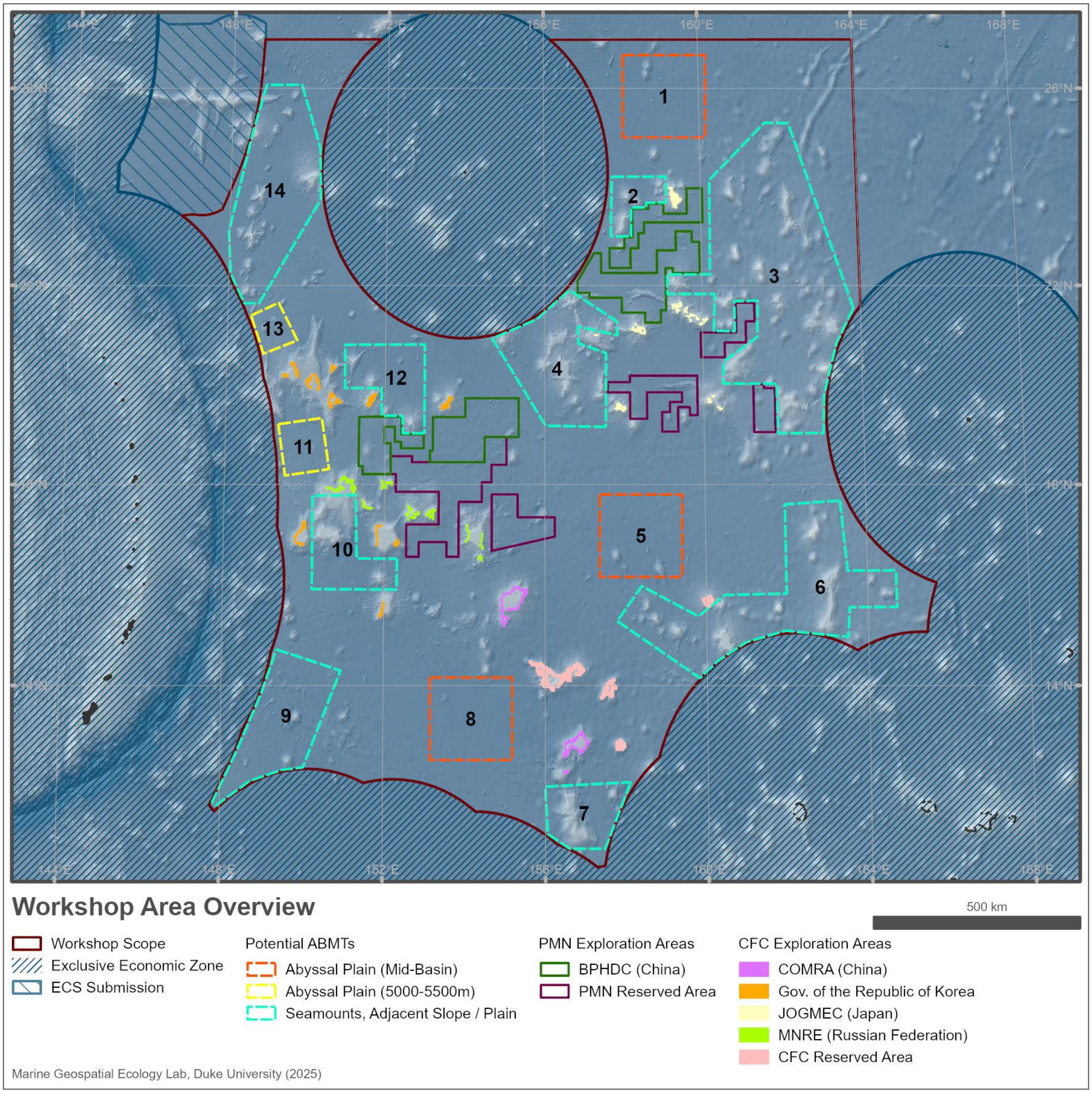

Figure 1. Potential ABMTs identified during the 2020 workshop.

B. Summary of break-out discussion relating to the geological aspects of the marine environment for the Area of the Northwest Pacific Ocean.

6. Participants discussed the geological considerations relevant to the development of the REMP for the Area of the NWP Ocean, particularly the locations of the potential ABMTs.

7. Participants noted that geological diversity (geodiversity) comprises the foundational environment which underpins habitat-specific ecosystems and biodiversity. In view of this, discussions centered around the range and spatial distribution of geodiversity in the Area of the NWP Ocean.

8. The five contractors with ISA exploration contracts in the Area of the NWP presented geological data relevant to their respective contract areas, and in some cases, data related to the broader region. Participants noted that high-resolution data (such as multibeam bathymetry, rock/sediment sampling and analysis, geochemistry, geochronology, and imagery) is largely confined to the exploration contract areas. Differences were noted in terms of the data types, resolutions, quality control, and methodologies between the respective contractors. It was noted that these differences in data introduce uncertainty and pose challenges in terms of comparing between sites and extrapolating broader regional patterns in geodiversity.

9. Participants noted that there is additional historical data associated with prospecting and scientific research, prior to the current exploration activities (the earliest of which commenced in 2014). It was noted that some of this data is stored in digital repositories, but other datasets may require digitization.

10. Participants recommended that ISA secretariat undertake an initiative to support the compilation and harmonization of contractors' data and historical data, in order to generate a comprehensive dataset of current geological data in the Area of the NWP, as relevant to the discussions of the REMP, noting that certain types of geological data are confidential under ISA and possibly national regulations.

11. Participants recalled that there were two types of mineral resources currently under exploration in the Area of the NWP Ocean, namely:

a. CFC occurring on seamounts, known at depths between 800m and 5,500m.
b. PMN occurring on the abyssal plains of NWP Inter-seamount Basin (NPIB), typically at depths between 4,000m and 6,000m.

12. Consequently, discussions progressed around understanding the geodiversity associated with 1) seamounts and 2) the abyssal plains of the NPIB, as the two major geological landforms occurring in the Area of the NWP Ocean.

13. Participants noted that the oceanic crust in the Area of the NWP Ocean is amongst the oldest on earth (~130-170 Ma), whereas the seamounts are typically of Late Cretaceous age (66-100.5 Ma) and formed due to several hotspot volcanism tracks.

14. In their geological past, some of the seamounts formed subaerial islands which subsequently subsided below the ocean surface, providing foundations for the upward growth of reef constructing corals. Following prolonged subsistence coupled with the upward growth of reef construction corals, these seamounts underwent several stages of evolution: initially forming volcanic islands with fringing reefs, then barrier reefs, then atolls, and eventually guyots. Seamounts that underwent this geological history are now guyots, which have a carbonate platform on top of an underlying volcanic edifice. Guyots have a relatively flat top with varying coverages of foraminifera rich carbonate sediment and CFC.

