Moana Minerals

Environmental Scoping Exercise – ESIA Scoping Study

Report to Moana Minerals

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ERIAS

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Moana Minerals
Environmental Scoping Exercise
ESIA Scoping Study

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Executive Summary

The Moana 1 Project

Moana Minerals Limited (hereafter referred to as Moana) has been awarded an Exploration Licence to undertake the Moana 1 Project: an investigation into the nodule resource and the environment over a Licence Area in the Cook Islands Exclusive Economic Zone (CIEEZ). Moana intends to execute the environmental and social studies through the exploration period with the framework of an Environmental and Social Impact Assessment (ESIA) to focus the studies on the information requirements for in to an environmental impact statement for minerals harvesting. The present Scoping Study describes the rationale and plans for the ESIA program of work.

Moana's Licence Area is some 200 km from the nearest landmass (the island of Aitutaki) where water depths average approximately 5,200 m. Detailed project engineering of a future deep-sea minerals harvesting system is in progress; however, the main operative components would involve a Collector, that moves along the seabed collecting nodules that will then be delivered to a Riser pipe within a Vertical Transport System (VTS). The VTS will then lift nodules and seawater to a Production Vessel. Once on board, nodules will be de-watered and stored, until ready for transfer to an international processing plant(s) via an Ore Transport Vessel. Water separated from nodules during the dewatering process will be pumped back down a return pipe to be discharged to the water column at a depth to be specified. Onshore facilities will include an office and operational support base in Cook Islands to provide first-line community engagement and technical support. Support vessels operating out of the Port of Avarua and potentially Aitutaki would be used to mobilise equipment and personnel to- and from the operations area.

Globally, nodule harvesting is identified as a potential source of metals required to transition to renewable energy technologies. Exploration activities are focused on a range of metals within the polymetallic nodule including cobalt (Co), nickel (Ni), copper (Cu), manganese (Mn), and rare earth elements (REEs), as an alternative to the current terrestrial sources which are associated with considerable environmental and social impacts. The main use of these metals will be in the area of transport electrification, energy storage, and other high tech "green energy" applications. Cobalt is the primary metal, based on its value as well as its grade in Cook Islands nodules.

By investigating the interactions between the potential pressures associated with deep-sea nodule harvesting and the receiving biophysical and socio-cultural environment, the Scoping Study screens issues into or out of the ESIA and identifies the studies required during the Exploration Program. The Scoping Study uses an Ecosystem-Based Management (EBM) approach to scope these studies, making use of an ecosystem model that will serve as decision-support tool. EBM recognises the importance of maintaining whole-of-ecosystem functions and values to society rather than focusing on a single species or individual habitat. The EBM approach ensures that the environmental and social studies are suitably scheduled and targeted, data are integrated and regularly assessed for adequacy, and any adaptive management needs are identified.

Regulatory Environment

Future environmental permitting of the Moana 1 Project will fall within the remit of three key pieces of legislation: the Cook Islands (i) Environment Act (2003), (ii) Seabed Minerals Act (2019) and the associated Draft Environment Regulations (2020), and the (iii) Marae Moana Act (2017). The requirements of these core legislative instruments demand rigorous environmental assessment throughout the permitting process and are detailed in the Scoping Study. In addition, there is a suite of other instruments of best practice and various technical review oversight that will overlay the Moana 1 Project. These include scrutiny by stakeholders and various interest groups such as active environmental NGOs.

The Scoping Study outlines the permitting process to the extent that it is known, caveated by the fact that a first mover in the deep-sea nodule harvesting space will be operating in a relatively un-tested regulatory space. As such, there is a need for ongoing stakeholder engagement as Moana recognises the fact that avoiding negative socio-economic and environmental impacts while maximising positive socio-economic and environmental impacts will be essential to exploration and future commercialisation of nodule harvesting.

Benthic Environment

Knowledge of the Cook Islands nodule environment comes from several exploratory voyages, principally by Japanese research agencies and small-scale nodule sampling in recent times by Ocean Minerals Limited and another contractor. Polymetallic nodules in Moana's Licence Area of the South Penrhyn Basin (SPB) are differentiated from nodules in the Clarion Clipperton Zone (CCZ), a region where third-party polymetallic nodule resource assessments are underway. Nodules in the Licence Area are principally spherical, epibenthic with little to no sediment/ooze covering, relatively high in cobalt concentration, and have different percentages of iron and manganese compared to those in the CCZ. Licence Area bottom currents are dominated by the dense, cold, and relatively highly oxygenated Antarctic Bottom Water. In the SPB, flats, troughs, abyssal hills, seamounts, and knolls occur. Depth gradients interactions (with geoforms and substrate types, as well as currents and primary production regimes), are likely to influence benthic communities.

Little is known of the benthic communities of the SPB but decades of studies in other nodule zones are informative with respect to patterns of species diversity and abundance on abyssal nodule beds. The SPB is in a different benthic biogeographic zone to the CCZ, so significant differences in community composition are expected. However, the general principles of environmental factors influencing biological distributions, and limiting factors to biomass, are likely to apply. One key differentiating factor is the relatively low rate of surface primary production in the SPB which is expected to result in low rates of particulate organic matter delivery to the seafloor, thus limiting nutrient sources for benthic organisms. While there may be low nutrient concentrations in the surface and midwater environment, the benthic boundary layer (water column close to the seafloor) can have locally, relatively high concentrations due to interactions with the seafloor. Sediment type in the SPB (predominantly red-brown clays) is another factor that is likely to differentiate SPB communities from those in the CCZ.

The collective biomass of benthic communities in the Cook Islands abyssal basin has been modelled to be among the lowest globally. In general, there is a decline in abundance and body size with depth and as such benthic communities on abyssal plains are dominated by microfauna (bacteria) and meiofauna communities, but this does not necessarily translate to reduced biodiversity. Studies from the CCZ have revealed high diversity that is characteristic of nutrient-limited niche diversity, albeit with many species in sampling campaigns represented by singleton records. The patchiness and low abundance of abyssal fauna, combined with technical sampling and taxonomic constraints, complicate ideas about constructing exhaustive baseline species lists. Rather, indicators of ecosystem function and condition are required to inform impact assessments and design monitoring programs that can be operationalised.

Pelagic Environment

Moana's Licence Area is located within the 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. The Licence Area is located to the south of, and potentially outside the influence of, the South Equatorial Current (SEC). The dominant midwater masses are the cold Antarctic Intermediate Mode Water (~1,000 m to 3,500 m depth) and Antarctic Bottom Water (from ~3,500 m depth to the seabed). At abyssal depths, there is a relatively stable temperature, and any variation would be driven by large-scale processes such as seasonal variation and climatic events such as cyclones and El-Niño Southern Oscillation (ENSO).

Surface primary production is modelled to be low in surface waters and there is relatively little fluctuation in surface Net Primary Production in Moana's Licence Area; however, from June to November there may be increased productivity due to the influence of the SEC encroaching from the north and Subtropical Water from the south. The most ecologically significant process in the pelagic zone is diel vertical migration. It is the mass movement of micronekton from deep to shallow strata (0-200 m) at night, and their return during the day. This processbrings these deep-dwelling species within foraging range of pelagic predators, where they constitute a large proportion of the diet of tunas and other apex predators, and the process contributes to 'the biological pump' that transports sunlight-derived energy down to the unlit deep-sea.

In Cook Islands, large-bodied predators such as tunas, billfishes, and dolphinfish are of most interest to commercial fisheries. Sharks and cetaceans (whales and dolphins) also occur in the pelagic zone. There are 25 marine protected areas surrounding Cook Islands including shark and whale sanctuaries. The Cook Islands oceanic environment also supports a diverse marine seabird fauna with regionally significant colonies of sooty terns, lesser frigatebirds, red-footed boobies, and red-tailed tropicbirds in the northern islands. The southern group maintains a large colony of red-tailed tropicbirds, great frigatebirds, red-footed boobies, and brown boobies.

Conservation Areas

Conservation areas that will interact with exploration activities will include legislated Marine Protected Areas (MPAs), Ecologically or Biologically Significant Marine Areas (EBSAs), or Biological Preservation Areas (BPAs), that are either known today or will emerge through the ESIA studies. Futhermore, future mine planning would involve the placement of Preservation Reference Zones (PRZs) within contract areas.

The Marae Moana Act (2017) is unique to Cook Islands in that it establishes the entire EEZ as an area in which ecological, biodiversity, and heritage values of the marine environment are protected. The Act is founded on the traditional principals of '*rā'ui*', a form of traditional spatial management applied in ancestral society, that also reflects modern marine spatial and EBM approaches. The legislation established MPAs extending 50 nautical miles around every island, although this does not include the passage of ships. In the offshore environment, outside the 50 nautical mile zone, the Act allows for seabed minerals harvesting proposals to be assessed and approved using spatial management and regional conservation principles.

Socio-cultural Environment

Cook Islands is a self-governing ocean state in free association with New Zealand. The nation is a sovereign parliamentary democracy with its heads of State being the British monarch and the New Zealand High Commissioner. Traditional leadership, pre-colonisation, was through chiefs (or Ariki), each being the head of his own tribe (vaka), within his own village. Since 1966, post-independence, the Cook Islands Constitution has incorporated the House of Ariki which comprises 14 Ariki. While they do not have legislative power today, they advise the Government of matters relating to tradition and custom and are strongly respected among the community. Their position on matters of policy-setting holds significance and they are considered key stakeholders with respect to the social licence to embark on nodule harvesting in Cook Islands. The Koutu Nui (Council of Traditional Leaders) are secondary level chiefs and are a subsidiary of the House of Ariki.

An overarching theme of the Cook Islands people is the cultural and spiritual connection to the ocean, underpinned by the belief that the ocean has '*mana'* (spiritual authority). Oral traditions and cosmologies of Cook Islands signify that the sea ties them to their ancestors, who believed it vital to be good to the ocean: 'in order to harvest, you first have to protect'. This sentiment is central to the aforementioned Marae Moana Act (2017). It is also a position shared across many Pacific communities and is enshrined in the Ocean Declaration of Maupiti (2009), of which Cook Islands is a signatory, making cultural considerations of nodule harvesting fundamental to the ESIA.

The Cook Islands people were once heavily reliant on artisanal and subsistence fishing. Today, Cook Island's main driver of economic production is tourism, however, the impact of the Covid-19 pandemic led to the tourism sector experiencing negative growth in 2020. There is anecdotal evidence that people are turning back to subsistence production and informal agricultural activities for their livelihood. One of the country's largest exports are black pearls that are commercially cultured in Manihiki and Penrhyn lagoons in the country's north, situated ~600 km from Moana's Licence Area.

Population decline is a concern for the Cook Islands Government as an ageing population is combined with younger people leaving the island for education, training, and employment opportunities elsewhere. Other challenges the nation faces are related to limited natural resources, remoteness from major trade and industrial centres, inadequate infrastructure, and a small labour force.

The Cook Islands Economic Development Strategy 2030, outlined by the Cook Islands Government in 2021, laid out a 10-year plan to meet five core economic objectives: (1)

Improving equity and access for all, (2) Transforming the economy, (3) Developing people and culture, (4) Investing in islands, and (5) Greening the economy. Nodule harvesting is being evaluated by the Government and the people of Cook Islands in light of these challenges and objectives. Nodule harvesting would not only assist achievement of sustainable development obligations, but it would also support a wide range of direct benefits.

ESIA Context and Framework

There are few examples of ESIAs for deep-sea minerals harvesting projects. Several ESIAs for seabed minerals harvesting proposals have been met with difficulty around the world, notable examples being the seabed phosphate proposal in Namibia being denied a permit and triggering a Government imposed 10-year moratorium on the practice, the denial of a permit for seabed phosphate and iron sands minerals harvesting proposals in New Zealand, and the denial of a permit for a seabed phosphate minerals harvesting proposal in Mexico, followed by protracted legal proceedings.

Successful marine minerals harvesting has occurred closer to shore, with diamond mining spanning decades in Namibia where it is the largest contributor to the country's income. However, the Solwara 1 seafloor massive sulphides minerals harvesting project in Papua New Guinea remains the only example of a successful environmental permit application in deep-sea minerals harvesting, although that project has not been developed due to other non-environmental factors. In the CCZ, Environmental Impact Assessments (EIAs) published to date are limited to trial minerals harvesting and component testing exercises during exploration. A full exploitation EIA is yet to be tested through the regulatory system of the International Seabed Authority.

Some of the failures in environmental permitting of the aforementioned seabed minerals harvesting proposals can be ascribed to potential impacts to nearshore ecological values, or at least unsatisfactory study and assessment quality of those potential impacts. However, more broadly, the factors contributing to past failures in environmental permitting include failure to engage in Ecosystem Based Management (EBM), failure to have an adaptive management plan that is genuinely responsive to monitoring, failure to have an integrated impact assessment process, failure to suitably address residual uncertainty, and a failure to suitably address societal concerns.

In the regulatory environment of the CCZ, fundamental ocean research is touted as the key solution to meeting the challenge of an EIA in deep-sea nodule harvesting. This has ushered in a period of intense research in the physical, chemical, and biological sciences that has significantly advanced scientific knowledge of abyssal ecosystems. Uncertainty has been reduced in the areas of characterisation of the existing environment. However, whether this research effort has reduced uncertainty in understanding the impacts of harvesting and informed monitoring and management is arguable. This period of increased exploration and research in the CCZ has also coincided with a period of increased NGO activity in deep-sea minerals harvesting opposition that has had substantial reach.

Set within this history is the fact that Cook Islands is at the beginning of implementing and testing seabed minerals legislation and guidelines, within an EEZ that has a high onus of protection under the Marae Moana Act (2017), in a sovereign nation with strong cultural connections to the ocean. Therefore, an ESIA for polymetallic nodule harvesting in Cook Islands needs to be operated within an EBM framework, supported by robust data and evidence, with a comprehensive social impact assessment and genuine stakeholder engagement. Impact assessment expertise, that is separate from but interfaces closely with scientific subject-matter expertise, is required. The ESIA needs to integrate closely with minerals exploration and engineering design and other Moana business functions.

The Scoping Study describes an DPSIR (drivers-pressures-status-impact-responses) ecosystem model that is one tool to implement EBM. Populated to an *a-priori* conceptual level, the model is used to design studies and structure the impact assessment in this Scoping Study. The hierarchical model will become progressively quantified over time and statistical approaches will be applied to investigate scenarios and support decisions around mine planning and adaptive management. Throughout the ESIA process, the model framework will maintain a connection between the field data capture and the impact assessment needs. The model can also serve as a tool to communicate how harvesting pressures and issues are being connected to studies.

Key Ecological Functions and Ecosystem Services

Some degree of impact is inevitable from nodule harvesting and indeed any human activity in Cook Islands. Critical to the assessment of whether impacts are acceptable from a regulatory and societal point of view will be whether ecological function can be maintained at a scale that is ecologically relevant. The ecological functions identified as being critical to maintain are distributions and biogeography, biodiversity, food webs, and population connectivity. Specific ESIA studies will target communities (e.g., benthic invertebrate taxonomy) and processes (e.g., sediment biogeochemistry) and in addition to providing baseline data, these studies will inform on ecological functions and the scales at which they operate in the benthic and pelagic environment.

Similarly, maintenance of ecosystem services will be key to assessing acceptability of deep-sea nodule harvesting impacts. The Scoping Study profiles the Supporting and Regulatory services, Provisioning services and Cultural services of the Cook Islands oceanic ecosystem. ESIA studies will investigate the dimensions of these ecosystem services including the scales at which they operate and assess the potential for interference.

Studies and Reporting

Issues are screened for inclusion into the ESIA and, subject to further stakeholder workshopping and regulator engagement, the studies are specified to a level that can be taken forward to selection of service and research providers. Existing regulations, recommendations, and guidelines inform the selection and specification of studies. Importantly, the studies are nested within the ecosystem model structure and connection is made between studies and the data management system. These measures aim to address key requirements for EBM and an integrated ESIA. These include: maintaining a focus on the information requirements as opposed to atomised research projects, correctly sequencing studies so that they are accurately placed within a spatial context and temporally in-step with project planning, maintaining a direct connection between operations, samples, raw data and interpreted products, and a method to transmit that data.

Careful consideration has been given to the sequencing of studies and this sequencing is reflected in Moana's Exploration Program work plan. Environmental and social studies generally fall into categories of (a) field programs collecting new primary data, which may be continuous, repeated, or one-off studies, (b) modelling studies that create interpreted products from field data and existing data, (c) desktop studies using existing literature and data, and (d) impact assessment studies that may be qualitative or quantitative depending on the significance of impact in question. Studies will be provided by a blend of research subject-matter expertise, professional consulting services, and in-house technical experts.

Parallel to the ESIA studies, there will be a range of other supporting activities including stakeholder consultation, regulator liaising, and technical review interactions. Regulatory oversight and transparency in the environmental and social space will initiate several output and interfacing points. At a minimum, throughout the Exploration Program, formal reporting outputs are expected to include annual work plans, cruise execution plans, cruise reports, and annual progress reports supported by annual data transmissions. Public documents, meetings, planned community interaction points, and ad-hoc local engagement are some of the other activities that are expected to occur alongside the ESIA.

The ESIA program overall represents a tremendous opportunity to advance understandings of the Cook Islands deep-sea environment, the nodule resource, ecological values, and socio-cultural aspects of deep-sea nodule harvesting. Several opportunities exist for contractor collaboration in the ESIA studies, particularly considering the challenge around availability of vessels, technical equipment, and expertise. Training and capacity-building in the environmental space are also key drivers for the Cook Islands Government and Moana alike.

Acronyms

AABW (Antarctic Bottom Water)

ACT (Aitutaki Conservation Trust)

ADCP (Acoustic Doppler Current Profilers)

APEIs (Areas of Particular Environmental Interest)

BBL (Benthic Boundary Layer)

BIE (Benthic Impact Experiment)

BPA (Biological Preservation Area)

CBD (Convention on Biological Diversity)

CCA (Crustose Coralline Algae)

CCD (Carbonate Compensation Depth)

CCOP/SOPAC (The Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas)

CCZ (Clarion-Clipperton Zone)

CIAA (Cook Islands Airport Authority)

CIBD (Cook Islands Biodiversity Database)

CICC (Cook Islands Christian Church)

CIEEZ (Cook Islands Exclusive Economic Zone)

CIPA (Cook Islands Port Authority)

CoTS (Crown-of-Thorns starfish)

CTD (Conductivity-Temperature-Depth)

DIC (dissolved inorganic carbon)

DOC (dissolved organic carbon)

DOM (dissolved organic matter)

DPSIR (drivers-pressures-status-impact-responses)

DRC (Democratic Republic of the Congo)

DSC (Deep Sound Channel)

DVM (diel vertical migration)

EBA (ecosystem-based adaptation)

EBSA (Ecologically or Biologically Significant Marine Areas)

EBM (Ecosystem-Based Management)

ECE (early childhood education)

EEZ (Exclusive Economic Zone)

EIA (Environmental Impact Assessment)

EIS (Environmental Impact Statement)

ENSO (El-Niño Southern Oscillation)

EPA (Environmental Protection Agency)

ESIA (Environmental and Social Impact Assessment)

EU (European Union)

EU-SPC DSM Project (European Union funded Deep-Sea Minerals Project of the Pacific Community

EV (electric vehicle)

FAD (Fish Aggregating Device)

FPIC (Free Prior and Informed Consent)

GDP (Gross Domestic Product)

GES (Good Environmental Status)

GHG (greenhouse gas)

GOBI (Global Ocean Biodiversity Initiative)

HYCOM (Hybrid Coordinate Ocean Model)

ICI (Ministry of Infrastructure Cook Islands)

IMO (International Maritime Organisation)

IOM (Interocean Metals)

ISA (International Seabed Authority)

IUCN (International Union for Conservation of Nature)

LAT (Lowest astronomical tide)

LCA (Life-cycle assessment)

LFPR (Labor Force Participation Rate)

LMMA (Locally Managed Marine Areas)

LOF (Living Oceans Foundation)

MARPOL (The International Convention for the Prevention of Pollution from Ships)

MBES (multibeam echosounder)

MERI (Monitoring, Evaluation, Reporting, and Improvement)

MFEM (Ministry of Finance and Economic Management)

MMAJ (Metal Mining Agency of Japan)

MMC (Marae Moana Council)

MMR (Ministry of Marine Resources)

MOH (Ministry of Health)

MoT (Ministry of Transport)

MOTU (Molecular Observable Taxonomic Unit)

MPA (Marine Protected Area)

MRI (Magnetic Resonance Imaging)

MSFD (Marine Strategy Framework Directive)

NES (Cook Islands National Environment Service)

NGO (Non-Government Organisation)

NIWA (National Institute for Water and Atmospheric Research)

OC (organic carbon)

OML (Ocean Minerals LLC)

OTEC (ocean thermal energy conversion)

OTV (Ore Transport Vessel)

Pacific-ACP states (African, Caribbean and Pacific Group of States)

PED (Pacific Equatorial Divergence)

PIANGO (Pacific Islands Association of NGOs)

POC (particulate organic carbon)

PRA (Preservational Reserve Area)

PRZ (Preservation Reference Zone)

PTS (permanent threshold shift)

PV (Production Vessel)

RAC (Religious Advisory Council)

RALS (Riser and Lift System)

REEs (Rare earth elements)

ROV (Remotely operated vehicle)

SBMA (Cook Islands Seabed Minerals Authority)

SDA (Seventh Day Adventist)

SEC (South Equatorial Current)

SEP (Stakeholder Engagement Plan)

SFPA (Sustainable Fisheries Partnership Agreement)

SMS (seafloor massive sulphides)

SOLAS (Safety of Life at Sea Convention)

SOPAC (South Pacific Applied Geoscience Commission)

SPB (South Penrhyn Basin)

SPC (Secretariat of the Pacific Community)

SPREP (Secretariat of the Pacific Regional Environment Programme)

TAG (Technical Advisory Group)

TCI (Telecom Cook Islands)

TOML (Tonga Offshore Mining Limited)

TTS (temporary threshold shift)

UK (United Kingdom)

UKSR (UK Seabed Resources)

UKSRL (UK Seabed Resources Development Limited)

UNCLOS (United Nations Convention on the Law of the Sea)

US (United States)

USBL (Ultra-short baseline acoustic positioning system)

VDS (Vessel Day Scheme)

VTS (Vertical Transport System)

Definitions

Abyssopelagic: the abyssopelagic zone extends from 4000 m below the ocean surface to the seabed. This region is mostly inhabited by demersal species which prey on benthic fauna. Abyssal species are adapted to high pressures, darkness, and calm water conditions.

Bathypelagic: the bathypelagic zone extends from 1000 m to 4000 m below the ocean surface. The currents in this zone are very slow, resulting in low oxygen concentration and low faunal levels.

Benthic: refers to anything associated with or occurring on the bottom of a body of water.

Driver: drivers are one of the components of a DPSIR (drivers-pressures-status-impact-responses) model. Drivers are causes of change in the ecosystem. Drivers can be natural (e.g., climate, geological events, water currents) or human, if caused by activities (Kelble et al., 2013).

Ecosystem model: an ecosystem model is a representation of the ecosystem and all its relationships. These models can be qualitative or quantitative when measurable parameters populate the models. It describes the interactions among the ecosystem components, for example, species or trophic groups (organisms sharing similar feeding behaviour). Ecosystem models usually focus on trophic interactions, but they can be implemented to include ecosystem functions and socio-economic aspects. Ecosystem models are the foundation of ecosystem-based management.

Ecosystem Services: benefit provided by the natural environment to humans. Key ecosystem services discussed herein are in the categories of Provisioning, Supporting and Regulating, and Cultural.

Environmental and Social Impact Assessment (ESIA): a comprehensive document of a project's potential environmental and social risks and impacts.

Epibenthic: this term refers to the organisms living on the seafloor surface.

Epifauna: organisms living on the surface of sediments (as opposed to infauna below).

Epipelagic: the epipelagic zone represents the upper region of the ocean from the surface to approximately 200 m depth. Processes in this zone are dominated by light and interaction with the atmosphere. Generally, marine species are largely distributed in this zone.

Harvesting: refers to the minerals harvesting of polymetallic nodules by the minerals harvesting system.

Infauna: organisms living within the intersticies of sediments or occupying burrows penetrating the sediments. In the ISA regime, deep-sea infauna and epifauna are classified as microfauna (< 32 µm body size), meiofauna (32–250 µm body size), macrofauna (>250 µm to 2 cm body size), or megafauna (>2 cm body size).

Mesopelagic: the mesopelagic zone, also known as the twilight zone, extends from 200 m to 1000 m depth. The light conditions in this zone do not allow for photosynthesis, limiting the food availability. Mesopelagic species migrate to the epipelagic zone for feeding.

Micronekton: small pelagic organisms intermediate between zooplankton and nekton. Micronekton consists mainly of decapod crustaceans, small cephalopods and small fishes.

Nekton: aquatic organisms that are actively swimming.

Pelagic: refers to the water column of the open ocean and can be further divided into regions by depth.

Plankton: plankton are drifting organisms living in the water column. Their body size is too small to allow them to swim against currents. Organisms constituting plankton are divided into two groups, phytoplankton (plants) and zooplankton (animals).

Precautionary Principle: refers to the precautionary principle of the Rio Declaration and should be applied where there are threats of serious or irreversible damage, and acknowledges 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.

Pressure: physical, chemical, and biological inputs to an ecosystem that cause a response in the ecosystem (Kelble et al., 2013) and are one of the categories of the DPSIR model. Changes in the ecosystem can be permanent or temporary.

1. Introduction

1.1. Purpose

The purpose of this Environmental Scoping Exercise – Environmental and Social Impact Assessment (ESIA) Scoping Study, hereafter referred to as the Scoping Study is to:

- Describe the development of the Moana 1 Project, which refers to Moana Minerals' (Moana's) investigation of the polymetallic nodule resources within the Cook Islands Exclusive Economic Zone (CIEEZ) and the associated environmental and social impacts of harvesting these resources.
- Describe the biophysical, socioeconomic, and cultural settings of Cook Islands.
- Identify the potential environmental, socioeconomic, and cultural heritage issues associated with nodule harvesting and screen those issues into or out of the ESIA work program within the context of an ESIA framework.
- Outline the logic and process that the ESIA will follow.
- Outline the environmental and social studies that will be completed to inform the ESIA.
- Provide information to the National Environment Service (NES) to allow the development of a Terms of Reference for the ESIA.

