OCEAN MINERALS

MOANA MINERALS

AN OCEAN MINERALS GROUP COMPANY

Cook Islands Exploration License Application

Environmental Management Plan

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1 OBJECTIVES OF OCEAN MINERALS' ENVIRONMENTAL MANAGEMENT PROGRAM

The Ocean Minerals Group of companies (OM) is comprised of US registered parent company Ocean Minerals, LLC (OML) and wholly owned subsidiary companies including US registered OML Rare Earth, LLC and Cook Islands registered Moana Minerals Limited (Moana). For practical purposes, all funding, management, and operational activities are performed by OML personnel under intercompany agreements. Parties to contracts with contractors and consultants will be at subsidiary level whenever practical, and as such meet the requirements for local content and spending. For purposes of the application, when OM is referenced, it could imply either OML or Moana Minerals, or both.

Moana Minerals' specific Work Plan is described in document ***NPPLN-00000-EXWRK-00 Exploration Work Program*** and the key elements of the environmental aspects of the work plan are summarized herein. The plan will draw on the lessons that the team has learned through decades of experience in the deep-sea mining sector, our exposure to activities in the CCZ and our appreciation for the factors that are unique and specific to the Cook Islands.

OM recognizes the importance of good corporate stewardship to the successful implementation of seabed minerals exploration and mining. The appreciation of the cultural connections that Cook Islanders have with the ocean is a key aspect of the social dimension of the EMP and related Local Engagement, Training and Business Development Plan. This EMP recognizes the traditional and 'modern religious' aspects of the cultural environment and the direct link between these aspects and the Marae Moana Act (2017), a modern legislative instrument that is underpinned by indigenous approaches of '*rā'ui*' – a traditional form of natural resource management – and that was instituted with strong bipartisan support and in collaboration with the House of Ariki.

OM's strategy to establish the environmental studies within an over-arching Environmental and Social Impact Assessment (ESIA) framework that includes a robust engagement and consultation plan reflects our understanding of the importance of social and cultural dimensions to environmental management.

The general objectives of the exploration Environmental Management Program (EMP) are to:

- Operationalize OM's Environmental Policy and international best environmental practice.
- Fulfil OM's regulatory obligations.
- Avoid Serious Harm in exploration.
- Adopt a Precautionary Approach.
- Provide a structure for administration, environmental monitoring and reporting of the environmental work plan and a basis for adaptive management.
- Harmonize geological resource exploration with environmental baseline data collection.
- Embed environmental studies in the exploration program within an Environmental and

Social Impact Assessment (ESIA) framework so that OM can pivot from exploration to environmental permitting of exploitation.

- Initiate environmental studies that are on the critical path to exploitation permitting and financing, particularly those that require long temporal baselines.
- Embed environmental studies within an Ecosystem-based Management framework.
- Target studies to generate information required for the environmental management of deep-sea mining, while also connecting with broader knowledge generation in the Cook Islands and marine scientific research opportunities.
- Provide a platform for best available scientific knowledge for use in evidence-based decision making.
- Provide a platform for capacity building, education and stakeholder consultation.
- Provide transparency in communicating environmental data and information to Cook Islands and international stakeholders.
- Be part of an emerging Best Practice in Cook Islands seabed minerals exploration and collaborate with the SBMA and other agencies to meet Sustainable Development Plans and Seabed Minerals Policy.

2 DEFINITIONS, ABBREVIATIONS AND ACRONYMS

Field	Description or Definition
µm	Micron
AABW	Antarctic Bottom Water
AUV	Autonomous Underwater Vehicle
CBD	Commission on BioDiversity
CCZ	Clarion Clipperton Zone
CEO	Chief Executive Officer
CI	Cook Islands
CIEEZ	Cook Islands Economic Exclusion Zone
EBSA	Ecological and Biological Sensitive Area
EEZ	Economic Exclusion Zone
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
EU	European Union
EWP	Exploration Work Plan
FAD	Fisheries Aggregating Device
FFG	Free Fall Grab
GHG	Greenhouse Gas
IRMP	Incident Response Management Plan
ISA	International Seabed Authority
ISA	International Seabed Authority
km	Kilometer
LAT	Average Low water Mark
m	Meter(s)
MARPOL	The International Convention for the Prevention of Pollution from Ships
Moana	Moana Minerals Limited
NES	National Environmental Service
NGO	Non-Governmental Organization

nM	Nautical Mile
OM	Ocean Minerals Group comprised of Ocean Minerals LLC, and Moana Minerals Limited
OML	Ocean Minerals LLC
POC	particulate organic carbon
ROV	Remote Operated Vehicle
SBMA	Seabed Minerals Authority
SEC	South Equatorial Current
SMS	Submerged Massive Sulphide
SOP	Standard Operating Procedure
SOPAC	South Pacific Applied Geoscience Commission
SPB	South Penrhyn Basin
UNESCO	United Nations Educational, Scientific and Cultural Organization

3 POLICIES, LEGISLATION, GUIDELINES AND TREATIES

3.1 OM Environmental Policy

3.1.1 Overview

OM is committed to causing no serious environmental harm in any of our operations and mitigating direct and indirect environmental impacts across our business. OM will apply international best practice in environmental sustainability and strive for excellent performance in environmental management.

3.1.2 Scope

This policy applies to all OM employees and contractors in all of our land-based and offshore operations.

3.1.3 Principles

OM will:

- Comply with the environmental laws and regulations of the jurisdictions in which we operate.
- Develop an ecosystem-based environmental management framework that centralizes our environmental knowledge base, identifies project environmental risks, prioritizes environmental studies, and operationalizes this policy in Environmental Impact Assessments.
- Respect traditional knowledge and customary practices of environmental management and incorporate these cultural environmental aspects into our environmental management framework.
- Apply the Precautionary Principle where appropriate in our operations.
- Recognize the significant potential for deep-sea mining to contribute to economic development in our areas of operation and the responsibility to adhere to global and jurisdictional Sustainable Development Goals and Policies.
- Develop and nurture a culture of environmental management across the company and implement programs of employee awareness, energy and emissions reduction and sustainable supply chains.
- Foster a culture of corporate environmental stewardship and collaboration among regulators, stakeholders and research partners and install an adaptive management approach to continually improve environmental performance.
- Apply best available scientific and technological approaches to environmental management.

3.1.4 Breaches

OML recognizes that breaches of this policy at the level of the individual employee to business units has the potential to cause economic, social, and ecological impacts. All suspected breaches will be investigated, and appropriate disciplinary and remedial action taken.

3.1.5 Policy Interaction

This policy links with:

- Environmental, Community, Occupational Health and Safety Policy
- Risk Management Plan
- Quality and Best Practice as defined in the Environmental Data and Sample Quality Assurance processes of the Exploration Program (see Section 5.1).

3.2 Cook Islands Legislation, Policies and Guidelines

The key legislation, policies, guidelines, and programs in place for the Cook Islands are listed in Table 1.

Table 1 - Cook Islands legislation, policies, guidelines, and programs

Instrument	Description	Responsible Department/Agency
Legislation		
Seabed Minerals Bill (2019), Seabed Minerals Amendment Act (2020), Seabed Minerals (Exploration) Regulations (2020), Environment (Seabed Minerals Activities) Regulations (2020)	Sets out the governance requirements for the licensing of exploration and exploitation activities. Upholds the requirements of the Environment Act (2003) and establishes compliance requirements.	Seabed Minerals Authority, Seabed Minerals Commissioner, Seabed Minerals Advisory Board
Cook Islands Environment Act (2003)	Core legislation under which an ESIA will be completed and which controls the permitting of activities that have the potential to cause significant environmental harm.	The Cook Islands National Environment Service
Marae Moana Act (2017)	Requires that the Cook Islands EEZ area be managed for the primary purpose of protecting and conserving the ecological, biodiversity and heritage values of the Cook Islands marine environment. Founded on the traditional principals of '*rā'ui*' – a form of traditional spatial	Marae Moana Council, Marae Moana Technical Advisory Group, and other agencies

	management applied in ancestral society. Allows for seabed mining.	
Marine Resources Act (2005)	Establishes the entire Cook Islands EEZ as a whale sanctuary and a shark sanctuary. This declaration provisions for the protection of whale and shark species against commercial exploitation and the management of tourism, fisheries and scientific research and other activities that have the potential to intentionally or inadvertently interact with these species.	Ministry of Marine Resources
Cook Islands Natural Heritage Trust Act (1999)	Establishes a Cook Islands Natural Heritage Trust with the necessary resources and powers to investigate, identify, research, study, classify, record, issue, preserve and arrange publications, exhibitions, displays and generally educate the public on the science of, and traditional practices and knowledge relating to, the flora and fauna of the Cook Islands.	
Prevention of Marine Pollution Act (1998)	An act to provide for the prevention of marine pollution, the dumping and transportation of other waste in Cook Islands Waters by vessels and to give effect to various international conventions on marine pollution and protection of the marine environment.	Ministry of Transport
Maritime Transport Act (2008)	Provide for the maritime safety of the Cook Islands and Cook Islands vessels and protect the marine environment.	Ministry of Transport
Maritime Zones Act (2018)	Declares the territorial sea (LAT to 12 nM), contiguous zone (LAT to 24 nM), exclusive economic zone (LAT to 200 nM), and continental shelf of the Cook Islands as the maritime zones of the Cook Islands. Declares, and expresses the rights of the Cook Islands and other States in relation to, the maritime zones of the Cook Islands consistently with international law. Repeals with Continental Shelf Act (1964) and the Territorial Sea and	All

	Exclusive Economic Zone Act (1977).	
Traditional Knowledge Act (2013)	Gives legal recognition to and protection of the rights in the traditional knowledge of the traditional communities of the Cook Islands (e.g. traditional canoe carving, traditional conservation practice, fishing practice, etc.)	Ministry of Cultural Development
Policy		
National Seabed Minerals Policy (2014)	Sets out the Government's sustainable management and regulation of seabed minerals.	Seabed Minerals Authority
Te Tarai Vaka (Cook Islands Environmental and Social Safeguards Policy)	Sets out the Government's objectives for environmental and social safeguards for the Cook Islands.	Central Policy and Planning Office of the Office of the Prime Minister, Ministry of Finance and Economic Management
Guidelines		
Te Tarai Vaka (Cook Islands Environmental and Social Safeguards Guideline)	Guidance for environmental and social safeguards for the development seabed mining in Cook Islands.	Central Policy and Planning Office of the Office of the Prime Minister, Ministry of Finance and Economic Management
Te Kaveinga Nui (Cook Islands National Sustainable Development Plan 2016-2020)	Sets out Cook Islands sustainable development goals.	Central Policy and Planning Office of the Office of the Prime Minister, Ministry of Finance and Economic Management

The Cook Islands Marae Moana Act (2017) establishes the entire EEZ as an area to be managed for the primary purpose of protecting and conserving the ecological, biodiversity and heritage values of the Cook Islands marine environment. Marae Moana is somewhat unique in that it considers the whole EEZ as a connected ecosystem that is 'protected', while also identifying areas within the EEZ where industry can be allowed. As such, Marae Moana is considered an overarching ocean management framework, within which deep-sea mining is identified as an allowed, spatially defined activity. The Marae Moana Act (2017) also establishes formal marine protected areas of 50 nM around each land mass, where commercial activities are prohibited. OM's Application Area is outside the 50 nM protected areas. Marae Moana is underpinned by indigenous approaches of 'rā'ui' – a traditional form of natural resource management that prevented access to certain areas or during certain times – which is reflected in modern marine spatial management and ecosystem-based management.

Marae Moana has strong bilateral government support and strong support from the community. The Act is administered by the Marae Moana Council that is chaired by the Prime Minister and comprises the opposition lead, a religious leader, a representative of the finance ministry and community leaders. The Act was established in consultation with the House of Ariki: the 'house' of chiefs. The Seabed Minerals Amendment Act (2020) upholds the requirements of the Marae Moana Act (2017) and in practice, a deep-sea mining application received by the Seabed Minerals Authority would be assessed against the nine Marae Moana principles of ecologically sustainable use (Table 2).

Table 2 - Principles of the Marae Moana Act (2017) against which seabed mining applications will be assessed.

Principle	Description
1. Principle of protection, conservation, and restoration	the principle of protection, conservation, and restoration is that the areas within the marae moana should be— (i) protected, and their biodiversity conserved, for their cultural and natural heritage value; and (ii) shared by all Cook Islanders:
2. Principle of sustainable use to maximize benefits	the principle of sustainable use to maximise benefits is that the marine resources should be used to maximise benefits, while meeting key environmental objectives to benefit current and future generations of Cook Islanders:
3. Precautionary principle	the precautionary principle is that the precautionary principle of the Rio Declaration should be applied where there are threats of serious or irreversible damage, and that a lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation in accordance with the Cook Islands' capabilities in the implementation of the marae moana:
4. Principle of community participation	the principle of community participation is that all stakeholders should participate in the planning and implementation processes, which means that information exchange, consultation, respect for differing points of view, recognition of culture and traditions, equitable access to opportunities for present and future generations, easily understood and openly justified processes, and the shared ownership of responsibility should be promoted and encouraged in the decision-making processes of the marae moana:
5. Principle of transparency and accountability	the principle of transparency and accountability is that the processes for assessing, planning, allocating, managing, and evaluating management of ocean resources should provide transparent and clear lines of accountability:
6. Principle of integrated management	the principle of integrated management is that the integration of decision making across all relevant stakeholders (Government, non-government, and external partners) should be pursued in decisions affecting the operation of this Act:

7. Principle of investigation and research	the principle of investigation and research is that a culture of investigation and research as a basis of discussion and decision-making should be fostered, and that ocean planning and management decisions should be based on the best available scientific and other information, recognising that current information regarding ocean resources may be limited:
8. Principle of ecosystem-based management	the principle of ecosystem-based management is that there should be an ecosystem-based approach to the management of natural resources that aims to sustain the health, resilience, and diversity of ecosystems of species, while allowing for sustainable use by humans of the goods and services they provide:
9. Principle of sustainable financing	the principle of sustainable financing is that adequate funding for activities implemented for the marae moana should be pursued to achieve desired outcomes.

3.3 International Regulations and Guidelines

International regulations and guidelines are listed in Table 3. While these are not directly required for operation in the Cook Islands EEZ, it has been made explicit by the Cook Islands Seabed Mineral Authority that equivalency is sought where appropriate with regulations, guidelines, and experiences from the Area (the ocean areas outside of any EEZ where mineral resources are under the jurisdiction of the International Seabed Authority). These regulatory instruments and guidelines form a growing body of international best practice in the deep-sea mining industry and because they have been developed through collaboration with scientists and a diversity of interests, are likely to inform the expectations of stakeholders in Cook Islands.

Table 3 - International regulations and guidelines.

Instrument	Description	Responsible Department/Agency
Regulations and Recommendations		
Consolidated Regulations and Recommendations on Prospecting and Exploration (2015)	Compilation of guidelines and regulations related to prospecting and exploration in The Area	International Seabed Authority
Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area	2020 recommendations for EIA during exploration	International Seabed Authority
Draft Regulations on Exploitation of Mineral Resources in the Area (ISA 2019)	Draft 2019 for exploitation regulations in The Area	International Seabed Authority

MARPOL	Global shipping environmental controls	International Maritime Organization
Guidelines		
Pacific-ACP States Regional Environmental Management Framework for Deep Sea Minerals Exploration and Exploitation	EU-funded project with SOPAC to harmonize approaches to deep sea mining in Pacific states, including assistance with the establishment of state legislation. Establishes regional scale framework and recommendations for environmental management.	EU-Pacific Community (SPC)
Pacific-ACP States Regional Scientific Research Guidelines for Deep Sea Minerals	EU-funded project with SOPAC to harmonize approaches to deep sea mining in Pacific states, including assistance with the establishment of state legislation. Recommends approaches to engaging in scientific research.	EU-NIWA-Pacific Community (SPC)
Pacific-ACP States Regional Financial Framework for Deep Sea Minerals Exploration and Exploitation	EU-funded project with SOPAC to harmonize approaches to deep sea mining in Pacific states, including assistance with the establishment of state legislation. Establishes regional scale financial framework.	EU-Pacific Community (SPC)
Various think pieces and guidelines published as ISA technical studies	Documents and workshop presentations that collectively informs the growing 'best practice' basis in The Area	International Seabed Authority

3.4 Conventions and Treaties

Cook Islands is signatory to the treaties listed in Table 4. These agreements generally set out the Government's aspirations and duties for environmental protection and sustainable development and they recognize the importance of cooperation among Pacific Island states, particularly in relation to transboundary issues.