15. Participants noted that the Area at the focus of this workshop spans from 10°N to 27°N latitude, which is within the known latitudes for coral reef growth/ carbonate platform formation, even more so when considering the northern paleo-movement of the Pacific plate. It was also noted that all known geological investigations on guyots in the Area of the NWP Ocean have encountered carbonate platforms. Therefore, it is assumed that guyots in the Area of the NWP Ocean have carbonate platforms. Opposed to other known guyots at higher latitudes which do not have carbonate platforms (and merely consist of wavecut, flat-topped, volcanic edifices) due to their locality outside of latitudes conducive to coral growth.

16. Conversely, some of the seamounts in the Area of the NWP Ocean never reached the elevation of the ocean surface and consequently did not support the growth of reef constructing corals. Subsequently, seamounts which underwent this geological history are entirely comprised of a volcanic edifice, with no carbonate platform. These seamounts are typically deeper than the guyots and have a conical shape, with varying coverages of CFC.

17. Participants noted that the seamounts in the Area of the NWP Ocean have experienced slope instability, including large-scale edifice collapses, resulting in scarps which control seamount shape. Subsequently, many seamounts have lost their original conical form, and now consist of irregular shapes, including elongated ridge shaped features. It was also noted that in some instances closely spaced seamounts have coalesced into elongated ridge shaped features.

18. Several frameworks for classifying seamounts into different categories were discussed by the participants, with participants agreeing to designate the seamounts into 3 primary categories:

c. Guyots: flat-topped peaks rising more than 1000 m above the seafloor, which represent drowned atolls, comprised of a carbonate platform on top of an underlying volcanic edifice.
d. Conical: cone shaped peaks rising more than 1000 m above the seafloor, with a length/width ratio < 2, which are volcanic edifices with no carbonate platform.
e. Ridge: peaks rising more than 1000 m above the seafloor, with a length/width ratio > 2, which are elongated volcanic edifices with no carbonate platform.

19. Harris et al (2014) provides a framework for classifying seamounts into the categories above. The paper notes that seamounts should be manually inspected to ensure that guyots are correctly classified. There is not time to conduct this manual inspection of all seamounts in the Area of the NWP Ocean during the workshop, thus participants recommend this manual check of the classification is carried out in future.

20. Participants also agreed to categorize the seamounts further based on the depth of the seamount summit, as depth is an important factor in terms of supporting different biodiversity. It was agreed that the specified depth intervals for categorization of the seamounts should be guided by the biology break-out group, whose expertise is more appropriate in terms of understanding biodiversity and habitat variability with depth.

21. Participants discussed patterns of substrate as a potential factor in influencing biodiversity. Surveys from the contractors indicated that sediment composition and characteristics of CFC influence fauna distribution on the seamounts.

22. Participants noted that occurrences of nodules in the vicinity of the Suda Seamount appear to be associated with a large-scale paleo debris avalanche deposit, which is thought to have provided nucleus material for nodule growth, and thus contributed to high nodule concentrations locally (Li et al. 2021). The

results indicate a possible link between seamount sector collapse and manganese nodule occurrence in the abyssal plains in the NWP Ocean.

23. It was noted that there is significant evidence from literature globally that PMNs typically occur between depths of 4,000m and 6,000m on the abyssal plains (associated with low sedimentation rates, moderately high oxygen levels, and other environmental factors) with no relationship to debris aprons adjacent to seamounts. Therefore, participants emphasized the importance of considering ABMTs in the abyssal plains, away from seamounts, to protect nodule habitats in these areas.

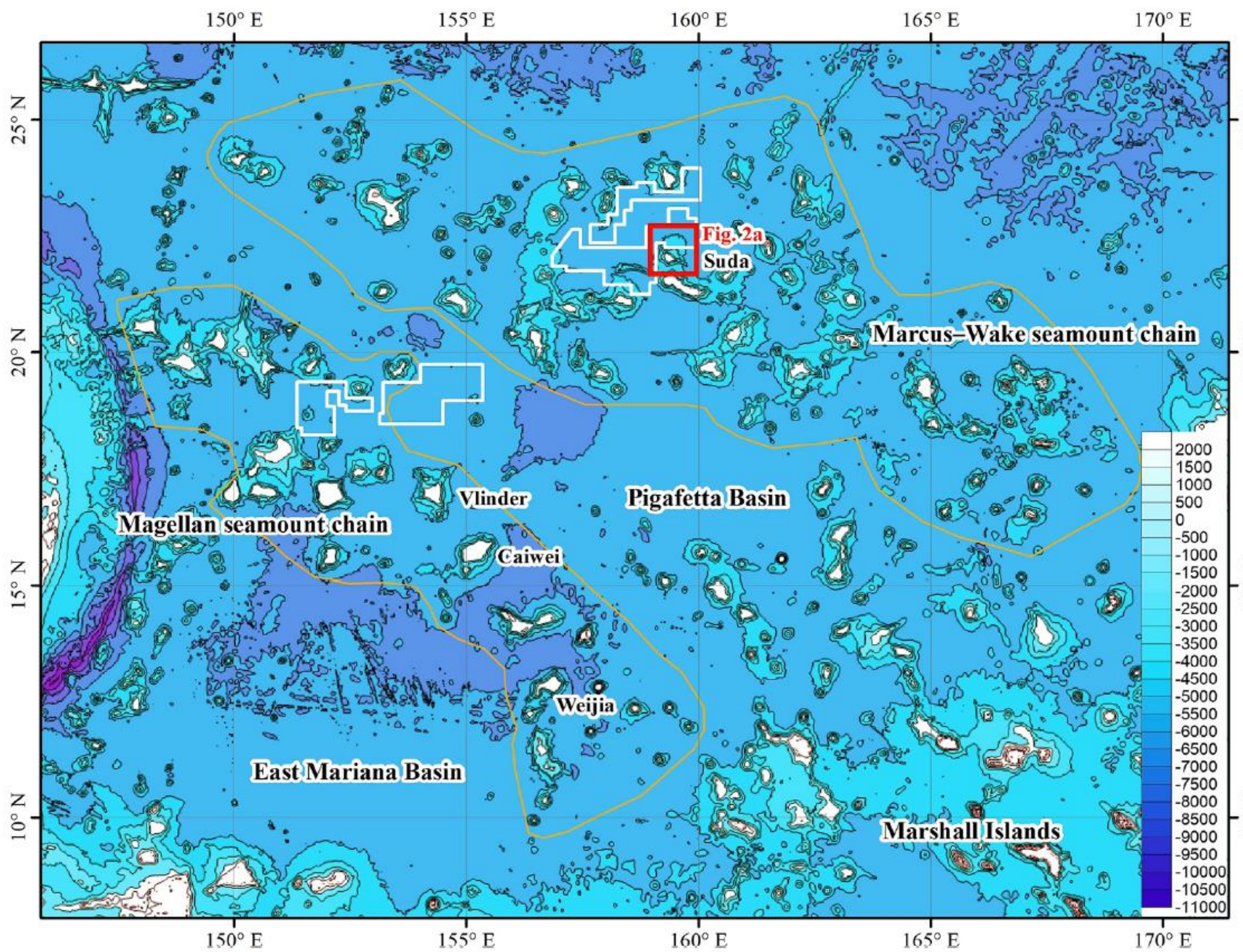

Figure 2. Bathymetric map of the NWP showing the location of the Suda seamount (map from Li et al. 2021).