As of February 2022, Moana has been awarded an Exploration Licence that allows the execution of a minerals Exploration Program to occur within a designated Licence Area of the CIEEZ (Figure 1-1). The 5-year Exploration Program (The Moana 1 Project) will be conducted within an ESIA framework with the objective of understanding the potential environmental and social impacts of future nodule harvesting activities.

The Scoping Study is intended to represent a 'roadmap' to future environmental approvals and a social licence to operate. The Scoping Study affords regulators and key stakeholders an opportunity to agree on the adequacy of the scope of the proposed exploration activities and studies. The Scoping Study is consultative and the programs of work will be subject to adaptive management on the basis of progressive findings.

The Scoping Study considers a base case for the design of components in a future minerals harvesting project, such as the seafloor nodule Collector, Vertical Transport System (VTS) (also referred to as the RALS: Riser and Lift System), and vessels. Project design is subject to ongoing studies into engineering design optimisation and feasibility and therefore, a highly quantified risk-consequence assessment is not possible at this time. However, an issues screening assessment has been completed to inform the scope of ESIA studies. It is normal for an ESIA to proceed through multiple levels of project definition where environmental, social, and engineering developments are responsive to one another.

The ESIA process for the Exploration Program resides within an Ecosystem-Based Management (EBM) framework, as required by Principle 8 of the Marae Moana Act (2017) (see Section 2.4 below). One tool used to implement EBM will be an ecosystem model approach. The ecosystem model establishes the relationships between nodule harvesting pressures and the receptors in the environment as well as ecosystem services. By implementing this approach, Moana seeks to generate data that provide evidence-based decision support. The ecosystem model can be parameterised to a level commensurate with the level of knowledge at any given time, from conceptual through to fully quantified sub-models that can be used to test scenarios and assess ecosystem responses. The ecosystem model used in this study is based on an extensive review of deep-sea literature and experience with other projects to identify nodes and links of key concern, and to identify the required ESIA studies to a level that can be further workshopped.

With respect to defining ESIA studies, the objective of the Scoping Study is to provide a suitable level of environmental and social study detail to allow planning to proceed (e.g., planning vessel, equipment requirements, and access to the appropriate experts) and to contribute to tender specifications that international providers can respond to.

1.2. Moana 1 Project Overview

Moana has been awarded an Exploration Licence to undertake the Moana 1 Project. This involves an investigation into the polymetallic nodule resources and surrounding environment, as well as the potential impacts of harvesting these resources, over a Licence Area in the South Penrhyn Basin (SPB) within the CIEEZ. The location of Moana's Licence Area is shown in Figure 1-1. By designing an Exploration Program in the context of the information requirements of a future ESIA, Moana will ensure that there is maximum benefit from the data and knowledge obtained.

The ESIA Scoping Study identifies Exploration Program studies required to support a future impact assessment. It balances global research objectives with knowledge gain, capacity building for Cook Islanders, and the specific data requirements of assessing the nodule resource and potential environmental and social impacts of proposed nodule harvesting. The 5-year Program will adopt a four-pronged approach, with objectives in the areas of (1) the environment, (2) socio-cultural impacts, (3) nodule resources, and (4) engineering, project design, and economics. Exploration activities will employ a range of habitat mapping instruments as well as sampling platforms to characterise the seabed and water column, assess nodule resources, and identify biological communities. This report is planned to provide a basis for environmental and social work plans for the Exploration Program, thereby pivoting at the end of the Exploration period to an application for an environmental exploitation permit.

Proposed exploitation activities will involve nodule harvesting by a Collector that will move along the seabed, the design of which is currently under development. Nodules will pass from the Collector to a VTS which will lift the nodules as a slurry to a Production Vessel (PV) that is dynamically positioned and physically connected to the subsea equipment. On board the PV, nodules will be de-watered and stored in dedicated holds. Water from the dewatering process will be discharged at depth via a pipe budled with the riser. Nodules will be transferred from the PV to an Ore Transport Vessel (OTV) using a method of transfer that will be determined in the design phase. The OTV will deliver the nodule ore to an international processing plant(s). Periodically, a Supply Vessel will arrive at the PV to re-supply the vessel with personnel, food, and other supplies. The PV may also be serviced by Crew Transport Vessels for personnel movements.

The at-sea operations will be some 200 km from the nearest island (Aitutaki) and will not be visible from any land. Moana will establish an office and operational support base in Cook

Islands that will provide first-line community engagement, technical support, logistics, and administration. The Port of Avarua (Rarotonga) will likely be used to mobilise personnel and equipment to- and from the operations area and crew changes may also be coordinated out of Aitutaki. The PV and OTV are not expected to enter the Port of Avarua at any time throughout harvesting operations.

The principal metals of interest include cobalt (Co), nickel (Ni), copper (Cu), manganese (Mn), and rare earth elements (REEs), although Moana is investigating all metals for recovery and sale. The main use of these metals will be in the area of transport electrification, energy storage, and other high tech "green energy" applications. Cobalt is the primary metal, based on its value as well as its grade in Cook Islands nodules.

Cook Islands was one of the first nations to develop seabed minerals legislation. The environmental permitting of the Moana 1 Project will fall within the remit of three key pieces of legislation: the (i) Cook Islands Environment Act (2003), (ii) Seabed Minerals Act (2019) and associated Draft Environment Regulations (2020), and the (iii) Marae Moana Act (2017). These core legislative instruments demand rigorous environmental assessment throughout the permitting process that contains multiple consultation and expert review milestones.

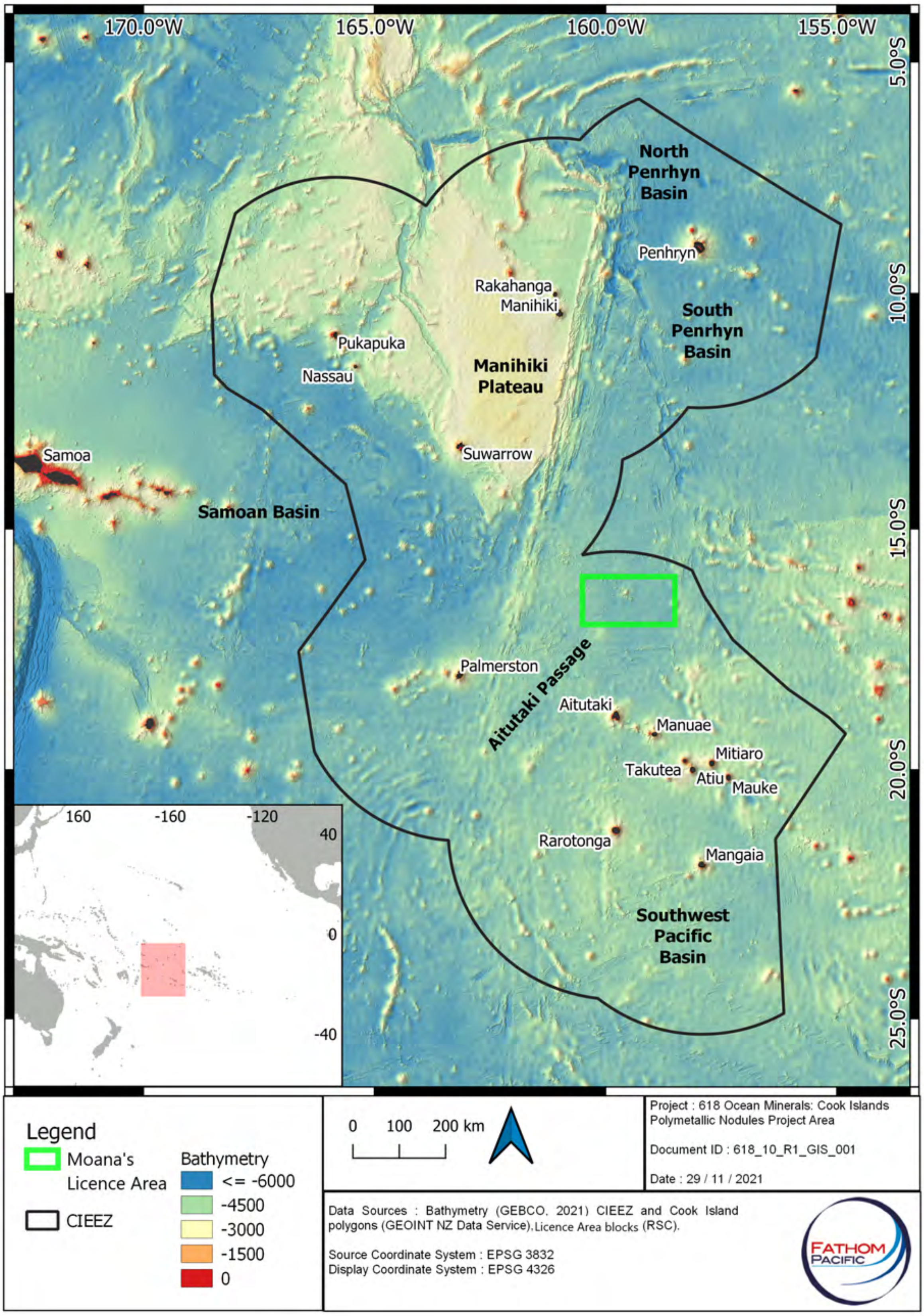


Figure 1-1 Location of Moana's Licence Area.

2. Legal and Regulatory Framework

2.1. Key Legislation, Policies, Regulations, and Guidelines

The key legislation, policies, regulations, and guidelines in place for Cook Islands are listed in Table 2-1. The following Cook Islands and international instruments will form the core legislative framework for the environmental approvals process.

2.2. Cook Islands Seabed Minerals Act (2019)

Cook Islands was one of the first Pacific nations to develop deep-sea minerals harvesting regulations, but they have yet to be tested through to the Environmental Permitting and minerals harvesting licence application stage. The Cook Islands Seabed Minerals Act (2019) and associated Amendments (2020 and 2021) uphold the requirements of the Environment Act (2003) and establishes a Cook Islands Seabed Minerals Authority (SBMA) as a statutory agency of the Government of Cook Islands. The Seabed Minerals Act (2019) provides for the appointment of a Seabed Minerals Commissioner and Officers to oversee the functions of the Seabed Minerals Act as required, reporting to an appointed responsible Minister. The Cook Islands Seabed Minerals Act (2019) sets out the administrative framework, duties, and responsibilities of the proponent and the SBMA, and penalties for non-compliance. Interface between the Government and the community is via the Cook Islands Seabed Minerals Advisory Board, which is comprised of a chairperson (appointed by the responsible Minister), the Seabed Minerals Commissioner, five members representing the island communities of Cook Islands, and additional members as required.

The Seabed Minerals (Exploration) Regulations (2023) set out the Exploration Licence application regulations with respect to SBMA and contractor obligations. Additional regulations are likely to be established throughout Moana's Exploration Program as described in the next section.

2.3. Cook Islands Seabed Minerals Standards and Guidelines

SBMA and NES are responsible for monitoring, managing and enforcing compliance of seabed minerals activities under their respective statutory mandates. To this end, SBMA and NES, in consulation with key stakeholders are currently developing the Seabed Minerals Standards and Guidelines.

The Standards and guidelines will assist the SBMA and NES, as regulators to monitor Licence Holder performance and to ensure that Licence Holders comply with the terms and conditions of their Exploration Licence, environmental approvals and relevant Cook Islands law.

2.4. Cook Islands Environment Act (2003)

The Cook Islands Environment Act (2003) is the core legislation controlling the permitting of activities that have the potential to cause significant environmental harm. Application for a minerals harvesting licence will trigger the requirement for an Environmental Impact Assessment (EIA), pursuant to that Act and international best practice in environmental management. An EIA is not required for exploration activities that do not have the potential to cause significant impact, a threshold which is partly dictated by the area of seafloor impacted by operations (<10,000 m^2 per year) and the magnitude and intensity of impacts generated by the activity. Annual work plans submitted to the regulators, that will be supported by desktop risk assessment based on existing data and literature, will be the main tool for assessing the requirements for exploration level impact assessments. Offshore observers, monitoring, and annual reports will be tools for confirmation of predictions of no significant impact during the Exploration Program. The Cook Islands National Environment Service (NES) is the agency responsible for permitting, monitoring, and enforcing environmental laws under the Environment Act (2003). The NES also plays an important role in research and stakeholder engagement in the area of sustainable development of seabed minerals harvesting in Cook Islands.

Table 2-1 Cook Islands legislation, policies, standards and guidelines central to the ESIA.

Instrument	**Description**	**Responsible Department/Agency**
Legislation		
Seabed Minerals Act (2019), Seabed Minerals Amendment Acts (2020 and 2021), Seabed Minerals (Exploration) Regulations (2020), Environment (Seabed Minerals Activities) Regulations (2020), Seabed Minerals (Royalties) Regulations (2013)	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 conducted and which controls the permitting of activities that have the potential to cause significant environmental harm.	Cook Islands National Environment Service
Marae Moana Act (2017)	Requires that the CIEEZ 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 management applied in ancestral society. Allows for seabed minerals harvesting.	Marae Moana Council, Marae Moana Technical Advisory Group, and other agencies
Marine Resources Act (2005)	Establishes the entire CIEEZ 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 Cook Islands.	Cook Islands Natural Heritage Trust

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 Cook Islands and Cook Islands vessels and protects the marine environment.	Ministry of Transport
Maritime Zones Act (2018)	Declares the territorial sea (Lowest Astonomical Tide, LAT, to 12 NM), contiguous zone (LAT to 24 NM), exclusive economic zone (LAT to 200 NM), and continental shelf of Cook Islands as the maritime zones of Cook Islands. Declares, and expresses the rights of Cook Islands and other States in relation to the maritime zones of Cook Islands consistently with international law. Repeals the Continental Shelf Act (1964) and the Territorial Sea and Exclusive Economic Zone Act (1977).	All
Traditional Knowledge Act (2013)	Gives legal recognition to and protection of the rights in the traditional knowledge of the traditional communities of 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 Cook Islands.	Central Policy and Planning Office of the Office of the Prime Minister, Ministry of Finance and Economic Management
Standards		
Standards relating to seabed minerals activities	Currently being developed, the standards will assist in the implementation of the respective regulations and provide interpretive guidance on specific regulatory text.	Seabed Minerals Authority, National Environment Service
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
Guidelines		

Guidelines relating to seabed minerals activities:	Currently being developed, the standards will assist in the implementation of the respective regulations and provide interpretive guidance on specific regulatory text.	Seabed Minerals Authority, National Environment Service
Te Tarai Vaka (Cook Islands Environmental and Social Safeguards Guideline)	Guidance for environmental and social safeguards for the development of seabed minerals harvesting 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

2.5. Cook Islands Marae Moana Act (2017)

The Marae Moana Act (2017) is unique to Cook Islands in that it establishes the entire Exclusize Economic Zone (EEZ) as an area in which marine biodiversity, cultural values, and subsistence fishery resources are protected. The Marae Moana Act (2017) is founded on the traditional principals of *rā'ui*, a form of traditional spatial management applied in ancestral society that also reflects modern marine spatial and EBM approaches. Marae Moana is also based on the traditional belief that the ocean has *mana* (spiritual authority). The legislation established Marine Protected Areas (MPAs) extending 50 NM around every island, although this does not include the passage of ships. In the offshore environment, outside the 50 NM zone, the Marae Moana Act (2017) allows for seabed minerals harvesting proposals to be assessed and approved using spatial management and regional conservation principles.

Marae Moana has strong bilateral Government support and strong support from the community. The Act is administered by the Marae Moana Council (MMC) 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 regulations of this Act require development activity to be screened-in as allowable spatially-defined activity. This is a subtle but important distinction of assessing any minerals harvesting operations for inclusion into a 'protected' area regime, and adds additional layers of precaution that are already inherent in global considerations of deep-sea nodule harvesting. In practice, a deep-sea minerals harvesting application received by the SBMA would be assessed against the nine Marae Moana principles of ecologically sustainable use (Table 2-2).

Table 2-2 Principles of the Marae Moana Act (2017) against which seabed minerals harvesting 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 protected, and their biodiversity conserved for their cultural and natural heritage value; and shared by all Cook Islanders.
2. Principle of sustainable use to maximise 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 states 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 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.

2.6. Policy Drivers

2.6.1. National Seabed Minerals Policy (2014)

The Cook Islands National Seabed Minerals Policy, adopted in 2014, provides the regulatory and managerial procedures for seabed minerals harvesting activities within the CIEEZ. The policy provides the Government's position on the implementation of key aspects of the legislative scheme for seabed minerals harvesting activities such as ensuring seabed minerals harvesting activities are managed to: provide the greatest national benefit to the people, continue to build stakeholder confidence in the management of seabed minerals harvesting activities, and make informed decisions regarding seabed minerals harvesting investing and participation. This legal framework was established under UNCLOS (United Nations Convention on the Law of the Sea), and affords Cook Islands the exclusive rights to utilise its seabed minerals harvesting resources within its EEZ, subject to compliance with UNCLOS requirements which include the protection of the marine environment and mitigation of social impacts. UNCLOS is a multilateral agreement on the law of the sea that allows countries to exploit their own resources under an internationally agreed framework that establishes guidelines for businesses, the environment, and the management of marine natural resources. The convention created three new institutions being the International Seabed Authority (ISA), International Tribunal for the Law of the Sea, and the Commission on the Limits of the Continental Shelf. The convention has become the legal framework for marine and maritime activities. The convention was opened for signature in 1982 and entered into force in 1994. Cook Islands was one of the first nations to ratify (by accession) the convention in 1982.

2.6.2. Te Tarai Vaka (Cook Islands Environmental and Social Safeguards Policy)

The Te Tarai Vaka Environment and Social Safeguards Policy (A6) was established to mitigate and manage any adverse activities that may impact the environment and local communities, ensuring a 'do-no harm' approach. The policy outlines processes for assessing and managing potential adverse environmental and social impacts and is an essential part of the Te Tarai Vaka legislative document. The policy specifically looks to identify and exploit opportunities to conserve and enhance the environment and social wellbeing of Cook Islands.

2.6.3. Te Kaveinga Nui (Cook Islands National Sustainable Development Plan 2016-2020)

The Te Kaveinga Nui outlines the key values and principles of Cook Islands and engages a 16-goal process to develop the nation in accordance with environmental and social aspirations towards a sustainable future. The plan reflects improvements in the policy and planning of the Government with the recent development of more sector-based policies and plans. The plan also articulates key performance indicators from the broader national policy suite to represent national development. These indicators underpin the 16 development goals which are aligned to commonly identifiable sectors. Goal 12 outlines the sustainable management plan for the ocean, lagoons, and marine resources including minerals from deep sea minerals harvesting, ensuring economic returns to the nation. The biggest challenge for this plan is balancing sustainable economic returns on resources with protecting and preserving the overall health of the Cook Islands marine environment.

2.6.4. Cook Islands Economic Development Strategy 2030

The Cook Islands Economic Development Strategy 2030 laid out a 10-year plan to meet the economic challenges faced in the country, which include infrastructure and housing limitations, sanitation and waste management, equitable access to development, post-pandemic recovery, and economic resilience. The strategy outlines five core economic objectives:

1. Improving equity and access for all
2. Transforming the economy
3. Developing people and culture
4. Investing in islands
5. Greening the economy

Nodule harvesting has links to several of these objectives and the Economic Development Strategy specifically identifies social and environmental limits to economic development as determinants of building quality economic growth which connects to the ESIA.

2.7. Conventions and Treaties

Cook Islands is a signatory to the treaties listed in Table 2-3. These agreements generally set out the Government's aspirations and duties for environmental protection and sustainable development and they recognise the importance of cooperation among Pacific Island states, particularly in relation to transboundary issues.

Table 2-3 Summary of relevant international treaties that Cook Islands is a signatory to.

Treaty	Description
Convention on Biological Diversity (1992) (CBD), 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.
Produced at the 1992 United Nations 'Conference on Environment and Development' in Rio de Janeiro, Brazil	Recognises 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. Internalisation 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.
The Convention on Conservation of Nature in the South Pacific (Apia Convention) 1976	• undertaken to create protected areas to safeguard representative samples of natural ecosystems, superlative scenery, striking geological formations, and regions and objects of aesthetic, historic, cultural, or scientific value (art.2); • commit to not alter national parks so as to reduce their area except after the fullest investigation; their resources are not to be subject to commercial exploitation and hunting, and collection of species is to be prohibited and provision is to be made for visitors (art. 3); • agree to maintain lists of indigenous fauna and flora in danger of extinction and to give such species as complete protection as possible (art. 5); and • provision may be made as appropriate for customary use of areas and species in accordance with traditional cultural practices (art. 6).
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 utilisation 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 (Noumea 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 organisations, 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 programmes relating to the Convention Area and co-operate, as far as practicable, in the establishment and implementation of regional, sub-regional, and international research programmes. The Noumea Convention is complemented by two Protocols: the Dumping Protocol and the Pollution Emergencies Protocol, which are applicable to Parties' EEZs and to areas of the high seas beyond national jurisdiction that are completely enclosed by these EEZs. 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.
The International Marine Minerals Society Code for Environmental Management of Marine Mining Voluntary code for environmental management of marine mineral activities (exploration and exploitation)	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 life cycle of operations; • to maintain an environmental quality review program and deliver on commitments; and • 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.
Convention on the Conservation of Migratory Species of Wild Animals (CMS) 1979 Convention on the Conservation of Migratory Species	Platform for the conservation and sustainable use of migratory animals and their habitats.
Memorandum of understanding for the Conservation of Cetaceans and their habitats in the Pacific Islands region (2006)	Recognises that cetaceans are integral to the marine environment and connects ecosystems and cultures. Recognises they are highly migratory and therefore, dependent on conservation measures across a wide area. Agreement to: • Take steps to conserve all cetaceans that occur in the Pacific Islands region. • Ratify or accede international instruments that enhance protection. • Review enact or update legislations as appropriate. • Implement an Action Plan that will address threat reduction, habitat protection, research and monitoring, education and awareness, information exchange, capacity building, strangling and entanglement

	responses, sustainable and responsible tourism, and international cooperation • Facilitate exchange of information.
Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States, 2005	Actions and strategies in 19 priority areas of the Barbados Program of Action for the Sustainable Development of Small Island Developing States (BPOA), which address the economic, environmental, and social developmental vulnerabilities facing islands. Priority areas include climate change and sea-level rise resources, energy resources, biodiversity resources, science and technology, human resource development, etc. The Programme identifies culture as a key pillar of sustainable development.

2.8. Other Instruments of Best Environmental Practice

The most significant international regulations and guidelines are listed in Table 2-4 and key instruments are described below.

2.8.1. New Zealand

There are close socio-political ties between Cook Islands and New Zealand. Cook Islands was a New Zealand colony from 1901 to 1965 when it became self-governing in “free association” with New Zealand (Cook Islanders are New Zealand citizens). The New Zealand dollar is the currency of Cook Islands and New Zealand is the country’s main trading partner. The relationship between Cook Islands and New Zealand was reaffirmed under the 2001 Joint Centenary Declaration of the Principles of the Relationship between New Zealand and Cook Islands. Therefore, while Cook Islands is a sovereign independent state, its ties with New Zealand are considered likely to result in New Zealand-based technical assistance being provided if requested by Cook Islands in relation to matters such as the environmental effects of nodule harvesting.

2.8.2. Pacific Community (SPC)

The potential opportunities of nodule harvesting to increase revenue and thus improve socioeconomic conditions in Pacific Island nations has been recognized for some time (World Bank, 2017; SPC, 2013, 2016a). The EU-funded Deep-Sea Minerals Project of the Pacific Community (EU-SPC DSM Project), administered by the Secretariat of the Pacific Community (SPC) division of the South Applied GeoScience Commission (SOPAC), recognises this potential and has been instrumental in establishing and harmonising policy, governance and management arrangements in Pacific Island countries. SPC is central to sustainable development across multiple sectors in the Pacific islands and the EU-SPC DSM Project has played a key role in an overall increase in the awareness of nodule harvesting throughout the region.

The Regional Environmental Management Framework (SPC, 2016b) and Scientific Research Guidelines (SPC, 2016a), produced by the Pacific Community and the European Union, provide guidance for ensuring environmental protections in Oceania generally. These guidelines, along with the lessons from seabed minerals exploration in neighbouring jurisdictions, most notably Papua New Guinea, New Zealand, and Tonga will inform the application of a 'precautionary approach' to development, an over-arching principle of the 1992 Rio Declaration that further ensures environmental protection.

2.8.3. Secretariat of the Pacific Regional Environment Programme (SPREP)

SPREP is a regional organisation established by the Governments and Administrations of the Pacific region that aims to protect and manage the environment and natural resources of the Pacific. Cook Islands is a member country of SPREP which implements European Union-funded projects. SPREP hosts the Pacific Environment Data Portal and other library resources that seek to promote sustainable development, climate change resilience, waste and pollution control, etc. SPREP hosts workshops on deep-sea minerals harvesting, has published position statements on the subject[1] and hosts literature on the subject. Given that SPREP is the representative body of several significant European Union-funded projects in the Pacific and represents Pacific nations that have supported a moratorium on deep-sea minerals harvesting, it is expected that SPREP will play a role in deep-sea minerals harvesting considerations in Cook Islands. The organisation's projects to develop guidelines around Environmental Impact Assessment and Strategic Environmental Assessments and efforts to promote multilateral environmental agreements may be expected to interface with deep-sea minerals harvesting considerations in Cook Islands.

2.8.4. International Guidelines

Where legislated environmental thresholds do not exist in Cook Islands (e.g., marine water quality criteria), international guidelines will be adopted in consultation with the regulator, as is common practice in neighbouring jurisdictions. Such thresholds (e.g., Australian and New Zealand water and sediment quality guidelines (ANZG 2018), US EPA water quality criteria) are established to protect aquatic life, ecological function, and aesthetic values and would represent a compliance monitoring tool to ensure environmental protection.