Table 4 - Cook Islands signatory international treaties.

Treaty	Description
Convention on Biological Diversity (1992) **Adopted at the 1992 United Nations 'Conference on Environment and Development' in Rio de Janeiro, Brazil**	Aims to conserve biological diversity and species in natural surroundings, and to rehabilitate degraded ecosystems. Activities which may adversely affect biodiversity require: • Article 7. Identify and monitor impacts. • Article 8. Establish a system of protected areas (including within the marine environment). • Article 14(a). Conduct environmental impact assessments. • Article 14(c). Promote consultation.

	The CBD adopts an ecosystem approach as its primary framework for action, defining the 'ecosystem' as a dynamic complex of plant, animal and micro-organism communities and their non-living environment, interacting as a functional unit.
Convention on Biological Diversity (1992) - Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS)	Provides a legal framework for the effective implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources. The '2020 Aichi Targets' includes a target that by 2020, parties are to implement at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, that are ecologically representative and connected.
1992 United Nations 'Conference on Environment and Development' – Agenda 21	A non-binding voluntarily implemented action plan for sustainable development. It outlines key policies for achieving sustainable development that meets the needs of the poor and recognizes the limits of development to meet global needs. Specific chapters applicable to environmental management of deep-sea minerals development include: • Chapter 8. Integrating environment and development in decision-making. • Chapter 15. Conservation of biological diversity. • Chapter 17. Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas and coastal areas, and the protection, rational use and development of their living resources.
Nouméa Convention (1982) **The Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (Nouméa Convention), adopted in 1982.**	Promotes two main objectives: 1) to prevent, reduce and control pollution from any source; and 2) to ensure sound environmental management and development of natural resources. Article 8 'Pollution from Seabed Activities' of the Nouméa Convention states, 'The Parties shall take all appropriate measures to prevent, reduce and control pollution in the Convention Area, resulting directly or indirectly from exploration and exploitation of the seabed and its subsoil'. Article 17 'Scientific and Technical Co-Operation': 1) the Parties shall co-operate, either directly or with the assistance of competent global, regional, and sub-regional organizations, in scientific research, environmental monitoring, and the exchange of data and other scientific and technical information related to the purposes of the Convention; and 2) in addition, the Parties shall, for the purposes of this Convention, develop and co-ordinate research and monitoring programs relating to the Convention Area and co-operate, as far as practicable, in the establishment and implementation of regional, sub-regional and international research programs.

<table>
<tr><td></td><td>The Nouméa Convention is complemented by two Protocols: the Dumping Protocol and the Pollution Emergencies Protocol, which are applicable to Parties' EEZ and to areas of the high seas beyond national jurisdiction that are completely enclosed by this EEZ. In particular, Parties must prevent, reduce and control pollution caused by discharges from vessels, resulting directly or indirectly from exploration and exploitation of the seabed and its subsoil. It contains an EIA requirement, which must include opportunity for public comment and consultation with other States who may be affected.</td></tr>
<tr><td>The International Marine Minerals Society Code for Environmental Management of Marine Mining
Voluntary code for environmental management of marine mineral activities (exploration and exploitation)</td><td>1. Environmental principles for marine mining:
to observe the laws and policies and respect the aspirations of sovereign States and their regional sub-divisions, and of international law, as appropriate to underwater mineral developments.
to apply best practical and fit-for-purpose procedures for environmental and resource protection, considering future activities and developments within the area that might be affected.
to consider environmental implications and observe the precautionary approach.
to consult with stakeholders and facilitate community partnerships on environmental matters throughout the project's life cycle.
to maintain an environmental quality review program and deliver on commitments.
to report publicly on environmental performance and implementation of the code.
2. A set of operating guidelines for application at a specific mining site.
Guidelines to set an environmental management program for an exploration or extraction site, that can be used by all stakeholders; including government agencies, intergovernmental and non-governmental organizations, scientists, and local communities to check environmental management plans and their implementation.</td></tr>
<tr><td>Convention on the Conservation of Migratory Species of Wild Animals (CMS) (Bonn Convention) (1979)</td><td>Platform for the conservation and sustainable use of migratory animals and their habitats.</td></tr>
<tr><td>Memorandum of understanding for the Conservation of Cetaceans and their habitats in the Pacific Islands region (2006)</td><td>Agreements to take steps to conserve all cetaceans. Action plan to address:
a) Threat reduction
b) Habitat protection, including migratory corridors
c) Research and monitoring
d) Education and public awareness
e) Information exchange</td></tr>
</table>

	f) Capacity building g) Responses to stranding and entanglements h) Sustainable and responsible cetacean-based tourism i) International cooperation
United Nations 'Conference on Environment and Development' in Rio de Janeiro, Brazil (1992)	Recognizes the importance of preserving the environment to the success of long-term economic progress. The following principles particularly address issues in regard to the management, protection and preservation of the environment. • Principle 2. States are responsible to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond limits of the national jurisdiction. • Principle 3. The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations. • Principle 4. Environmental protection shall constitute an integral part of the development process. • Principle 7. States shall cooperate to conserve, protect and restore the Earth's Ecosystem. • Principle 9. States should cooperate to strengthen capacity-building for sustainable development by improving scientific understanding. • Principle 10. Environmental issues are best handled with participation of all concerned citizens. • Principle 11. States shall enact effective environmental legislation. • Principle 14. States should cooperate to discourage or prevent relocation or transfer of substances that cause severe environmental degradation. • Principle 15. The precautionary approach shall be widely applied. • Principle 16. Internalization of environmental costs so the polluter bears the costs of the pollution. • Principle 17. Environmental impact assessments shall be undertaken for activities that are likely to have a significant adverse impact on the environment. • • Principle 19. Prior and timely notification of adverse transboundary environmental effects.

4 CHARACTERIZATION OF THE MARINE ENVIRONMENT

4.1 Benthic Environment

There is little existing information on deep-sea benthic environments in Cook Islands. The geomorphology of the seafloor is discerned from broad scale bathymetry (Gebco, 2014) and sections of multibeam bathymetry from historical exploration voyages (from OML data holdings). OM's Application Area in the South Penrhyn Basin (SPB) is at 5,200 m water depth and this part of the SPB in general is characterized by the presence of nodules and surficial oxic brown to dark red-brown ferromanganiferous clays (Cronan et al., 2010). This sediment composition is fundamentally different to that in the CCZ, where siliceous sediments are dominant in high nodule areas.

Abyssal hills occur in the SPB and the tectonic interpretation of Viso et al. (2005) indicates that there are two orientations: approximately east–west trending and north–south trending abyssal hills, separated by the Tongareva triple junction. The abyssal hills are reported to be 100–500 m high and 1–10 km side to side and 10–100 km long (Viso et al., 2005). The southwestern Pacific region in general is characterized by an abundance of seamounts and knolls (Yesson et al., 2011), although in the SPB large areas without these structures are apparent (Figure 1).

Mining will target the relatively flat terrain of the abyssal plain. Seamounts and knolls, which can harbor diverse and sensitive biology communities (Althaus et al., 2009; Clark et al., 2014), are not sites of high nodule abundance and are currently unable to be traversed by nodule collectors, precluding them from mining. In the Application Area, benthic communities can be generally considered as comprising:

1. Sessile nodule-attached epifauna: organisms attached to hard nodule surfaces.
2. Sessile sediment epifauna: organisms attached to the sediment surface.
3. Mobile epifauna that range across both nodule and sediment habitats.
4. Sediment infauna: organisms living within under the sediment surface, withing the interstices of the sediment bed.
5. Hyperbenthic organisms: residing in the semi-liquid layer and water column close to seabed (benthic boundary layer).

Within these groups of organisms, size ranges vary. In the terminology applied by the ISA, benthic organisms are classed as microfauna (bacteria and eukaryotic organisms < 32 μm in body size), meiofauna (eukaryotes 32–250 μm body size), macrofauna (>250 μm to 2 cm body size) or megafauna (>2 cm, visible in seabed imagery).

The entire SPB falls within a single, large abyssal biogeographic zone known as the South Pacific Abyssal Province (UNESCO 2009) reflecting the broad geographic distributions of most abyssal benthic fauna. In general, the abundance of organisms and species diversity for most groups (particularly macrofauna and megafauna) decreases with depth (Rex and Etter, 2010). Studies in the CCZ have shown that the abundance of organisms decreases along the size spectrum from bacteria to megafauna (Wei et al., 2010), due in most part to water chemistry at these depths (below the carbonate compensation depth and low in silicates) and low rates of benthic production and nutrient supply. In the SPB, nodules are likely to provide a hard substrate for the attachment of sessile invertebrates as has been observed in other nodule provinces (e.g., Bluhm 1994; Simon-Lledo et al. 2020). Foraminiferans, bryozoans, sponges, and black corals are among some of the nodule-attached fauna identified from CCZ nodules (Veillette et al., 2007). While nodule-attached fauna of some kind is expected in the SPB nodule province, this is yet to be confirmed.

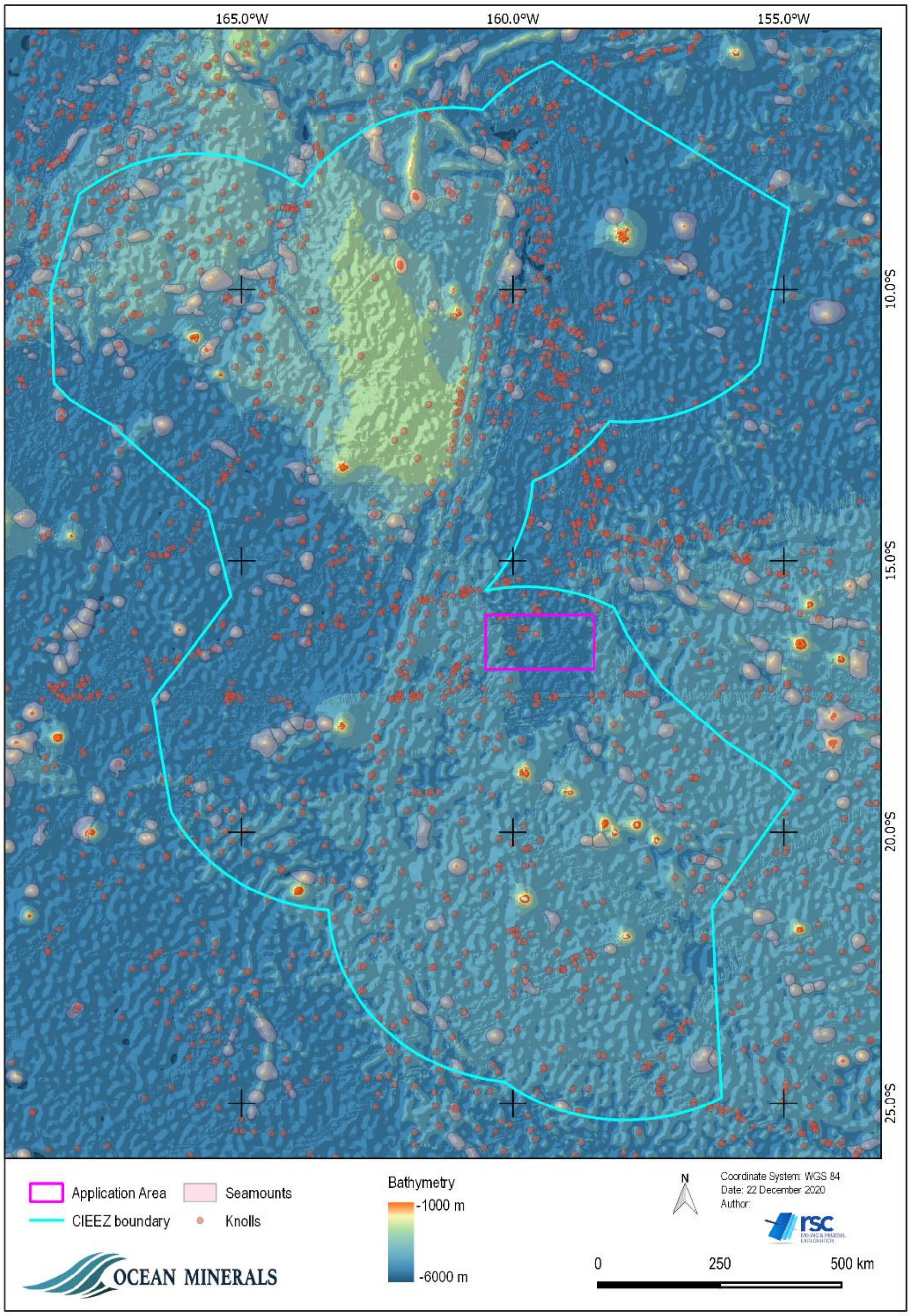

Figure 1 - Seamounts and knolls in the Cook Islands EEZ in relation to OML Reserved areas/Moana Minerals Application Area (Source: Yesson et al., 2011).

On sediments in the CCZ nodule province, giant protists (Xenophyophora) are the dominant sessile epifaunal (living on the sediment surface) organisms in the macro- to megafauna size range (Kamenskaya et al. 2013, 2015). Sediment infauna (living on the sediment interstices or in burrows) in the CCZ nodule province, and indeed many other abyssal sites, tends to be dominated by species in the meiofauna size range. In the macrofauna size range, sediment infauna in the CCZ nodule province is typically dominated by polychaete worms, crustaceans (isopods, amphipods and tanaids) and molluscs (bivalves and gastropods) (e.g. Stoyanova, 2014). Sediment macrofauna communities from the Indian Ocean nodule province show similarities to those in the Pacific province (Ingole et al., 2001). Furthermore, Glover et al. (2002) showed ubiquitous distributions of 30–40 polychaetes (90% of the total polychaete assemblage) among sites that were 3,000–4,000 km apart. Therefore, benthic macrofauna of SPB is expected to have broad similarities with other nodule provinces and the small number of biological samples that have been reported from the SPB indeed show these similarities (McCormack, 2016).

Mobile epifauna in the CCZ and other abyssal zones tends to be dominated by echinoderms (mainly holothurians, seastars and urchins) and these organisms are among the most abundant in seafloor imagery and as a result can be identified with some confidence (e.g., Tilot, 2006). Burrows, dwelling traces, and waste casts of various types (collectively known as lebbenspuren) are also among the most conspicuous and frequently observed structures in seafloor imagery. These features contribute to the quantification of bioturbation and to infer populations of mobile epifauna (e.g. echinoderms) and large burrowing species (e.g. various large worm species) (Lauerman and Kaufmann, 1998; Dundas, 2009).

Sinking of particles from the surface layers of the ocean (particulate organic carbon (POC) flux) is the main source of productivity to the abyssal sea floor. Benthic communities in the CCZ and other Pacific abyssal sites are typically dominated by deposit-feeders that specialize in foraging on surface-derived production and populations may respond to short-term enhancements in supply related to, for example, surface phytoplankton blooms or benthic ‘storms’. Therefore, productivity at the ocean surface and processes of nutrient uptake, recycling and repacking in the water column is key to controlling biomass of benthic organisms. There are indications that POC flux in the SPB is lower than that of the CCZ (Smith et al., 2008; Hannides and Smith, 2003) which may partly explain the low infaunal species richness and abundance recorded in the SPB compared to the CCZ (McCormack, 2016).