C. Summary of break-out discussion relating to the biological and oceanographical aspects of the marine environment for the Area of the NPW Ocean

1) Environmental proxy and representativity

24. Participants discussed potential environmental drivers of seamount biodiversity, and regional patterns of such drivers. Analyzing the spatial and temporal patterns of such environmental drivers is important for understanding patterns of biodiversity and habitat variability at the regional scale. This understanding is important for applying the representativity criterion in the identification of the ABMT network.

25. Data constraints in the region are due to a relatively small sample size for most variables and a lack of sampling efforts outside the contract areas. While contractor representatives presented the data available in their respective contract areas, most of these data cannot be used to support an analysis at the regional scale.

26. It was noted that there is a north-south gradient in productivity in the region, and the movement of POC and nutrients can also be influenced by storms and currents over space and time. The importance of thermocline and halocline, euphotic zone, bottom currents, gyres, and upwelling was noted, which influence the level of nutrients and abundance and diversity of fauna on the seamounts and in the water column.

27. The substrate type and characteristics of CFC on seamounts also influence faunal communities. However, it is difficult to analyze regional patterns of such environmental drivers based on the data available, which are limited to a few locations within individual contract areas.

28. There is a correlation between the vertical profile of oxygen concentration and oxygen minimum zone (OMZ) and the development of CFC, since the geochemical composition of the seawater influences the formation of substrata on the seamounts. Further, topography on the seabed could drive variability in the OMZ, the depth of which varies among the different contract areas. For example, the OMZ occurs at a depth between 400m to 2200m in the MNRE contract area, compared to 1200m – 2400m in the COMRA contract area. A high level of variability has also been observed for the Carbon Compensation Depth.

29. There was a consensus to use the depth of seamount summits as a proxy for biodiversity, for which regional patterns can be derived using available datasets. In general, the summit and upper slope areas of a seamount are considered the most important areas in terms of biodiversity richness and abundance. Seamounts in the region have summits at different depths, which may present an ecologically meaningful way to categorize seamount biodiversity. However, there was no resolution to a discussion around whether certain depth ranges could represent major types of faunal communities. Breaks or gradients of faunal composition appeared inconsistent between seamounts and contractor areas, and so a uniform depth bin approach was taken. Hence the biological significance of certain depths is uncertain.

30. There are other variables that can influence biodiversity and habitat variability, such as sediment types, however, participants agreed as a compromise to focus on the depth of summits and geomorphology of seamounts as proxies for seamount biodiversity.

2) Seamount classification

31. Participants agreed on using the seamount classification system as described in the above paragraphs 18-19.

32. Discussions also occurred on defining the appropriate depth zones to categorize seamounts. As described in paragraph 29, definitive depth boundaries were not agreed. However, it was felt more consideration should be given to seamounts with summits shallower than 2000m from the surface, as most CFC contract areas are located on the top of such shallow seamounts. Given that depth may have a stronger influence on biodiversity in shallow seamounts compared with deeper seamounts (where environmental conditions associated with epipelagic and bathyal zones are more variable), participants agreed to divide depth zones at 500m intervals for seamounts with summits shallower than 3000m, and then every1000m for seamounts with summits at a greater depth.

33. There was consideration of trying to classify seamounts based on characteristics such as summit shape, morphology, sediment type, edge, slope, hill, and bottom of seamounts. Participants decided to focus on the summits and upper slopes, which are usually characterized by a higher level of biodiversity and physical and hydrodynamic variability. Participants also noted the role of water masses driven by the singular seamount, especially on the upper part of the seamount.

34. Flat-topped small seamounts, as well as guyots, can have sediments on the top, therefore hosting different types of biodiversity. Sediment composition will need to be considered in the future. In addition, the area of summits, steepness of slopes, and natural events such as slides and slumps, are factors that can affect biodiversity.

35. It was noted that there were 9 seamounts with summits shallower than 500m. This region is highly oligotrophic and shallow seamounts may therefore be more influenced by primary productivity and consequently have different species distribution/abundance, as well as being fisheries hot spots.

Seamounts as a functional unit: connectivity within and among seamounts, viability and replication

36. Participants agreed to consider a whole seamount as a functional unit. Preferably, ABMTs should not be designed in a way that covers only part of a seamount.

37. There was also a discussion on how to define a single seamount. Some seamounts are close to each other and have multiple summits, and there should be consideration on how to group them from an ecological perspective. However, there is no data available to justify how seamounts should be grouped into clusters apart from proximity and depth.

38. Connectivity may exist between different seamounts or within a single seamount. Potentially ABMTs can be set up within a seamount, to help maintain self-recruitment within a seamount. However there is limited data available on connectivity at the regional scale.

39. Isolated seamounts may play an important ecological role, in view of maintaining self-sustaining ecological units. Hence, the number of individual seamounts is important as well as the total area of seamounts in assessing the replication criterion in the design of the ABMT network.

Buffer zones around APEIs

40. Participants noted that the size of ABMTs in abyssal plain areas identified during the 2020 workshop was 200km x 200km. This was based on the core sustainability/dispersal distance used in the derivation of the APEIs in the CCZ. However, this size does not include a buffer zone which expanded the size of APEIs in the CCZ to 400km x 400 km.

41. There was also a discussion about the distance for plume dispersal resulting from PMN mining. The buffer zone of 100 km, as in the case of the CCZ EMP, was an interpretation of experiments conducted in the 1990s. Recent evidence based on models developed by the contractors indicates that the extent and impacts of plume might be more limited than previously thought.

42. With regards to the impacts from CFC mining, tests showed that plume dispersion for CFC was confined to a small distance around 1km. The crust particles are very heavy, hence limited dispersion and mostly deposition is to be expected. However, the dispersal range of fine sediments and particles is uncertain.

43. Currents in this area are influenced by the presence of seamounts, which may need to be considered when modelling and experimenting with plume impacts.