2.8.5. International Seabed Authority (ISA)

It is generally recognised that most scientific understanding of polymetallic nodules and potential impacts of harvesting them has been generated from the Clarion Clipperton Zone (CCZ) and, to a lesser extent, the Indian Ocean nodule provinces. Outside global EEZ boundaries (known as 'The Area'), nodule resources are managed by the ISA. The ISA is an autonomous international organisation established under UNCLOS to organise, regulate, and control activities in the Area (international waters), where activities are defined by Article 1 of UNCLOS as '…all activities of exploration for, and exploitation of, the resources of the Area' and resources are defined as '…all solid, liquid or gaseous mineral resources in situ in the Area at or beneath the seabed, including polymetallic nodules' (Article 133 of UNCLOS). The ISA has the duty to ensure the effective protection of the marine environment from harmful effects that may arise from deep-sea-related activities. The ISA comprises the European Union and 167 Member States of which Cook Islands is a member state (ISA, 2021).

[1] Deep-Seabed Mining: A Pacific Environmental and Governance Challenge. SPREP Document ID 30SM/Officials/WP 8.4.3/Att.1

There has been a large amount of work done by contractors, researchers, and other stakeholders in the CCZ to establish ISA guidelines for environmental studies and these precedents and guidelines have matured to represent one form of industry best practice. The ISA has also released guidelines and regulations for exploration and prospecting (2015) and draft regulations for exploitation (2018). These instruments form a part of a body of international best practice in the nodule harvesting industry. As Cook Islands, via the Cook Islands Investment Corporation (CIIC), is in a partnership with Global Sea Mineral Resources (GSR) holds a licence area in the Clarion-Clipperton Zone (CCZ) there is likley an expectation that ISA recommendations, standards and guidelines will play a role in the regulatory and stakeholder considerations.

Liaison with the Cook Islands Government has identified that general equivalency is sought with the ISA guidelines in recognition of this instrument of accepted best practice. Ongoing engagement through the Exploration Program and ESIA process will establish the finer details of how that equivalency is applied in Cook Islands. While it is acknowledged that there may be broadly comparable environmental issues in both areas, it must also be recognised that the biophysical environment and nodule metallurgy in Cook Islands differs from the CCZ. Furthermore, there should also be an ongoing review and evaluation of what in the ISA regime has and has not been beneficial to the advancement of the research, environmental management practice, social, and stakeholder considerations.

Spatial planning (being the collective process of establishing non-minerals harvesting zones, identifying areas of particular ecological interest, identifying un-navigable terrain, investigating spatial aspects of mine plans in relation to the distribution of the resource, ecological values and currents) is recognised as one effective tools to achieve protection at the large scales of the marine environment. The identification of Preservation Reference Zones (PRZs) that set aside areas of equivalent biodiversity value and ecological function as the mined area, is one example where parity between ISA guidelines and best practice in Cook Islands will be expected.

2.8.6. Global Cooperative Research Programs

Environmental programs in deep-sea minerals harvesting have been identified in the international research community as providing useful input to global databases. Examples include Ocean Biodiversity Information System (OBIS) and the Seabed 2030 Project. These types of international data repositories and sharing platforms have two common requirements: (1) the use of unique identifiers and data linking keys, (2) the use of consistent terminologies, category labels/descriptors.

In the area of consistency in taxonomic terminology, international efforts to coordinate biodiversity data sharing have resulted in two standards:

- World Register of Marine Species (WORMS): a repository of taxonomically valid names, tracking any changes to the taxonomic names with immutable unique identifiers (aphiaIDs). Storage of WORMS aphiaIDs alongside any biological data allows for coding routines to query the WORMS database and update name changes and ensure consistency among datasets.

- DarwinCore: a data standards system for biodiversity informatics that defines rule sets for required fields and valid values in biological data. These required fields and consistency in field usage allows data to be ingested and referenced in international databases such as OBIS and GBIF that are queried online.

Biological data collected by Moana will conform with these two data standards, and those more broadly required by SBMA for annual data reporting, thus allowing integration with international databases. Indeed, it is MOANAs intention to contract science partners in the ESIA that include several of the key investigators contributing to these initiatives, further bolstering consistency in data.

Table 2-4 International regulations and guidelines.

Instrument	**Description**	**Responsible Department/Agency**
Regulations		
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
Draft Regulations on Exploitation of Mineral Resources in the Area (2018)	Draft 2018 release for exploitation in The Area.	International Seabed Authority
The International Convention for the Prevention of Pollution from Ships (MARPOL)	Global shipping environmental controls.	International Maritime Organization (IMO)
Guidelines and Recommendations		
Pacific-ACP States Regional Environmental Management Framework for Deep-sea Minerals Exploration and Exploitation	EU-funded project with SOPAC to harmonise approaches to deep-sea minerals harvesting 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 harmonise approaches to deep-sea minerals harvesting 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 harmonise approaches to deep-sea minerals harvesting in Pacific states, including assistance with the establishment of state legislation. Establishes regional scale financial framework.	EU-Pacific Community (SPC)
ISA Recommendations and Guidelines, including those listed here	Report stemming from workshop to Standardise Megafaunal Taxonomy for Contract Areas in the Clarion-Clipperton Fracture Zone. Report stemming from workshop on Taxonomic Methods and Standardization of Meiofauna in the Clarion-Clipperton Fracture Zone. Recommendations for the guidance of contractors for the assessment of the possible environmental	International Seabed Authority

	impacts arising from exploration for marine minerals in the Area (ISBA/25/LTC/6/Rev.1) Draft guidelines for the establishment of baseline environmental data (ISBA/27/C/11)	

3. Purpose of the Development

3.1. Metals Demand and Markets

Nodule harvesting aims to extract several resources from collected polymetallic nodules. While the focus is on cobalt retrieval, recovery of nickel, copper, manganese, and REEs is also of importance[2]. The availability of terrestrial sources of these metals, along with the environmental and social impacts of extracting terrestrial sources, are projected to be limiting factors of the increasing demand for vehicle electrification, consumer products, energy storage systems, and other markets that utilise these metals such as aerospace alloys, tooling materials, and chemical products.

Individually, each of these metals is used in a variety of applications, across commoditised industrial as well as specialty end-markets. Cobalt demand comes from a range of market uses such as superalloys, hard metals, and metal alloys, to pigments for paint and glass. Nickel and manganese demand is derived largely from the steelmaking industry where it is used to make alloys and superalloys such as stainless steel. Uniquely, each of these metals and metal compounds are all used in various components of most new electric vehicles (EVs) produced and sold around the world. Cobalt, nickel, and manganese are primarily used in lithium-ion batteries, copper is used as an electrical conductor, and REEs are used in permanent magnets and other applications in EV motors.

As these metals have been essential components of various industries for decades, their production rates are stable. Due to low volatility in demand, global mining and processing companies have historically been able to plan for demand with brownfield expansions and limited greenfield exploration to ensure future supply. This balance has been upset by increasing demand from the EV market, as well as from other advanced energy storage industries. Furthermore, diminishing societal acceptance of the impacts of terrestrial mining, and in particular cobalt mining that is reported to be exploitative, may risk future supply[3]. As the demand for most of these commodities is projected to rise, prices of most of the critical nodule metals are forecast to increase.

Increased demand for battery metals and metal compounds is likely to present global challenges due to a combination of existing supply risks and a lack of new projects. For example, the cobalt market is largely supplied by mines in the Democratic Republic of the Congo (DRC), providing nearly 70% of the world's raw material supply. Cobalt yield is most often reliant on the mining of primary copper or nickel deposits, which limits the market's ability to effectively and efficiently respond to additional demand. Mines in the DRC are the largest, and some of the highest-grade cobalt mines in the world; however, expansion opportunities are limited due to geological, environmental, social, corporate, and

[2] Under current commodity prices, project revenues are split Co 77%; Ni 11%; Mn 10% and Cu 2%.

[3] Reduced societal acceptance of current terrestrial cobalt minerals harvesting was illustrated in lawsuits against end-user product manufacturers Apple and Google in 2019. https://www.theguardian.com/global-development/2019/dec/16/apple-and-google-named-in-us-lawsuit-over-congolese-child-cobalt-mining-deaths. Although it should also be noted that this delimma has also been parsed as an opportunity for car manufacturers to fund ways to improve artisanal cobalt mining in DRC https://www.mining.com/volkswagen-joins-cobalt-group-supporting-artisanal-drc-miners/

Governmental factors. This geographically concentrated resource presents a supply risk, as outages or interruptions to these raw materials would have an increasingly significant effect on advanced technology end markets which are reliant on cobalt supply. In addidtion to geographic issues, long supply chains, infrastructure concerns and reports of child labour practices are also major issues facing cobalt mining in DRC.

Nodule harvesting offers the opportunity to source critical raw materials to feed global market demand on a time scale that is required, providing an operational hedge to the existing supply chain infrastructure for cobalt, nickel, copper, manganese, and REEs.

3.2. Previous Nodule Exploration in Cook Islands

Unlike nearby Tonga, Solomon Islands, and Papua New Guinea where seafloor massive sulphide (SMS) deposits are associated with back-arc spreading centers in water depths of approximately 1,000 to 2,000 m, the CIEEZ hosts polymetallic nodules at abyssal depths of approximately 5,200 m in the SPB. By comparison, nodule fields in the CCZ are approximately 1,000 m shallower than those in the CIEEZ. Cobalt-rich ferromanganese crusts associated with seamounts and metalliferous abyssal sediments also potentially occur in the CIEEZ (SPC, 2013) but these are not currently being explored. Another differentiating feature of the Cook Islands nodule fields compared with SMS deposits in the Pacific is their distance from the nearest landmass.

The potential opportunities of nodule harvesting to increase revenue and thus improve socioeconomic conditions in Pacific Island nations has been recognised for some time (World Bank, 2017; SPC, 2013, 2016a). The first voyages dedicated to investigating nodules in Cook Islands were mounted in the mid-1970s by the New Zealand Oceanographic Institute (Glasby and Lawrence, 1974). Subsequently, The Committee for Coordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC)[4] carried out a number of cruises in the Cook Islands region between 1976 and 1981 (Figure 3-1).

Nodules were collected during these cruises and their mineralogy was used to define areas of potential economic interest that were surveyed, in more detail, by later cruises under the Japan-SOPAC Cooperative Study on Deep-sea Mineral Resources in the South Pacific (Cronan, 2013).

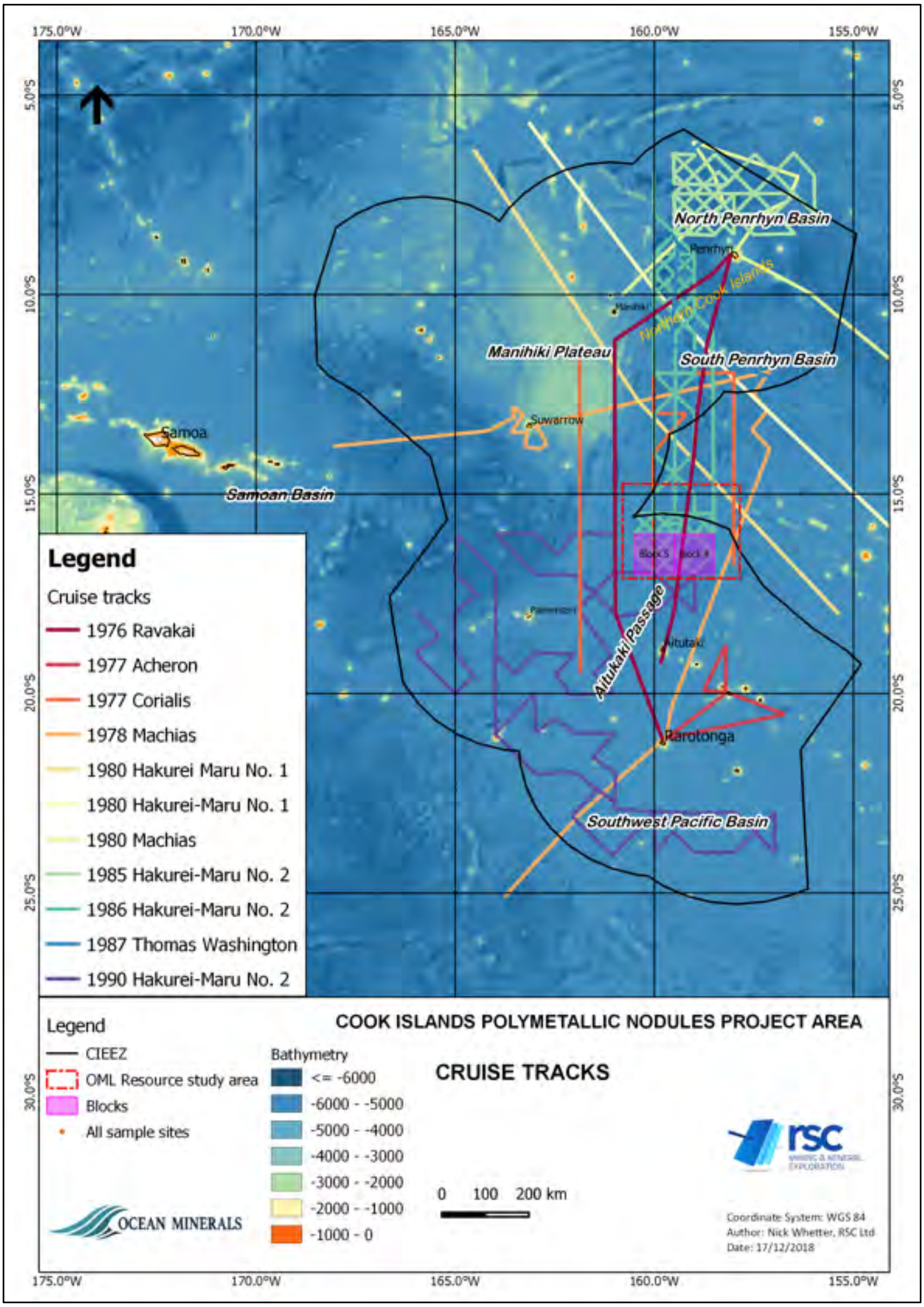
Japan/SOPAC Co-operative Study on Deep-sea Minerals Resources in the South Pacific completed three cruises in the Cook Islands region using the vessel *Hakurei-Maru No 2* (1985-1990) targeting the Penrhyn Basin and southern Cook Islands. In the same period, Scripps Institution of Oceanography completed sampling in the North Penrhyn Basin using the vessel *Thomas Washington*. This voyage collected polymetallic nodules and associated sediments in a range of sedimentary environments in order to understand the drivers of nodule mineralogy, and to use this knowledge to construct a geological /geochemical model (Cronan, 1987; Cronan and Hodkinson, 1994). In 2000, Metal Mining Agency of Japan (MMAJ) carried out a follow up cruise in the Cook Islands region on *Hakurei Maru No 2*, surveying previously studied areas

[4] An intergovernmental, regional organisation with 21-member countries, that was established in 1972 under the Economic and Social Division of the UN.

in more detail with the results generally confirming the conclusions from earlier cruises (MMAJ, 2001).

In recent times, the EU-SPC DSM Project, administered by the Secretariat of the Pacific Community (SPC) division of SOPAC, recognised the potential of deep-sea minerals in the Pacific region and has been instrumental in establishing and harmonising policy, governance, and management arrangements in Pacific Island countries.

While the historic samples have formed the basis of a geological and financial model, additional samples are required to confirm the geochemistry of the nodules, which can then determine metallurgy. Processing technologies and metal recoveries are key to financial models and thus mine planning and this ESIA. The early studies determined that Cook Island nodules, particularly in the southern sector of the Penrhyn Basin are relatively high in cobalt.



Source: OML Preliminary Economic Assessment.

Figure 3-1 The Cook Islands Polymetallic Nodules Project Area (pink blocks). This has since been termed the Licence Area.

4. Viability of Minerals Harvesting Operations

4.1. Proponent's Credentials

Moana Minerals is a wholly owned, Cook Islands registered limited company and is a subsidiary of Ocean Minerals LLC (OML). Moana's team is made up of experts in offshore, deep-water engineering and operations, seabed diamond mining, SMS and polymetallic nodules exploration, deep-water oil and gas drilling, deep-sea ecology, and minerals harvesting impact assessment. Some members of the team, including the company founder, were active members of research teams exploring the manganese nodule fields of the CCZ in the 1970s and 1980s. The Moana team is supported by global partners and service providers in the areas of logistics, community consultation, offshore operations, scientific laboratory services, conservation, and other specific subject-matter experts.

Moana has entered into a partnership with Transocean Ltd. to develop and operate the minerals harvesting system. Transocean Ltd, founded in the early 1970s, is one of the world's largest offshore drilling contractors.

4.2. Economic Viability

In 2017, Moana's parent company OML commissioned an independent resource assessment for the Licence Area to JORC and NI 43-101 standards (RSC, 2017a, 2017b), which reported a polymetallic resource containing sufficient quantities of the key metals for modern battery and renewable energy technologies (cobalt, nickel, copper, manganese, and REEs) as to be economically viable for further development. Of particular importance was the reporting of 1 million tonnes of contained cobalt within the nodules in Moana's Licence Area based upon existing data, with the potential for up to an additional 1.5 million tonnes of cobalt according to resource modelling. Combined, this would make up one of the three largest cobalt deposits on earth.

In 2018, OML commissioned an Engineering Scoping Study and cost estimate for a minerals harvesting system (DRT, 2019) and in 2019 an independent third party produced a Preliminary Economic Assessment (AMC, 2019b), which concluded that the development of the proposed nodule design was potentially both technically and economically viable.

The Project's economic viability is dependent upon commodity prices, especially cobalt, and the cost to produce a product. While commodity price forecasts are always uncertain, a key to economic viability for the Project is that the estimated cash operating costs on a pro-rata basis (costs distributed in proportion to revenues from different metals) on a dollar per tonne of cobalt produced basis is in the lower quartile of competing projects to produce new sources of cobalt for increasing demand for battery materials. Therefore, if there is to be sufficient cobalt, the price must reach a point that will justify new sources to be developed, and a Preliminary Economic Assessment indicated that the Moana 1 Project is one of the lower cost options[5].

[5] New sources of cobalt outside the DRC are expected to be dominated by high-cost nickel laterite mines in Australia and Indonesia.

Furthermore, the Project is one of the only primary cobalt projects that can expand to meet demand without affecting by-product markets.

4.3. Technical Viability

4.3.1. Minerals Harvesting System

Nodule minerals harvesting was the subject of intense development in the 1970s and three consortia carried out pilot minerals harvesting tests in the Clarion Clipperton Zone (CCZ) between 1977 and 1979. The tests provided "proof of concept" for the recovery of large volumes of nodules using hydraulic collection and lifting. A valuable summary of the history of nodule minerals harvesting development is included in AMC (2016).

Today, several offshore exploration contractors are developing seafloor harvesting systems and associated vessels for projects in the CCZ. Tests of a seafloor collecting system were performed by the DEME/GSR group in 2021, and Pilot Minerals Harvesting Tests occurred in 2022 by TMC/Allseas. Moana has entered into partnership with Transocean to develop the minerals harvesting system which includes the Production Vessel, Vertical Transport System, nodule Collector, onboard material processing, storage, and offloading equipment. Transocean's development strategy is to combine their extensive in-house resources with key equipment suppliers to integrate systems and equipment into the overall minerals harvesting system design.

Drawing upon the broad knowledge of the offshore minerals harvesting, bulk shipping, and oil-and-gas industries, as well as previous experience in deep sea minerals exploration, a robust solution will be developed to address the operation's specific environmental and technical challenges. Further, public knowledge gained from exploration ongoing in Cook Islands and the CCZ will also help inform the minerals harvesting vessel design.

The design of the minerals harvesting system will developed with consideration to environmental objectives. Key areas for optionality in the minerals harvesting system include the method of Collector propulsion, plume management methods, nodule lift systems, depth of return water discharge, and mine plan strategies.

4.3.2. Metallurgy and Processing

Several tests of physical and chemical characteristics have been conducted on nodule samples collected from Moana's Licence Area to date and additional testwork is underway. Testwork has indicated the potential viability of a new hydrometallurgical process that is a modification of the Cuprion process developed for CCZ nodules (Hubred 2005) that appears to achieve excellent extraction of cobalt, good extraction of nickel, and acceptable extraction of copper from Cook Island nodules with potential to also recover REEs, all at ambient temperature and pressure.

4.4. Environmental and Social Viability

Investigation of polymetallic nodules and the associated harvesting opportunities is consistent with Cook Islands' national goals and strategies, which promote resource development while balancing the associated environmental and social impacts, including: the Cook Islands Seabed

Minerals Policy (2014), the Te Tarai Vaka Environment and Social Safeguards Policy, and the Te Kaveinga Nui (Cook Islands National Sustainable Development Plan 2016-2020).

The permitting process of the Moana 1 Project will include a multi-year environmental baseline and ESIA, culmulating the the preparation of an environmental impact statement (EIS). The studies described in this Scoping Study, workshopped through stakeholder engagement, will assess potential impacts from ocean surface to the seabed and will address physical, chemical, and biological impacts along with socio-economic and cultural impacts in Cook Islands. The results of the ESIA, which will include public consultation and engagement with relevant Government and other stakeholder groups, will ultimately determine the environmental and social viability of future nodule harvesting.

In addition to the regulatory thresholds of acceptability, it is anticipated that the viability of nodule harvesting will continue to evolve in Cook Islands from a societal acceptability perspective. The ESIA program of work will maintain a focus on objective, evidence-based decision making. It will also comply with Moana's policies, Cook Islands regulations and guidelines, ISA regulations and recommendations, and emerging industry best practice.

5. Descriptions of the Proposed Development

Proposed future harvesting operations will be within the Licence Area, where water depths average 5,200 m. Proposed harvesting will involve the deployment of a nodule minerals harvesting system that will move along the seabed collecting nodules. The minerals harvesting system consists of a seabed Collector, a VTS and a PV (from which the Collector and VTS will be deployed and controlled). Nodules will be harvested from the seabed by the Collector, then transported via the VTS to the PV. Once on board, nodules will be de-watered and transferred to an OTV alongside the PV for delivery to international ports for offloading and eventual processing. The PV will have onboard storage to contain a volume of nodules sufficient to acommodate the time taken for OTVs to swop out and for any potential delays in OTV arrival to the PV. Water separated during the dewatering process will be pumped down a return pipe and discharged at a depth to be determined, but nominally below the mesopelagic-bathypelagic boundary.

5.1. Seabed Minerals Harvesting System

5.1.1. Collector

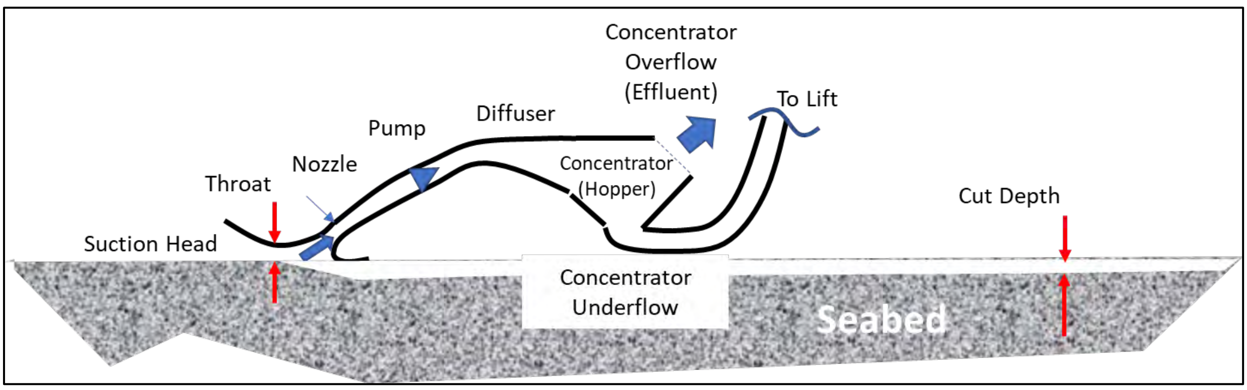
Selection of the preferred Collector design is presently underway, where considerations such as seafloor trafficability, track control, environmental issues, and harvesting strategies, are all being assessed to inform the final design.

The Collector will take the form of either:

- A passive hydraulic Collector on skids that will be towed by the VTS, or
- A tracked, self-propelled Collector.

The Collector will move along a predetermined track based on seafloor topography and nodule abundance within a planned and permitted minerals harvesting area. The nodule collection depth (cut depth) will be determined on the basis of data on vertical nodule distribution, which initial studies have shown to be principally epibenthic and not significantly buried in seafloor sediments.

A schematic of the key elements of a conceptual preliminary Collector process is shown in Figure 5-1.



Source: OML minerals harvesting system scoping study, 2019.

Figure 5-1 Base case conceptual Collector schematic.

The nodule harvesting industry has seen a convergence of industry-accepted designs, the performance of which are being tested in a range of laboratory and field tests. Concurrently, Moana is participating in a development project, funded by the U.S. Department of Energy[6], to design and test a collector which would remove all the sediment picked up by the collector from the slurry the enters the riser and lift system, see Figure 5-2. This concept features a clean water intake which provides water to lift the nodules to the surface.

Other industry-wide research related to environmental impact mitigation like this is underway and will undoubtably lead to improved enviromental performance of 1st and 2nd generation minerals harvesting systems.