Decades of work in the CCZ and other abyssal zones reveal two factors relevant to the establishment of an environmental baseline and assessment of potential impacts:

1) taxonomic descriptions are incomplete, and it is highly likely that any new sampling in any part of the abyssal zone will uncover species that are new to science;
2) biological distributions are patchy and highly variable at multiple spatiotemporal scales.

Therefore, environmental baseline studies and impact assessment of seabed mining must take a multiple-lines-of-evidence approach, using multiple indicators (e.g. direct sampling and seabed imaging) and take advantage of new technological solutions where appropriate (e.g. genetic methods) and deal with residual uncertainty in a transparent and consultative manner under a precautionary framework such as exists in the Cook Islands regulations.

In the Cook Islands, Okamoto et al. (2003) collected 575 images and identified a variety of megafauna including unidentified sponges, sea pens, crinoids, sea anemones and at least three types of sea cucumbers. Of 733 individual biota seen, sponges were most frequently observed at 593 individuals, followed by 70 sea cucumbers, and 44 starfish. No specific biota to substrate relationships were identified. Nekton fauna observed included shrimps, many fish (200 mm long) and jelly forms of swimming fauna were noted. The survey also showed the presence of bioturbation on the seabed. Macrofaunal biota belonging to nine groups and a few unknown organisms were confirmed by Okamoto et al. (2003) at all stations in samples sieved to 300 µm. The most common fauna were foraminifera, ostracoda and isopoda, which occurred at three stations. Other fauna included nematodes, bivalves, polychaetes, harpacticoids and amphipods. The total number of animals per sample ranged from 31 to 85. Samples were examined by 10 mm depth intervals to 50 mm and macrofauna were most abundant in the upper 10 mm of sediment.

The extensive work carried out within the CCZ has shown that traditional taxonomy is complex and labor intensive, even though considerable work on taxonomic methods and standardization has been undertaken (see for example Mullineaux 1987, Thiel et al. 1993, Veillette et al. 2007, Kamenskaya et al. 2013; 2015, Martinez Arbizu 2015, Vanreusel et al. 2016, Amom et al. 2016, De Smet et al. 2017, Stoyanova 2014, Pape et al. 2017, Miljutina et al. 2010, Raschka et al. 2014, Radziejewska, 2014). The patchy distributions and generally low abundance of fauna represents a major sampling challenge and reviews have indicated that after some 40 years of sampling, the knowledge of total biodiversity of meiofauna, for example, is still unknown. In recent times, genetic tools and ecosystem-based assessments have proven to be useful in bolstering and in some areas replacing traditional taxonomic style studies.

4.2 Pelagic Environment

4.2.1 Oceanography

The water column overlaying the SPB is a subcomponent of a large pool of Western South Pacific oceanic water. Biochemically, the oceanic waters of Cook Islands are part of the large South Pacific Subtropical Gyre Province that spans Easter Island to Samoa (Longhurst 2007). The Cook Islands EEZ is characterized by relatively low surface primary production (Verlaan et al. 2004, one of the key indicators of oceanic biological productivity (Menkes et al. 2015). Surface chlorophyll-a concentrations in the Cook Islands EEZ are generally lower than those observed in the CCZ (Figure 2). Subsurface chlorophyll maxima, not measurable by satellite imagery, typically occur in tropical waters at 50 to 100 m depth (Longhurst 2007, Furnas and Mitchell 1996, Menkes et al. 2015). Sinking particles from the surface layers of the ocean (particulate organic carbon (POC) flux) is the main source of productivity to the abyssal sea floor. Therefore, low productivity at the ocean surface is expected to be a limiting factor on benthic faunal biomass.

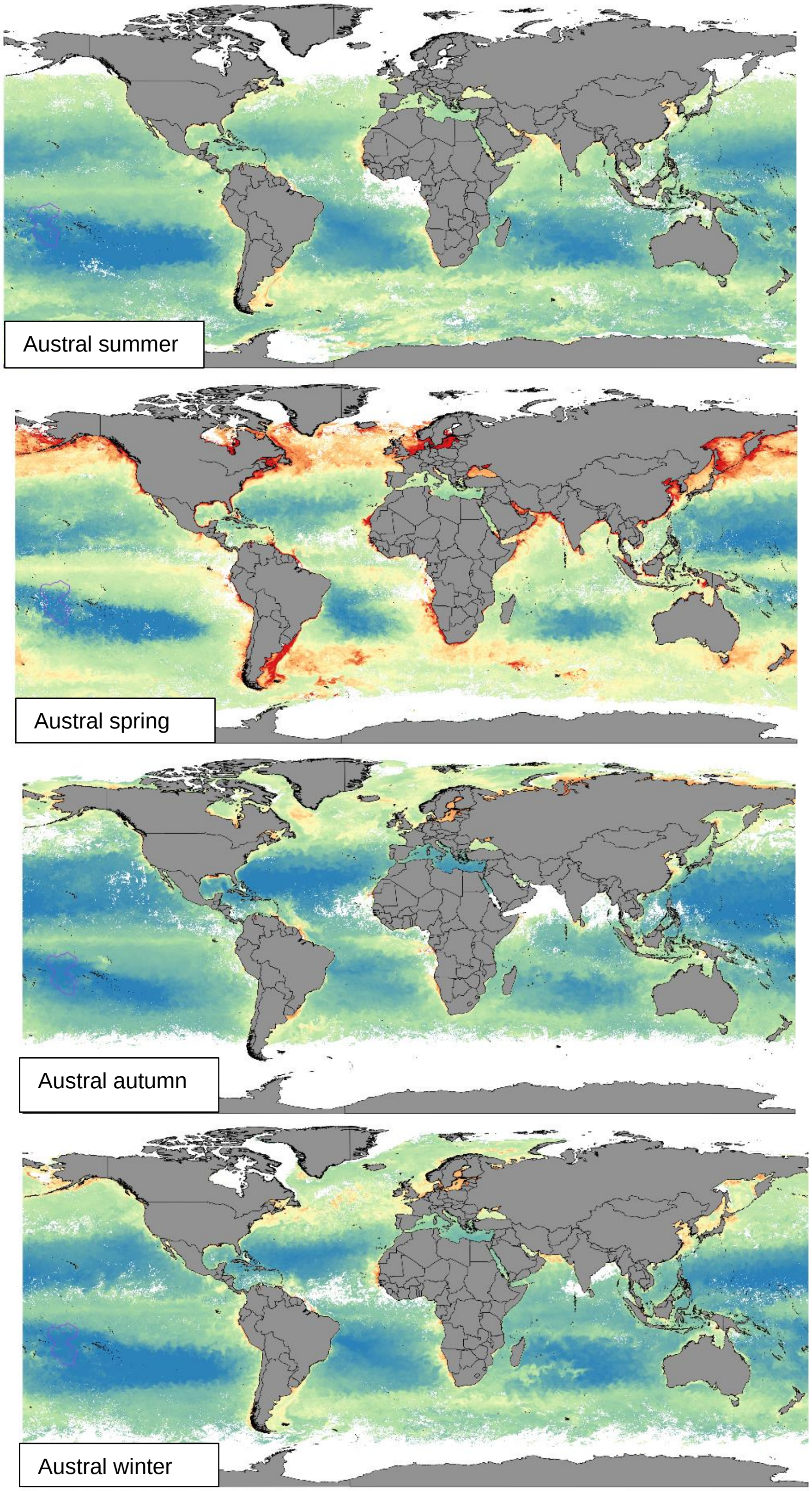

Figure 2 - Seasonal surface chlorophyll-a concentration in Cook Islands EEZ (purple polygon) relative to other ocean regions, cool colors = low concentration, warm colors = high concentration. (Source: NASA Earth Observation, MODIS satellite, 2017)

At abyssal depths in the SPB, the dominant water mass is known as Antarctic Bottom Water (AABW), a cold (~1˚C), dense water mass some 1,000 m thick that migrates slowly north towards the equator from Antarctica (Tsuchiya 1991, Hartin et al. 2011). Available temperature data indicates relatively uniform structure at abyssal depths (Figure 3). The chemical oceanography in the abyssal zone in the SPB is expected to be temporally stable. Any temporal variation is likely to be expressed mainly in surface layers and driven by large-scale processes such as seasonal variation, climatic events such as cyclones and El-Niño.

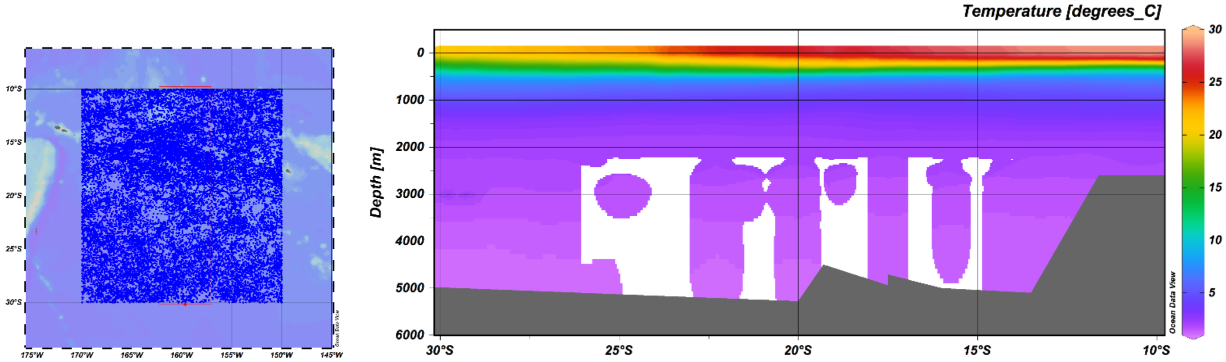

Figure 3 - World Ocean Database 2013 stations covering Cook Islands (left) and temperature profile (right) through a north-south section.

Cook Islands is situated within the South Pacific subtropical gyre (Ridgway and Dunn 2007) and the dominant large-scale surface current system influencing the region is the westerly flowing South Equatorial Current (SEC) (Keppler et al. 2018). The SEC drives net westward flows from 0 m to approximately 1,000 m depth (Ganachaud et al. 2014). Eddies, island wake features and responses to south easterly trade winds and climatic events such as tropical cyclones influence surface currents (Keppler et al. 2018). However, the Cook Islands in general and OML's reserved areas lay to the east and south of the zonal jets of the SEC that occur west of ~170˚E (Webb 2000, Ganachaud et al. 2014).

Below the influence of the SEC, the dominant water masses are the cold Antarctic Intermediate Mode Water (~1,000 m to 3,500 m depth) and Antarctic Bottom Water (~3,500 m to the seabed) (Sokolov and Rintoul 2000, Bostock et al. 2013). Antarctic Bottom Water flows north through the Aitutaki Passage to influence the South Penrhyn Basin and flows around the northern margin of the Manihiki Plateau, to the north of the Cook Islands EEZ (Yamazaki, 1992) (**Error! Reference s ource not found.**). Water temperature near the seabed is approximately 1 ˚C (Reid 1997).

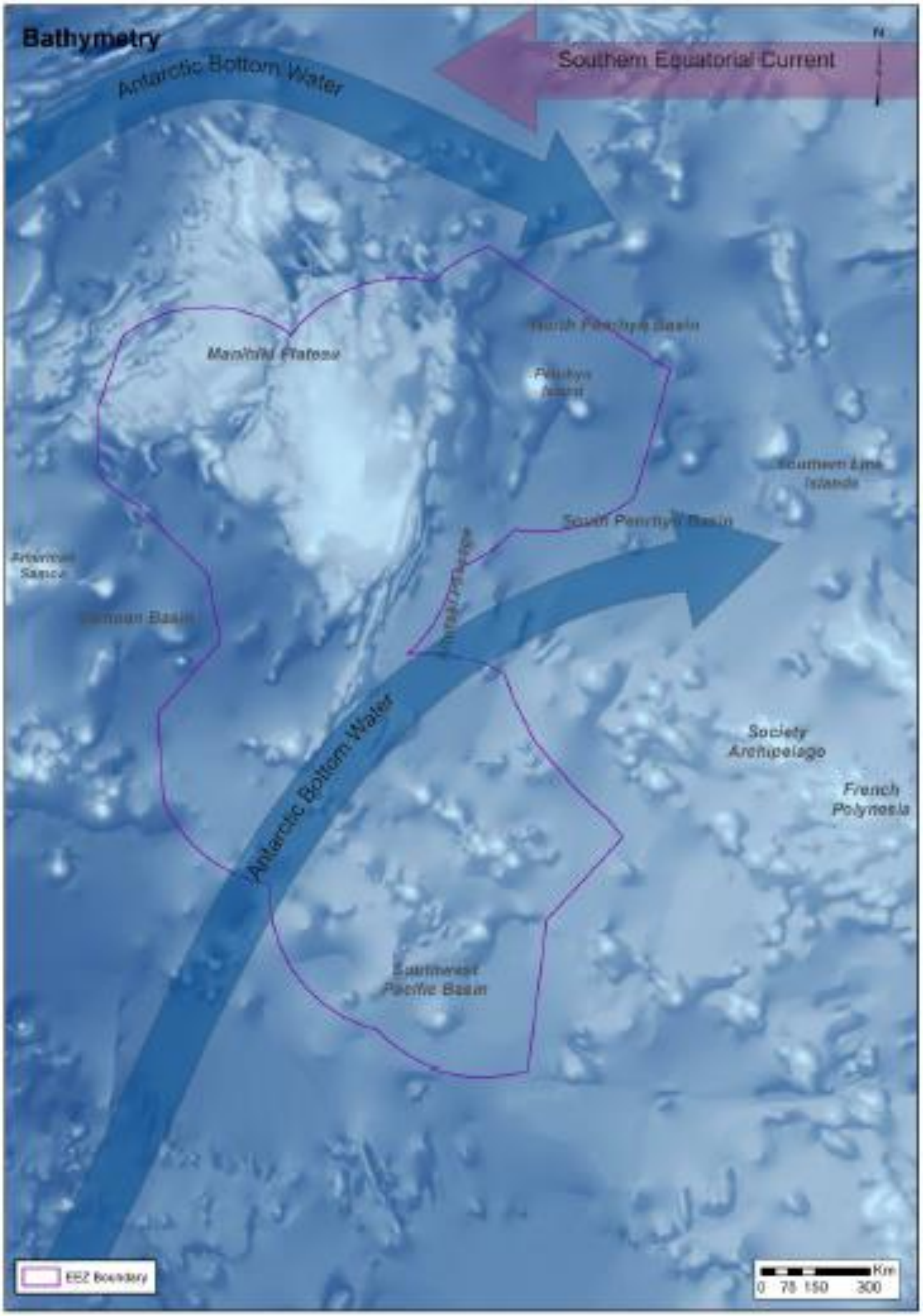

Figure 4 - Schematic of dominant surface and bottom ocean currents in the CIEEZ (after Kenex, 2014).

4.2.2 Biological Communities

The oceanic waters of the Cook Islands are considered part of a large biogeographic zone known as the Southern Central Pacific Region (Sutton et al. 2017), reflecting the fact that surface and subsurface water masses are ubiquitous throughout the region and many of the species inhabiting the oceanic environment have broad geographic distributions. In a later data-driven and delphic bioregionalization, the Cook Islands region was ascribed to an Eastern Subtropical Gyre region (Dunstan et al. 2020) characterized by oligotrophic characteristics that are less favorable for micronekton development. Foodwebs in these regions are characterized by low nitrogen fixation (Deutsch et al., 2001; Shiozaki et al., 2014) and new primary production is fueled by nitrate leading to generally short food chains where large phytoplankton such as diatoms are directly grazed by macrozooplankton (Le Borgne et al., 2011).