D. Spatial analyses

44. Based on the break-out group discussions, a number of spatial analyses were conducted to 1) assess the representativity, adequacy and replication of the potential ABMTs identified during the 2020 workshop; and 2) identify habitats containing PMN outside the contract and reserved areas.

Analyses on seamounts

45. To better understand the different categories of seamounts that are included in CFC contract areas and potential ABMTs, the technical team categorized seamounts using the Harris et al. 2014 geomorphology to define seamounts in the workshop boundary as guyots, ridged seamounts, or conical seamounts. The seamount layer used was the narrow aggregation seamount layer derived from the Benthic Terrain Modeler (BTM) during the 2020 online workshop. The narrow aggregation includes only the crest and upper slope terrain forms from the BTM analysis results (see the workshop report for more information).

46. For each seamount within the workshop boundary, they were classified first as guyot if they overlapped with the guyot layer from Harris et al. 2014, then as ridges as per Harris et al. 2014, and any remaining seamounts were classified as conical seamounts. During a review with workshop participants, it was determined that the Govorov seamount (see Figure 3) needed to be changed from a ridged seamount to a guyot.

Table 1. The total count for each of the seamount classifications for seamounts within the workshop extent.

Seamount Type	Count
Guyot	25
Ridged Seamount	45

Conical Seamount | 135

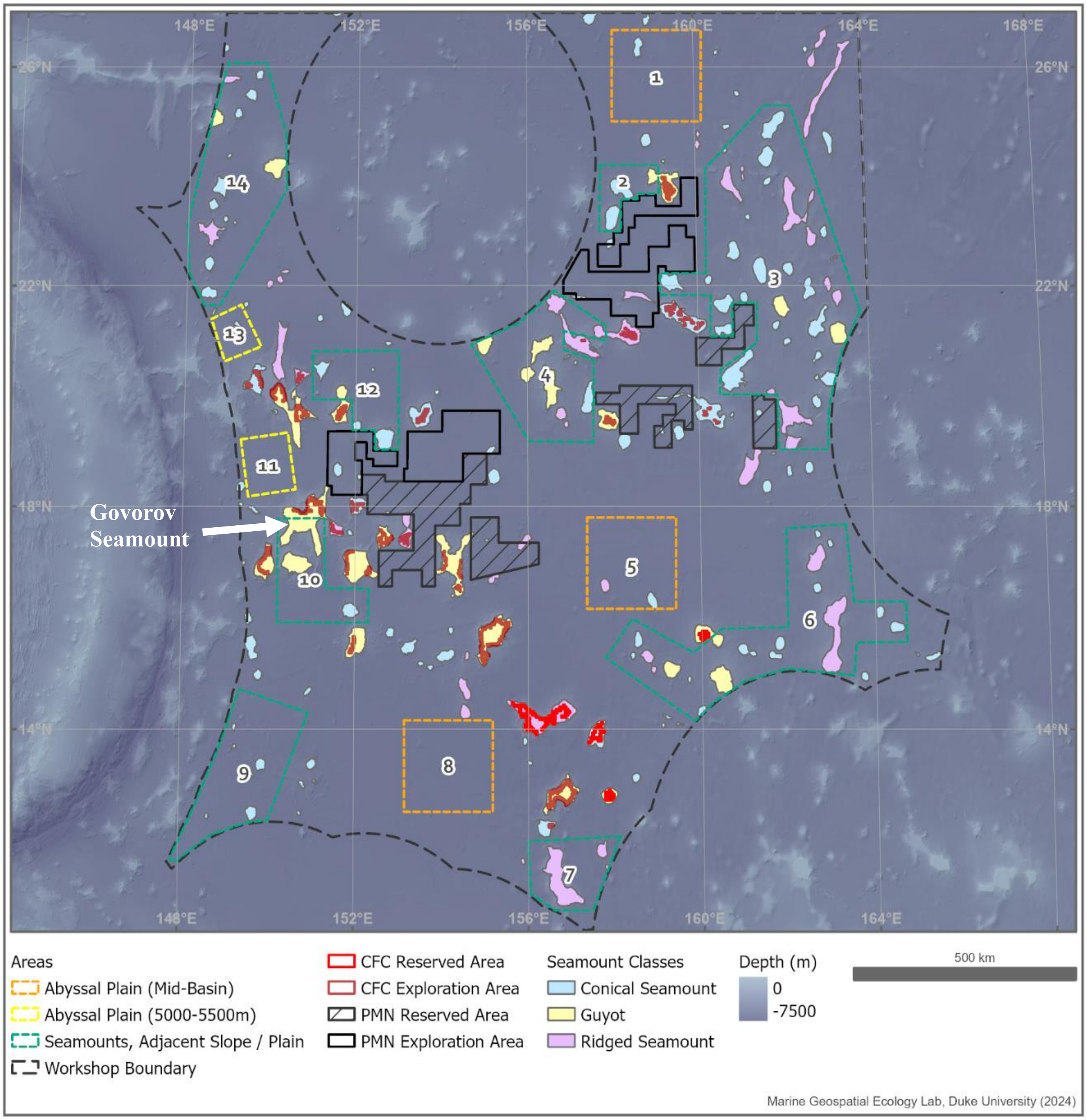

Figure 3. The seamount classes within the workshop boundary based on Harris et al. 2014, shown together with the potential ABMTs identified in the 2020 workshop.