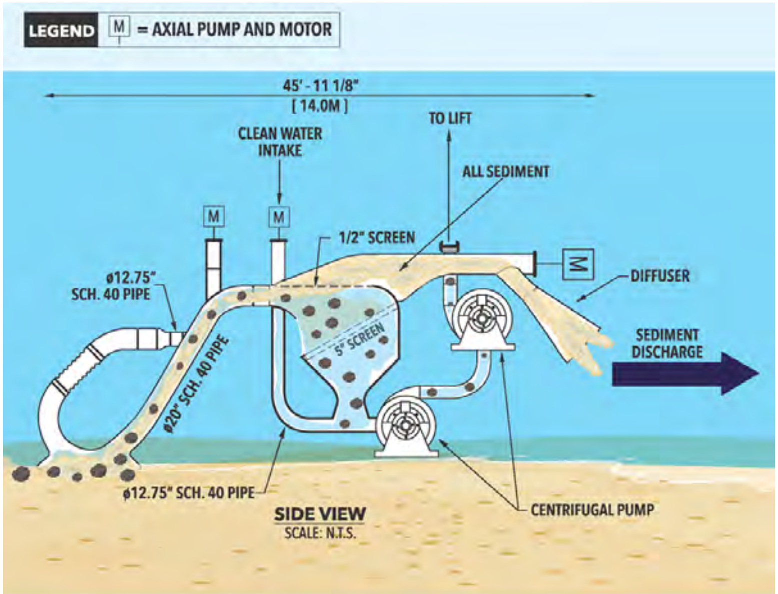


Figure 5-2 Conceptual schematic for Collector being researched to remove all sediment from slurry entering the rise and lift system. Patent pending.

5.1.2. Vertical Transport System (VTS)

The VTS or Riser and Lift System (RALS) will serve three main functions:

1. Hydraulic lifting of the slurry using either an airlift system or submersed pump(s) through a main riser pipe.
2. Discharge of the seawater and undersized solids component of the slurry after dewatering has occurred at the surface via a separate discharge pipe bundled with the VTS.
3. Towing and control of the Collector (if the tow method is used).

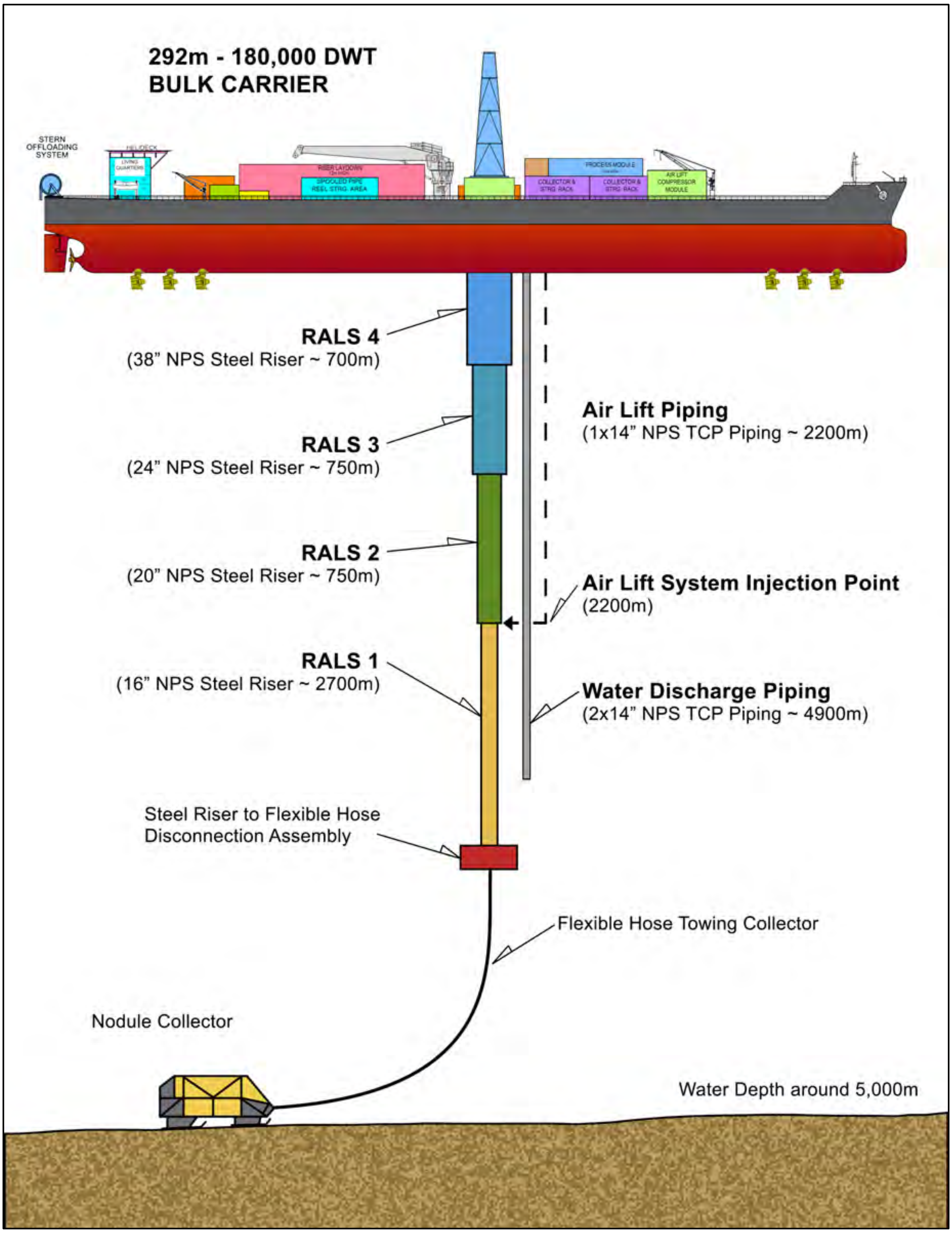
It will also provide support for an umbilical which will provide power and communications for the Collector. The system conceptualised in a 2018 Scoping Study is shown in Figure 5-3 and consists of the following components:

- Jumper hose: to connect the Collector with the riser pipe.

[6] https://www.deepreachtech.com/arpa-e-sbir-news-release

- Riser pipe: the riser pipe will extend from the PV to a water depth of 4,900 m and will nominally consist of four main body segments of steel pipe. Slurry will be lifted from the seafloor to the surface via the riser pipe. Two lift options are currently under investigation and other options may emerge through the Exploration Program:
  - Air lift: used to inject compressed air into the riser pipe that will lift the slurry to the surface.
  - Subsea pumps: fitted to the riser pipe and used to pump the slurry to the surface.
- Return pipe: a return pipe will be used to discharge a water and undersized solids slurry generated during the dewatering process back to the marine environment. The depth of discharge will be informed by environmental factors and engineering feasibility and optimisation.

Subsea harvesting activities will be supported by two work class Remotely Operated Vehicles (ROVs) that will be used in various intervention and inspection tasks including connection/disconnection of the Collector jumper hose and other manual manipulation tasks. The ROV facility will also create several opportunities for environmental monitoring during operations.



Source: OML minerals harvesting system study scope, 2019.

Figure 5-3 Conceptual diagram of the Vertical Transport System (VTS), not to scale.

5.2. Production Vessel (PV)

Multiple concepts are under consideration for the PV, including the conversion of a 6th generation drilling ship, converted Capesize bulk carrier, or a newly built vessel. The vessel will be dynamically positioned and have an overall length of approximately 290 m. The vessel will store, deploy, operate, and supply all power to the surface and subsea harvesting systems. It will accommodate the offshore workforce, and will be used to temporarily store nodules and transfer them to an OTV.

Once the nodule/seawater slurry is lifted to the PV, the nodule component of the slurry will be gravity settled in the holds while seawater and undersized solids will be separated from the nodules via decanting weirs and pumped through the VTS return pipe for discharge at depth.

5.3. Ore Transport Vessel (OTV)

During production, an OTV will be alongside or astern the PV to receive nodules. A number of options for transferring nodules are being considered. As soon as the OTV is full, it will depart the PV and an empty OTV will take its place to continue receiving nodules.

Since nodules will be harvested and transferred directly onto OTVs, a single harvesting spread can maintain multiple vectors for distribution to various downstream processors located at or near the end users. The raw nodule material will be exported by OTVs from the Licence Area to the processing site.

5.4. International Ore Processing Component

Initially, nodules are likely to be delivered to one or more international brownflield sites which can be adapted to process nodules. Brownfield sites already have most of the required infrastructure in place (e.g., permitting, water, power, transport, and tailings storage) and possibly some process plant components. End products will be dependent on location and markets.

6. Offshore Marine Biophysical Environment

6.1. Seafloor

6.1.1. Seafloor Environment and Habitats

The SPB is an abyssal plain punctuated by seamounts (rising ~1,000-4,000 m from the seafloor), abyssal hills (broad regular features rising up to ~1,000 m from the seafloor), and knolls (rising ~500-1,000 m from the seafloor) (Yesson et al., 2011). The tectonic interpretation of Viso et al. (2005) indicates that there are two orientations of abyssal hills in the SPB: approximately east–west trending and north–south trending, separated by the Tongareva triple junction. These 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). While the area is largely flat (Figure 6-1), there is an identifiable seamount in the centre and Okamoto (2003) has reported the presence of a knoll field on the west-southern flank (Figure 6-2).

Below 5,000 m, the Carbonate Compensation Depth or CCD (the depth at which calcium carbonates can dissolve into solution) is surpassed. Therefore, the SPB seafloor environment tends to lack calcareous sediments and organisms which need a calcareous skeleton (McCormack, 2016). The seafloor sediments are dominated by red-brown clays (Cronan et al., 2010) and these sediment types have been observed in Moana's exploration voyages to date. However, the seamount-knoll field in the Moana Licence Area may consitute localised calcareous clays as reported by Kojima (2001).

Deep Reach Technology (DRT) recently performed analysis of the particle size distribution of sediments collected in freefall grab samples from Moana's Licence Area. The samples comprised approximately 4% sand, 20% silt and 76% clay, which is higher in clay content than samples collected from an area in the CCZ. Mineralogical analysis showed a high concentration of Fe-rich (iron) material as compared to CCZ sediments which commonly showed Ca-rich clay content.

At 5,200 m depth, polymetallic nodules occur at their highest density in the SPB's Central Area. They are formed under the influence of the oxygen-rich, northward Antarctic Bottom Water (AABW). This is a cold (~1˚C) and dense water mass (~1000 m thick) that migrates slowly north towards the equator from Antarctica (Tsuchiya, 1991; Hartin et al., 2011, Petterson and Tawake, 2019). The dynamics of bottom currents in Moana's Licence Area are unknown, but topographically-induced flow acceleration may occur as bottom currents are funnelled through the Aitutaki Passage, to the east of Manihiki Plateau. This would be consistent with the preliminary observations of spherical nodules that are mainly unburied and closely packed in the SPB (Figure 6-3) which are a feature of the post-Paleogene seafloor sediments (Usui et al., 1993).

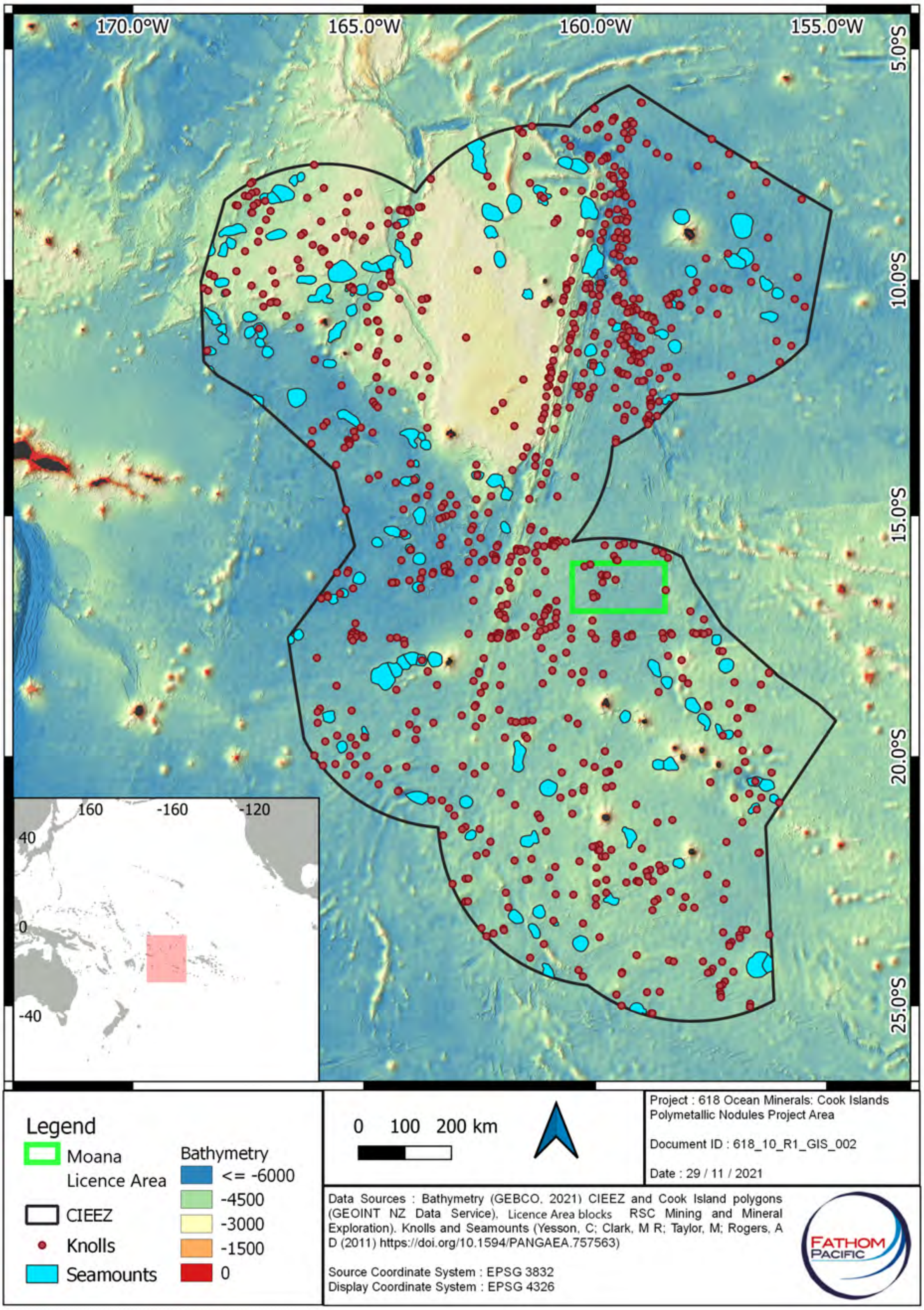
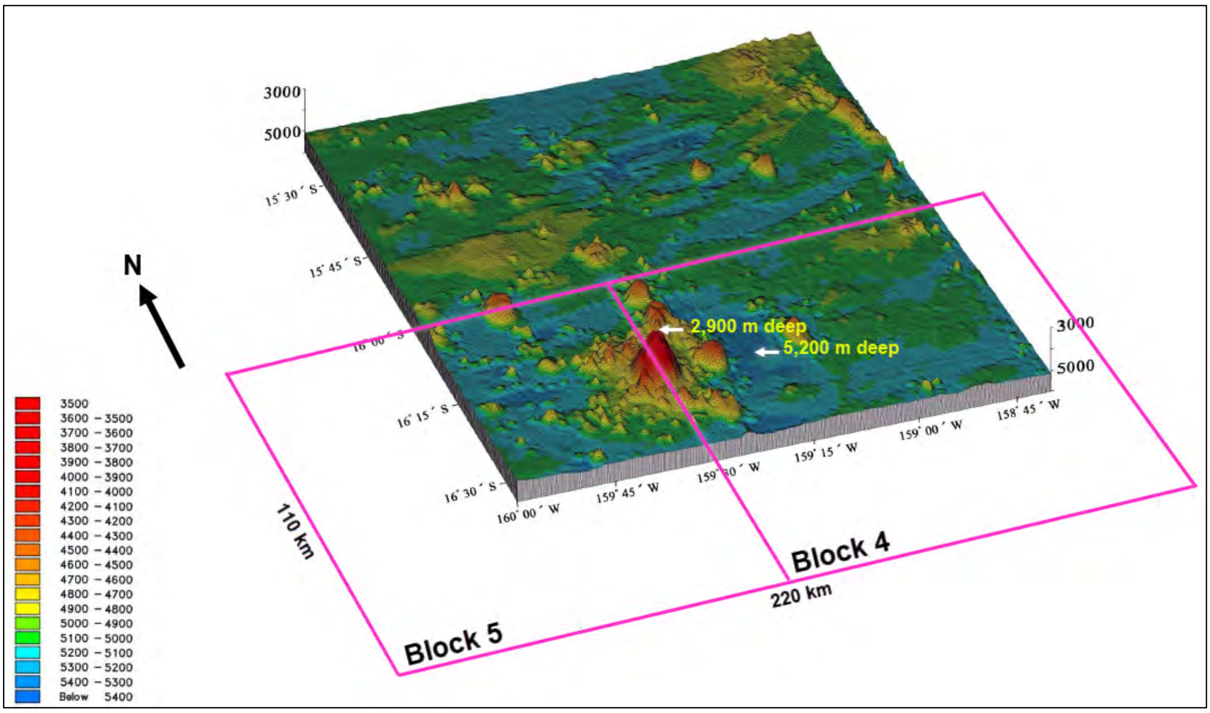


Figure 6-1 Modelled distribution of seamounts and knolls in the CIEEZ.

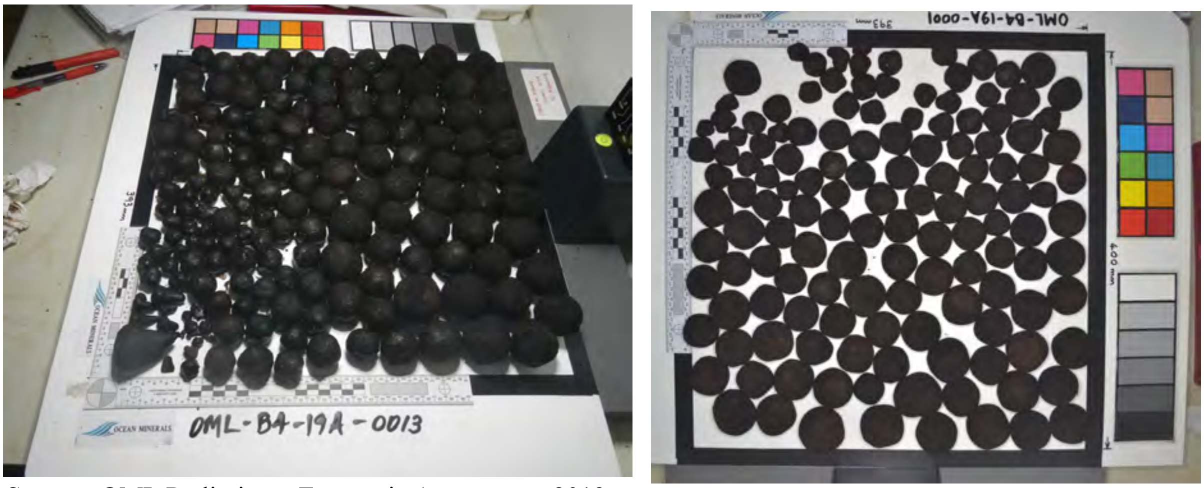


Source: Okamoto, 2003.

Figure 6-2 Detailed bathymetry showing high relief seamount-knoll zone in the centre of the Moana Licence Area.

Source: https://www.seabedmineralsauthority.gov.ck/image-gallery

Figure 6-3 View of a nodule bed in the South Penryhn Basin, Cook Islands.

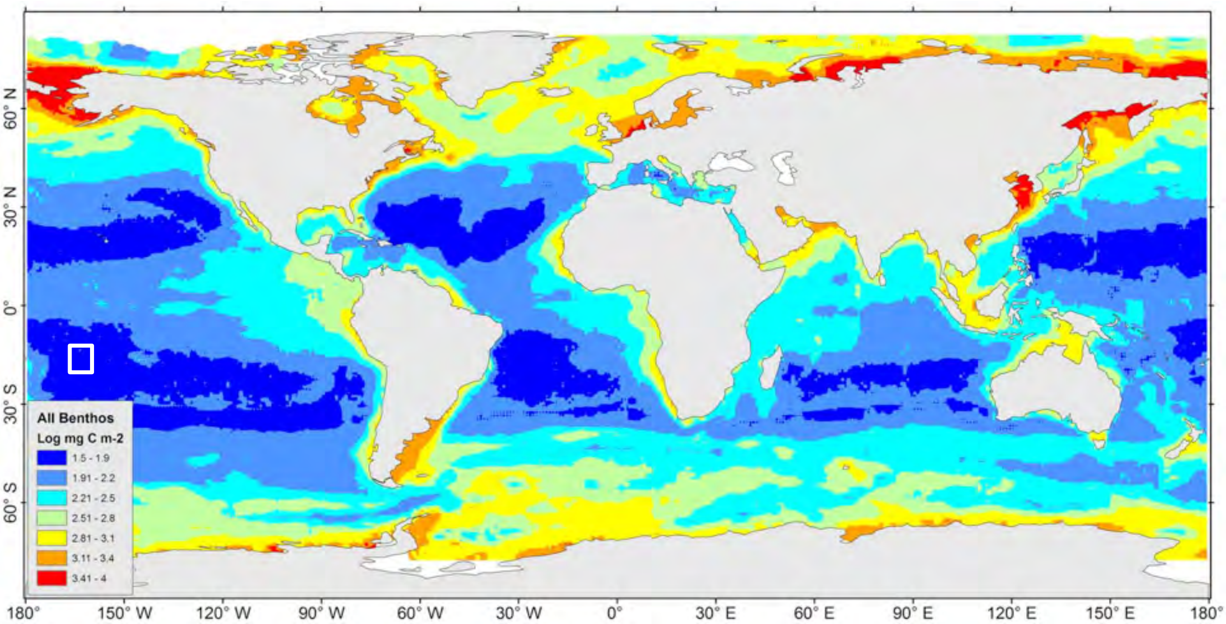


Source: OML Preliminary Economic Assessment, 2019.

Figure 6-4 Samples of nodules collected from Moana's project area.

6.1.2. Seafloor Biological Communities

In the terminology applied by the ISA, benthic organisms can be classed as microfauna (bacteria, archaea 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 body size, visible in seabed imagery). The abundance of organisms and species diversity for most groups (particularly macrofauna and megafauna) generally decreases with depth (Rex and Etter, 2010). This is due largely to the physical and chemical conditions at these depths and low rates of benthic nutrient supply. The collective biomass of benthic bacteria, meiofauna, macrofauna, and megafauna in the Cook Islands abyssal basin, is modelled to be among the lowest on the planet (Wei et al., 2010) (Figure 6-5).



Source: Wei et al., 2010.

Figure 6-5 Distribution of predicted benthic biomass. Approximate location of CIEEZ indicated by white rectangle (not to scale).

In general, there is a decline in abundance and body size with depth and as such, benthic communities on abyssal plains are dominated by bacteria (microfauna) and meiofauna communities (Wei et al., 2010). This does not imply diminished biodiversity. Species richness can be high in the meiofauna and macrofauna size range and given the low abundance, repeated sampling often continues to identify low numbers or singletons of additional species, resulting in species accumulation curves that are rarely asymptotic, even after multiple surveys.

Benthic organisms can be broadly categorised as:

1. Sediment infauna: organisms living under the sediment surface, within the interstices of the sediment bed or within burrows, or amongst the semi-liquid layer at the sediment-water interface.
2. Sessile sediment epifauna: organisms embedded in the sediment surface.
3. Mobile epifauna: organisms that range across both nodule and sediment habitats.
4. Sessile nodule-attached epifauna: organisms attached to hard nodule surfaces.

Sessile sediment and nodule attached epibenthos can form biogenic habitat structure for multi-species assemblages (Stratmann et al., 2021). The vast majority of benthic meiofaunal and macrofaunal infauna resides in the top 5 cm of the sediment, with a small fraction of macrofaunal community extending to 10 cm. Burrowing megafauna can extend deeper into sediments with burrows extending to perhaps 30 cm depth (Rex and Etter, 2010).

Little is known of the CIEEZ benthic communities but the findings of decades of benthic fauna taxonomy in the CCZ are informative with respect to patterns of diversity and abundance. The sections below summarise the relevant findings from the CCZ that inform this Scoping Study but these results must be viewed in recognition of the fact that POC flux and sediments in Cook Islands are likely to differ significantly from those in the CCZ, which is expected to result in differing benthic communities.

Nodules may provide a hard substrate for the attachment of sessile invertebrates as has been observed in the CCZ and other nodule provinces. Eukaryote sediment infauna in the CCZ nodule province, and indeed many other abyssal sites, tends to be dominated by organisms in the meiofauna size range. Prokaryote microfauna communities are key to sediment biogeochemistry which is central to overall ecological function in the abyssal plain ecosystem. A similar situation is expected in Cook Islands.

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). Therefore, benthic macrofauna of the 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 reflect these similarities (McCormack, 2016).

The sinking of POC from the surface layers of the ocean is the main source of nutrition to the abyssal seafloor. Benthic communities in the CCZ and other Pacific abyssal sites are typically dominated by deposit-feeders that specialize in foraging on this surface-derived organic matter and populations may respond to short-term enhancements in supply related to, for example, surface phytoplankton blooms, benthic 'storms', or whale falls. Therefore, productivity at the ocean surface and water column processes of sinking, uptake, and recycling are key to controlling biomass of benthic organisms.

Okamoto et al. (2003) collected 575 images of benthic fauna in the SPB and identified a variety of megafauna including unidentified sponges, sea pens, crinoids, sea anemones, and at least three types of sea cucumbers.

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.

6.1.2.1. Microfauna

Microfauna (bacteria, archaea, and microscopic eukaryotes) are key to ecological function in deep-sea sediments. Organisms in this size range are orders of magnitude more diverse and abundant than any other size range. Microfauna play a key role in carbon cyling and the microbial food web, mediating the transfer of energy from suspended and sedimented detritus to the larger size range Biogeochemical processes described by the interactions between oxygen, nutrient and physicochemical characteristics of sediments, and the biological activity of microfauna and other size ranges such as nutrient recycling and bioturbation are key to the maintenance of ecological function.

6.1.2.2. Meiofauna

Deep-sea meiofauna communities tend to be dominated by Loricifera and Tardigrada, Copepoda, Kinorhyncha, Nematoda, and Foraminifera. Nematodes are typically the most abundant meiofauna in deep-sea sediments. In the central Pacific, nematodes constituted 44%–56% of the total meiofauna (Lambshead et al., 2003). In the French claim areas of the CCZ, nematodes are reported to constitute 84–100% of the meiofauna (Renaud-Mornant and Gourbault, 1990). Across three sites of the DOMES experiment (A, B, and C), nematodes constituted ~80% of the total meiofauna community (Ozturgut et al., 1978).