In the expansive habitat of the pelagic zone in the open ocean, biomass is dominated by small-bodied invertebrates and fishes, known as micronekton, that are broadly distributed and occur in generally low abundance (Ceccarelli et al. 2013, Menkes et al. 2015). The global phenomenon of diel vertical migration, the mass movement of micronekton from deep (~1,000 m) to shallow strata (0-200 m) at night, and their return during the day, is the most ecologically significant processes in the pelagic zone. This behavioral phenomenon brings deep-dwelling micronekton within foraging range of pelagic predators in the South Pacific Ocean where they constitute a large proportion of the diet of tunas and other apex predators (Young et al. 2010; 2015).

Large-bodied predators such as tunas, billfishes and dolphinfish are spatiotemporally variable in their distribution and are of most interest to commercial fisheries. The entire Cook Islands exclusive economic zone (CIEEZ) is a declared shark sanctuary, established under the Marine Resources Act (2005), prohibiting the commercial exploitation of sharks. The Application Area does not include habitats for inshore and deep slope fishes, and no such habitats exist within 200 km of the Project. Oceanic fish species expected to occur in the OM Application Area include a number of tuna species (albacore (*Thunnus alaunga*), yellow-fin *T. albacares*), big-eye (*T. obsesus*), skipjack (*Katsuwonus pelamis*), dog-toothed (*Gymnosarda unicolor*)). Tuna species can be surface or pelagic and migratory. Non-tuna species are expected to include billfish (blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*). Other pelagic species such as wahoo [Pa'ara] (*Acanthocybium solandri*); dolphinfish [Ma'i ma'i] *Coryphaena hippurus*) and rainbow runner [Roroa] (*Elagatis bipinnulatus*) are likely to occur in the area. Oceanic species feed largely on epipelagic fishes, squids and crustaceans. A number of different species of flying fish (all of the family Exocoetidae) are common. In the oceanic waters of Cook Islands are 16 species of flying fish, which occur near Samoa. Flying fish are schooling, pelagic fishes found near the ocean's surface where they feed on small fishes and plankton.

Cetaceans (whales and dolphins), sharks and seabirds also occur in the pelagic zone. In 2001, Cook Islands EEZ was declared a Whale Sanctuary (Cook Islands, 2001), which provides a mechanism for managing activities that interact with whales such as fisheries, scientific research and tourism. A total of 13 cetacean species have been identified within the Cook Islands EEZ with a further 11 species thought to likely occur in the region (Figure 5). Humpback whales (*Megaptera novaeangliae*) are seasonally prevalent in the southern Cook Islands every year between early July and late October (Hauser et al., 2010, cited in McCormack, 2016). Humpback whales are less frequently observed north of Palmerston Island and in the central area of the SPB. Humpback whales visiting Cook Islands are reported to be either transiting through the region (Hauser et al., 2010, cited in McCormack, 2016) or utilizing the area for calving (Hauser and Clapham, undated). Previously, cetacean surveys in the SPB have been spatially limited, with dedicated surveys in the Cook Islands largely restricted to coastal regions with a strong focus on humpback whales and largely restricted to nearshore waters around Rarotonga.

Table 5 - Summary of marine mammal known to be present in the CIEEZ

Common name	Scientific name	Notes
Humpback whale	*Megaptera novaeangliae*	Likely breeds and calves in the region
Sei whale	*Balaenoptera borealis*	
Blue whale	*Balaenoptera musculus*	Likely *B. m. brevicauda*
Dwarf minke whale	*Balaenoptera bonaerensis/acurorostrata sp.*	Likely dwarf minke
Bryde's Whale	*Balaenoptera edeni*	
Sperm whale	*Physeter macrocephalus*	
Killer whale	*Orcinus orca*	
Fin whale	*Balaenoptera physalus*	
False killer whale	*Pseudorca crassidens*	
Short-finned pilot whale	*Globicephala macrorhynchus*	
Pygmy killer whale	*Feresa attenuata*	
Risso's dolphin	*Grampus griseus*	
Rough toothed dolphin	*Steno bredanesis*	
Melon headed whale	*Peponocephala electra*	
Bottlenose dolphin	*Tursiops truncatus*	
Pantropical spotted dolphin	*Stenella attenuata*	
Peale's dolphin	*Lagenorhynvhus australis*	
Common dolphin	*Delphinus delphis*	
Spinner dolphin	*Stenella longirostris*	Likely dwarf form
Striped dolphin	*Stenella coeruleoalba*	
Fraser's dolphin	*Lagenodelphis hosei*	
Cuvier's beaked whale	*Ziphius cavirostris*	
Blainville's beaked whale	*Mesoplodon densirostris*	
Pygmy sperm whale	*Kogia breviceps*	
Dwarf sperm whale	*Kogia simus*	

Source: Hauser & Clapham (2012).

The CIEEZ supports a diverse marine seabird fauna. McCormack (2005) provides a summary of key elements of the seabird community. Suwarrow atoll in the Northern Group support regionally significant colonies of sooty terns (100,000 pairs), lesser frigatebirds (5,000 pairs), red-footed boobies (1,000 pairs), and red-tailed tropicbirds (500 pairs) along with other species. Takūtea, in the Southern Group has a large colony of red-tailed tropicbirds (1,500 pairs), and the only Southern Group colonies of great frigatebirds (100 pairs), red-footed boobies (100 pairs) and brown boobies (20 pairs).

Three marine turtles are found in Cook Islands and may occur in the Application Area. These are the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle ['Onu] (*Chelonia mydas*) (Kulbicki et al. 2011) and the loggerhead turtle (*Caretta caretta*). The green and loggerhead turtles are endangered and the hawksbill critically endangered[1]. Turtles are recorded as nesting on Manihiki, Pukapuka, Penryhn and Palmerston.

4.3 Cultural Environment

Cook Islands Maori are Polynesian, and several tribes trace their ancestry back to Samoa and Raiatea (French Polynesia). By tradition there are also connections between the Rarotongans and the New Zealand Maori. Cook Islanders and all South Pacific peoples have a strong spiritual and cultural connection to the ocean. This cultural connection has several dimensions that can be broadly categorized as 'traditional' and 'modern religious' aspects. The traditional dimension is expressed in The Ocean Declaration of Maupiti (2009), of which Cook Islands is a signatory and which states that for many Pacific communities:

- There are sacred and intrinsic links with land, sky, and ocean. This constitutes for many a fundamental and spiritual basis of existence.
- The ocean is a holistic reality of the life cycles of the earth.
- The ocean is their identity, way of living, values, knowledge, and practices that have sustained them for millennia.

Marae Moana is underpinned by indigenous approaches of 'rā'ui' – a traditional form of natural resource management that prevented access to certain areas or during certain times – which is reflected in modern marine spatial management and ecosystem-based management.

The modern religious dimension is expressed in Christian religious beliefs that may be underpinned by the traditional basis that the ocean has 'mana' (spiritual authority). Modern religious beliefs have been expressed in the consultation processes of deep-sea mining exploration. The belief that a Christian God has blessed Cook Islands by providing nodule resources that, in lieu of other primary industry potential, can be exploited for the betterment of Cook Islanders has been expressed and illustrates the importance of religion in modern life.

Therefore, although subsistence and artisanal activities may be limited to the coastal environment, there are expected to be cultural considerations of deep-sea mining that will be investigated through the ESIA.

[1] https://www.maraemoana.gov.ck/index.php/biodiversity

4.4 Ecosystem Services

4.4.1 Supporting and Regulating Services

4.4.1.1 Circulation, Nutrient Cycling and Climate Regulation

Below 1000 m, the vast volumes of cold deep-sea water masses are isolated from the atmosphere, circulating around the globe and creating a buffer for the carbon and nitrogen cycles and regulating climate. The process of ocean circulation is a supporting and regulating service due to the link between water mass structure and movement and nutrient cycling and climate regulation and CO_2 exchange (Thurber et al. 2014).

The sinking of particulate organic matter, generated in the productive sunlit upper layers of the ocean, and the progressive degradation of labile compounds, and transport of materials to the seafloor (a process known as the biological pump) is the primary source of energy to the abyssal seafloor in the open ocean. Processes such as upwelling and diel vertical migration of zooplankton and micronekton can also re-suspend nutrients back into the surface and sub-surface layers. At abyssal depths and in areas where surface primary production is relatively low, the quantity of carbon and quality of nutrition is generally low which limits the benthic biomass able to be sustained. The deep-sea water column and seabed therefore provide both supporting services (e.g. supporting the production of biomass) and regulating services (e.g. sequestering carbon and cycling nutrients).

4.4.1.2 Primary and Secondary Production

Primary production is limited to the upper sunlit layers of the open ocean, but is vast and drives many of the trophic interactions that are connected to human values (e.g. foodwebs supporting fisheries and megafauna). Primary production can reach the seafloor in the form of “falls” of pelagic organisms (e.g. whale falls) or debris (e.g. terrestrial plant material). These spatially constrained inputs of primary production can create isolated secondary production on the seafloor in the form of chemosynthetic production and biomass growth in heterotrophic organisms. In recent years, there has been a new appreciation of the amount of primary chemosynthetic production generated in the unlit layers of the open ocean water column by microbes feeding of the vast pool of dissolved inorganic carbon. Other compounds may also be used in this process of chemosynthetic production, which are provided by the progressive degradation and repackaging of sinking particulate organic matter.

Organic carbon degradation and assimilation in the formation of biomass is one of the major supporting services of consideration for fisheries. The respiration of most organisms involved in secondary production is stored in the deep-sea, and thus the deep sea provides an important regulating service. Recent evidence shows the major role that seabirds can have in ingesting and transporting production from the upper layers of the ocean to terrestrial environments (Otero et al., 2018). The existence of large seabird colonies in Cook Islands is expected to be reflected in a significant contribution of these predators to open ocean ecosystem processes. Furthermore, there has been recent appreciation of the importance of production enhancement and nutrient mixing via the feeding of large-bodied predators such as whales, dolphins and tunas (Roman and McCarthy 2010).

4.4.1.3 Waste Absorption and Detoxification

The deep-sea is recognized as a place where waste products can be stored and sometimes detoxified through natural processes. The deep-sea ecosystem is considered among the most remote from human interaction and waste products including disused chemical weapons and discharge from mining processing plants (e.g. deep-sea tailings deposition) are intentionally placed on the deep seafloor. Transport and absorption of waste from effluent sources closer to continental shelves and areas of human habitation is recognized as a regulating ecosystem service. Bioremediation by seafloor microbial communities has been reported for hydrocarbon spills and releases. This service can represent negative impacts in the form of pollution, contamination and bioaccumulation. To our knowledge, no such deep-sea dumping of waste has occurred in the CIEEZ.

4.4.2 Provisioning Services

4.4.2.1 Mining

The deep-sea provides the conditions for the existence of concentrated minerals and obviously the presence of polymetallic nodules in the CIEEZ represents a major potential provisioning service. The processes involved in exploring and commercializing deep-sea mining, scientific research and consideration of the impacts and societal benefits of deep-sea mining is a global undertaking. Technological solutions to extraction, development of regulations and consideration of environmental impacts have accelerated in response to increasing demand.

Other mineral resources that occur in the deep-sea include mineralized sediments, seafloor massive sulphide (SMS) deposits and cobalt crusts (SPC 2016b). Potential mineralized sediments have been identified in CIEEZ, although no SMS or cobalt crusts have been identified as yet.

4.4.2.2 Offshore Fisheries

The offshore tuna fishery is the most important commercial fishery in the CIEEZ, and it is a sub-component of the large West and Central Pacific tuna fishery. Offshore fishing at the Cook Islands is made up of longline fishing for tuna and tuna-like species, purse seine fishing (operating under the US Multilateral Treaty and bilateral agreements) and Cook Island registered trawlers that operate in the southern Indian Ocean under the South Indian Ocean Fisheries Agreement (SIOFA) (fao.org). The Cook Islands entered into an agreement with Korea and Kiribati flagged companies in 2016.

Yellowfin, albacore skipjack and bigeye tuna are harvested, and other species include mahi mahi, wahoo, and billfishes (Anon 2000). Local vessels, along with those from Japan, Korea and Taiwan target tuna mainly by long line, for the export sashimi market and canneries, particularly those in American Samoa and Fiji. Foreign vessels are restricted to fishing outside the 12-mile territorial sea around each island to avoid conflict with the artisanal fishing (Anon 2000).

Commercial fishing intensity within the Cook Islands EEZ is relatively low compared to other areas in the South Pacific region (Figure 5).

In the vicinity of OM's application area, commercial fishing activity appears to be negligible. Future studies aim to access vessel monitoring data to quantify the spatial extent and intensity of ocean commercial fishing.

Since 2012, there has been a ban on the commercial fishing of shark within the CIEEZ. A quota management system was implemented on 1 January 2017 for albacore (total allowable catch of 9,750 t, bigeye tuna 3,500 t) fished from Cook Islands waters.

It is thought possible but uncommon that vessels engaged in exploration will interact with Cook Islands commercial fishing vessels. However, this statement may be amended as stakeholder engagement progresses. EIA studies will aim to access vessel monitoring data to quantify the spatial extent and intensity of ocean commercial fishing.

The longline fleet is made up of ten vessels operating within the Western and Central Pacific Fisheries Commission Convention area (WCPFC-CA). Of these, three domestic vessels were licensed to fish within national jurisdiction only. Eight vessels were authorized to fish both within the CIEEZ and on the High Seas, but rarely fished beyond national jurisdiction. The majority of the longline fishing activity targeting South Pacific albacore tuna (*Thunnus alalonga*), was concentrated in the northern CIEEZ, in areas north of 15˚S.

During 2017, 45 foreign flagged vessels (from two Chinese companies operating out of Pago Pago, Suva, Papeete and Kosrae (Federated States of Micronesia)) were authorized to operate in the CIEEZ. These vessels were not permitted to fish within the 12 nM limit of all islands and within 24 NM of Rarotonga). Three Rarotonga based longliners catch albacore tuna and a range of species to cater mainly for the local market, with some exports to Japan. These vessels are around 20 m in length and operate within 100 nM of Rarotonga (MMR 2017).