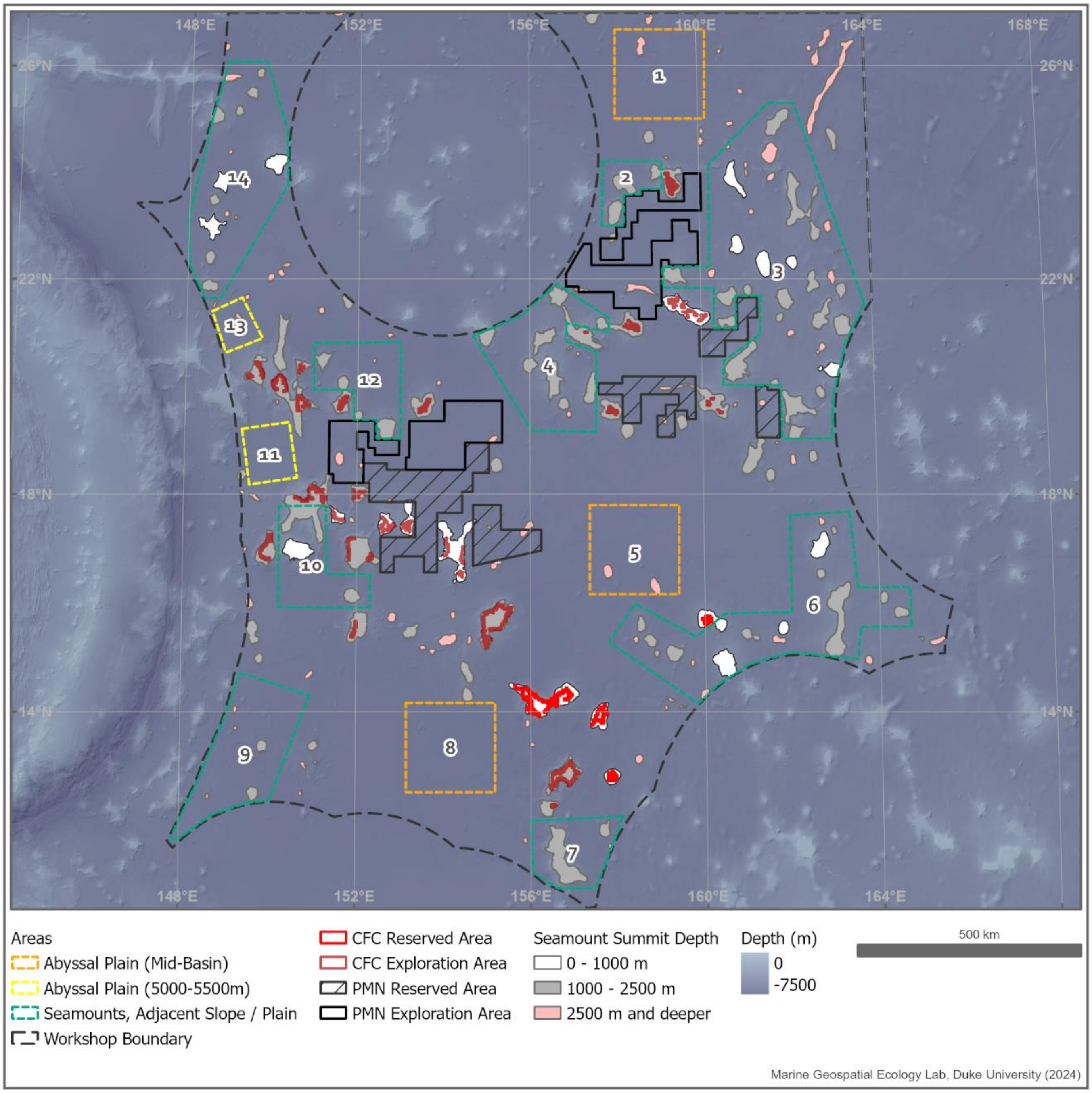

Figure 4.The summit depth of seamounts within the workshop extent.

1) Analyses for abyssal plain areas

47. The technical team was asked to help the workshop participants review the representativity of nodule-containing areas within the potential ABMTs. The technical team performed a simple analysis to summarize several datasets inside the existing nodule contract areas and then map where these same data values occurred elsewhere in the workshop boundary. The environmental variables used for this analysis included:

- proximity to seamounts – derived from BTM seamounts from the 2020 workshop
- depth – General Bathymetric Chart of the Oceans (GEBCO) 2023 database
- slope – derived from General Bathymetric Chart of the Oceans (GEBCO) 2023 database
- dissolved oxygen at the seafloor – Seiter et al. 2005 (same dataset as in Dutkiewicz et al. 2020)

48. Several dataset analysis options were explored by the technical team between workshop sessions. These options were presented to the workshop participants and a final approach was established from this review. These options included:

- From which zones should data be collected to summarize environmental characteristics?
  - **Only PMN contract areas**
  - Both PMN contract and reserve areas combined
- Which method should be used to calculate proximity to seamounts?
  - **Kernel Density Estimate (KDE)**
  - Focal Statistics: seamount count
- What summary statistics should be used?
  - Mean +/- 1 standard deviation
  - **Min/Max**

49. The workshop agreed to not use the slope variable as it was felt not to be useful in deriving a similarity index. So the final approach involved using statistics from the nodule contract areas only, using the min/max statistics, and using the KDE seamount proximity approach. The following table describes the values extracted from the PMN contract areas and used in the subsequent similarity analysis.

Table 2.Summary statistics for environmental characteristics inside PMN contract areas

	Mean	Standard Deviation	Minimum	Maximum
Seamount KDE	0.000083	0.000024	**0.000045**	**0.000146**
Depth (m)	-5394.9	313.9	**-5924**	**-2961**
Dissolved Oxygen (mmol/m^3)	176.8	2.8	**163**	**181**

50. With these Min/Max values a simple data classification was performed to classify each dataset into a binary (1/0) dataset. These three binary datasets were then added together to produce a simple similarity

index. This new index represented the number of dataset values that a given location had in common with the nodule contract areas (from 0 to 3). A value of 0 meant that a given pixel had values outside of the nodule contract area min/max envelope for all 3 datasets. A value of 3 means that a given pixel had values inside of the PMN contract area min/max envelope for all 3 datasets.

51. The following map shows that most of the nodule observations are found in areas that are similar to the existing PMN contract areas across these three datasets.

52. Given the time-bound constraints of the workshop, a complete evaluation of the nodule contract area similarity index could not be performed. However, a presence/absence dataset of published nodule observations in this region was compiled by workshop participants. The nodule presence/absence points were collated from the following sources:

- Deng et al. 2022
- Dutkiewicz et al. 2020
- Li et al. 2021
- Rem et al. 2022
- Yang et al. 2020
- Yang et al. 2023

53. It should be noted that there was no consensus in using proximity to seamount as a proxy for PMN occurrences, due to a lack of supporting evidence as summarized in the above paragraphs 22 and 23. There is evidence indicating the association of depth and dissolved oxygen with PMN occurrence.

2) *Analyses on the coverage of the ABMT network*

54. The technical team performed a simple analysis on the coverage of different depth zones in the potential ABMTs as identified in the 2020 workshop, based on the revised depth zonation as summarized in the above paragraph 32. The results are summarized in Table 3 below.