6.1.2.3. Macrofauna

A consistent finding from studies in the CCZ spanning from 1978's experiment baseline studies through to modern contractor sampling is that the benthic macrofauna of the CCZ is usually dominated by four classes: Polychaeta (class of phylum Annelida), Crustacea (subphylum of Arthopoda), Bivalvia and Gastropoda (both classes of phylum Mollusca). Among the crustaceans, the orders Isopoda, Amphipoda, and Tanaidacea are typically the most abundant. These classes and orders typically constitute as much as 90% of the macrofauna diversity in the CCZ.

6.1.2.4. Megafauna

Bottom photographs at the DOMES A, B, and C sites (4,400-5,400 m depth,) covering a total area of 81,355 m^2, showed that echinoids (urchins), ophiuroids (brittle stars), actiniarians (anemones), and holothurians (sea cucumbers) made up at least 80% of the total megafauna (Ozturgut et al., 1978). A dominance of holothurians, which are deposit feeders (ingest particles from the sediment), in megafauna communities was also reported in the TOML contract areas of the CCZ (Simon-Lledó et al., 2020). The dominance of deposit feeders in the CCZ is consistently reported in megafauna studies. However, in Kiribati, suspension feeders (ingest particles from suspension) were most abundant, potentially as a result of the relatively high near-bottom currents modelled for this area (Simon-Lledó et al., 2019).

Megafauna are visible to humans and are often the focus of stakeholder interest in the deep-sea. Ecologically, they are among the least abundant and lowest diversity groups, owing principally to the effects of pressure and lack of food resources.

6.2. Benthic Boundary Layer

The benthic boundary layer (BBL) refers to the immediate physical environment of the benthos (McCave, 1976) and for this assessment we refer to the BBL as describing the environments and communities of the water layer close to the seabed (Mees and Jones, 1997). The BBL of the SPB is relatively data poor, not only due to the lack of surveys in the region, but also due to terminology confusion which may have attributed hyperbenthic biota to benthic environments and communities in previous studies.

6.2.1. Benthic Boundary Layer Environment and Habitats

The BBL comprises the near-bottom water layer, which in the SPB is composed of AABW (Tsuchiya, 1991; Hartin et al., 2011) with a temperature of approximately 1˚C. The influence of the BBL dynamics on surrounding biota in the SPB is uncertain (Jorgensen, 2000) but in general this zone is characterised by higher diversity and biomass than pelagic layers above the

6.2.2. Benthic Boundary Layer Communities

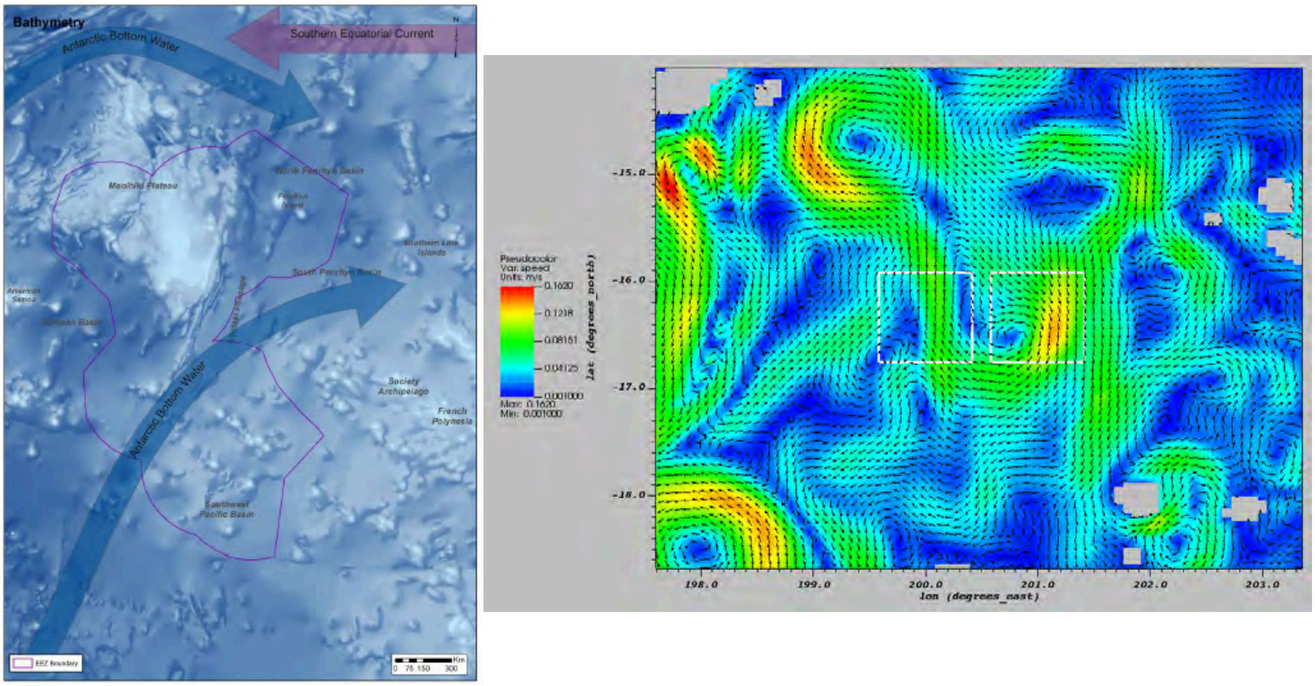
Meiofauna and macrofauna that exist in the BBL generally include copepods, annelids, nematodes, bivalves, ostracods, and amphipods among others. Nekton fauna observed by Okamoto et al. (2003) that may have resided in the BBL included jelly form swimming fauna, 200 mm long fishes, and shrimps.

6.3. Pelagic

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). Below the low levels of nutrients in surface waters (<1,000 m depth), nutrient concentrations increase rapidly to around 5,000 m depth, which continues to rise towards the seabed (McCormack, 2016).

6.3.1. Midwater Environment and Habitats

Below the influence of the South Equatorial Current (SEC), the dominant water masses are the cold Antarctic Intermediate Mode Water (~1,000 m to 3,500 m depth) and AABW (~3,500 m to the seabed) (Sokolov and Rintoul, 2000; Bostock et al., 2013). It is generally considered that the AABW flows north through the Aitutaki Passage to influence the SPB and flows around the northern margin of the Manihiki Plateau, to the north of the CIEEZ (Yamazaki, 1992) (Figure 6-6). However, modelled data indicate the potential presence of more complex bottom currents possibly stemming from the southward flows entering the Licence Area from AABW being directed around the northern side of the Manihiki Plateau (see Figure 6-6).



Source: left: Kenex, 2014; right: HYCOM.

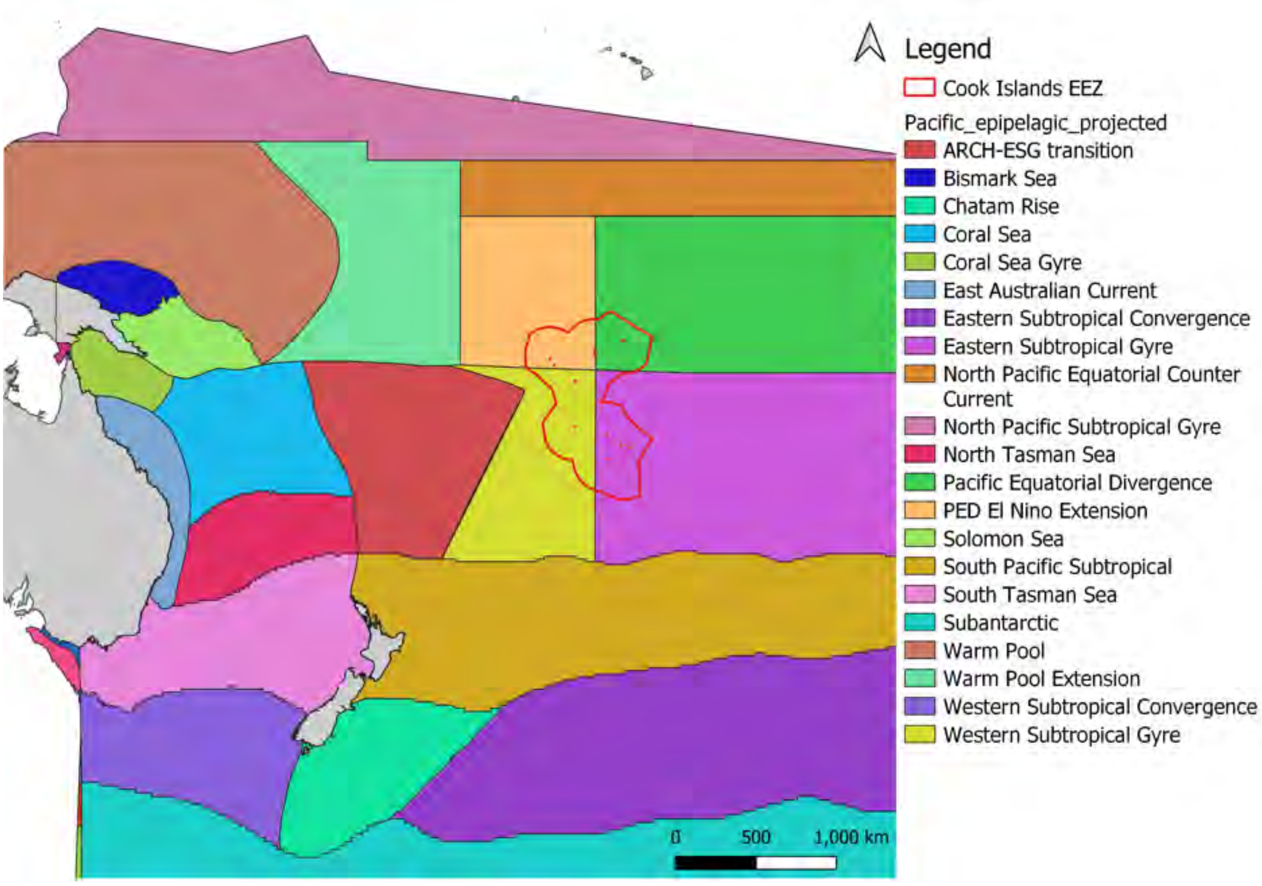
Figure 6-6 Schematic of dominant surface and bottom ocean currents in the CIEEZ (left) and modelled bottom currents (4,000–5,000 m) depth layer (right).

Available temperature data indicates relatively uniform structure at abyssal depths. The chemical oceanography in the abyssal zone of the SPB is expected to be temporally stable. Any temporal variation is likely to be expressed mainly in surface layers and is driven by large-scale processes such as seasonal variation, and climatic events such as cyclones and ENSO processes (El-Niño Southern Oscillation).

Midwater oxygen concentrations are an important driver of biological distributions and data indicates a mesopelagic oxygen minimum at approximately 400 m, which may be related to a zone of increased respiration (biological activity). Tropical oligotrophic waters are known to have deep chlorophyll maxima (Longhurst, 2007; Furnas and Mitchell, 1996) which is related to increased levels of phytoplankton and primary production (and therefore oxygen concentrations)

6.3.2. Midwater Communities

Tropical pelagic bioregions of the Indian and Pacific Oceans were defined in 2020 as part of the Global Ocean Biodiversity Initiative (GOBI) (Figure 6-7).



Source: GOBI, Dunstan et al., 2020.

Figure 6-7 Pelagic bioregions.

The Cook Islands is located in four epipelagic bioregions: the Pacific Equatorial Divergence (PED), PED El Niño Extension, the Eastern Subtropical Gyre, and the Western Subtropical Gyre (Figure 6-7). The straight lines in Figure 6-7 reflect the uncertainty in these analyses, but the results of this regionalisation indicate that the large latitudinal and longitundinal range spanned by the CIEEZ is likely to drive differing biological communities. The ecology of pelagic habitats is closely linked to regional water movements, temperature, salinity, and climate conditions, which influence nutrient supply (Ceccarelli et al., 2013). Therefore, biogeography can inform general understandings of the likely pelagic ecosystem structure.

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 CIEEZ is a shark sanctuary, established under the Marine Resources Act (2005), and prohibits the commercial exploitation of sharks. The Moana Licence Area does not include habitats for inshore and deep slope fishes, and no such habitats exist within 200 km of the Licence Area.

Oceanic fish species expected to occur in the Moana Licence Area include several tuna species: albacore (*Thunnus alaunga*), yellow-fin (*T. albacares*), big-eye (*T. obsesus*), skipjack (*Katsuwonus pelamis*), and dog-toothed (*Gymnosarda unicolor*)). Tuna species can be surface or pelagic and migratory. Non-tuna species expected are billfish: (blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphias gladius*), and sailfish (*Istiophorus platypterus*).

Other pelagic species such as wahoo [Pa'ara] (*Acanthocybium solandri*); dolphin-fish [Ma'i ma'i] *Coryphaena hippurus*), and rainbow runner [Roroa] (*Elagatis bipinnulatus*) are likely to occur in the Licence Area. Oceanic species feed largely on epipelagic fishes, squids, and crustaceans. A few 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 (Cook Islands Offshore Fisheries Annual Report, 2017).

Cetaceans (whales and dolphins), sharks, and seabirds also occur in the pelagic zone. In 2001, the CIEEZ was declared a whale sanctuary, which provides a mechanism for managing activities that interact with whales such as fisheries, scientific research, and tourism (Cook Islands, 2001). A total of 13 cetacean species have been identified within the CIEEZ, with a further 11 species thought likely to occur in the region (Table 6-1).

Table 6-1 Summary of marine mammals known to be present in the CIEEZ.

Common name	Scientific name	Notes
Blue whale	*Balaenoptera musculus*	Likely *B. m. brevicauda*
Fin whale	*Balaenoptera physalus*	
Sei whale	*Balaenoptera borealis*	
Bryde's Whale	*Balaenoptera edeni*	
Omura's whale	*Balaenoptera omuai*	
Dwarf minke whale	*Balaenoptera acurorostrata subsp.*	
Humpback whale	*Megaptera novaeangliae*	Likely breeds and calves in the region
Sperm whale	*Physeter macrocephalus*	
Pygmy sperm whale	*Kogia breviceps*	
Dwarf sperm whale	*Kogia simus*	
Cuvier's beaked whale	*Ziphius cavirostris*	
Blainville's beaked whale	*Mesoplodon densirostris*	
Longman's beaked whale	*Indopacetus pacificus*	
Killer whale	*Orcinus orca*	
False killer whale	*Pseudorca crassidens*	

Short-finned pilot whale	*Globicephala macrorhynchus*	
Pygmy killer whale	*Feresa attenuata*	
Melon headed whale	*Peponocephala electra*	
Risso's dolphin	*Grampus griseus*	
Rough toothed dolphin	*Steno bredanesis*	
Bottlenose dolphin	*Tursiops truncatus*	
Pantropical spotted dolphin	*Stenella attenuata*	
Common dolphin	*Delphinus delphis*	
Spinner dolphin	*Stenella longirostris*	Likely dwarf form
Striped dolphin	*Stenella coeruleoalba*	
Fraser's dolphin	*Lagenodelphis hosei*	

Source: Modified from Jefferson et al., 2015.

6.4. Sea Surface and Atmosphere

6.4.1. Environment and Habitats

DRT commissioned Oceanweather, Inc. to perform a statistical hindcast study of wind, wave and surface current in the Moana Licence Area as part of the engineering scoping study done in 2018[7]. The area is subject to persistent south-easterly trade winds of 6–10 m/sec and waves 2–3 m (significant wave height). Maximum wave heights are about 1.8 times the significant wave height. Surface currents flow to the southwest at about 25–50 cm/sec most of the year. The area is also affected by about three cyclones per year.

Seasonal temperatures in Cook Islands vary between the islands and any temperature changes are often strongly tied to the surrounding sea temperature. The northern group of islands have a stable annual temperature due to their proximity to the equator, with the annual average at Penrhyn being 28°C. In the southern group, temperatures drop during the dry season (May to October) and the annual average temperature at Rarotonga is 24.5°C (Australian Bureau of Meteorology and CSIRO, 2011). Rainfall in this region is heavily influenced by the South Pacific Convergence Zone which causes thunderstorm activity when winds meet and air rises over warm waters. This band of heavy rainfall extends across the South Pacific Ocean from the Solomon Islands to the east of Cook Islands and has an influence on the northern group from November to March, and the southern group from November to May. June to October are the country's dry months overall.

A major factor affecting the Cook Islands climate are ENSO processes which affect the northern and southern groups differently. Rarotonga and the southern group experience drier and cooler conditions than the average during El Niño, while the Northern Group experiences wetter conditions. ENSO also warms the ocean temperatures in the north (Australian Bureau of Meteorology and CSIRO, 2011) and the cyclone season is generally considered November to April. Rising sea temperatures have seen the sea levels also rise, with satellite data recording an increase of 4 mm since 1993 (Australian Bureau of Meteorology and CSIRO, 2011).

Surface waters in the CIEEZ are characterised by low levels of nutrients (Verlaan et al., 2004). This is due to low levels of plankton and therefore, low levels of primary productivity (Menkes et al., 2015), although primary production in deeper layers (deep chlorophyll maxima) may occur.

Surface chlorophyll-a concentrations in the CIEEZ are generally lower than those observed in the CCZ.

6.4.2. Communities

The CIEEZ supports a diverse marine seabird fauna (Table 6-2). McCormack (2005) provides a summary of key elements of the seabird community. Suwarrow atoll in the northern group supports 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

[7] Oceanweather, Inc. (2018) Global Reanalysis of Ocean Waves 2012 (GROW2012) - Cook Islands GP069363 [Lat 16.0º S, Long 201.0º E, Depth 5055.5 m]; Naval Research Laboratory (NRL) HYCOM Global 1/12º Reanalysis (GROW-HYDRO)

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).

Table 6-2 Seabird species recorded within Cook Islands.

Scientific Name	English Name	Traditional Name
Diomedea epomophora	Royal Albatross	
Diomedea exulans	Wandering Albatross	
Fregata ariel	Lesser Frigatebird	Kōta'a Iti*
Fregata minor	Great Frigatebird	Kōta'a Nui*
Larus atricilla	Laughing Gull	
Fregetta grallaria	White-bellied Storm-Petrel	
Nesofregetta fuliginosa	White-throated Storm-Petrel	
Oceanites oceanicus	Wilson's Storm-Petrel	
Oceanodroma leucorhoa	Leach's Storm-Petrel	
Pelagodroma marina	White-faced Storm-Petrel	
Phaethon lepturus	White-tailed Tropicbird	Rākoa
Phaethon rubricauda	Red-tailed Tropicbird	Tavake
Daption capense	Pintado Petrel	
Macronectes giganteus	Southern Giant-Petrel	
Macronectes halli	Northern Giant-Petrel	
Pseudobulweria rostrata	Tahiti Petrel	
Pterodroma alba	Phoenix Petrel	
Pterodroma brevipes	Collared Petrel	
Pterodroma cervicalis	White-necked Petrel	
Pterodroma cookii	Cook's Petrel	
Pterodroma heraldica	Herald Petrel	Kōputu
Pterodroma inexpectata	Mottled Petrel	
Pterodroma neglecta	Kermadec Petrel	
Pterodroma nigripennis	Black-winged Petrel	Tītī
Pterodroma ultima	Murphy's Petrel	
Puffinus griseus	Sooty Shearwater	
Puffinus lherminieri	Audubon's Shearwater	Rākoa (MG)
Puffinus nativitatis	Christmas Shearwater	
Puffinus pacificus	Wedge-tailed Shearwater	Ūpoa
Sterna bergii	Crested Tern	
Sterna fuscata	Sooty Tern	Tara (MH)
Sterna hirundo	Common Tern	
Sterna lunata	Spectacled Tern	
Sterna sumatrana	Black-naped Tern	Kakavai Māui (MH)
Anous minutus	Black Noddy	Rakia (TN)
Anous stolidus	Brown Noddy	Ngōio
Gygis alba	White Tern	Kākāia
Procelsterna cerulea	Blue grey Noddy	Kāra'ura'u (MG)
Sula dactylatra	Masked Booby	Lulu (PK)
Sula leucogaster	Brown Booby	Kena (MH)
Sula sula	Red-footed Booby	Toroa

Source: McCormack, 2007.

7. Nearshore Marine and Coastal Biophysical Environment

7.1. Islands and Coral Reefs

Cook Islands are made up of 15 landmasses totalling 240 km^2. They are spread over an oceanic area of 1.9 million km^2 and are divided into a northern and southern group (Table 7-1).

Table 7-1 Attributes of Cook Islands. For atolls, land was defined as areas with some vegetation cover.

Region	Island	Land Area (km^2)[1]	Highest Elevation (m)[2]	Landform	Inshore marine habitats	Use
Northern Group	Penrhyn	10	3	Atoll	Lagoon	Inhabited
	Rakahanga	4	3	Atoll	Lagoon	Inhabited
	Manihiki	4.9	5	Atoll	Lagoon, brackish ponds	Inhabited
	Pukapuka	3.8	4	Atoll	Barrier reef, deep lagoon	Inhabited
	Nassau	1.3	9	Sand Cay	Barrier reef, deep lagoon	Inhabited
Southern Group	Suwarrow	0.4	3	Atoll	Lagoon	Wildlife Reserve
	Palmerston	2.1	5.3	Atoll	Lagoon, fringing reef	Inhabited
	Aitutaki	18	124	Almost-atoll	Lagoon, saltwater marshes, fringing reef	Inhabited
	Manuae	6.2	10	Atoll	Fringing and barrier reefs, lagoon	Wildlife Reserve
	Mitiaro	22.3	15	Makatea[3]	Fringing reef	Inhabited
	Takutea	1.0	5	Sand Cay	Fringing reef	Wildlife Reserve
	Atiu	26.9	72	Makatea	Fringing reef	Inhabited
	Mauke	19.1	29	Makatea	Fringing reef	Inhabited
	Mangaia	48.3	169	Makatea	Fringing reef	Inhabited
	Rarotonga	67.4	652	High Island	Fringing coral reef and shallow lagoon	Inhabited

Source: Table adapted from the 5th National Report to the Convention on Biological Diversity (NES, 2017). 1. These figures were provided by Dan-Olaf Rassmussen, National Environment Service based on measuring polygons of areas from 2010 satellite images. 2. Source: Wood & Hay (1970) 3. Makatea refers to a raised reef platform island.

Limited data exist regarding coral and sponge diversity across Cook Islands (NES, 2017), however, surveys conducted in 2013 and 2015 assessed coral reef health at Rarotonga, Palmerston, and Aitutaki (Purkis et al., 2018). The latter includes its nearby island neighbour Manuae, with which it shares an atoll. Reef health varied greatly between each surveyed island. Aitutaki's reefs were reported as severely impacted by the invasive Crown-of-thorns starfish (CoTS) *(Acanthaster planci)* and as a result, have low live coral cover. CoTS are noted for their widespread coral destruction in the Great Barrier Reef (Pearson, 1969), Guam (Chesher, 1969), and Japan (Yamaguchi, 1986). Palmerston had the most live coral cover (50-62%) and was classified as being in good condition. Rarotonga displayed moderate reef health consistent with many other islands throughout the South Pacific.

Aitutaki is closest to Moana's exploration area and constitutes a remnant volcanic island containing a rim-enclosed lagoon. It has a distinct morphology resulting in a different marine habitat to the other surveyed islands. The fore reef area is 5.9 km^2 and the deep fore reef slope area is 3.7 km^2. Its large back reef coral habitat has prevalent lagoonal coral communities within 10-35 m depth. These include *Acropora*, lagoonal floor coral bommies, massive corals, and patch reefs. The CoTS outbreak was most prevalent at Aitutaki, which had the poorest reef health of all three surveyed islands. It had a low live coral cover of 18% compared to 34% at Rarotonga and 51% at Palmerston. Dominant coral species were of the genera *Acropora*, *Porites*, *Montipora*, *Montastrea*, *Leptoria*, and *Pocillopora*. While having low coral cover, Aitutaki had the highest coral diversity (Purkis et al., 2018). Algae coverage on the seafloor at Aitutaki was high, at 75%. It was predominantly crustose coralline algae (CCA) which is an encouraging indication of recovery for the reefs. In addition to CoTS outbreaks, Rongo et al. (2013) cited cyclone damage to reefs as a potentially important stressor.

Throughout Rarotonga, Palmerston, and Aitutaki, Purkis et al. (2018) identified 242 fish species from 39 families, with fish diversity being similar across the three locations. Fish proportions at each trophic level were also comparable, suggesting the trophic structure is similar throughout surveyed sites. Aitutaki and Rarotonga had large herbivorous populations compared to other trophic groups. Scaridae (parrotfish) constituted the highest proportion of biomass at both sites, despite Acanthuridae (surgeonfish) being the most abundant. Small fish (11-20 cm length) were the largest proportion surveyed at all sites, with the proportion of fish in each size category declining as size increased at Aitutaki and Rarotonga (Purkis et al., 2018).

Across Cook Islands, it is common for reef ecosystems to have low macroalgae and high CCA cover, with a relatively healthy fish and invertebrate population to constrain macroalgal growth and allow space for coral larval recruitment to occur. At least 11 species of holothurians (sea cucumbers) are known from Cook Islands (within reefs, reef flats, lagoons etc.). Many of these are known to be of importance in subsistence fishing. It is possible that over-fishing of holothurians has impacted the denitrification processes that burrowing holothurians contribute to in the inner sandy lagoon, which potentially exacerbates nuisance algal blooms.

Three marine turtles are found in Cook Islands and may occur in the Licence Area. These are the hawksbill turtle (*Eretmochelys imbricata*), 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 is critically endangered (Marae Moana, 2021). Turtles are recorded as nesting on Manihiki, Pukapuka, Penryhn, and Palmerston but range widely throughout the open ocean.