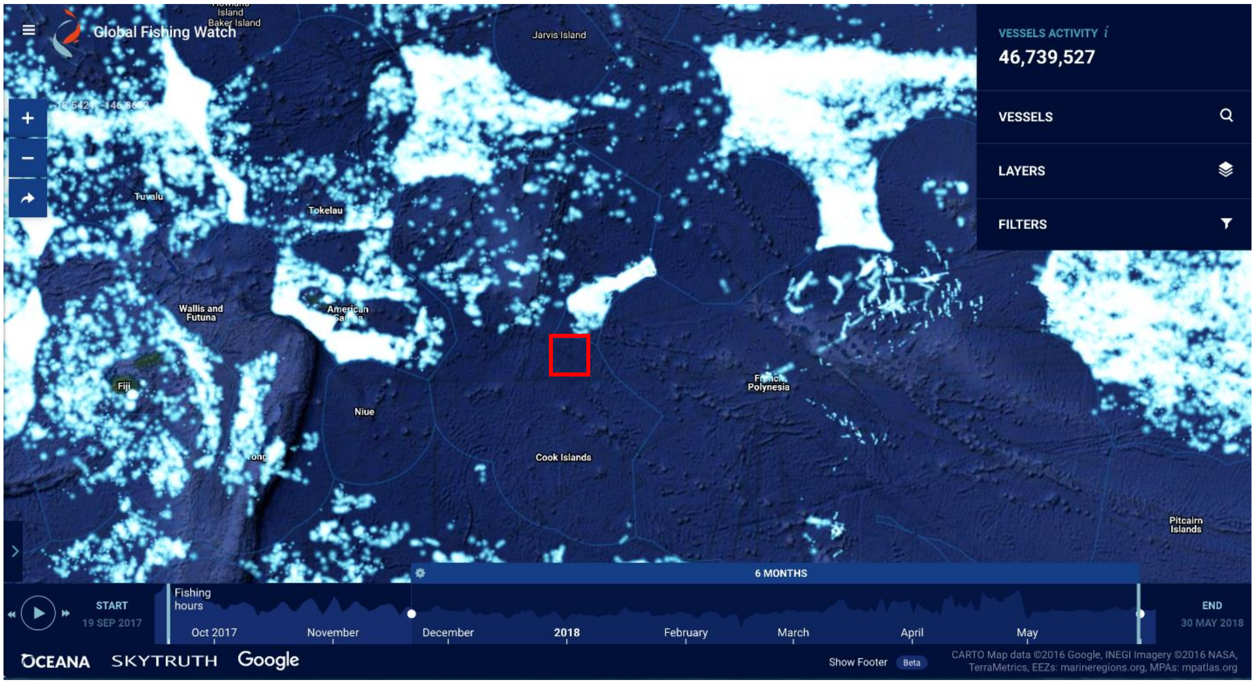

Figure 5 - Commercial fishing intensity in Cook Islands EEZ (data range = 6 months to 30 May 2018). Red square = Approximate location of the OML project region of interest (Source: Global Fishing Watch, globalfishingwatch.org/map)

There is a strong seasonal trend evident in Cook Islands fisheries. In general, first and fourth quarter catch rates and total catch are low, with this period referred to as the off-season. Second and third quarter catches are the peak of the fishing season. The longline fishery is typically delineated around 15°S however longline fishing effort and catch continues to extend further south than in previous years. In 2017, 45% of key tuna species were caught below 15°S latitude. Bigeye tuna is mostly taken in the northernmost part of the CIEEZ, north of Penrhyn, closer to the equatorial belt. Albacore were taken south of 15°S, towards Aitutaki and south of Mangaia.

Albacore dominate the overall 2017 catch totaling about 3,552 t and accounting for 65% of the total species catch composition. Yellowfin tuna comprised 18% of the longline catch (971 t) and bigeye tuna 5% (277 t). Other species make up the remaining 12% of catch, including blue marlin (123 t), skipjack tuna (79 t), wahoo (107 t), swordfish (54 t), mahi (59 t) and others (MMR 2017) (*Figure 6*).

Purse seine fishing occurs within the CIEEZ. The purse seine fishery is a surface fishery targeting schooling skipjack tuna (*Katsuwonus pelamis)* in the tropical waters of the Western and Central Pacific Ocean. The purse seine fishery operates in the northernmost waters of the CIEEZ and catches are unloaded at canneries in Pago Pago, American Samoa (MMR 2017).

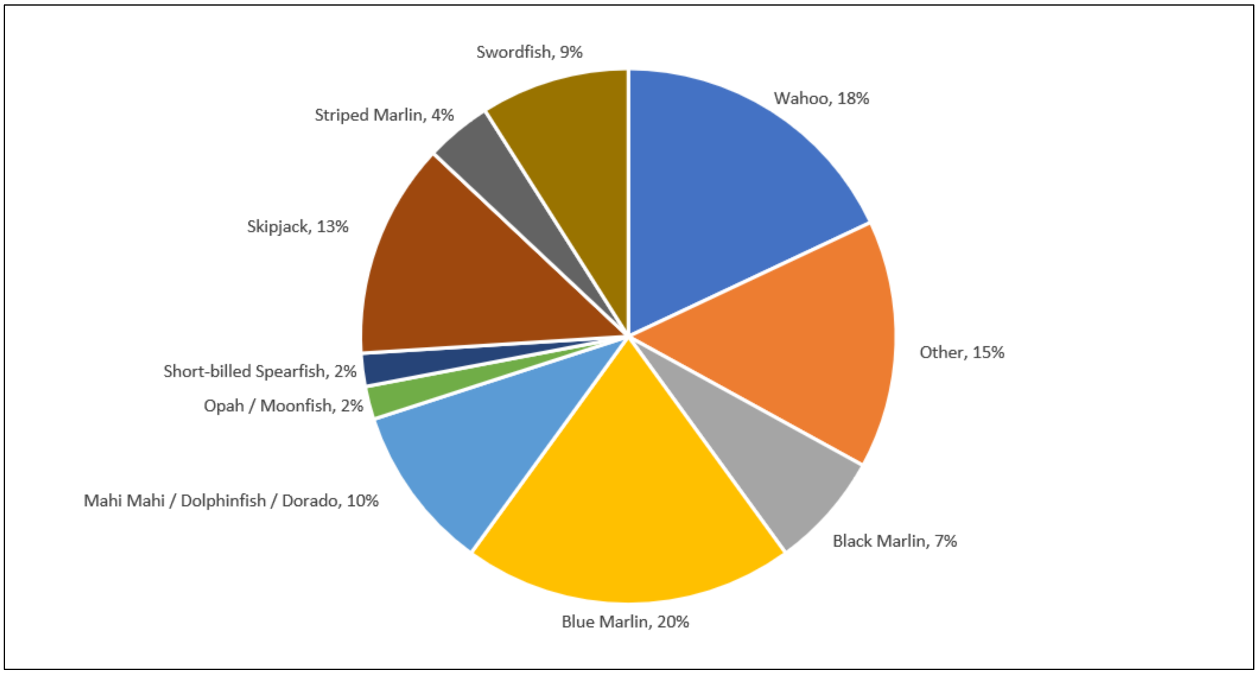

Figure 6 - Long line fishery, species composition of the other species in the 2017 catch (Source: from MMR 2018)

The purse seine fishery is controlled by fishing effort using the Vessel Day Scheme (VDS), which monitors the days fished inside the CIEEZ. 2017 was the third year the Cook Islands agreed bilateral arrangements to license purse seine vessels in addition to vessels under the US Multilateral Treaty with Pacific Islands States (US Treaty). In 2017, an additional 15 vessels from Korea, Kiribati and Spain were licensed to fish in the CIEEZ. Cook Islands has a declared Purse Seine limit of 1,250 vessel days available annually, of which 350 days are reserved for US vessels under the US Treaty. US vessels fished 456 days in the CIEEZ in 2017. All purse seine vessels are prohibited to fish within 24 NM of each island and 48 NM of Rarotonga. Three Rarotonga based longliners catch tuna and other species for the local market and operate within 100 NM of Rarotonga (MMR 2017).

A Sustainable Fisheries Partnership Agreement with the European Union was signed in October 2016 and came into force in May 2017. Two Spanish purse seine vessels were also authorized to fish under the EU Sustainable Fisheries Partnership Agreement (SFPA), with a capped total of 7,000 t from a national tonnage limit of 30,000 t. In 2017 the Spanish vessels fishing under the SPFA caught 650 t and were present in the CIEEZ for 13 days.

Of the total purse seine catch, 90% was skipjack tuna, 8% was yellowfin, and 2% of bigeye tuna. Of the total catch in 2017, 95% was taken from fishing aggregating devices (FAD) associated sets and 5% from free school sets. Since 2012, an average of 79% of the total purse seine catch has been from associated sets, with 21% from un-associated sets, indicating the reliance on FAD sets for the viability of the fishery in Cook Islands waters. There is a strong seasonal trend in the purse seine fishery, with the fourth and first quarter of the year the peak season of the fishery. This is opposite to the longline fishery which operates largely through the winter months. The purse seine fishery is subject to a three-month FAD closure from July to September, which prohibits the setting of nets on FADs (MMR 2017). The composition of bycatch in the purse seine fishery available from observer data coverage on 2017 purse seine sets indicates that silky sharks comprise the largest component of bycatch, followed by blue marlin and rainbow runners, mahi, dolphin fish and dorado (MMR 2017).

The spatial distribution of purse seine catches is exclusive to the northernmost parts of the EEZ, north of 13˚S. This is north of the Application Area.

4.4.2.3 Coastal Zone Fisheries

Pelagic and reef-associated fish species in the coastal zone are important to subsistence, artisanal and small-scale commercial fisheries in Cook Islands (Cook Islands Ministry of Marine Resources). The majority of this fishing takes place in the coastal zone (Gillett 2016) and not in the oceanic environment over the South Penrhyn Basin. The Cook Islands artisanal fishery occurs from all inhabited islands, primarily targeting tuna and pelagic species.

In 2017 there were 265 active artisanal vessels reporting on the artisanal database. Of these, 96% were small powered boats with outboard motors, 3% were recreational sport charter vessels (tourist operators), and 1% were unpowered canoes.

Common fishing methods include hook-and-line, vertical longline, gill net and other netting methods, spearfishing, fish trapping and manual gleaning (Anon undated). Artisanal fishers with powered vessels often troll around the coast of the islands, while unpowered canoes tend to fish at fishing aggregating devices (FADs) using handlining methods.

Artisanal catch data was recorded from the islands of Aitutaki, Atiu, Mangaia, Manihiki, Mitiaro, Mauke, Pukapuka, Rakahanga, and Rarotonga. Artisanal catch estimates totalled 255 t in 2017. The majority of the reported catch comes from Aitutaki and Rarotonga.

Catch from the artisanal fishery is consumed locally and sold through local markets. The nearshore fishery is variable and different species are known to be seasonally abundant (Anon 2000).

Pelagic and reef-associated fish species in the coastal zone are important to subsistence, artisanal and small-scale commercial fisheries in Cook Islands (Cook Islands Ministry of Marine Resources). The majority of this fishery takes place in the coastal zone (Gillett 2016) and not in the oceanic environment over the SPB. Common fishing methods include hook-and-line, vertical longline, gill net and other netting methods, spearfishing, fish trapping and manual gleaning (Anon undated). Fishing for pelagic species is concentrated around Fish Aggregating Devices (FADs) deployed for the purpose of attracting fishes. Catch from the artisanal fishery is consumed locally and sold through local markets. The nearshore fishery is variable and different species are known to be seasonally abundant (Anon 2000).

4.4.2.4 Aquaculture

A variety of marine aquaculture projects have been developed and undertaken but none is associated with deep offshore waters within the CIEEZ.

Developments in the mariculture of round pearls using the black-lip pearl shell, *Pinctada margaritifera* have led to the development of a black pearl industry in Cook Islands. Pearls are commercially cultured in Manihiki and Penrhyn lagoons in the north of the country, some 600 km from OM's Application Area, and have become one of the country's largest exports. There are 210 pearl farms in total occupying an area of some 10 km^2 in Manihiki Lagoon and 1 km^2 in

Penrhyn Lagoon (Anon 2000). The fishery is based on two species, the small pearl oyster (*Pinctada maculata*, which produces a golden pearl) and the black-lipped pearl oyster (*Pinctada margaritifera*, which produces the more valuable black pearl). Pearl exports are valued between NZ$5–10 million and the Cook Islands Ministry of Marine Resources is encouraging the spread of pearl farming to other islands.

Efforts are also being made to commercially develop milkfish (*Chanos chanos*) culture and capture fisheries based on trochus shell (*Trochus niloticus*).

4.4.2.5 Energy Production

The deep ocean provides sources of oil and gas reserves. Energy generation from harnessing temperature differentials of hydrothermal venting and the natural temperature stratification in the ocean (ocean thermal energy conversion, OTEC), wave energy and tidal energy are among some of the renewable energy sources provided by the ocean. Exploitation of these renewable sources is limited but is coming under increasing scrutiny and interest in much the same way that deep-sea mining interest has increased: driven by increased demand and technological advances in solving some of the early commercialization problems. To our knowledge, there is no active exploitation of subsea energy in CIEEZ, however it is recognized that scientific research for OMs exploration program has potential foundational significance for a variety of other marine research that could follow.

4.4.2.6 Bioprospecting

The deep-sea is considered a potential source for novel natural products that have pharmaceutical properties. It is generally considered that compounds of potential value to biomedicine and cosmetic industries exist. It is interesting to note that the 2008 Nobel prize for chemistry was awarded to researchers who isolated a bioluminescent protein from a jellyfish which is used to investigate nerve cells and cancer. To our knowledge, there is no active bioprospecting in CIEEZ, however it is recognized that scientific research for OM's exploration program has potential foundational significance for a variety of other marine research that could follow.

4.4.2.7 Communications

The deep-sea provides a provisionary service by hosting telecommunications infrastructure in the form of subsea cables. In the Cook Islands, the Manatua cable comes to shore at Rarotonga and Aitutaki and connects to the global internet via Samoa and Tahiti (Figure 7). To our knowledge there is no subsea communications infrastructure intersecting OM's application area.

High speed internet afforded by the Manatua cable will benefit the project by allowing efficient data sharing and will obviously be a benefit to the broader Cook Islands community.

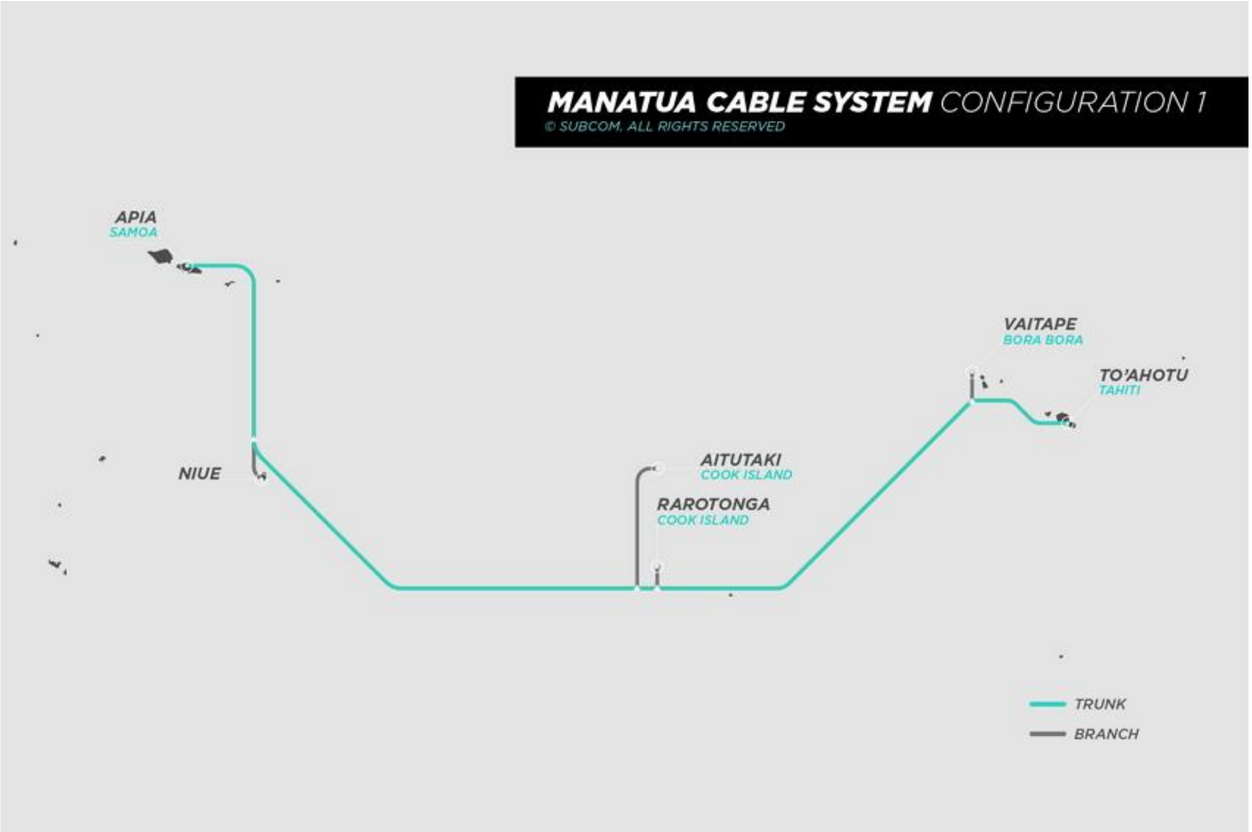

Figure 7 - The Manatua submarine cable system. (Source: Manatua Consortium Media Release, February 2020).