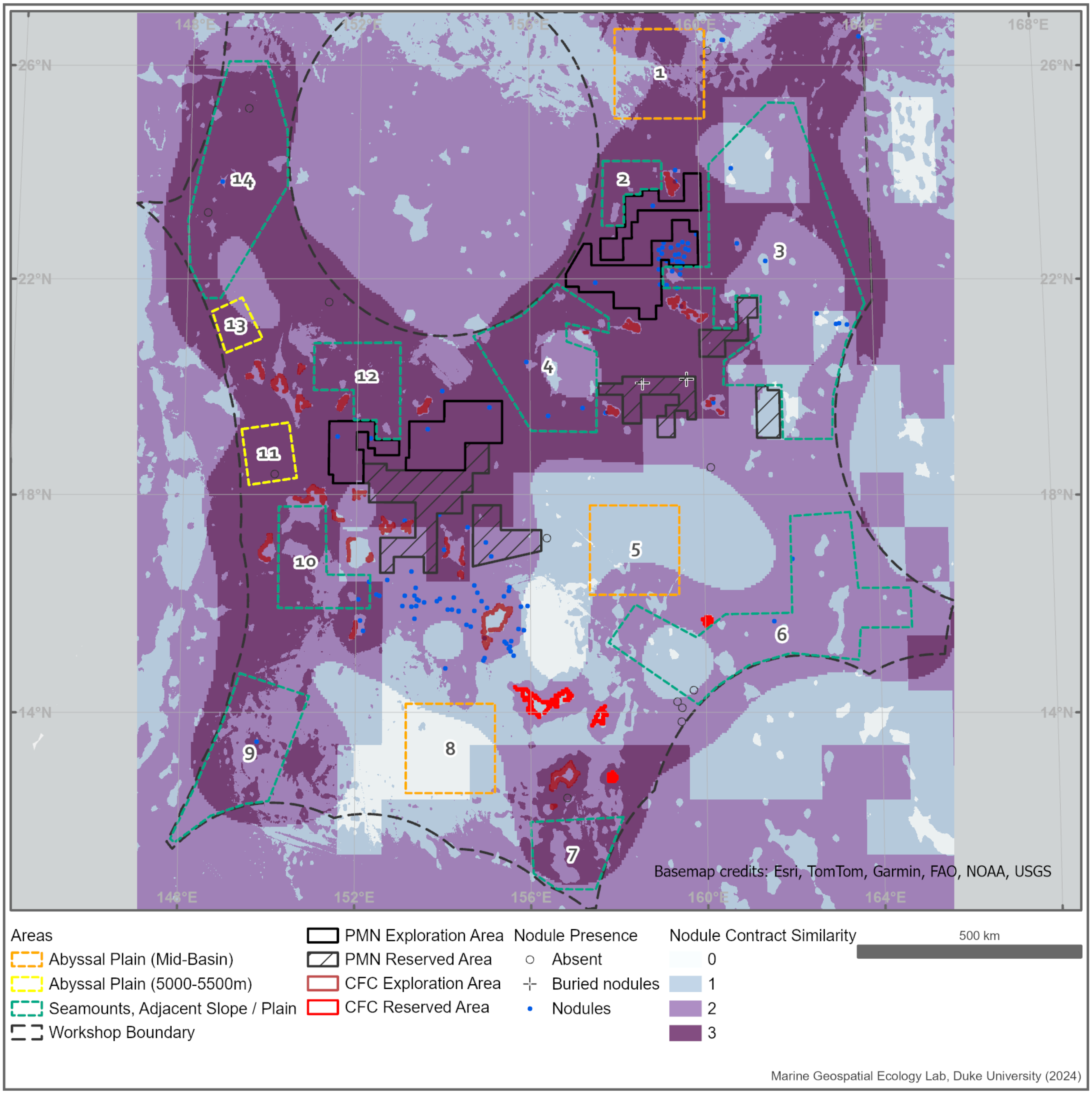

Figure 5. Map displaying occurrences of PMN (blue dots) in NWP Ocean and the degree of similarity to PMN contract areas. PMN occurrences are those documented in the publications as listed under paragraph 52. The degree of similarity to PMN contract areas is calculated based on distance to seamounts, depth and dissolved oxygen level. White areas indicate minimum similarity compared with such characteristics in PMN contract areas, grey and light purple indicate low and medium similarity

index and deep purple indicates areas with maximum similarity compared with such characteristics in PMN contract areas.

Table 3. The total area of each depth zone in the extent of the workshop, potential ABMTs, and the seamounts with CFC contract areas.

Depth Zone (m)	Depth Zone in Workshop Extent (km^2)	Depth Zone in potential ABMTs (km^2)	Percentage in potential ABMTs	Depth Zone on Seamounts with CFC contract areas (km^2)	Percentage of depth zone on Seamounts with CFC contract areas
0-500	774.6	457.7	59.1	316.9	40.9
500-1000	1295.1	561.0	43.3	734.1	56.7
1000-1500	17518.7	5709.4	32.6	11939.9	68.2
1500-2000	22208.7	10079.4	45.4	12914.9	58.2
2000-2500	21374.7	11574.0	54.1	9479.9	44.4
2500-3000	27029.9	13269.5	49.1	10470.7	38.7
3000-4000	88726.6	46068.6	51.9	20450.8	23.0
4000-5000	216848.5	110362.4	50.9	4380.8	2.0
5000-6000	1517528.1	459463.6	30.3	44.4	0.0
6000-7000	204303.4	52645.8	25.8	nan	nan

E. Comments on the potential ABMTs identified during the 2020 workshop

55. Participants also reviewed each of the potential ABMTs identified in the 2020 workshop, and the deliberations are summarized in the table below. It was noted that the identification of such areas differed among seamounts and abyssal plain habitats. For seamount habitats, the design of potential ABMTs is mainly driven by the network criteria, i.e., the need to capture ecologically important areas while ensuring representativity, replication, adequacy and connectivity at the regional scale. For abyssal plain habitats, the design of potential ABMTs is mainly driven by the need to capture habitats similar to those contained in

the PMN contract and reserved areas, in particular habitats with PMN occurrence, as well as the north-south productivity gradient.

56. In discussion of individual potential ABMTs different views were expressed on the issues of distances from the Exclusive Economic Zones (EEZs) and extended continental shelves, space between the potential ABMTs and the contract areas, the shape of the potential ABMTs, and whether or not to include part of a seamount in the potential ABMTs.

57. Participants again stated the preference for protecting whole seamount as a functional unit. It was clarified that the partial seamounts would only be considered if the ecological objectives would not be met by protecting only whole seamounts.

58. Where partial seamount protection is identified as ecologically valuable, there is a need to look at options for the protection of sensitive habitats or areas important for connectivity within or next to contract areas. These could include establishing small-scale ABMTs, or additional guidance to contractors in their EIA or relinquishment processes.

59. The need for and configuration of buffer zones and core zones around seamounts within the potential ABMTs was also discussed, along with smooth boundaries around some of the seamounts instead of straight lines, which should be based on fine scale bathymetry.

60. It was noted that the distance from the EEZs needs to be further considered in the next step of REMP development. It was also mentioned that potential impacts from mining within the EEZs may also need to be considered.

61. Some suggestions would lead to a large expansion of potential ABMTs, including some near the reserved areas. Participants discussed the need for balancing different aspects of the ISA mandate in designing the future APEI network.