The outer reef slopes in Cook Islands, like all tropical coral reef environments, support populations of deep-water fish species. Kulbicki et al. (2011) reported deep-water snapper species (mainly red and flower snapper) (67.1%) followed by grouper (15.4%), trevally, jacks, tunas, and mackerels (4.8%), sharks (2%), other teloests (6.9%), and shallow water snappers, emperors, oil-fish and snake mackerels along with barracuda and sea-pikes (4.05%). Fish such as oil-fish and snake mackerel are caught in depths of 200-800 m. Four species of shark were identified in Kulbicki et al. (2011) as having been taken as bycatch by dropline gear in Cook Islands: white-tip shark (*Carcharinus albimarginatus*), grey reef shark [Papera] (*C. amblyrhynchos*), black-tip shark (*C. melanopterus*), and reef white-tip shark [Ngarara] (*Triaenodon obesus*). The silky shark (*C. falciformis*) is recorded by Anon. (in press) and also the hammerhead shark [Mango iravaru] (*Sphyrna* sp.).

7.2. Mangroves and Estuaries

Mangrove systems have not been observed in Cook Islands. A reduction in mangrove stature occurs from west to east of the Pacific Islands, up to Samoa, after which they have not been observed in the Kermadec Islands, Niue, Tokelau Islands, or the Phoenix Islands (Wilder, 1931; Luomala, 1951; Parham, 1971; Sykes, 1970, 1977 as cited in Woodroffe, 1987). Species have been introduced further east of Cook Islands with *Rhizophora stylosa* in Tahiti, Moorea, and Bora Bora in the Society Islands (Taylor, 1979), with other introduced species (*Rhizophora mangle* and *Bruguiera gymnorrhiza*) becoming established in the Hawaiian Islands (Wester, 1981).

Cook Islands have a relatively small system of rivers and lakes. Therefore, there are limited freshwater and estuarine habitats. The Avatiu River on Rarotonga is the country's longest at 5 km, with a catchment area of 5.5 km^2. The country has 114.4 ha of wetlands and 190 ha of swamps which can be categorised into four types: freshwater marshes and swamps, permanent freshwater lakes, tidal salt marshes, and freshwater streams. The water quality of freshwater streams on Rarotonga and Aitutaki have been deteriorating (NES, 2017). They have high bacteria and nutrient concentrations and have declined in dissolved oxygen levels and water clarity. Reported causes are bacteria from animals and human waste, and fertilisers. The reduced water quality can result in increased algal levels and potential Ciguatera or fish poisoning for residents (fish contaminated with the Ciguatera toxin can be consumed by people) (Hajkowicz and Okotai, 2006).

8. Cook Islands Terrestrial Environment

The largest of Cook Islands' 15 atolls and islands is Rarotonga which is home to the Capital Avarua (Figure 8-1) and is situated ~500 km south of Moana's Licence Area. Aitutaki, the closest island to the Licence Area, is located ~200 km south and is encircled by a 12 km-long coral reef atoll and lagoon. The southern edge of the atoll is almost completely submerged while the eastern side is composed of a string of small islands including Mangere, Akaiami, and Tekopua. The western side of the atoll contains the only boat passage through the barrier reef.

Source: World Atlas, 2021.

Figure 8-1 Map of Cook Islands.

The fringing coral reef hosts 15 islets adjacent to the main island. Two islets are volcanic islets and the rest are coral-based. The remainder of Cook Islands is made up of a variety of small mountainous islands and sandflat atolls dispersed throughout the EEZ.

8.1. Physical Environment

8.1.1. Climate

Cook Islands is located within the persistent and extensive easterly trade wind zone of the South Pacific. It has a tropical, mild climate with a wet season from November to April, when two-thirds of the annual rain (2,000 mm) falls, and a mild, dry season from May to October. Temperatures are stable throughout the year and typically range from 21°C to 28°C (BOM, 2021).

Tropical cyclones can occur during the wet season. Cyclones tend to form to the far west of the northern Cook Islands and migrate towards the south. Annually, Cook Islands has up to three cyclones. Cyclone frequency increases during an El Niño cycle.

The climate is often strongly influenced by large inter-annual variation and the ENSO phenomenon. During El Niño years, the southern group of islands can experience a reduction in rainfall, sometimes by up to 60%, while in the northern group rainfall can increase by as much as 200% (in excess of 2,300 mm annually). This regime reverses during a La Niña cycle.

8.1.2. Topography

The northern group is primarily coral atolls and the southern group are predominantly volcanic islands. Many of the larger islands host volcanic hills and are fringed by lagoons and barrier reefs. Rarotonga is the largest and highest island with a rugged volcanic interior. The relief and steepness of the island is considerable with many ridges separating deep valleys. Rarotonga also has the highest peak of any island, Te Manga, which reaches 652 m (Britannica, 2021). In contrast, Aitutaki is mostly comprised of sandy flats and coral fringes. Alluvial flats and swampy depressions are also found along the coastline (Antoniou et al., 2018). The maximum elevation is 123 m (Maunga Pu hill).

Due to the limited topography and small island sizes, there are no notable rivers within Cook Islands. The largest islands, however, have ephemeral streams that flow from small freshwater lakes on the mountain peaks of Rarotonga, Mangaia, Aitutaki, and Mitiaro (Britannica, 2021).

8.1.3. Geology and Soils

Alkaline basalts represented by weathered scoria and agglomerate, and nepheline basalts are the geological formations that make up Aitutaki atoll, the closest island to Moana’s Licence Area. The differentiation in geological basalts is thought to represent two main phases and types of volcanic activity during the creation of the island (Wood, 1967). The northern part of the island is primarily undulating Nikaupara soils with scattered patches of Punganui hill and Rakautai soil (ESDAC, 2021a). The southern part of the island is made up of Tautu soils. The island is bordered by Muri sandy soil with the exception of the northeastern side which is bordered by Vaipeka soils.

Cook Islands' largest island, Rarotonga, is primarily composed of Basaltic Eruptive and Phonolitic Eruptive volcanic rock. Geological formations found within the two main volcanic rocks are identified as olivine basalt, olivine-free basalt, limburgite, ankaramite and analcime basalt, separated by beds of rubbly scoria, red, brown, or yellow cinders, and ash (Wood, 1967). The entire central island is situated on Temanga clay loams with latticing veins of Avana stony loams (ESDAC, 2021b). The island is outlined by a fringe of Muri sand and Matavera clay loam while lateritic soils such as Pouara clay loams and Tikioki clay loams are sporadically scattered along the inner fringe (ESDAC, 2021b).

Cook Islands is located in a seismically stable region and are not considered to be at risk from strong earthquake events. Seismic readings dating back to 1900 have not recorded an earthquake event close to Rarotonga (Volcano Discovery, 2021).

8.1.4. Surface and Groundwater

In the southern group of islands, surface water is mainly sourced from springs and streams within catchments and valleys. In the northern group, water is mainly sourced from rainwater and groundwater.

8.1.4.1. Surface Water

The larger islands such as Mangaia, Aitutaki, and Mitiaro have ephemeral streams that flow from freshwater lakes on the peaks of the islands. Rarotonga has 12 main streams that flow from freshwater lakes dispersed throughout the island. Each of the streams are a water supply source that feeds into the distribution system servicing Rarotonga (Burke and Ricci, 1996).

The freshwater streams on Rarotonga are generally in poor condition due to high bacteria and nutrient levels (GCI, 2017b), this is due to faecal bacteria from animal manure and human sewage. Freshwater on Aitutaki is also poor with generally higher levels of bacteria than Rarotonga (GCI, 2017b). Local residents rely heavily on rainwater tanks.

8.1.4.2. Groundwater

Several groundwater bores exist in the northern parts of Aitutaki. The depth of these bores (up to 76 m) suggests the presence of a basal aquifer where groundwater accumulates (Antoniou et al., 2018). The presence of coastal springs at various locations around the island indicates that groundwater from the basal aquifer likely discharges into the sea (Antoniou et al., 2018). The majority of non-potable water on Aitutaki is supplied from six main groundwater infiltration galleries located within the villages of Vaipeka, Vaipae, Tautu, Vaimaru, and Vaitekea.

There is currently not enough data to fully understand the deep circulation of groundwater in the volcanic rocks of Rarotonga, however, seismic surveys have revealed fractures within the rocks. Burke and Ricci (1996) posit these fractures allow deep circulation of water.

8.2. Natural Environment

A variety of native species of flora and fauna occur within Cook Islands, with several species endemic to the country. Compared to the marine environment, the terrestrial environment is considered lacking in diversity with only 185 native flowering plants, 100 native ferns and allies, 29 native birds and one native mammal: the Pacific fruit bat (*Pteropus tonganus*) (GCI, 2017b). The distribution of species is highly dependent on the location, age, and size of the islands. The minimal land area is a limiting factor to the possible range of habitats and ecosystem types, therefore further restricting terrestrial diversity (GCI, 2017b).

8.2.1. Native Terrestrial Flora

A search of the Cook Islands biodiversity database (CIBD) listed 33 endemic flora species; 12 of these species are listed by the IUCN as "critically endangered", "endangered", or "vulnerable" (Table 8-1) (National Environmental Services Cook Islands [NES] 2017).

Table 8-1 Threatened flora species of Cook Islands.

Type	Scientific Name	Common Name	Location	IUCN Status
Fern	*Microsorum katuii*	Cook Islands Oak-leaf Fern	Mangaia, Ma'uke, Mitiāro, Manuae	Endangered
Fern	*Acrophorus raiateensis*	Rarotonga Acrophorus	Rarotonga	Critically Endangered
Grass	*Garnotia cheesemanii*	Rarotonga Garnotia-Grass	Rarotonga	Critically Endangered
Herb	*Lepidium sp. (undescribed)*	Mitiaro Peppergrass	Mitiāro	Endangered
Herb	*Balanophora wilderi*	Rarotonga Balanophora	Rarotonga	Endangered
Herb	*Habenaria amplifolia*	Rarotonga Ground-Orchid	Rarotonga	Endangered
Palm	*Pritchardia mitiaroana*	Mitiaro Fan-Palm	Mitiāro	Endangered
Shrub	*Haloragis sp. (undescribed)*	Rarotonga Haloragis	Rarotonga	Endangered
Shrub	*Cyrtandra lillianae*	Te Manga Cyrtandra	Rarotonga	Endangered
Shrub	*Coprosma laevigata*	Rarotonga Coprosma	Rarotonga	Vulnerable
Shrub	*Cyrtandra rarotongensis*	Rarotonga Cyrtandra	Rarotonga	Endangered
Shrub	*Sclerotheca viridiflora*	Rarotonga Sclerotheca	Rarotonga	Endangered

Source: National Environmental Services Cook Islands, 2017.

Rarotonga, the tallest island in the group with elevations reaching 650 m, has more than 150 native flowering plant species, 18 of which are endemic. Rarotonga is home to the only cloud forest in Cook Islands and hosts a variety of species including rainforest, modified wetlands, and strand forest species. The cloud forests provide critical habitat for eight of the island's 10 endemic flora listed by the IUCN as "critically endangered", "endangered", or "vulnerable" (NES, 2017).

A survey of Rarotonga in 2015 identified 107 vascular plant species with most communities dominated by indigenous varieties (NES, 2017). Three species of concern listed by the IUCN as 'critically endangered' or 'endangered' were identified: *Coprosma laevigata, Cyrtandra* *lilianae,* and *Sclerotheca viridiflora.* Indigenous non-vascular flora species were also identified during this survey including lichens, liverworts, and mosses.

The southern group islands of Mangaia, Mauke, Mitiaro, and Atiu have 124 species of native flowering plants and one to six endemic species on each island. Mitiaro is home to three species listed by the IUCN as 'critically endangered' or 'endangered': *Lepidium sp., Pritchardia mitiaroana,* and *Microsorum katuii.*

Aitutaki has 43 native flowering plant species and 10 native fern species. Wetland species such as *Pemphis acidulous* dominate the marshlands of Aitutaki providing nurseries and spawning grounds for many lagoon fish. No species considered threatened are native to Aitutaki.

8.2.2. Native Fauna

Cook Islands supports a variety of terrestrial fauna species, including 39 resident species of bird, 15 species of mammal, and 16 species of reptile (NES, 2017).

8.2.2.1. Birds

Cook Islands has 39 resident bird species, including six endemics, 10 migratory, and 15 that are globally threatened. All the endemic birds and the majority of migratory birds found within Cook Islands (Table 8-2Table 8-2) are on the IUCN Red List of Threatened Species.

Table 8-2 Threatened and endemic bird species of Cook Islands.

Scientific Name	Common Name	IUCN Red List Status	Location
Acrocephalus kerearako	Cook Islands Reed-warbler	Near threatened	Mangaia, Mitiaro Endemic
Aplonis cinerascens	Rarotonga starling	Vulnerable	Rarotonga Endemic
Collocalia sawtelli	Atiu Swiftlet	Vulnerable	Atiu Endemic
Pomarea dimidiate	Rarotonga Monarch	Vulnerable	Rarotonga, Atiu Endemic
Ptilinopus rarotongensis	Cook Islands Fruit-dove	Vulnerable	Rarotonga, Atiu Endemic
Todiramphus ruficollaris	Mangaia Kingfisher	Vulnerable	Mangaia Endemic
Vini kuhlii	Rimitara lorikeet	Endangered	French Polynesia, Cook Islands
Todiramphus tutus	Chattering Kingfisher	Near Threatened	Cook Islands, Bora Bora.
Thalassarche impavida	Campbell Albatross	Vulnerable	Migratory
Thalassarche eremita	Chatham Albatross	Vulnerable	Migratory
Pterodroma leucoptera	White-winged Petrel	Vulnerable	Migratory
Pterodroma cookii	Cook's Petrel	Vulnerable	Migratory
Pterodroma solandri	Providence Petrel	Vulnerable	Migratory
Pterodroma cervicalis	White-necked Petrel	Vulnerable	Migratory
Procellaria parkinsoni	Black Petrel	Vulnerable	Migratory
Ardenna bulleri	Buller's Shearwater	Vulnerable	Migratory
Vini peruviana	Blue Lorikeet	Vulnerable	Migratory

The islands also provide refuge for a variety of migratory seabirds including the IUCN listed "near threatened" bristle-thighed curlew *(Numenius tahitiensis),* the "vulnerable" Campbell albatross (*Thalassarche impavida*), and the "vulnerable" Buller's shearwater (*Ardenna bulleri*).

8.2.2.2. Mammals

Cook Islands are home to 15 species of terrestrial mammal including the native Pacific fruit bat (*Pteropus tonganus*). The remaining mammals on the islands are introduced or invasive and are used for agricultural purposes such as pigs (*Sus scrofa)*, goats (*Capra hircus),* horses (*Equus caballus),* and cows (*Bos taurus),* domestic animals such as dogs (*Canis familiaris)* and cats (*Felix catus),* or pests species such as the house mouse (*Mus musculus),* Pacific rat (*Rattus exulans)* and the invasive ship rat (*Rattus rattus).*

8.2.2.3. Reptiles

Sixteen species of terrestrial reptile inhabit Cook Islands, including eight species of gecko, six species of skink, and two tortoise species.

The fox gecko (*Hemidactylus garnotii*), tree gecko (*Hemiphyllodactylus typus*), mournful parent gecko *(Lepidodactylus sp*.), and Pacific slender-toed gecko (*Nactus pelagicus)* are listed by the IUCN as endangered, and the Cook Islands skink (*Emoia tuitarere*) is listed as vulnerable.

8.2.3. Invasive Species and Threats to the Natural Environment

Increasing populations and tourism have seen an increase in demand for goods distributed to Cook Islands in recent years and with it new threats and introduced species have brought new environmental pressures such as predators, diseases, and strong competition for space (NES, 2017). Table 8-3 shows threats to the endemic species of Cook Islands.

Table 8-3 Cook Islands threatened endemic species and their key threats.

Species	IUCN Red List Status	Location	Threat
Cook Islands reed-warbler (*Acrocephalus kerearako)*	Near Threatened	Mangaia, Mitiaro	Cats, Pacific and ship rats (predation); goats (habitat modification)
Rarotonga starling (*Aplonis cinerascens)*	Vulnerable	Rarotonga	Common myna (competition, disturbance); ship rats (predation); introduced diseases
Atiu swiftlet (*Collocalia sawtelli)*	Vulnerable	Atiu	Land crabs (predation)
Rarotonga monarch (*Pomarea dimidiate)*	Vulnerable	Rarotonga, Atiu	Cats, ship rats (predation); weeds (habitat modification)
Cook Islands fruit-dove (*Ptilinopus rarotongensis*)	Vulnerable	Rarotonga, Atiu	Common myna (competition, disturbance); ship rats (predation); introduced diseases
Mangaia kingfisher *(Todiramphus ruficollaris)*	Vulnerable	Mangaia	Common myna (competition, disturbance); cats, (predation); goats (habitat modification)
Cook Islands skink *(Emoia tuitarere)*	Vulnerable	Rarotonga	Cats, and potentially Pacific, Norway and ship rats (predation)

Note: The arrival of ship rats on islands where they are currently absent, e.g. Atiu, is identified as a very significant potential invasive species threat.

Source: National Environmental Services Cook Islands, 2017.

The Cook Islands Government has identified 33 individual terrestrial invasive species (with 19 of these species appearing since 2000), including five mammals such as the ship rat, two birds including the common myna (*Acridotheres tristis*), 16 plant species such as the grand balloon vine (*Cardiospermum grandiflorum*) and 10 invertebrate species including tropical fire ants (*Solenopsis geminata*).

Cook Islands completed a National Invasive Species Strategy and Action Plan (NISSAP) in 2019. It identifies the threats posed by invasive species already in the country to native biodiversity, potential threats in the future, and all necessary actions to eradicate the impacts to the natural environment (Cook Islands National Invasive Species Strategy and Action Plan 2019–2025, 2019).

Other threats include contaminated water due to increased human activity and growing populations generating more waste. Water quality monitoring in freshwater streams on Rarotonga and Aitutaki shows low quality results that subsequently impact lagoons and the wider marine environment through increased bacteria and nutrient levels. This can lead to periodic algal blooms in the nearshore marine environment (NES, 2017).

Other human influences affecting the environment include climate change impacts; sea level rise, warming temperatures, and increased cyclone activity (NES, 2017).

8.2.4. Sanctuaries and Protected Areas

Cook Islands has 17 terrestrial protected areas across the 15 islands as listed in Table 8-4.

Table 8-4 Cook Islands protected terrestrial areas.

Area	Designation	Location	Area (km^2)
Suwarrow National Park	National Park	Suwarrow	1.62
Takitumu Conservation Area	Conservation Area	Rarotonga	1.55
Takutea Wildlife Sanctuary	Conservation Area	Takitumu	1.2
Highland Paradise	Local Nature Reserve	Rarotonga	0.32
Moko'ero Nui	Nature Reserve	Atiu	1.2
Maina Reserve	Reserve	Aitutaki	0.8
Te Miromiro	Ra'ui (see table note)	Atiu	0.09
Te Ana	Ra'ui	Atiu	0.019
Keia Puna	Ra'ui	Mangaia	7.42
Tavaenga Puna	Ra'ui	Mangaia	11.5
Mangaia Tanga'eo Sanctuary	Ra'ui	Mangaia	48.35
Unga Ra'ui	Ra'ui	Mauke	2.67
Auru	Ra'ui	Mauke	0.43
Kakemaunga	Ra'ui	Mauke	0.13
Motu Kotawa	Ra'ui	Pukapuka	0.09
Motu Ko	Ra'ui	Pukapuka	0.3
Te Kainga	Ra'ui	Rakahanga	0.06

Footnote: The '*rā'ui*'system is the traditional method of conservation and preservation of natural resources and translates to "giving it back to the gods".

Source: National Environmental Services Cook Islands, 2017.

The Moko'ero Nui Nature Reserve on Atiu, established in 2016, is the first terrestrial nature reserve in the outer islands. The reserve is dominated by rich forests housing the IUNC red listed Near Threatened Chattering Kingfisher (*Todiramphus tutus).*

There are also 25 MPAs surrounding Cook Islands including whale sanctuaries and shark sanctuaries.

9. Socioeconomics and Cultural Heritage

The Cook Islands Māori people have ancient Polynesian heritage, with many of their tribes being rooted in Samoan and Raiatea (French Polynesia) ancestry. A strong traditional connection also exists between the Rarotongans and the New Zealand Māori. A prominent aspect of Cook Islands culture, as with all South Pacific people, is their cultural and spiritual connection to the ocean. The several facets of this connection can be broadly divided into 'traditional' and 'modern religious' aspects. For example, Marae Moana is underpinned by indigenous approaches of 'rā'ui'. This is a traditional form of natural resource management that restricts access to certain areas or during certain times. Modern religious beliefs have been voiced in the consultation processes of nodule harvesting exploration, expressed broadly as a 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. Underpinning both traditional and modern aspects is the belief that the ocean has 'mana' (spiritual authority). Therefore, although subsistence and artisanal activities may be restricted to the coastal environment, cultural considerations of nodule harvesting are critical to the ESIA.

9.1. Governance and Administration

Cook Islands became a British protectorate in 1888. By 1900 administrative control was transferred to New Zealand. In August 1965, Cook Islands became self-governing in free association with New Zealand (GCI, 2016). Cook Islands is a sovereign parliamentary democracy, with its heads of State being the British monarch and the New Zealand high commissioner. The head of the Government is the prime minister, who appoints a cabinet. Cook Islands has a unicameral parliament with elected members and a maximum parliamentary term of four years. Twenty-four members represent different districts, and one represents islanders living in New Zealand.

New Zealand retains responsibility for external affairs and defence in consultation with Cook Islands. For most practical purposes, and in accordance with 'The Joint Centenary Declaration of the Principles of the Relationship between the Cook Islands and New Zealand', Cook Islands conducts its own foreign affairs, and develops foreign policy to its particular needs.

Traditional leadership, pre-colonisation, was through chiefs (or Ariki), each being the head of his own tribe (vaka), within his own village[8]. Ariki were said to be imbued with divine powers and were the custodians of all natural resources, the settlers of all disputes, and the overseers of all labour (CIB, 2021).

The Cook Islands Constitution provides for a House of Ariki comprising up to 14 Ariki who are appointed by the Queen's Representative. Established in 1966, the functions of the House of Ariki are to advise the Government on matters relating to tradition and custom. The House of Ariki does not have legislative power. Secondary level chiefs comprise the Koutu Nui (Council of Traditional Leaders), a subsidiary of the House of Ariki. The legal function of the Koutu Nui is to consider and make recommendations to parliament and the House of Ariki on matters 'relating to the customs, traditions (and usages of the indigenous people) of the Cook

[8] Traditionally, only males were permitted to hold chiefly titles.

Islands' (CIB, 2021). While these two statutory bodies attempt to integrate traditional leadership and customs into the Westminster system of Government, in practice these groups no longer reflect the structures that were in place and in use pre-European and New Zealand administration. Ariki authority has been largely superseded by that of the Parliament.

Notwithstanding the parliamentary structures and legislation, it is generally acknowledged that Ariki today are respected as thought-leaders among the community whose position on matters of policy-setting holds significance. As such, Ariki are considered key stakeholders with respect to the social licence to embark on nodule harvesting in Cook Islands, overlaying the formal legislated licence.

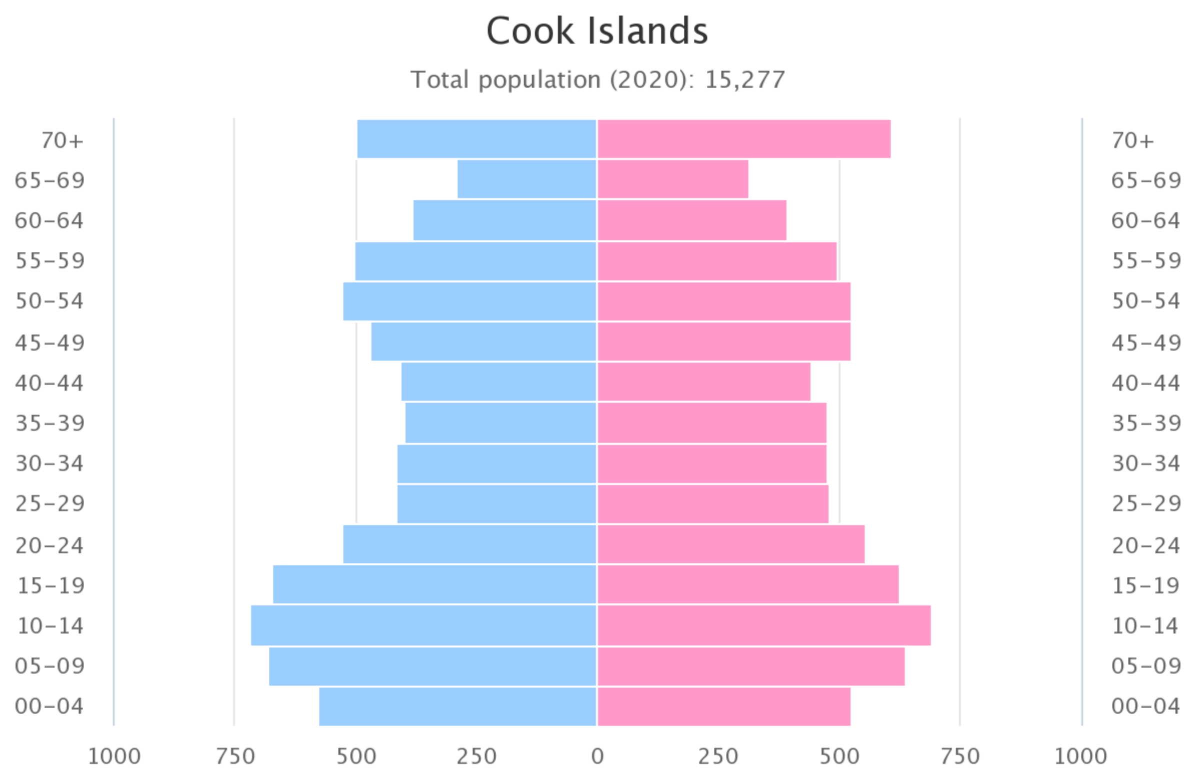
9.2. People and Culture

9.2.1. Population and Demographics

The population of Cook Islands at the time of the last census (2016) was 17,434 (including 2,599 temporary residents). The population had declined by 2% since the previous census in 2011 and more broadly, the population has been in a state of decline since 1996 (GCI, 2018a). Approximately 70% of the resident population live on Rarotonga, with a population density of 2,205 inhabitants per km^2 (GCI, 2018a). Around 20% of the population live in the other eight islands of the southern group (GCI, 2016). The remote northern group of Pa Enua, more than 1,250 km from the capital, is made up of seven low lying, sparsely populated (203 inhabitants per km^2), coral atolls and sand cays, with little arable land (GCI, 2016; GCI, 2018a).