4.4.2.8 Military

The deep-sea environment hosts military activities. The extent of military use of the deep-sea environment in CIEEZ is unknown but is expected to be generally lower than Pacific continental shelf and continental slope locations, and lower than that of deep-sea locations that are closer to major military bases (e.g. Hawaii). It is conceivable that there are interrelationships between seabed minerals explorations, particularly seabed mapping, and military use (e.g. identification of navigable deep-sea routes). However, it is recognized that the spatial scale of seabed minerals exploration in CIEEZ and the vessel and technological resources used in exploration are likely to be minor in comparison to the areas of operation and resources of the various militaries operating in the ocean.

4.4.2.9 Shipping

On a global scale, shipping and total vessel traffic in the Cook Islands EEZ is generally low (

Figure 8) but commercial shipping is critically important to the delivery of products to Cook Islands (individually and collectively) and the economy in general. The Port of Rarotonga has limited size and infrastructure and is not an all-weather port, which places a restriction on the size class of ships able to be received. Inter-island shipping is also important in Cook Islands. OM's exploration project will interact with shipping operations, mainly within the Port of Rarotonga where berthing space and wharf infrastructure and resources may be limited. Interactions with transiting vessels at the OM application area is expected to be minimal but vessels may come into radar or visual range. Normal ship transiting practice of Automatic Identification System (AIS), radar, radio communications and visual lookout will be used to identify passing ships and avoid negative interactions.

In the future, mining operations are likely to require personnel and supply shipping, representing an opportunity for expanding existing inter-island shipping operations.

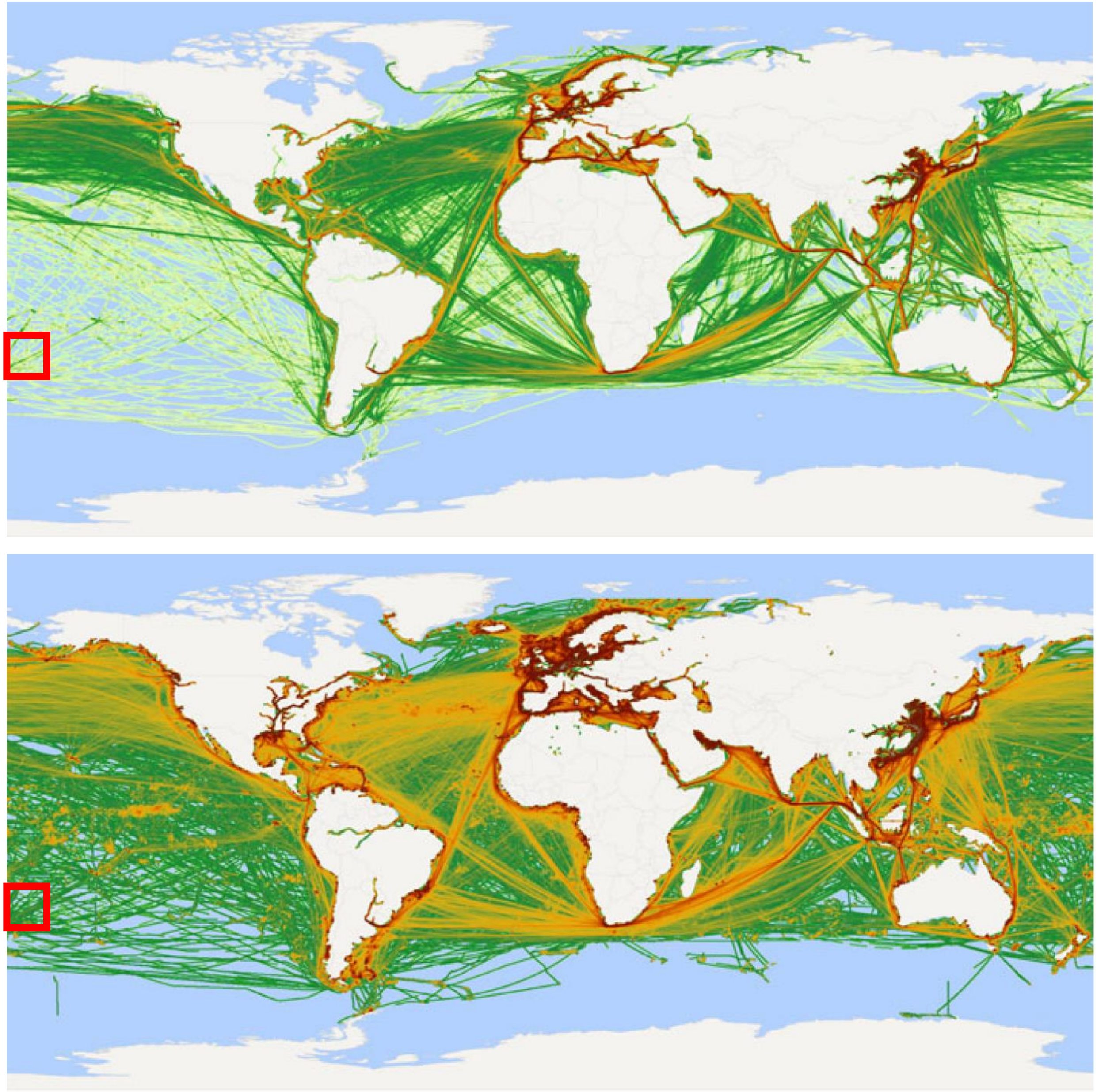

Figure 8 - Comparative global cargo ship (a) and total vessel density (b). Approximate location of Cook Islands EEZ is shown by red square. (Source: Wu et al. 2017).

4.4.3 Cultural Services

4.4.3.1 Cook Islands Traditional Beliefs, Knowledge and Values

The open ocean is integral to the origin stories, traditional knowledge, and cultural values of Cook Islanders. These values are upheld in the Marae Moana Act (2017) and are witnessed throughout everyday life. From traditional to modern beliefs, the ocean plays a key role in the identity of Cook Islanders and the EMP recognizes that this factor will be paramount in the social acceptability of deep-sea mining in Cook Islands and that excellent environmental performance will be one of the most important criteria in gaining that acceptability.

The exploration program will be nested within an Environmental and Social Impact Assessment (ESIA) framework. The social dimension is added in recognition of the fact that avoiding negative social impacts and maximizing positive social and socioeconomic impacts will be key to exploration and future commercialization of the project.

4.4.3.2 Global Human Culture

References to the deep-sea and an awareness of the 'wildness' of the open ocean holds an important place in human culture and imagination. Beyond the fact of being a habitat for wildlife that we admire and wish to preserve, the existence of the oceanic deep-sea environment is meshed into ancient and modern civilization in form of mythologies, stories and literature, art, music, aesthetics, entertainment, tourism, and technological development. As such, while OM's exploration activities will take place in the CIEEZ, and will recognize the cultural values of Cook Islanders, it is also recognized that global cultural values will be influential.

4.4.3.3 Marine-based Tourism

There are currently 12 game fishing charter vessels in the Cook Islands. These are high powered outboard and inboard motorboats and are approximately 8–12 m in length. Trolling is the main fishing method used to target billfish, tuna, and other pelagic game fish species.

Tourism, and the supporting activities of restaurants and accommodation, is the Cook Island's biggest export, contributing approximately 50% to GDP (Cook Islands Ministry of Finance and Economic Management). Tourists from New Zealand form the majority of tourists and activities are centered on Rarotonga and other islands where the natural values of the marine environment are primary attraction. Diving, snorkeling, charter fishing, whale watching, and other water sports and marine-based activities are key to tourism.

There is no information that indicates that the Application Area activities will occur in vicinity of tourism related activities. This information will be updated through stakeholder engagement.

4.4.3.4 Marine Scientific Research and Education

The Cook Islands has limited dedicated marine research facilities. The National Environment Service and The Cook Islands Natural Heritage Trust are the two main science providers and other agencies include the Aitutaki Marine Research Centre and the Centre for Cetacean

Research and Conservation, Rarotonga. In addition, a number of NGOs engaged in marine research and conservation operate in the country (see Section 3.4.5.1).

The University of the South Pacific has a campus in Cook Islands and offers Bachelor of Science courses and undergraduate courses in Ocean Resources Management. New Zealand-based academic institutes may also operate research programs in Cook Islands.

4.4.3.5 Archaeology

Cook Islands terrestrial archaeological sites relating to Polynesian maritime migration, culture and colonization are significant (Weisler et al. 2016). Underwater artefacts may be expected to occur, particularly around islands where most human interaction was centered. The presence of Polynesian or other archaeological sites, such as World War II wrecks, at the mining site will be the subject of further study throughout the exploration and ESIA program. Detailed multibeam echo sounding over the mining site will be a primary data input to this assessment. Cook Islands generally was not a significant WWII theatre and there does not appear to be known congregations of wrecks such as those known from nearby states such as Solomon Islands[2]

4.5 Stakeholder Environment

4.5.1 Cook Islands Government Agencies

4.5.1.1 Seabed Minerals Authority

The Seabed Minerals Bill (2019) and the Seabed Minerals Amendment Act (2020) establishes a Cook Islands Seabed Minerals Authority as a statutory agency of the Government of the Cook Islands. The Environment (Seabed Minerals Activities) Regulations (2020) set out the requirements for environmental permitting of exploration activities. The Act provides for the appointment of a Seabed Minerals Commissioner and Officers to oversee the functions of the Seabed Minerals Bill as required, reporting to an appointed responsible Minister. Seabed Minerals Amendments Act (2020) sets out the administrative framework, duties and responsibilities of the proponent and the Seabed Minerals Authority and penalties for non-compliance. Interface between the Government and the community is via the Cook Islands Seabed Minerals Advisory Board, comprised of a chairperson (appointed by the responsible Minister), the Seabed Minerals Commissioner, five members representing the island communities of the Cook Islands, and additional members as required.

4.5.1.2 National Environment Service

The Cook Islands National Environment Service is the agency responsible for permitting, monitoring and enforcing environmental laws under the Environment Act (2003). The National Environment Service also plays an important role in research and stakeholder engagement in the area of sustainable development of seabed mining in Cook Islands.

[2] http://www.seaaustralia.com/wwii_shipwrecks.htm; https://www.pacificwrecks.com/provinces/cook.html

The Seabed Minerals Amendment Act (2020) upholds the requirement to comply with the Environment Act (2003), the core legislation controlling the permitting of activities that have the potential to cause *significant environmental impacts*.

4.5.1.3 Marae Moana Council

The Marae Moana Act is administered by the Marae Moana Council that is chaired by the Prime Minister and comprises the opposition lead, a religious leader, a representative of the finance ministry and community leaders. The Act was established in consultation with the House of Ariki (see Section 4.5.1.4).

4.5.1.4 House of Ariki

The House of Ariki is a parliamentary body in the Cook Islands. It is composed of Cook Islands high chiefs (ariki), appointed by the Queen's Representative. There are up to twenty-four members, representing different islands of the Cooks.

4.5.1.5 Ministry of Marine Resources

The Ministry of Marine Resources is responsible for the conservation, management and development of marine resources. Established in 1984, the Ministry's objective is to ensure the sustainable use of living and non-living marine resources for the benefit of the people of the Cook Islands.

4.5.1.6 Ministry of Transport

The Cook Islands Ministry of Transport is a government entity with policy and primary oversight of the maritime administration; it is responsible for both domestic and international shipping services, including port and coastal state activities.

4.5.2 Marine-based Tourism

As described in Section 4.4.3.3, marine-based tourism is an important cultural service in the Cook Islands and contributes to the economy. There is no information that indicates that the Application Area activities will occur in the vicinity of tourism related activities. This information will be updated through stakeholder engagement and EIA studies.

Tourism operators often have significant knowledge of the marine environment and can be among the thought-leaders in small communities. Experience from elsewhere would suggest that marine-based tourism may be sensitive to any negative impressions expressed in the media or perceptions of clientele as to the quality of experience. As one example, game fishing charters tend to attract knowledgeable, senior figures in the community and the interactions at fishing/yacht clubs in some South Pacific locations can be opinion-forming.

4.5.3 Marine Commercial Fisheries

The tuna fishery is the most important commercial fishery in the Cook Islands EEZ. Commercial fishing intensity within the Cook Islands EEZ is relatively low compared to other areas in the South Pacific region. In the vicinity of OM's Application Area, commercial fishing activity appears to be negligible. EIA studies will aim to access vessel monitoring data to quantify the spatial extent and intensity of ocean commercial fishing.

Experience from elsewhere would suggest that commercial and artisanal fishers may be sensitive to any negative impressions expressed in the media or perceptions of seafood quality.

4.5.4 Cook Islands Society

OM commits to proactive and open engagement with the Cook Islands community throughout our Exploration Work Plan (EWP) and Environmental Management Program (EMP).

OM's objective is to engage the community within the Cook Islands as a whole, to not only support the idea of seabed mineral exploration, but to also advocate on behalf of and participate in that mineral exploration. It is recognized that Cook Islanders' traditional subsistence and artisanal activities may be limited to the coastal environment, but there are cultural considerations of deep-sea mining that will be investigated through the ESIA and incorporated in OM's planning.

4.5.5 International Agencies

4.5.5.1 Non-Governmental Organizations (NGOs)

Deep-sea mining attracts considerable attention from NGOs, some of which are already actively engaged in considerations of nodule mining in CCZ (e.g., PEW Charitable Trusts, Seas At Risk, Deep Sea Conservation Coalition, Fair Oceans, Global Ocean Trust). NGOs differ in their levels of opposition to deep-sea mining, and therefore their levels of engagement with industry and regulators. In some cases, religiously affiliated NGOs, or church councils themselves have come out in opposition to deep-sea mining or the governance of the industry. For example, in Papua New Guinea, The Council of Churches called for a ban on seabed mining in PNG. Known public figures such as Sir David Attenborough are among those putting their voice behind opposition to deep-sea mining.

Our experience at workshops run by the International Seabed Authority, involvement in scientific research, and observations of NGO activity indicates that vocal opposition to deep-sea mining from NGOs will be a challenge for the project. OM intends to closely monitor activities, have a strong internal policy and plan for NGO engagement and maintain a focus on robust evidence-based decision making.

Table 6 - Some NGOs with active presence in Cook Islands

Organization	Key people	Website
Te Ipukarea Society	Jacqueline Evans, Kelvin Passfield (Technical Director)	http://www.tiscookislands.org/
Living Oceans Foundation		https://www.livingoceansfoundation.org/global-reef-expedition/pacific-ocean/cook-islands/
Centre for Cetacean Research and Conservation	Nan Hauser	http://www.whaleresearch.org/

Secretariat of the Pacific Regional Environment Program (SPREP)	Kosi Latu (Director), Easter Chu Shing-Galuvao (Director, Environmental Monitoring and Governance)	https://www.sprep.org/
International Fund for Animal Welfare (IFAW)	Rebecca Keeble, Director for Oceania	https://www.ifaw.org/australia
South Pacific Whale Research Consortium	Scott Baker (Executive Director), Dave Paton (Executive committee member)	https://mmi.oregonstate.edu/ccgl/research-projects/south-pacific-whale-research-consortium
World Wide Fund for Nature (WWF)		http://www.wwfpacific.org/
Pacific Islands Association of NGOs (PIANGO)	Ms Ngara Katuke – President	http://www.piango.org/our-members/member-countries/cook-islands/
Aitutaki Conservation Trust	Mike Lee	http://www.aitutakiconservation.com/Home.php
PEW Charitable Trusts	Conn Nugent – Project Director, Seabed Mining Project	https://www.pewtrusts.org/en/projects/seabed-mining-project

4.5.5.2 Academic Research Institutes

The strong research component of environmental studies in previous deep-sea mining exploration projects has fostered a sporadic but generally strong academic science involvement. Exploration companies operating in the CCZ often link with academic research consortia who come to the collaboration with vessels and research packages that address the various ISA environmental requirements. Scientific papers in peer reviewed journals generated by this activity range from policy to environmental discoveries.