62. The issue of connectivity between seamounts was often mentioned, and the anticlockwise circulation patterns on some seamounts were noted. The need for a regional scale oceanographical model was also mentioned, to guide this discussion.

63. It should be noted that due to time constraints, some mapping or analyses suggested by participants on potential adjustments to the potential ABMTs could not be completed during the workshop. It was decided that the above issues and the suggested adjustments to the potential ABMTs will be further examined by the LTC, to provide guidance on how such issues will be addressed in the next step of developing the REMP.

Table 4. Summary of discussions on the potential ABMTs identified during the 2020 workshop.

The numbering of the potential ABMTs is the same as shown in Figures 1-4.

Potential ABMT number	Comments and suggestions for adjustment
1	The area includes a deep seamount, and bears some similarity to nodule contract areas. Relatively higher impacts from climate change may be expected towards the northern part of this region, therefore protecting this potential ABMT may contribute to increased resilience against climate change.

5	This potential ABMT was identified based on north-south gradient of productivity. No comments were made on this potential ABMT.
8	This area was identified to cover the deep abyssal plain habitats. It seems to cover multiple habitat types, and there is a deep seamount to the north of this area. There was a suggestion to extend it northwards to capture more seamounts and potentially nodule habitats.
11	This area is close to the Mariana Trench, an important cultural heritage feature, and intended to protect abyssal plain habitats. The area also includes part of a seamount that extends into the Mariana Trench Marine National Monument.
13	This area is close to the Mariana Trench and includes abyssal plain habits and small seamounts. It was noted that the size of the ABMT was less than 200km by 200km. It was suggested that the area could be extended to the northeast to make it more rectangular in shape, so that more seamounts located in the north can be included. A suggestion was also made to consider merging this area with area #14. The seamounts next to the potential ABMT will be further examined.
2	It was noted that distances between this ABMT and the nearby PMN and CFC contract areas are between 2 to 9km. Based on the current understanding of technology, some impacts to this area would be expected if mining takes place in the nearby contract areas, hence there is a possible need for a buffer zone. The area also includes part of a seamount with CFC contract areas. Participants stated the preference for including a whole seamount in the ABMTs as a functional unit. The rational for including the partial seamount was that it presented similarity to the contract areas based on the seamount classification work done, , , which also highlighted the low coverage of this particular seamount class outside contract areas. It may play a role in connectivity given the direction of current flow from the east to west, although no data was available to verify connectivity patterns. Further analyses need to be carried out to fully understand how it affects representativity of any ABMT network if the partial seamount is not included. There was a suggestion to look at detailed bathymetry as the seamount to the north of the potential ABMT may represent similar morphology as the partial seamount in question.

14	This area is designed to capture environmental gradients from north to south and is located next to the Mariana Trench. Questions were raised on the potential impacts on fisheries in shallow seamounts in the potential ABMT. More information on the shallow seamount will be needed. There was a suggestion to merge this area with potential ABMT #13, and extend this area to the southeast.
12	This potential area includes a partial seamount. There was a suggestion to examine the bathymetry and morphology of the seamount to compare characteristics across the contract area and the potential ABMT.
10	It was noted that there were two shallow seamounts to the east, which may have ecological importance in terms of increased productivity and cascading effects to the deep waters.
9	This potential ABMT includes deeper seamounts and abyssal plain habitats. There was a suggestion to extend its scope to cover the seamount in the north, and possibly merge with nearby potential ABMTs.
7	There seemed to be consensus on this potential ABMT.
6	It was noted that the area includes multiple habitat types, including shallow seamounts similar to the CFC contract areas, and interstitial areas.
4	This area includes a variety of habitats, including seamounts and nodule habitats. Participants commented on the size and shape of the potential ABMT, and its distance from the nearby reserved area. There was also a discussion on the vertical spacing between this area and nearby PMN reserved area.
3	This area includes seamounts at different depths and with different geomorphology. Such seamounts may be stepping stones, or source of larvae to the seamounts to the west, although there is no data to verify this. It was also suggested to extend this area to cover the ridge seamount to the north.

References

Deng X, He G, Xu Y, Liu Y, Wang F, Zhang X (2022) Oxic bottom water dominates polymetallic nodule formation around the Caiwei Guyot, northwestern Pacific Ocean. Ore Geology Reviews 143:104776.

Dutkiewicz A, Judge A, Müller RD (2020) Environmental predictors of deep-sea polymetallic nodule occurrence in the global ocean. Geology 48:293–297.

Harris PT, Macmillan-Lawler M, Rupp J, Baker EK (2014) Geomorphology of the ocean. Marine Geology 352, 4-24.

Li Z, Li H, Hein JR, Dong Y, Wang M, Ren X, Wu Z, Li X, Chu F (2021) A possible link between seamount sector collapse and manganese nodule occurrence in the abyssal plains, NW Pacific Ocean. Ore Geology Reviews 138:104378.

Ren J, He G, Deng X, Deng X, Yang Y, Yao H, Yang S (2022) Metallogenesis of Co-rich ferromanganese nodules in the northwestern Pacific: Selective enrichment of metallic elements from seawater. Ore Geology Reviews 143:104778.

Seiter K, Hensen C, Zabel M (2005) Benthic carbon mineralization on a global scale. Global Biogeochemical Cycles 19.

Yang Y, He G, Ma J, Yu Z, Yao H, Deng X, Liu F, Wei Z (2020) Acoustic quantitative analysis of ferromanganese nodules and cobalt-rich crusts distribution areas using EM122 multibeam backscatter data from deep-sea basin to seamount in Western Pacific Ocean. Deep Sea Research Part I: Oceanographic Research Papers 161:103281.

Yang Q, Liu S, Jiang X, Liu G, Xia J (2023) Parameter matching of deep-sea polymetallic nodule collection device based on the Coanda effect. Ocean Eng, 41, 181–192.

Annex V

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

I. Introduction

1. Workshop participants considered the results of cumulative impact modeling for both benthic and pelagic ecosystems, the initial development of which was carried out during the 2020 workshop[16]. Participants were invited to validate the inputs to the models based on their knowledge and available scientific information.

2. Participants were divided into the following two groups for focused discussions, based on their expertise. Discussions focused on the list of pressures identified in the 2020 workshop as well as the importance of each of the pressures, alone and cumulatively.

- Seamount benthic ecosystem
- Pelagic and abyssal plain ecosystems

3. The discussion benefitted from a presentation by Mr. Piers Dunstan (CSIRO). The presentation provided an introduction to the broader management context for qualitative modelling, and the techniques and tools CSIRO have been developing to implement ecosystem-based management, including (i) the ecosystem based management cycle, (ii) key elements of the assessment process, (iii) qualitative mathematical modelling, (iv) exploitation pressures and cumulative impacts, (v) zones of influence, (vi) linking qualitative models to ecosystem complexes, and (vii) linking qualitative models to quantitative estimates of impact to key ecosystem indicator variables.