Figure 9-1 indicates an aged population, as younger people leave the islands to find education, training, and employment opportunities elsewhere. Today, there are at least four times as many Cook Islanders living in New Zealand and Australia (DFAT, 2021) compared to locally. The Cook Islands Government notes that continuing depopulation by Cook Islanders is a significant threat to the development of the nation (GCI, 2016).

In 2016, the Cook Islands Māori population accounted for 78% of the population. The non-Cook Island Māori population has been increasing, from 7% of the population in 2006 to 14% in 2016. Most reside on Rarotonga, the centre of commercial and Government activities (GCI, 2018a).



Source: Pacific Community, 2021.

Figure 9-1 Cook Islands population pyramid.

9.2.2. Language, Culture and Beliefs

Cook Islands has two official languages: English and Cook Islands Māori, also called Rarotongan, which is similar to the Māori spoken in New Zealand and Tahiti.

The culture and traditions of Cook Islanders trace their ancestry on the southern islands back to Tahiti and the Marquesas over 1,000 years ago, with Samoan and Tongan migrations settling in the northern islands. Cook Island tradition also says some of the New Zealand Māori migrations originated in their islands, and there is a strong traditional connection between the Rarotongans and the New Zealand Māori today.

Cook Islanders have a strong connection to their environment – both land and sea – which are seen as being interconnected. Myths, oral traditions, and cosmologies of Cook Islanders show that they conceived their world holistically, without distinctions between human and non-human, nature and culture, as objects. The mobile "people of the sea" envision their world embedded in the ocean (Tilot et al., 2021). They feel that the sea ties them to their ancestors, who believed that it is vital to be good to the ocean: 'in order to harvest, you first have to protect' (Tilot et al., 2021). This connection to environment is enshrined in the Ocean Declaration of Maupiti (2009), of which Cook Islands is a signatory. It 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.

Little is known about the indigenous religion, which is thought, like other Polynesian religions, to have a complex system of gods, each of which was responsible for a specific aspect of life. Crocombe (1961) reports that '*marae'* (sacred grounds enclosed by low stone walls in which ceremonies of a religious nature took place) were centres of religious activity, and those within a '*koutu'* (or the royal court of the Ariki[9]) were the centre of religious activity of the tribe. Polygamy was practiced prior to the introduction of the Christian churches and is no longer commonly practiced.

Contact with Christian missionaries since the early 1800s fundamentally changed Cook Islander culture and religious practices. Although influenced by local traditions and customs, Christianity is now an integral part of islanders' lives. Today, most Cook Islanders are Christian; 49% are Cook Islands Christian Church (CICC), 17% are Roman Catholics, and 8% are Seventh Day Adventist (SDA) (GCI, 2018a).

9.3. Customary Land Ownership

As with many other Pacific Island cultures, traditional land ownership and tenure contained a high degree of pragmatism, enabling people to move and adapt to changing conditions. Mobility was commonplace and tenure and use complex, with various rights and obligations pertaining to particular areas, groups, and individuals.

On Rarotonga, early chiefs and their families were allotted a block of land called a '*tapere'* – radial land units, centred on the inland valleys, each containing the mountain, coastal plain, lagoon, and reef resources, enabling each group access to the resources offered by each environmental zone (Crocombe, 1961; Smith and Jones, 2007; Reilly, 2018). The raised coral limestone islands such as Mangaia also have a concentric settlement pattern dictated by resource zones, where the land holdings are segments running from the centre of the island to the coast, containing each major resource zone (Smith and Jones, 2007). This traditional approach to resource management gives an interesting insight into the traditional understandings of EBM and spatial planning that should resonate with the ESIA program of work and local people.

The lands of the tribe were often spoken of as the lands of the *Ariki*. Likewise, the lands of smaller groups were referred to in the name of the lesser chief concerned (Crocombe, 1961). Most land (including reefs and fishing grounds) in the Pacific Islands was not considered 'common property' in the sense of being accessible to all people, or equal access to all members of a particular community which claims ownership (Ward, 1997; COA, 2008). However, the

[9] It was the special place where all offerings … to the ancient gods were first assembled … where all the chiefs and persons of note … and members of the ariki family were buried … where all tribal annual feasts were held…. Each tribe had its principal koutu and lesser grade koutu (Crocombe, 1961).

elite usually had multiple residences scattered around the various districts, and frequently travelled through these to receive offerings (Reilly, 2018).

Land rights were vested not in the land itself, but with membership with a particular social or descent group, and the *Ariki* allocated the rights among its members (COA, 2008). An individual's rights to land were largely contingent upon the person being resident on the land and a participant in the community/group or clan, and could also be dependent on social status (Crocombe et al., 2008; Reilly, 2018). For example, while all members of a tribe might have had access to hunt, gather, or collect water from any area within the community's broader territory, individual trees or products may be recognised as the property of individuals and control of hunting and gathering may rest with particular people or sub-groups. For other land, specific individuals, or families may hold relatively exclusive rights to occupy, stemming from the last period of cultivation of that land (Ward, 1997). Women's rights to family land were suspended when she married but could be reactivated if she became widowed or divorced or returned to live in her family's village (Crocombe et al., 2008).

Crocombe (1961) found that there are variations between the traditional systems of land tenure between the atolls of the northern group and those of the high islands of the southern group, imposed by environmental factors. Others are attributable to differences in cultural origin, and to a lesser degree there are minor variations within individual islands, although Crocombe (1961) noted no major differences between the southern group of islands.

Customary tenure has changed over time, as custom itself changes with technological, economic, social, and political change. The codification of land tenure systems when administration of Cook Islands was handed to New Zealand in 1901 and the New Zealand Government established a Land Court in 1902, which heralded a major change to the traditional system of customary land tenure[10]. The Land Court was introduced to resolve land disputes and record who owned land; reduce chiefly powers over land[11]; increase the commercial productivity of the land available to Cook Islanders; and to identify land to lease to Europeans to generate income (Crocombe et al., 2008).

Because holdings were surveyed, and owning groups specified, the processes which formerly allowed land to be reallocated as needs changed, largely ceased to operate, which resulted in a much more static situation than the traditional system (Crocombe et al., 2008; Ward, 1997). Further, lands were mostly allocated to the families of the *Ariki* and primary members of the occupying minor lineages to whom the land in question had been allocated under custom.

Now all tenure in Cook Islands is derived from the Crown, and is divided into two categories:

- Customary land, which is also referred to as uninvestigated land.

[10] The Land Court does not have jurisdiction over the islands of Mangaia, Mitaro, Nassau, and Pukapuka. Land on these islands is dealt with in accordance with local custom, unless the traditional chiefly authority (the Aronga Mana) requests Land Court assistance (ADB, 2015).

[11] While the concept of 'chiefly rights in land' was probably not very significant during the pre-contact era, it became an issue of considerable importance once commercial agriculture began and land assumed a cash value (Crocombe, 1961).

- Native freehold land, which is also referred to as investigated land.

While most readily accessible land on Rarotonga was investigated decades ago (and is thus mostly native freehold land), an estimated 95% of the land in Cook Islands is uninvestigated (customary) land (COA, 2008).

Land in Cook Islands cannot be bought or sold by non-Cook Islands citizens, except to the Government for public purposes. This is the case whether the land is registered as native freehold title or is land managed under customary practices (Crocombe et al., 2008). Land can be leased or have occupation rights granted by the Land Court (ADB, 2015).

9.3.1. Customary Land

The *Cook Islands Act 1915* provides for the recognition of land and other customary practices such as customary land, land titles, succession, and other Indigenous customs. The Act defines 'customary land' as 'land which, being vested in the Crown, is held by Natives or the descendants of Natives under the Native customs and usages of the Cook Islands'. While the term ‘Native’ is no longer commonly in use, its definition is considered to include those who trace their heritage to Cook Islands. However, there is still no consensus on what constitutes ‘custom’, which is a concept that varies between islands and has changed over time (Stenberg, 2017). The high-water mark demarcates the limit of customary land, and land below the high water mark is state land (ADB, 2015). As such, no customary rights are considered in terms of accessing the sea for nodule harvesting.

Since a Land Court ruling in 1957, ownership of customary land is now hereditary and is divided equally among the descendants of an owner after their death. As a result of this decision, traditional customary ownership and tenure were overruled by legislation, and land ownership has since become highly fragmented. To illustrate the extent to which this has become a problem, one study estimated that recognition of ‘customary’ title could mean up to 70 or more owners per household in Cook Islands (Crocombe et al., 2008). Customary land ownership is complicated further by the fact that most customary landowners do not live in Cook Islands (Crocombe et al., 2008).

9.3.2. Freehold (Ariki) Land

Almost all valuable land in Cook Islands is registered as 'native freehold title', including most of Rarotonga, and is primarily held by:

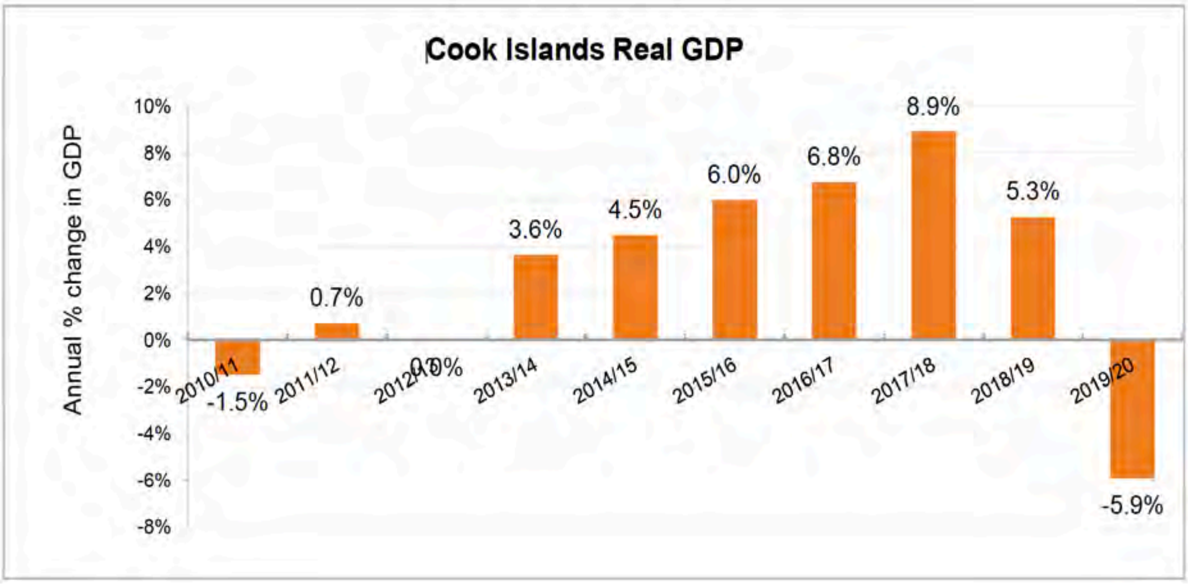
- The Crown, where it needs land for its own public purposes (i.e., public land).
- Native Cook Islands landowners, who have established their rights to an award of 'native freehold' title.
- The Cook Islands Christian Church.

Individuals with freehold title can make use of that land through occupation rights, leases, vesting orders (which allows for the transfer of land to a ‘Native’ (defined under the Cook Islands Act) or a descendant to provide a site for a dwelling), or a partition order (which is used to separate out different family interests from a common block). The fragmentation of native freehold titles has opened the way for some Cook Islanders (many living overseas) to acquire large areas of land through occupation rights, leases, or other means (Crocombe et al., 2008).

9.4. Economy and Livelihoods

9.4.1. Economy

The Cook Islands economy has experienced sustained economic growth, averaging 5.5% gross domestic product (GDP) growth per year from 2012–2018, and 7.0% in 2018 (ADB, 2019). Cook Islands per capita GDP is high relative to many other Pacific Island countries, however, due to its high reliance on tourism, the country's economy has sustained a significant reduction in economic activity due to the Covid-19 pandemic, with more than 70% of industries experiencing a negative growth in 2020 (GCI, 2020a). The effect of the Covid-19 pandemic was reflected in a decline in GDP to 2020 (Figure 9-2).

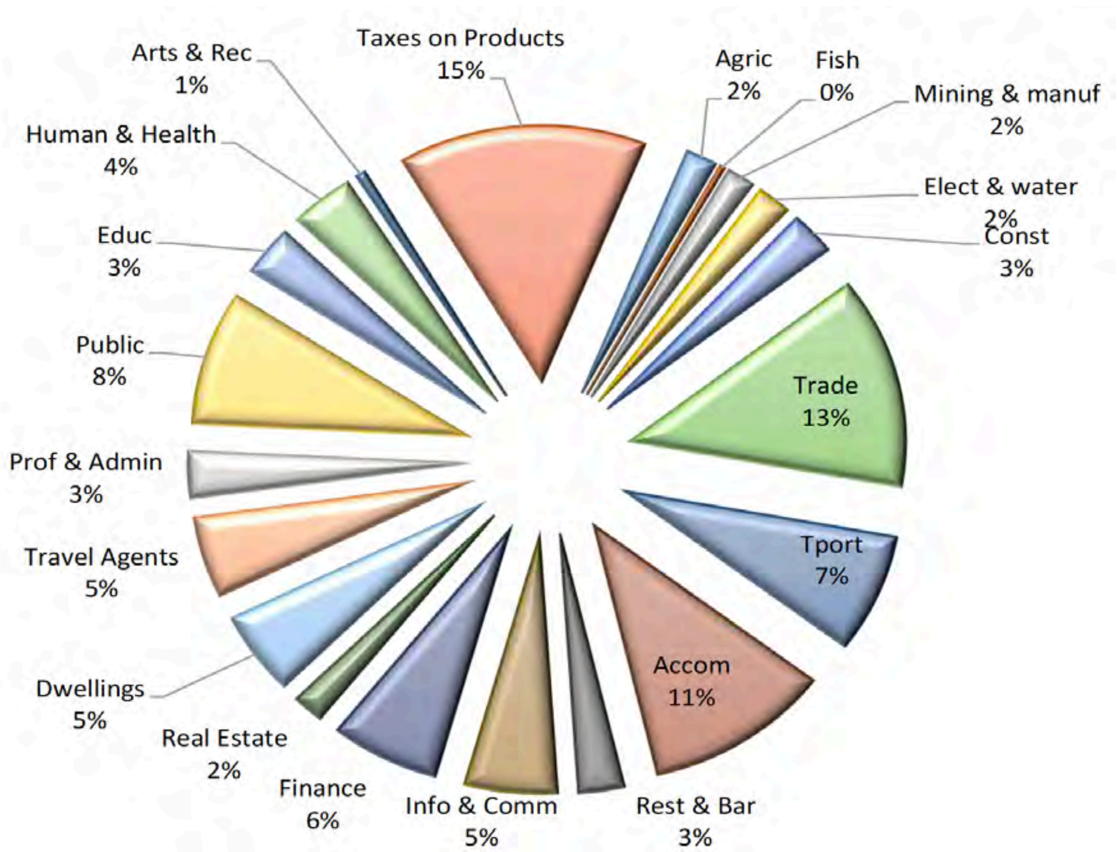


Source: Cook Islands Economic Development Strategy 2030.

Figure 9-2 GDP variation 2010–2020.

The Cook Islands economy faces challenges relating to limited natural resources, remoteness from major trade and industrial centres, inadequate infrastructure and a small labour force (IMF, 2020; Country Reports, 2021; DFAT, 2021). Despite these constraints, Cook Islands has developed a successful tourism industry, which is the primary driver of the economy. Approximately 80% of the activity is centred on Rarotonga, and Aitutaki is the other significant tourist destination (GCI, 2016). At the time of the last census (2016), the services sector was the largest employer in Cook Islands, comprising the accommodation and food service sector (20.9%), the wholesale and retail trade sector (15.8%), and the public administration sector (15%) (GCI, 2018b). The sectoral economy was broken down further for the 2019/2020 year as shown in Figure 9-3.

Some of the key economic sectors for Cook Islands are described below.



Source: Cook Islands Economic Development Strategy 2030.

Figure 9-3 Proportional contribution of industry sectors to the Cook Islands economy.

9.4.1.1. Tourism and Associated Services

Tourism, and the supporting activities of restaurants and accommodation, is Cook Islands' biggest export, contributing approximately 60% of the economy (ADB, 2015). New Zealand accounts for approximately 66% of visitors and has been the largest contributor to tourism growth since 2010. Australia is the second most important source market and has also experienced steady growth. Europe and North America are the other two major source markets (ADB, 2015).

Tourism activities are centred on Raratonga and other islands where the natural values of the marine environment support ecosystem services such as diving, snorkelling, charter fishing, whale watching, and other water sports. Tourism activity in the offshore environment is limited mostly due to inaccessibility, prevailing weather conditions, and lack of attractions for tourists. Some offshore game fishing charters may venture into these waters, but this activity is largely restricted to the nearshore environment around Rarotonga.

Data on visitor arrivals for the first six months of 2020 show that arrival numbers dropped by 65.8% compared to the same period in 2019 due to the Covid-19 pandemic (Pacific Community, 2020). The reduction in international tourism has had flow-on effects to local transport, accommodation, and hospitality businesses, and is likely to have had adverse socio-economic effects on individuals and families, particularly women who hold 60% of tourism-related jobs (ADB, 2020). There is also anecdotal evidence that many people are now turning back to subsistence production and informal agricultural activities for their livelihood. Despite this significant drop in tourism income, the Government of Cook Islands is continuing to prioritise tourism development (DFAT, 2021).

The industry experiences accommodation capacity constraints during the June–August high season, and new private sector investment in accommodation is required to sustain industry growth in the peak visitor season. There are also concerns that much of the existing hotel room stock requires refurbishment to remain competitive with other tourism destinations and attract visitors from the North American and European markets (ADB, 2015). Growth in the tourism industry, through the metric of increased 'total bed nights' is a priority for the Cook Islands (GCI, 2016).

9.4.1.2. Agriculture

The GCI (2016) reports that the rise in tourism and consumerism has coincided with the decline of agriculture as an industry, as land once used for agricultural production has been converted to residential or commercial (usually tourism) use. However, land suitable for agriculture still exists in Rarotonga and the southern group of outer islands. The northern group are all low-lying coral atolls with poor soils for crop production, except for coconuts and some timber and fruit trees (FAO, 2008).

Agriculture products grown in Cook Islands include copra, citrus, pineapples, tomatoes, beans, pawpaws, bananas, yams, taro, coffee, pigs, and poultry (Country Reports, 2021). Agriculture is not a major export industry for Cook Islands due to a range of challenges affecting the sector, including rising wages and land values. Cook Islands has experienced a steady overall decline in commercial and semicommercial agricultural activity, which has occurred predominantly on islands (other than Rarotonga) where specific crops for export, such as bananas and pineapples, were developed but suffered crop damage and were not sustained. While Rarotonga has also lost specific export crops such as pawpaw, it has retained a small (but important) commercial agriculture sector supplying local produce to residents, hotels, and restaurants (ADB, 2015).

In 2013, the agriculture sector accounted for 3.2% of GDP, however agriculture exports have steadily declined from 2009, and in 2013 comprised approximately 3.5% of total exports (ADB, 2015). Agricultural activity has been largely limited to the sale of fresh fruits and vegetables to Rarotonga and Aitutaki and small niche market opportunities, driven by the high cost of labour and the availability of more attractive employment alternatives (e.g., in tourism or the public sector) (ADB, 2008). The Cook Islands Government acknowledges that the Islands are currently heavily reliant on imported foods, and that there is a need to increase local food production.

9.4.1.3. Commercial Fisheries and Aquaculture

The pelagic fishery (targeting species such as yellowfin tuna, albacore tuna, skipjack tuna, bigeye tuna, mahi mahi, wahoo, and billfishes) in the CIEEZ consists of a longline fishery with vessels based both locally and operating from ports of neighbouring countries including American Samoa, Samoa, and Fiji. The pelagic purse seine fishery consists predominantly of vessels flagged to the United States (US), Korea, Kiribati, Vanuatu, and the European Union (EU) (MMR, 2020).

The longline fishery in the CIEEZ and on the adjacent high seas are characterized by two fleets; those of the southern fishery, and those of the northern fishery. The southern fishery, based out of Rarotonga, comprises small-scale vessels carrying out fresh fish operations to produce fish for domestic and international markets. The northern fishery is based principally out of Pago Pago, American Samoa and targets albacore tuna for canning (MMR, 2020). Foreign vessels are restricted to fishing outside the 12 NM territorial sea around each island to avoid conflict with artisanal fishing practices (Anon 2000). Commercial fishing intensity within the CIEEZ is relatively low compared to other areas in the South Pacific region (see Section 12).

The main economic benefit derived from commercial fishing is the revenue received by the Ministry of Marine Resources (MMR) from treaties and fishing licences. Cook Islands receives revenue from the US and the EU via fishing licences and agreements that allow ships from these jurisdictions to access tuna within the CIEEZ. For example, the EU have recently renewed their sustainable fisheries partnership agreement (SFPA), which allows EU fishing vessels operating in the Western and Central Pacific Ocean to continue fishing in the Cook Islands fishing grounds. Under the agreement, the EU and ship owners will contribute up to approximately NZD 6.8 million for the next three years, of which NZD 1.7 million will support Cook Islands' initiatives within the sectoral fisheries and maritime policy. The revenue obtained from this SFPA has previously allowed the Cook Islands Government to improve its social welfare system.

Starting in the 1980s, black-lipped oysters (*Pinctada margaritifera*) were cultured and seeded on Manihiki Islands to produce black pearls and a black pearl industry has since grown in Cook Islands (FAO, 2021). The pearls are commercially cultured in Manihiki and Penrhyn lagoons in the northern group of islands, and have become one of the country's largest exports, valued between NZD 5–10 million. The Cook Islands MMR is encouraging the spread of pearl farming to other islands (DFAT, 2021). Apart from pearl culture, aquaculture production in Cook Islands is relatively small and limited to subsistence and semi-commercial production of tilapia, milkfish, and clams. A few thousand live giant clams are produced annually from hatchery for stock enhancement (FAO, 2021). Beside pearls, a further nine commodities are identified as potential candidates for aquaculture: giant clams, trochus, tilapia, land crab, Malaysian crab, mantis shrimp, sea grapes, eel, and milkfish. Of these, the top priorities were pearls, giant clams, trochus, and tilapia (ADB, 2015). Developing marine resources within the CIEEZ is a primary priority of the Cook Islands Government (ADB, 2015; DFAT, 2021).

9.4.1.4. Public Administration

A downsizing in the public service and control of pay rates in the late 1990s resulted in a considerable decrease in the contribution to GDP from public administration from 1998 to 2001. Public administration expanded again in the mid 2000s, but far less than other sectors (ADB, 2008). Recently the public administration sector has contributed to the country's economic growth (IMF, 2020). The public administration sector is a significant employer in Cook Islands, with approximately 1,300 people employed in 2016 (GCI, 2018a).

9.4.1.5. Nodule Harvesting and Energy

The deep-sea provides the conditions for the existence of concentrated minerals. The presence of polymetallic nodules in the CIEEZ represents a major potential provisioning service. Exploring and commercialising nodule harvesting, undertaking scientific research, and considering the impacts and societal benefits of nodule harvesting is a global undertaking. Technological solutions to extractions, 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 mineralised sediments, SMS deposits, and cobalt crusts (SPC, 2016). Potential mineralised sediments have been identified in the CIEEZ, however, no SMS or cobalt crusts have been identified as yet. Opening up nodule harvesting of cobalt and manganese reserves is a Cook Islands Government priority (DFAT, 2021).

Cook Islands is a net importer of energy, dependant on fossil fuels. Power in the country is provided by diesel generators. Since 2011, Cook Islands has embarked on a programme of renewable energy development to improve its energy security and reduce greenhouse gas emissions. However, in 2018, only 5% of its energy came from renewable sources, and 100% of this was from solar (IRENA, 2021). While the ocean provides opportunities for energy generation, e.g., 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, to date, there are no known offshore renewable energy projects identified in Cook Islands.

In line with global efforts to reduce greenhouse gas emissions and ultimately transition to renewable energy, Cook Islands has committed to reducing reliance on diesel power. With assistance from development partners in New Zealand, Japan, Australia, and international financing groups such as the Asia Development Bank and the UN Development Programme, the Cook Islands Government is investing in solar technologies. A modest solar farm was installed at Rarotonga Airport in 2017 and the Ministry of Finance and Economic Management cites the northern islands as among the first priorities for solar infrastructure. Clearly there is a link between investing in renewable technologies and nodule harvesting which is likely to resonate with regulators and stakeholders. The provision of battery storage in particular is likely to be one area of interest. Development of deep-sea minerals harvesting is expected to generate new emergent technologies and present opportunities for technology transfer and cross-over to other industries.