For Cook Islands and other Pacific Island nations, where capacity building is a desirable outcome, engagement with regional universities and institutes may be desirable. We note the presence of a University of the South Pacific campus in Cook Islands and the potential for interaction with undergraduate courses and post-graduate research. SPC (2016a) outlined some guidelines for research in deep-sea minerals exploration and identified the contribution that minerals exploration can make to knowledge generation for Pacific island nations. SPC (2016a) also acknowledges the importance of trans-boundary issues and collaboration. There are links between academic research, precaution, and public opinion and OM recognizes that academic research is an important stakeholder in deep-sea mining project development and that objective scientific data is required for evidence-based decision making.

5 ENVIRONMENTAL MANAGEMENT SYSTEMS

5.1 Administration

The exploration EMP will be executed as part of an integrated information management system that will serve as the administration basis for the exploration project. It will provide the basis for reporting, auditing and review. The information management system will detail the company policy, permit requirements, monitoring processes, performance indicators, training requirements, required interactions with external parties etc. The information management system will facilitate routine environmental performance reporting and will outline the processes for training, incident management and corrective actions.

OM will apply the same concepts of quality assurance to the environmental program that are required for mineral resource assessment. An environmental database will be a central aspect of achieving this quality assurance (see Section 5.2 below). As the environmental activities of the exploration phase will be completed within an ESIA framework, early engagement with ESIA consultants and key research providers will be an additional layer of administration and independent quality assurance.

Execution of the EMP will be the responsibility of the Environmental Manager who reports directly to the CEO.

5.2 Data Management and Collaboration

OML recognizes that environmental data management is key to success of the exploration program and effective collaboration. An environmental database, known as q*Core*, will be used for the exploration project and this system is the same as that used for CCZ exploration projects and a major Marine Knowledge Framework project in Australia (CoastKit). qCore complies with the ISAs requirements for the data export and reporting and has integrated ecosystem-based management as a central design feature. The database is comprised of:

- Citations and sources of evidence.
- An ecosystem model structure so that study design can be linked to information requirements.
- Ecological classification tools to depict spatial distributions of habitats and biological communities.
- Tools to facilitate offshore sample and data registration directly into database forms, with chain of custody processes to eliminate manual data entry errors.
- Online portals to provide regulators, stakeholders and collaborators with direct visualizations of sampling activity, analytical results etc.
- Query tools to provide data exports and standard reports to regulators, stakeholders and collaborators.

OM recognizes that collaboration among Cook Islands and international agencies will be important to achieve social and academic acceptance of seabed mining in Cook Islands. It is intended that the environmental database and its ecosystem modelling tools will form a basis for direct collaboration, communication and evidence-based decision making in the ESIA process. It is also recognized that there are opportunities to contribute an emerging best practice and assist Cook Islands agencies such as SBMA and NES with development of similar database tools to assist with internal management of multi-contractor data in a similar way that ISAs DeepData database operates in CCZ. Effective standardization and management of multi-contractor data will be important for Cook Islands agencies to integrate information at the regional scale.

Through the conduct of exploration cruises, OM will encourage the involvement of independent observers as already done for the 2019 scientific research voyage.

5.3 Sample Handling

The exploration program will generate numerous environmental and geological resource samples. Proper sample registration and transmittal to accredited laboratories is essential to quality assured geological resource evaluation. Barcoded sample labels will be used as a basis for chain-of-custody and linking laboratory data to sites. OM recognizes the logistical challenge of moving large volumes of highly valuable samples to multiple international laboratories. OM successfully met this challenge during the 2019 scientific research voyage and the lessons learned during this survey will be valuable for the exploration program.

Representative samples will be shared with SBMA and opportunities for other sample sharing with researchers, educators and stakeholders will be sought.

5.4 Existing Protected Areas and Ecological and Biologically Significant Areas

The Marine Resources Act 2005 establishes the entire Cook Islands EEZ as a whale sanctuary and a shark sanctuary. This declaration provisions for the protection of whale and shark species against commercial exploitation and the management of tourism, fisheries and scientific research and other activities that have the potential to intentionally, or inadvertently, interact with these species.

The Marae Moana Act 2017 act establishes a Marine Protected Area 50 nautical miles around each of the islands in the country, one stated objective of which is to provide –

> *"…a seabed minerals activity buffer zone to provide for the protection of pelagic, benthic, coral reef, coastal and lagoon habitats of the marae moana by prohibiting all seabed minerals activities, while allowing other ecologically sustainable uses."*

All of OM's exploration areas as part of the Application Area fall outside areas covered by the Marae Moana Act 2017.

Cook Islands is signatory to the Convention on Biological Diversity (CBD), which lists a number of recognized or slated Ecologically or Biologically Significant Areas (EBSAs). These areas do not represent legislated protection areas but rather internationally recognized sites of high biodiversity value or ecosystem function/resilience value. Five EBSAs are recognized by the CBD in Cook Islands. Of these, two are associated with the islands and coastal waters around Suwarrow and Raratonga. One EBSA is associated with the Ua puakaoa seamounts in the western of the CIEEZ and there is one EBSA associated with the Manihiki Plateau in the north. The OM Application Area is separated from these sites by 100s to 1000s of kilometers. Another Cook Islands EBSA overlaps with the central SPB nodule province and OML's exploration activities, that being an area known as the Western South Pacific High Aragonite Saturation State Zone. This EBSA is erected by CDB to cover a large oceanographic feature area (not a seabed feature) characterized by water column physicochemical properties that render it potentially resilient to future climate change impacts. This EBSA overlaps with the central SPB nodule province and OM's areas Application Area. The overlap with OM's Application Area represents approximately 2% of the total area of the EBSA (see Figure 9). Exploration activities do not represent a risk to aragonite concentrations throughout the water column at the scale of this EBSA.

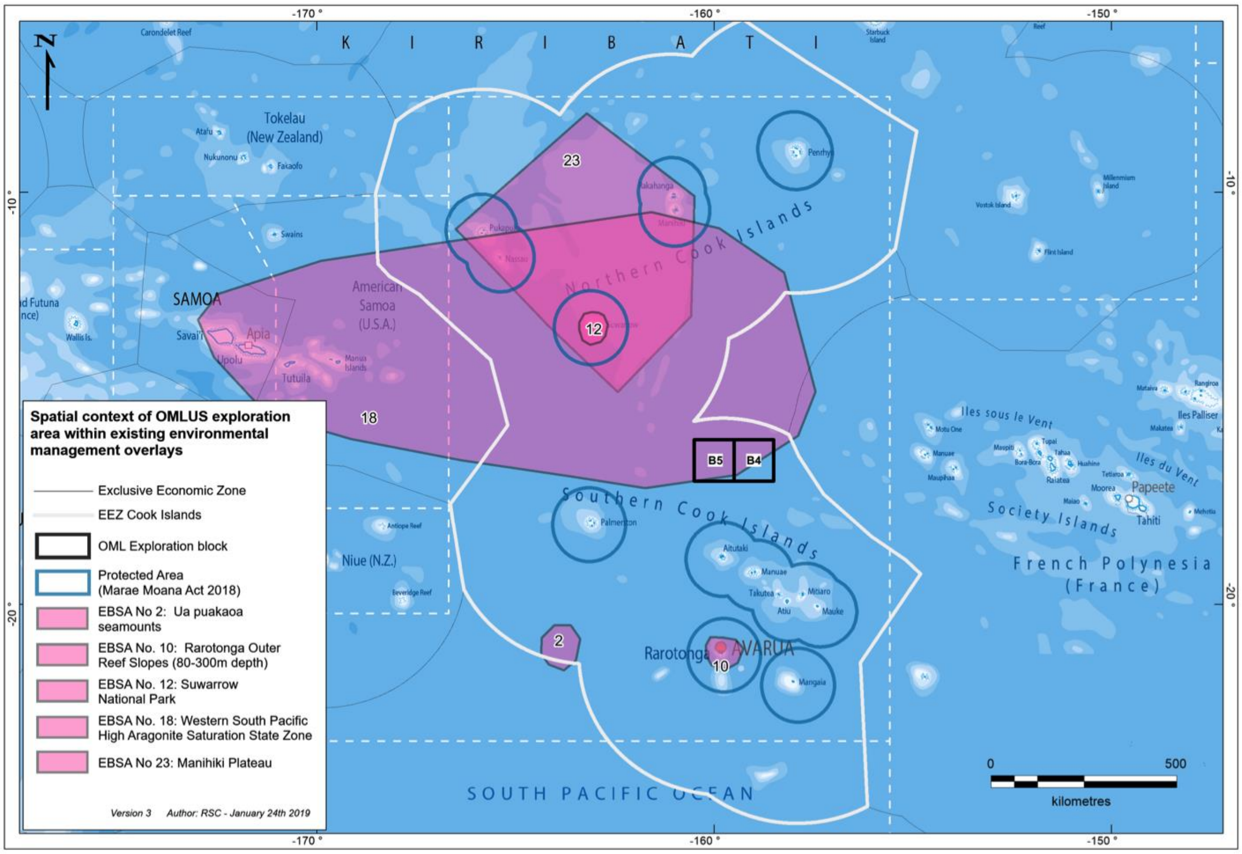

Figure 9 - OM application area comprised of OML Reserved Areas 4 and 5 in context of existing Marae Moana Act 2017 protected areas and Convention on Biological Diversity ESBAs.

6 EXPLORATION ENVIRONMENTAL RISK ASSESSMENT

6.1 Introduction

The Environment (Seabed Minerals Activities) Regulations 2020 (Schedule 1 and 2) describe the tiers of activity that require consent and those that require permitting. The following Risk Assessment addresses the known Tier 2 activities that will be carried out in the exploration program. By definition, these activities pose relatively low risk of significant impacts and therefore do not require a specific Environmental Impact Assessment (EIA). As described in the Work Plan, the need for OM's exploration program to conduct Tier 3 activities that do require a permit and EIA will be known at the end of Year 2. Tier 2 Planned Activities

Environmental sampling activities, sampling devices and instruments that will be used during the exploration program are typical of deep-sea scientific research activities around the world. The activities will interact with the sea surface, atmosphere, water column and seafloor. Interaction with the seafloor will cause negligible disturbances at the scale of the contract area and abyssal environment. The area disturbed will be considerably less than 10,000 m^2 and will be defined as Tier 2 activities that have low environmental risk by definition. The Tier 2 exploration activities and the receiving environments are listed in Table 7.

Table 7 - Tier 2 activities and receiving environments

Activity type	Activity	Receiving Environment
Vessel operations	Mobilization and demobilization	Nearshore - atmosphere
		Nearshore – water column
		Onshore – social
	Operation	Nearshore – water column
		Offshore – water column
Multibeam echosounding	Sampling	Offshore – water column
		Offshore – seafloor
Oceanographic moorings	Mooring deployment and operation	Offshore – water column
		Offshore – seafloor
Water sampling and CTD profiles	Sampling	Offshore – water column
Drifting hydrophones	Sampling	Offshore – water column
Nodule and sediment sampling	Freefall grab sampling	Offshore – seafloor
		Offshore – water column

	Boxcore sampling	Offshore – seafloor
		Offshore – water column
	Multicore sampling	Offshore – seafloor
		Offshore – water column
	Epibenthic dredge	Offshore – seafloor
		Offshore – water column
Seabed imaging	Towed camera, AUV, ROV	Offshore – seafloor
		Offshore – water column
Pelagic sampling	Net trawls and sampling	Offshore – water column
	Water sampling	Offshore – water column
	Bioacoustics	Offshore – water column
Benthic lander sampling	Lander experiments	Offshore – seafloor
	Lander trapping	Offshore – seafloor
	Lander imaging	Offshore – seafloor
Project execution	All activities	Onshore - social

6.2 Potential Environmental Risks

The potential risks of the exploration program are identified in Table 8. The assessment of the significance of these risks is informed by the understanding of the environment and experience of the project team with the observations made during the 2019 scientific research voyage, similar exploration programs in the CCZ and other activities in deep-sea and continental shelf environments.

The environmental risks of the majority of Tier 2 activities are negligible to low and involve interactions with the seafloor or water column habitats that are small in scale and/or intensity when contextualized within the spatial scales of the open ocean and abyssal environments of the EEZ.

Potential risks associated with logistical aspects of mobilization and demobilization from the Port of Rarotonga are ranked as Moderately significant. This is in recognition of the logistical challenges encountered during the 2019 scientific research voyage and an appreciation for the increased complexity of movements and international supply for the Exploration Work Program.

Other Moderate and High significance aspects of the project are associated with the potential for Positive Impacts. OM’s experience from the 2019 scientific research voyage, and feedback to the subsequent drafting of the Seabed Minerals Bill and Regulations and observing the stakeholder engagement processes is that there is potential for the exploration to have a positive impact on community awareness and perceptions. OM intends to collaborate with Cook Islands agencies to foster these positive impacts by encouraging participation of observers (as successfully implemented in the 2019 scientific research voyage), sharing of regionally significant data, and generally producing materials and engagement platforms that create awareness. The exploration program has the potential to create tangible high impact with respect to travel, accommodation and support services of exploration crew and scientists and we acknowledge the potential importance of this injection into the local economy in a post-COVID-19 recovery phase.

The risks associated with exploration voyages will be re-assessed after detailed project scoping at the project execution planning stage. Risk mitigations and management are discussed, and the process for reporting and reviewing environmental risks is laid out in document NPPOL-00000-RSKMG-00 - Risk Management Plan.

Table 8 - Tier 2 activity environmental risks/opportunities and significance

Activity type	Activity	Potential driver	Potential risks/opportunities	Potential Significance
Vessel operations	Mobilisation and demobilisation	Logistics and vessel traffic	Resourcing and stretching local resources with potential impact to normal logistics, berthing and vessel traffic management systems	MODERATE Logistical impacts experienced during previous campaign
		Wharf services	Increased pressure on local resources with potential impact to normal berthing, wharfing and shipping services	LOW Engaging international supply chain for logistics. Relatively low incremental pressure compared to existing supply, cruise ships etc.
		Personnel movements and services	Positive impact to local travel and accommodation services	MODERATE Travel and accommodation services hard hit by COVID-19 potentially benefitting from international personnel travel for exploration campaigns
		Vessel presence	Positive impact to societal interest, news, awareness raising and education	HIGH News stories, independent observers, shared experiences have potential to raise awareness and general knowledge and have a high positive impact in the community.
	Operation	Underwater noise	Potential disruption of animal communication/migration	NEGLIGIBLE Relatively low spatial influence of research vessel(s) in context of EEZ.
		Vessel discharges	Potential introduction of toxicants and contaminants	NEGLIGIBLE Normal vessel operations controlled by MARPOL and standard vessel procedures.
		Vessel travel	Potential direct animal strike	NEGLIGIBLE Relatively low spatial influence of research vessel(s) in context of EEZ. Standard vessel procedures with respect to avoidance of cetaceans and other fauna.