II. Results of group discussions

A. Seamount benthic ecosystem

4. There was a general consensus to maintain the structure of the models developed during the 2020 workshop, as they reflect the main ecosystem components and linkages among them. Following this, discussions focused on validating the list of pressures which were identified initially during the 2020 workshop. The results from the review of pressures were summarized in the tables below, and any updates suggested by workshop participants during this workshop are shown in blue text.

5. It was noted that the model is solely concerned with long-term effects. For example, crust removal will kill all the corals immediately, but if corals grow back, then there is no effect, according to the model.

6. Participants discussed and suggested modifications to the list of pressures and interactions as summarized in Table 1. Pressure effects associated with nutrients and abandoned equipment were suggested to be removed, as mining is not expected to affect nutrients levels, and equipment should not be left behind. Participants also suggested removing positive effects from ocean acidification, due to a lack of evidence.

16 See Annex IV, report of the workshop on the development of the REMP for the Area of the Northwest Pacific. Available at NWP_REMP_workshop_report.pdf

7. There was also a suggestion to include additional pressures. Subterranean flow may alter temperature, nutrients and upwelling at seamounts which are not targeted for mining. Such pressures could be combined with others.

8. Pressures P1-8 are associated with future mining activities, and other pressures are associated with other natural or anthropogenic changes not related to mining.

B. Pelagic and abyssal plain ecosystems

9. Participants suggested adding the following interactions to the ecosystem model:

- Interaction between phytoplankton and cetaceans, as cetacean feces may provide nutrients and organic materials which may enhance the growth of phytoplankton.
- Interaction between microbes and particular organic matter (POM).

Table 5. Suggested modifications to the description of potential pressures and their effects from natural and anthropogenic activities on benthic seamount ecosystems of the NWP region as identified during the 2020 workshop.

Pressure	Pressure effect	Suggested modifications to the description of the pressure and its effects on ecosystem components as identified during the 2020 workshop
Plume removal – Suspended sediment	negative	It was suggested adding the following to the direct effect: This pressure may also lead to dilution of food resources available for deposit feeders
Noise	negative	It was suggested adding the following to the direct effect: • Negative impacts on larval recruitment of corals. • Invertebrate deposit feeders may be negatively impacted due to hindered feeding behaviour and predation avoidance
Electromagnetism	negative	It was suggested that this pressure can be possibly combined with other pressures.
Light	positive	It was suggested adding the positive effect of light, as predators may be able to better identify prey
Toxicants	negative	It was suggested that any other species can be added to the components (all types of corals, sponges)
Nutrients		It was suggested that nutrients should be removed from the model as this would not be generated during future mining activities.
Abandoned equipment	negative & positive	It was suggested that this pressure be removed from the model as equipment should not be left behind.

Pressure	Pressure effect	Suggested modifications to the description of the pressure and its effects on ecosystem components as identified during the 2020 workshop
Ocean acidification	negative	In addition to the effects already identified during the 2020 workshop, it was suggested adding negative impacts on fish and invertebrates, as well as zooplankton and recruitment[17]
Ocean acidification	positive	It was suggested that the positive effects from this pressure be removed from the model, as there is no supporting evidence.
Ocean deoxy-genation	negative	In addition to the effects already identified during the 2020 workshop, this pressure will likely affect all animals to various degrees[18]
Temperature rise	negative	In addition to the negative effects already identified during the 2020 workshop, this pressure will likely affect all animals to various degrees This discussion needs to take into consideration the time frame during which a REMP will be in place, and the degree of temperature rise within this time frame.
Fisheries	negative	Participants noted the expectation that fish biomass would increase over the next several decades, which may lead to decreased fishing effort and lower impacts from fishing. Fishing days could be used as a more accurate pressure instead of fisheries. There were also questions about the impacts of ghost fishing on benthopelagic fish, given the lack of evidence in this region.

17 Kroeker, K.J., Kordas, R.L., Crim, R., Hendriks, I.E., Ramajo, L., Singh, G.S., Duarte, C.M., Gattuso, J-P. (2013) Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming. Glob. Chang. Biol. 19, 1884–1896.

18 Schmidtko, S., Stramma, L., Visbeck, M. (2017). Decline in global oceanic oxygen content during the past five decades. Nature, 542(7641), 335-339.

Kawahata, H., Fujita, K., Iguchi, A., Inoue, M., Iwasaki, S., Kuroyanagi, A., Maeda, A., Manaka, T., Moriya, K., Takagi, H., Toyofuku, T., Yoshimura, T., Suzuki, A. (2019) Perspective on the response of marine calcifiers to global warming and ocean acidification-Behavior of corals and foraminifera in a high CO2 world hot house. Progress in Earth and Planetary Science, 6, 1-37. doi:10.1186/s40645-018-0239-9 (17 Jan 2019)

Table 6. Suggested modifications to the description of potential pressures and their effects from natural and anthropogenic activities on pelagic and abyssal plain ecosystems of the NWP region as identified in the 2020 workshop.

Pressure	Pressure effect	Suggested modifications to the description of the pressure and its effects on ecosystem components as identified during the 2020
Slurry layer, defined as the material (liquified sediment) which remains after the nodule uptake	negative	In addition to the ecosystem components already identified during the 2020 workshop, it was suggested adding demersal fishes & invertebrates as they may also be negatively affected by this pressure
Mining plume (seabed)	negative	In addition to the ecosystem components already identified during the 2020 workshop, it was suggested adding microbial communities as they may also be negatively affected by this pressure
Return plume	negative	It was mentioned that as a mitigation measure, the return water may be discharged close to the seafloor, significantly reducing the impacts in the mid water.
Noise from mining vehicle at the mine site	negative	It was suggested that this pressure can be expressed as an energy input, with noise and vibration combined as a single source.
Noise from surface vessel	negative	In addition to the ecosystem components already identified during the 2020 workshop, it was suggested adding fish and zooplankton as they may also be negatively affected by this pressure. There is uncertainty regarding the size.
Noise from pumps on riser pipes in SOFAR (sound-fixing- and-ranging) layer	negative	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[19]
Light from surface vessel may affect plankton	positive	In addition to the ecosystem components already identified during the 2020 workshop, it was suggested adding birds as they may also be negatively affected.
Nutrients enrichment	positive	It was suggested adding oxygen enrichment to this pressure

[19] Drazen, J. C., Leitner, A. B., Morningstar, S., Marcon, Y., Greinert, J., Purser, A. (2019) Observations of deepsea fishes and mobile scavengers from the abyssal DISCOL experimental mining area. Biogeosciences, 16(16), 3133-3146.