		Greenhouse gas emissions	Emission of greenhouse gases	NEGLIGIBLE Relatively low incremental increase compared to existing shipping and global GHG emission etc.
		Interaction with other marine users	Potential disturbance to shipping and fishing operations	NEGLIGIBLE Low existing activity in Application Area. Relatively low incremental increased in spatial influence of research vessel(s) in context of EEZ.
Multibeam echosounding	Sampling	Introduction of acoustic energy	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Multibeam is relatively low energy and high frequency acoustic system, unlike seismic (sub-bottom) acoustic systems. No evidence for lethal or sub-lethal impacts of multibeam echosounding.
			Potential disruption of animal communication/movement/migration	NEGLIGIBLE Multibeam is relatively low energy and high frequency acoustic system, unlike seismic (sub-bottom) acoustic systems. No evidence for lethal or sub-lethal impacts of multibeam echosounding.
Oceanographic mooring installation and operation	Operation	Interaction with seabed habitat	Impact and compaction of anchors with seafloor habitat	NEGLIGIBLE Footprint of interaction with seafloor is small (<5 m^2) compared to extent of available habitat.
		Introduction of acoustic energy	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Acoustic doppler current meters (ADCPs) emit relatively low energy acoustic pulses intermittently. No evidence for lethal or sub-lethal impacts of acoustic current profiling.

			Potential disruption of animal communication/movement/migration	NEGLIGIBLE Acoustic doppler current meters (ADCPs) emit relatively low energy acoustic pulses intermittently. No evidence for lethal or sub-lethal impacts of acoustic current profiling.
		Introduction of manufactured debris	Placement of sacrificial anchors on the seabed upon recovery of the moorings	LOW Footprint of sacrificial anchors remaining on seafloor is small (<5 m^2) compared to extent of available habitat. Multiple anchors required for sequential deployment and recovery. Anchors will be made from non-toxic materials to the extent possible.
Water sampling and CTD profiles	Sampling	Removal of water and plankton	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Negligible volumes required for scientific sampling.
		Sensor measurements	Potential disturbance to water column habitat	NEGLIGIBLE Environmental sensors are low voltage systems with very limited spatial influence.
Drifting hydrophones	Sampling	Sensor measurements	Potential disturbance to water column habitat	NEGLIGIBLE Passive acoustic ('listening') sensors are low voltage systems with very limited spatial influence.
Nodule and sediment sampling	Freefall grab sampling	Interaction with seabed habitat, removal of nodules and sediment	Seafloor impact and substrate removal	NEGLIGIBLE Area of seafloor impact per deployment (<1 m^2) negligible compared to total abyssal habitat. Volume of nodule and sediment removal per deployment (<1 m^3) negligible compared to total abyssal habitat.

		Removal of biota	Direct removal of benthic biota	NEGLIGIBLE Abundance of abyssal fauna generally low compared to shallow water habitats. Scales of abyssal community distribution and ecosystem function are very large with typically low levels of small scale uniqueness. Volume of nodule and sediment removal per deployment (<1 m^3) negligible compared to total abyssal habitat. No macroscopic benthic biota observed in FFG samples from 2019 scientific program.
		Creation of sediment plume	Disturbance and redistribution of sediments at seabed due to sampling and introduction of sediments to water column due to recovery of equipment	NEGLIGIBLE Very small spatial scale and volume of sediment disturbance at seafloor. High dilution of escaping sediments in water column during ascent of sampling gear.
		Introduction of manufactured debris	Placement of sacrificial weights on the seabed upon recovery of the grab	LOW Footprint of sacrificial weights remaining on seafloor from FFG sampling is small (<0.5 m^2) compared to extent of available habitat. Multiple anchors required for sequential deployment and recovery. Anchors will be made from non-toxic materials to the extent possible.
	Boxcore sampling	Interaction with seabed habitat, removal of nodules and sediment	Seafloor impact and substrate removal	NEGLIGIBLE Area of seafloor impact per deployment (~1 m^2) negligible compared to total abyssal habitat. Volume of nodule and sediment removal per deployment (<1 m^3) negligible compared to total abyssal habitat.

		Removal of biota	Direct removal of benthic biota	NEGLIGIBLE Abundance of abyssal fauna generally low compared to shallow water habitats. Scales of abyssal community distribution and ecosystem function are very large with typically low levels of small scale uniqueness. Volume of nodule and sediment removal per deployment (<1 m^3) negligible compared to total abyssal habitat.
		Creation of sediment plume	Disturbance and redistribution of sediments at seabed due to sampling and introduction of sediments to water column due to recovery of equipment	NEGLIGIBLE Very small spatial scale and volume of sediment disturbance at seafloor. Box core is sealed, preventing escape of most sediments.
	Multicore sampling	Interaction with seabed habitat, removal of nodules and sediment	Seafloor impact and substrate removal	NEGLIGIBLE Area of seafloor impact per deployment (~5 m^2) negligible compared to total abyssal habitat. Volume of nodule and sediment removal per deployment (<5 m^3) negligible compared to total abyssal habitat.
		Removal of biota	Direct removal of benthic biota	NEGLIGIBLE Abundance of abyssal fauna generally low compared to shallow water habitats. Scales of abyssal community distribution and ecosystem function are very large with typically low levels of small scale uniqueness. Volume of nodule and sediment removal per deployment (<5 m^3) negligible compared to total abyssal habitat.

		Creation of sediment plume	Disturbance and redistribution of sediments at seabed due to sampling and introduction of sediments to water column due to recovery of equipment	NEGLIGIBLE Very small spatial scale and volume of sediment disturbance at seafloor. Multicore is sealed, preventing escape of most sediments.
	Epibenthic dredge sampling	Interaction with seabed habitat, removal of nodules and sediment	Seafloor impact, substrate removal and reworking	LOW Area of seafloor impact required to achieve desired nodule mass for metallurgical testing is approximately 7,000 m^2 (below the 10,000 m^2 threshold for Tier 3). Reworking of surface sediments spatially constrained and ecological impact of nodule removal is low compared to total area.
		Removal of biota	Direct removal of benthic biota	LOW Abundance of abyssal fauna generally low compared to shallow water habitats. Scales of abyssal community distribution and ecosystem function are very large with typically low levels of small scale uniqueness. Volume of nodule and sediment removal is low compared to total area.
		Creation of sediment plume	Disturbance and redistribution of sediments at seabed due to sampling and introduction of sediments to water column due to recovery of equipment	LOW Relatively small spatial scale and volume of sediment disturbance at seafloor per deployment.
Seabed imaging	Towed camera, AUV, ROV	Introduction of light, noise and acoustic energy	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Very small instantaneous footprint of imaging platform. High attenuation and of light introduced by platform.

				Noise introduced by strumming of tow cables, vibration of towed bodies or motors of AUVs/ROVs is relatively low energy.
			Potential disruption of animal communication/movement/migration	NEGLIGIBLE Very small instantaneous footprint and slow movement of imaging platforms. Low electromagnetic energy emissions with no evidence of impact to animal communication, movement or migration.
		Direct interaction with biota	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Low density of water column fauna that may collide with imaging platform. Slow movement of imaging platform.
Pelagic sampling	Net trawls and sampling	Removal of biota	Direct removal of pelagic plankton and micronekton	NEGLIGIBLE Abundance of deep-sea pelagic fauna generally low compared. Scales of pelagic community distribution and ecosystem function are very large with typically low levels of small scale uniqueness. Volumes of biological samples negligible compared to total open ocean habitat.
	Water sampling	Removal of water and plankton	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Negligible volumes required for scientific sampling.
		Sensor measurements	Potential disturbance to water column habitat	NEGLIGIBLE Environmental sensors are low voltage systems with very limited spatial influence.
	Bioacoustics	Introduction of acoustic energy	Potential disturbance to plankton and nekton populations	NEGLIGIBLE Bioacoustic sensing is relatively low energy system, unlike seismic (sub-bottom) acoustic systems. Relatively low spatial footprint of bioacoustic sensing.

				No evidence for lethal or sub-lethal impacts of bioacoustic echosounding.
			Potential disruption of animal communication/movement/migration	NEGLIGIBLE No evidence for lethal or sub-lethal impacts of bioacoustic echosounding.
Benthic lander sampling	Lander experiments	Introduction of light and energy	Potential disturbance to benthic populations	NEGLIGIBLE Very small footprint of lander platform compared to total habitat extent. High attenuation of light. Sensor systems with low electromagnetic energy.
	Lander trapping	Removal of biota	Direct removal of benthic scavenger fauna in baited traps	NEGLIGIBLE Removal of low numbers of benthic mobile species whose populations are large and widespread.
	Lander imaging	Baiting fauna	Attraction of benthic predators	NEGLIGIBLE Negligible impacts of lighting and videography of animals attracted to bait.
Cultural and Socioeconomic	Project execution	Personnel movements and interactions	Potential negative impacts of increased personnel movement and local interactions	LOW Personnel influx relatively low compared to cruise ships and other baseline tourism activity. Project staff induction to include training and compliance in the areas of respectful local engagement and behaviors.
			Potential positive impacts of increased personnel movement and local interactions	HIGH Personnel and logistical movements and engagement of the project with local providers.

				High positive impact to Cook Islands travel sector, particularly in a post-COVID-19 recovery phase.
		Project awareness and positive perceptions	Positive impacts of increased awareness and education	HIGH Experience from 2019 scientific research voyage indicates high interest and potential for positive impacts of stakeholder interactions. High positive impact of exploration activity contributing to national scientific knowledge High positive impact of direct observers in exploration voyages.
		Negative perceptions	Negative impacts of negative perceptions	LOW Experience from OMLs past interactions and experience of the SBMA 2020 stakeholder engagement process indicates low risk of negative perceptions.

6.3 Potential Tier 3 Activities

The need for Tier 3 exploration activities will be determined at the end of Year 2 of the Exploration Work Plan. The need for equipment or process tests/trials is dependent upon the status of engineering design and testing programs currently underway, and on a more fully developed understanding of the nature of seafloor sediments in the contract areas.

The types of Tier 3 activities that could potentially be involved include individual component tests in the midwater column and at the seafloor to integrated systems trials. The nature and scale of Tier 3 activities is unknown at this time and therefore the scale of environmental risk and potential impacts are unknown. However, on the basis of experiences from the CCZ, the types of environmental considerations that might be expected for Tier 3 activities include:

- Potential for increased physical interaction with seabed habitats and removal of nodules.
- Potential for increased disturbance of seafloor sediments and direct impact to benthic fauna.
- Potential for increased generation of near-bottom plumes and sedimentation.
- Potential for generation of water column plumes.
- Potential for increased underwater noise and electromagnetic energy.
- Potential for increased environmental sensor deployments for monitoring.

Should Tier 3 activities be required, these will trigger dedicated EIA and separate assessment of environmental risks. EIA triggered by Tier 3 activities will entail a dedicated and targeted baseline, impact assessment and monitoring program.

6.4 Avoidance, Management and Mitigation Measures

Scientific sampling will be subject to Standard Operating Procedures that will be subject to a full Risk Assessment prior to voyages to assess the risks of the detailed scope of work. The Risk Assessment will cover environmental and safety aspects of the operation. The risks associated with issues such as spills, leaks, hazardous chemicals, interaction with marine fauna etc. will be assessed and the SOPs will be lodged with the Offshore Voyage Manager who will be responsible for their implementation. The SOPs will be available for review by regulators and will be subject to monitoring and ongoing improvement as required. All exploration activities will be subject to monitoring and evaluation at-sea by the Offshore Voyage Manager (Party Chief) and Lead Scientists to confirm the predictions of the EMP and identify areas for improvement.

Most Tier 2 activities of the exploration program are of negligible to low significance (see Table 8) and therefore preclude the need for specific mitigation measures. However, specific avoidance and management measures of the program will include:

- Sharp look-out for cetaceans and other marine fauna while transiting and operating.
    - Standard cetacean avoidance measures by vessel Master’s course and speed changes to avoid adverse interactions.
    - Scan for presence of marine wildlife in vicinity of vessel prior to deployment of

over-the-side equipment.

- Particular care when approaching or leaving the coastal environment around Rarotonga during the July–October humpback whale season.
- Adopt principles of regional guidelines (e.g., Australian Government National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna).
- Register and report any interactions with marine fauna.

- Safe and secure storage of hazardous chemicals onboard as per manufactures Materials Safety Datasheet and vessel operator's requirements.
- Implementation of final Incident Response Management Plan.
- Proper maintenance of equipment and avoidance of leaks and spills from deck cranes, winches etc.
- Proper handling of waste offshore as per MARPOL requirements.
- Compliance with international best practice in ballast water management and the avoidance of introduction of marine pests under direction from Port Authority and vessel operator.
- Compliance with international best practice in freight management and customs to avoid introduction of terrestrial exotic species under direction from customs agents.
- Regular drills, training and checks on all equipment and procedures that are relevant to environmental controls (e.g. spills containment, fire prevention and firefighting, materials handling offshore).
- Comprehensive induction of all personnel that covers international travel, mobilization, interactions with local people, expected behaviors and confidentiality to mitigate the risk of negative perceptions.
- Comprehensive sample security and chain of custody documentation to provide secure and quality assured sample and data transmission.
- Publishing of Notice to Mariners for offshore moorings and communication to Ministry for Transport to avoid collisions or negative interactions with fishing gear.
- Use of state-of-the-art technologies and methods.

The following measures will be taken to maximize the potential positive impacts of the exploration program (further details are provided in the Local Engagement, Training and Business Development Plan (NPPLN-32000-LCTRB-00)):

- Maintaining a Rarotonga office, establishing business connections and staffing with individuals who can interface with stakeholders.
- Actively supporting regulator observer attendance.
- Actively supporting training and education.
- Producing data and reports for public dissemination and fostering evidence-based

decision making.

6.5 Accidents and Emergencies

Accidents and emergencies will be avoided by the implementation of best international practice in offshore exploration as described in the Incident Response Management Plan (NPPLN-41200-INRSP-00). The Seabed Minerals Bill (2019), Environment Act (2003) and best international practice require the reporting of incidents that may be deemed to affect the environment. In the case of accidents and emergencies, these may include:

- Fuel or lubricant spills.
- Chemical spills.
- Animal strikes.
- Serious injury.
- Negative interactions with other marine users such as shipping and commercial fishing.
- Loss of equipment (introduction of manufactured debris) in the water column or on the seabed in the case of malfunction, breakage or loss.
- Loss of samples and data.

Mitigation and controls for potential accidents and emergencies are listed in Table 9.

Table 9 - Controls and mitigation associated with accidents or emergencies

Accident/Emergency	Controls and mitigation
Spills and leaks	International best practice Shipboard Materials Handling
	International best practice Shipboard Oil Pollution Emergency Plan Maintenance and training of spill containment kits and procedures
Animal strike	International best practice vessel strike mitigation processes
	Dedicated offshore observation system for baseline studies feeding back to vessel master Formalized screening/scanning process before deployment of equipment
Serious Injury	Stabilize using onboard equipment Arrange for Medevac
Negative interactions with marine users	Registration and reporting of interactions of sampling equipment with fishing gear
	International best practice in marine operations, use of AIS systems and radar to avoid vessels and fishing gear
	Respectful interactions at-sea Publication of Notice to Mariners for moored equipment

Loss of equipment at sea	Use of experienced scientists, crew and offshore manager Registration and reporting of lost equipment Review of SOPs
Loss of samples and data	Use of experienced scientists, crew and offshore manager Offshore database, data registration and physical sample registration systems Off-ship cloud-based database systems Quality assured chain of custody processes

7 PROGRAM REVIEW AND IMPROVEMENT

Prior to each voyage, a detailed scoping study will be completed to confirm method selection, SOPs, data management processes etc., and a desktop risk assessment will be completed. During each voyage, the activities will be logged and monitored. Unexpected impacts or incidents will be reported through the proper channels in real time. The results of the voyage, along with any identified areas for improvement will be identified in voyage reports, annual reports and consultative processes. As such, a mechanism of review and improvement of the exploration program will exist and OM will report these to regulators and stakeholders.

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