9.4.2. Livelihoods

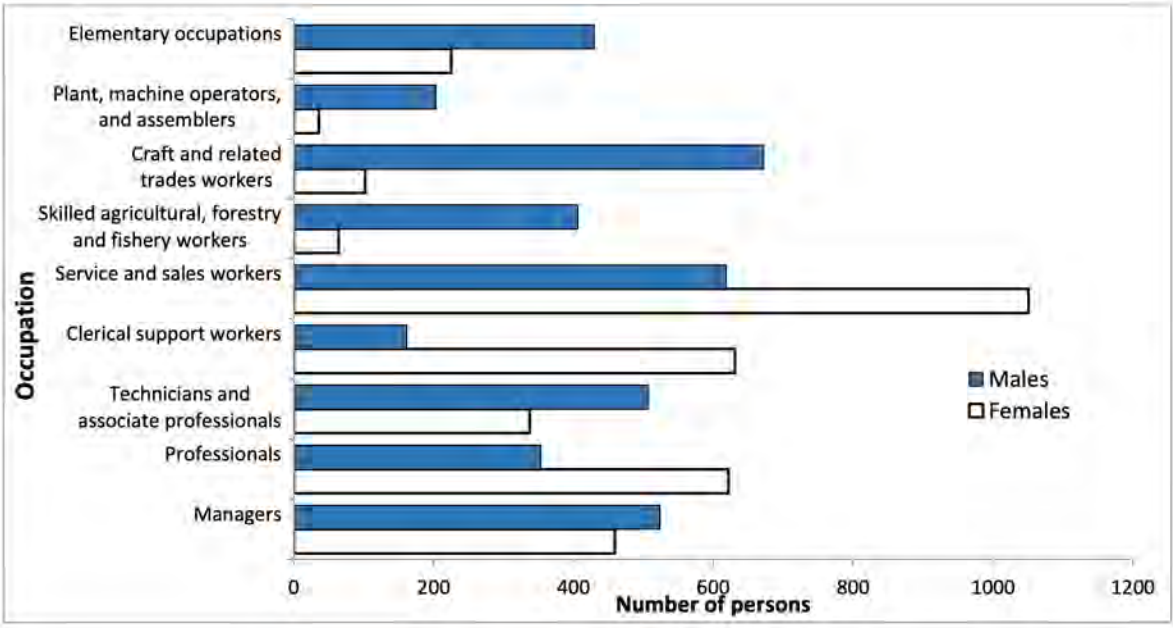
9.4.2.1. Employment and Income

The total labour force of Cook Islands at the last census (2016) was 7,774 people, which can be broken down into the self-employed (988), paid employees (6,028), unpaid workers and volunteers (305), and the unemployed (453). The Labor Force Participation Rate (LFPR) was 71.9%, which was slightly higher for males (77.2%) than for females (67%). The unemployment rate was 5.8% (GCI, 2018a).

Wages and salaries comprise an average of 60% of household income across urban and rural populations (GCI, 2018b). Wages are supplemented by household-managed businesses, rental income, and pensions or social benefits. In 2016, the average annual income of the resident population 15 years and older was NZD 17,221, (comprising NZD 18,677 for males and NZD

15,856 for females[12]). Income levels in Rarotonga were more than double than in the outer islands. Over 12% of the population had no income, and 3.3% had an income of more than NZD 40,000 per annum (GCI, 2018a).

Figure 9-4 identifies the occupations held by the resident Cook Island population during the 2016 census. Females were more dominant in service roles like shop assistants, housekeeping, and caregiving, while males tended to work in trades, crafts, and technical roles (GCI, 2018b).



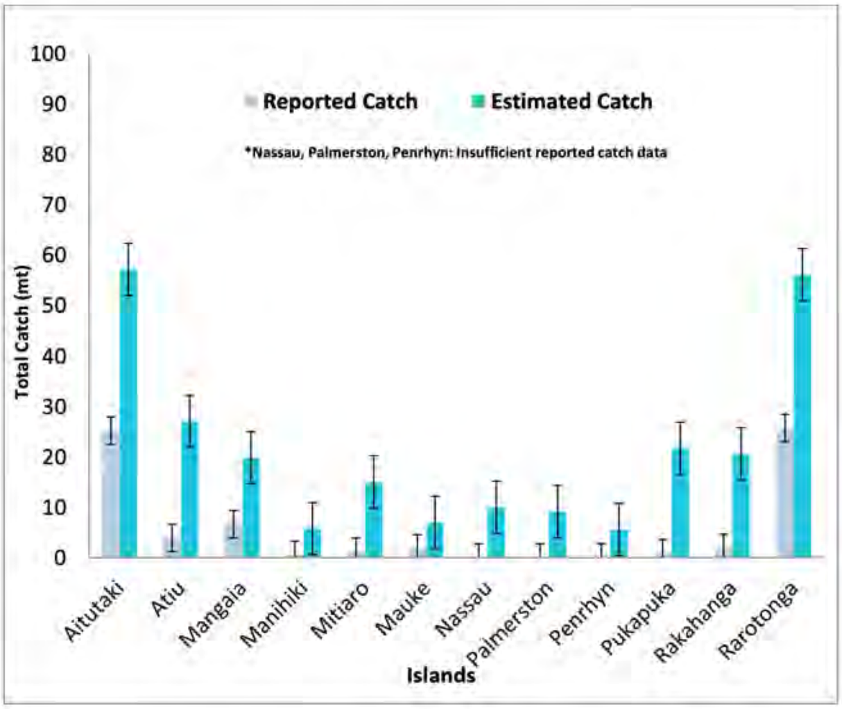
Source: GCI, 2018b.

Figure 9-4 Occupations held by Cook Islanders in 2016.

[12] This figure has increased from the 2011 census when most females were in an income group of less than NZD 5,000 pa (CISO, 2018).

9.4.2.2. Artisanal and Subsistence Fishing

Subsistence fishing comprises 55% of the fishing activity in terms of the number of people involved, and artisanal fishing (where the harvest is sold for income at local markets, restaurants, and hotels) makes up 35% of the total fishery sector (Solomona et al., 2009). The Cook Islands artisanal fishery occurs from all inhabited islands, primarily targeting tuna and pelagic species, however, most of the reported catch comes from the lagoons and inshore areas around Aitutaki and Rarotonga (Figure 9-5).



Source: MMR, 2018.

Figure 9-5 Artisanal reported and estimated catch totals (metric tonnes) per island for 2017.

Common fishing methods are hook-and-line, net fishing, spear fishing, and gleaning. Other fishing methods include traps using coral fencing and plaited baskets to catch schools of lagoon fish and freshwater eels, jabbing methods used to catch mantis shrimp, freshwater fishing using gillnets and hook-and-line to catch tilapia, eels, and snake mackerel (Solomona et al., 2009).

Subsistence fishing has declined on the main island of Rarotonga due to changes in lifestyle and increased wages, reducing the need for subsistence fishing practices. However, subsistence fishing is still practiced by communities on outer islands, where employment opportunities are minimal. At the time of the last household survey (2015) only 4.5% of urban households were involved in fishing activities whereas 42.4% of rural households were involved (GCI, 2018). The sale of yellow fin tuna and bigeye tuna is an important income source for rural areas, comprising 20% of household income from primary production activities (GCI, 2018).

9.4.2.3. Subsistence Farming

Traditional agricultural activities in Cook Islands include the cultivation of root crops such as taro, cassava, sweet potatoes and yams, breadfruit, and other important food and medicinal plants and trees (FAO, 2008). The crop sector is comprised primarily of family-owned farms. Crops are produced on small holdings, between 0.25–0.5 acres, mainly for home consumption with excess production for cash sales (FAO, 2008).

Data from the 2015–16 household survey (GCI, 2018) reports that 58% of households are involved in the home production of goods (i.e., agriculture, fishing, livestock, or handicraft) for their subsistence or for cash income generation (50% in urban areas and 79.5% in rural areas). On rural islands, crop and animal production are still important activities, and taro, melon, bananas, tomatoes, and copra are still grown in rural and urban areas for home consumption (GCI, 2018). Farmers on the main island, where there are abundant opportunities for the sale of produce, have shifted from a subsistence to a semi-commercial farming system where the bulk of the production is sold for cash (FAO, 2008). This production shift is associated with the demands of restaurants and hotels requesting a wider variety of food products. It's also driven by the eating habits of the modern population with an increased consumption of imported processed foods such as rice, bread, corned beef, and potatoes (FAO, 2008).

9.5. Natural Resource Management

As described in Section 9.3, traditionally, Cook Islanders had access to land and sea (through rights given by the *Ariki*), and therefore had access to the variety of natural resources provided by the islands. Poor soils and limited resources, weather events, over-population, conflict, disease, and isolation all contributed to Cook Islanders developing excellent natural resource management practices and traditional knowledge, enabling resilience and adaption to environmental and social changes.

Traditional marine management in the Pacific Islands region predates Western models for marine protection. Concepts such as the ecosystem approach, adaptive management, and MPAs had been in use in the Pacific Islands long before they became part of the international conservation dialogue (Vierros et al., 2010).

For many years the concept of *ra'ui* fell out of use on Rarotonga, but it has re-emerged due to the Koutu Nui reintroducing it in 1998 around Rarotonga's lagoon. In most of the outer islands, the practice of *ra'ui* never fell out of use and continues today (Vierros et al., 2010). Now, this indigenous approach to natural resource management has been embedded within modern legislation (notably that of the Marae Moana Act 2017). However, the introduction of legislation and legislative authorities, such as the Island Council and Environment Service, to regulate protected areas has weakened the authority of the traditional leaders to control *ra'ui*. This has created some confusion over the roles and jurisdiction of various entities in relation to protected areas in Cook Islands (Vierros et al., 2010).

9.6. Social and Economic Infrastructure

Cook Islands has made significant Government investment in health, education, and welfare and has experienced substantial improvement in the quality of economic and public sector management since the financial crisis of the mid-1990s. This good management has resulted in relatively high living standards, and Cook Islands now looks to New Zealand to set its benchmarks for service standards, opportunities, and incomes (ADB, 2008).

However, social and economic services are mostly limited to Rarotonga and Aitutaki, and service delivery on the 13 other small volcanic islands and coral atolls depends on the Government's capacity to generate revenue from tourism centred on these two main islands (ADB, 2008). Therefore, access to social and economic services tends to be unequal depending on location, where isolated rural areas fare worse than urban areas, and priorities for Government expenditure are likely to lie in economic infrastructure, education, and health.

9.6.1. Housing and Accommodation

Land available for housing and accommodation is highly constrained, due to the geography of the islands (and the very small land base), fragmentation of land ownership (see Section 10.3), a lack of land planning, and a lack of investment in tourism accommodation.

As described in Section 9.4, the Cook Islands experience accommodation capacity constraints during the high season, yet the sector has experienced very little new investment or reinvestment (ADB, 2015).

9.6.2. Transport

9.6.2.1. Shipping

Most vessel movements within the CIEEZ are through-traffic, either between the Americas and South-east Asia, Australia, or traffic moving between other island groups. In particular, large numbers of vessels are tracked to the west of Cook Islands, in Samoa and also to the east, near Tahiti (Riding et al., 2015). On a global scale, shipping and total vessel traffic in the CIEEZ is generally low but commercial shipping is critical to the delivery of products to Cook Islands and the economy in general. Avatiu Harbour on Rarotonga is the main commercial harbour in Cook Islands and receives the overwhelming majority of SOLAS (Safety of Life at Sea Convention) vessels including dry cargo, cruise ships, and yachts. It is a feeder destination for the Oceania–Pacific route (Riding et al., 2015).

The Cook Islands Port Authority (CIPA) manages the international seaport in Rarotonga (Port of Avatiu) and is a 100% state-owned entity (ADB, 2015). Reconstruction of Avatiu was completed in 2013 to provide a deeper harbour, more storage and operational areas, and increased capacity to cater for larger vessels. Rarotonga's port has limited size and infrastructure and is not an all-weather port. This places a restriction on the size class of ships it can receive. Two international shipping lines service Cook Islands on an approximate 3-week cycle. In 2013, the Port of Avatiu handled 50 ship movements and 2,376 containers (ADB, 2015).

Island Governments administer unregulated harbor facilities on the other islands, with technical support provided by the ICI (Ministry of Infrastructure Cook Islands) and CIPA. Inter-island shipping is essential in Cook Islands and is offered by the private sector. The overall quality (considering frequency and regularity, size, and condition of ships) of inter-island shipping services is low, and the market is not conducive to improving these services (ADB, 2015).

9.6.2.2. Roads

Cook Islands has approximately 320 km of roadways (295 kms are in Rarotonga) (ADB, 2015). Road condition is generally poor, due to limited specialised road construction equipment, lack of clear standards, and lack of a clear mandate for road maintenance. Heavy vehicle damage to roads and an increase in traffic (particularly on Rarotonga) has created the need for an improvement in road quality. Responsibility of road maintenance is also unclear due to roads not aligning with legal boundaries. Public expenditure on maintenance of infrastructure remains insufficient to bring the network up to acceptable standards (GCI, 2017a).

Deaths from road accidents involving motorised scooters (or mopeds) is a concern in Rarotonga and recently helmet laws have been introduced to curb injury.

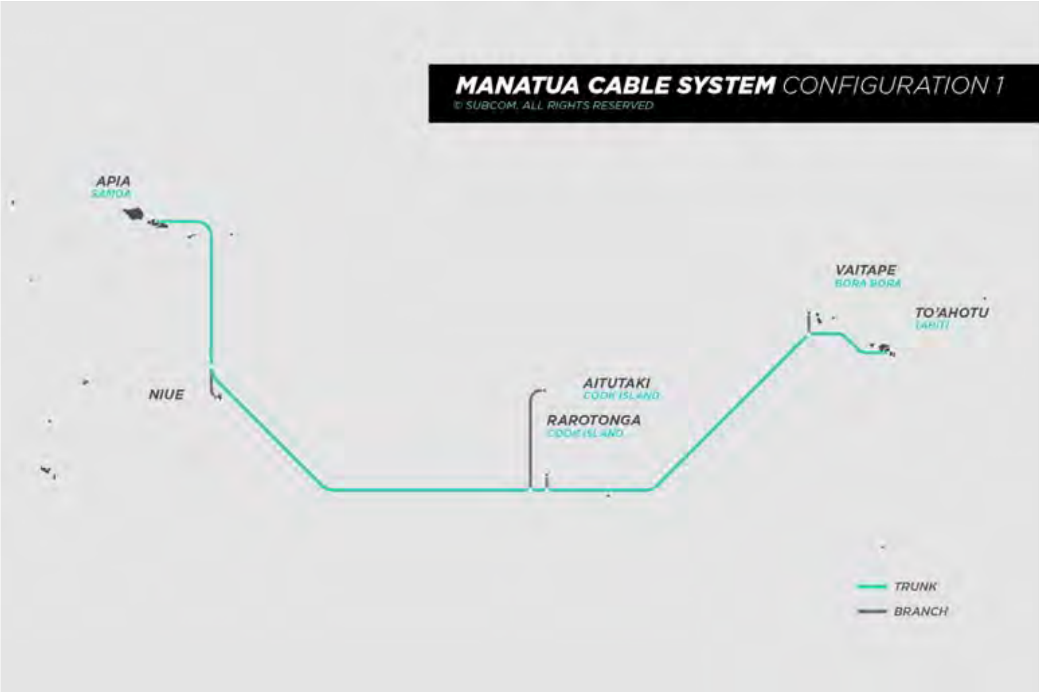
9.6.2.3. Airports

The Cook Islands Airport Authority (CIAA) manages the country's two main airports in Rarotonga and Aitutaki. The Rarotonga International Airport officially opened in 1974. Rarotonga International Airport has flights to nine destinations including the United States, New Zealand and Australia, among others. Aitutaki Airport is the country's next busiest and is serviced by the privately owned domestic airline (Air Rarotonga).

There are also (loose) coral-surfaced airstrips in the southern islands (Aitu, Mangaia, Mauke, and Mitaro) and northern islands (Manihiki, Penrhyn, and Pukapuka). Outer island Governments and communities administer and service these airstrips with technical assistance from the ICI and CIAA. These islands are serviced from Rarotonga.

9.6.3. Communications

Telecommunications in Cook Islands are provided by a subsea fibre-optic cable (the Manatua cable) which comes to shore at Rarotonga and Aitutaki and connects to the global internet via Samoa and Tahiti (Figure 9-6).



Source: SCN, undated.

Figure 9-6 The Manatua submarine cable system.

Telecommunications are regulated under the *Telecommunications Act 1989*. The Act provides Telecom Cook Islands (TCI) with a statutory monopoly in providing fixed line telephony, broadband, and mobile voice and data to residential and business customers. TCI is an integrated, self-regulating operator that is 60% owned by Teleraro, and 40% by the Cook Islands Government (ADB, 2015)

Almost 100% of households have access to information communication technology (phone and internet) with only 49 households reporting little to no access (GCI, 2018a). Mobile (cell) phone was the most popular means of communication technology (preferred by 82.8% of households). Internet at home is gaining popularity and 41% of households now have internet or wi-fi connections (GCI, 2018a).

9.6.4. Schooling

Education in Cook Islands is mainly provided by Government institutions. There are 31 schools, 23 are Government and eight are privately administered (five church schools and three independent schools). The education setting comprises one standalone early childhood education (ECE) centre, 11 primary schools (10 of which have ECE centres attached), four secondary schools, 14 area schools[13] (all with ECE centres), and a tertiary institute (GCI, 2020b). The University of the South Pacific maintains a campus in Rarotonga.

[13] An Area School is a school that provides education from Early Childhood through to secondary level on one site and under one management structure (GCI, 2020b).

Education is free and compulsory from ages 5 to 15 years. This has ensured access to primary (grades 1-6) and secondary (forms 1-7) level of education for all. At the 2016 census, 2,981 persons 5 to 15 years old (nearly 100% of the population of that age group) were enrolled in school (GCI, 2018a).

Nearly all (99.9%) persons 5 to 12 years old are enrolled at school. From that age onward, enrolment rates declined. There is very little difference in the proportion of males and females that have attended and/or completed the different educational levels. Persons aged 20-24 years had the highest proportion that has completed secondary education. Twenty per cent of females completed secondary education compared to 15% of males. The older the population, the more likely it was that they had no educational qualifications; 85% of males and 92% of females older than 65 years had no qualifications (GCI, 2018a).

9.6.5. Health Services

The Ministry of Health (MOH) is the main provider of health care services in Cook Islands, apart from a small number of private medical and dental clinics in Rarotonga. All health services are free in the outer islands, but in Rarotonga people aged 5–59 years are required to pay NZD 7 per consultation (ADB, 2008).

Administratively, health facilities and services are classified into four levels, based on community populations, facility services, and available staff (WHO, 2017). All islands have health centres and all, except the smallest islands of Nassau, Palmerston, and Rakahanga, have hospitals (ADB, 2008).

In 2008, the MOH estimated that Cook Islands had a Human Development Index of 0.83 which positioned the country in the 'high' human development category. Social development indicators related to health are high in comparison to other pacific countries, and Cook Islanders have good access to health services (MOH, 2017). The Cook Islands health profile and child health indicators remain close to developed country levels and the incidence of communicable diseases has generally declined, however, the re-emergence of old infectious diseases (e.g., tuberculosis) are a concern. Cardiovascular disease is the most prevalent non-communicable disease in Cook Islands, with an average of >200 cases each year from 2009 to 2015, followed by diabetes with an average of 100 new cases a year (MOH, 2017).

9.6.6. Disadvantaged Cohorts

Compared with residents of most developing countries, the people of Cook Islands have a high standard of living. Internationally, Cook Islands is a high-ranking, middle-income country, with a high life expectancy and adult literacy (ABD, 2008).

Despite this, Cook Islands is vulnerable to changes in economic and therefore, social circumstances from events such as cyclones, introduced diseases (i.e., agricultural), and as evidenced recently, through the global Covid-19 pandemic. With little paid employment opportunities outside of Rarotonga, and many households sourcing much of their livelihood from pensions and welfare, (particularly in the outer islands), some Cook Islanders have less access to economic opportunities and social services than others (ADB, 2008).

Beyond this general pattern of outer island disadvantage, vulnerable members of the community include people who are least able to help themselves, whose issues go unheard, and who often have special needs and require extra help. The causes of vulnerability include the breakdown in the traditional family support systems, emigration of caregivers, rising cost of living, and social and community obligations. The vulnerable are elderly, unemployed, single parents, children, and physically challenged, as well as smaller numbers of squatters and crime victims (ADB, 2008).

Gender is not as much a source of vulnerability as it is in some other Pacific Island nations. The main disadvantages relating to Cook Islander women are their relatively restricted opportunities for economic and political participation, generally lower earning capacity, and remaining forms of gender bias (ABD, 2008).

9.7. Cultural Heritage

Cook Islands is part of the geo-cultural region of Oceania - a "continent of islands" – which covers nearly a third of the Earth's surface and from the perspectives of the environment and culture, is unlike any other geo-cultural region. This Oceanic world has given rise to traditional ways of life that are unique to the region and are expressed through cultural landscapes and seascapes, settlements and monuments, and in the intangible heritage of traditions, knowledge, stories, song, music, and dance.

Cultural landscapes are at the interface between nature and culture, tangible and intangible heritage, biological and cultural diversity; they represent a tightly woven net of relationships that are the essence of culture and people's identity (Rössler, 2001). Cultural landscapes have the capacity to be read as living records of the way societies have interacted with their environment over time. Cultural landscapes are perhaps the most appropriate way to recognise the unique heritage of the Pacific region, as they reflect the inseparable relationship between people and their environment (Smith and Jones, 2007).

Cultural landscapes in Cook Islands are represented by traditional agricultural systems and practices, land tenure systems, the sacred and/or symbolic significance of natural features, and traditional natural resource management techniques (Smith and Jones, 2007). From a cultural heritage perspective, these tangible landscape features and practices are an inseparable component of Pacific Island intangible heritage, (i.e., traditional knowledge, customs, and language) (Smith and Jones, 2007). Therefore, while descriptions of cultural heritage often separate the tangible and intangible heritage values, instead here the various tangible aspects of heritage, interwoven with traditional and current practices, customs, knowledge and relationships to the land and sea are described.

Of particular importance in understanding the cultural values of seemingly natural landscapes and seascapes across the Pacific are traditional customary land and sea management practices, underpinned by traditional authority/leadership systems, land tenure systems and traditional knowledge of ecosystems, resources, and the environment. In Cook Islands, these management practices are represented by a system of *ra'ui*, whereby the gathering or collecting of particular foods or plants at certain times of the year and/or from certain places is restricted (see also Section 9.5).

There is extensive evidence that Pacific societies have frequently adapted to a multitude of environmental and social events in the past. Cook Islanders modified the natural landscape to facilitate ease of movement around the islands for agriculture and fishing, for warfare, and for ritual. For example, coral limestone or volcanic slabs were laid across the often sharp and jagged rocks of the islands (*makatea*) to facilitate easy access from the inland to the coast. Many are in use today and are periodically maintained (Smith and Jones, 2007). This form of tangible heritage is perhaps best represented by the *Ara Metua* (parent road) or great road of *Toi (Ara nui o toi)* in Rarotonga, which stretches around the coastal zone of the island and is one of the largest 'monuments' in Polynesia (Downes et al., 2018).

Both tangible and intangible heritage is represented by traditional fishing methods and approaches to marine resource conservation in Cook Islands. For example, on Aitutaki, fish weirs with stone walls (or '*pa'*) were made inside the reef, intercepting fish going out on a falling tide. Fish were caught by spearing or scooping up with a hand net. Most of the '*pa'* are very old, having been laid down far back in pre-European times. The most important weirs are named and are owned by particular families, and no outsider can use a weir without permission from the hereditary owners (Buck, 1927).

Prior to contact with Europeans, warfare was endemic in many parts of the Pacific, likely due to competition for resources associated with increasing populations and control of food-producing areas (such as taro swamps). Warfare resulted in significant changes to the landscapes through the construction of defensive works of earth and stone, usually at strategic points such as hilltops (Smith and Jones, 2007). In some islands defensive forts appear to have been occupied on a permanent or semi-permanent basis, necessitating easy access to gardens and/or the means of storing food within the defensive structure (Smith and Jones, 2007).

Sacred sites where ceremonies of a religious nature took place ('*marae'*) are common in the Cook Islands, although many are ruined. On Mangaia, the '*marae'* are rectangular and paved with gravel, sometimes with their perimeter defined with stone edgings. Upright stones representing deities are sometimes present at one end of the marae. When in use the *marae* had a small, thatched house on them in which the deities were presumed to take up residence (Smith and Jones, 2007). Historically, priests moved from district to district to perform various rituals at *marae*, their tribal leaders accompanied them to share in the large volume of food offerings given to the medium as a spirit being's human representative (Reilly, 2018).

Some *marae* continue their traditional role and all are important to present day Polynesian communities, although this is unlikely to be the case in Cook Islands, where modern religion has largely replaced traditional beliefs and the construction of churches, mission schools, and associated structures forever changed the cultural landscape of the Islands (see also Section 10.2). Many of the churches in Cook Islands are recognised for their historical values, and some researchers suggest that churches were originally conceptualised and constructed as the island's 'new *marae'*, renewing and recontextualising place meanings through their continued use (Hill, 2016). Hill (2016) maintains that 'churchscapes', like *marae*, remain entwined with tribal mana, hierarchy and land, and that they "continue to have cultural value for increasingly diasporic Cook Islands communities".

The ocean is integral to the origin stories, traditional knowledge, and cultural values of Cook Islanders, and the ocean plays a key role in the identity of Cook Islanders, from traditional to modern beliefs. Traditional knowledge comprises an intimate understanding of the relationships between natural systems (and how to manage them for the benefit of communal society), traditional practices, the weather or natural events, navigation and seafaring, and the routes that linked island communities.

Feasts, festivals and events featuring sorts or performances of song and dance were practiced for spiritual purposes, to commemorate the death of someone of rank, or for celebrations (Reilly, 2018). Music and dance are still used to tell stories today, often associated with the landscape or with feelings of love or sadness. Dancers wear traditional dress, comprising grass skirts and headbands.

The Pacific Island region is currently one of the most underrepresented regions on the World Heritage List. There are no World Heritage listed sites or landscapes in Cook Islands.

10. Existing Issues and Impacts

Marine ecosystems have been impacted by climate change (Brierley and Kingsford, 2009), bottom trawling and dredging (Thrush and Dayton, 2002), fish stock depletion, and the structural alteration caused by marine invasive species (Bax et al., 2003). This section profiles some of the headline environmental and social issues that exist in Cook Islands in order to inform an understanding of the baseline receiving environment, but also to identify key areas where the development of nodule harvesting may contribute to benefits and improvements.

10.1. Environmental

10.1.1. Fringing Reef and Lagoon

The fringing coral reef encircling Rarotonga has been exposed to regular cyclones and CoTS outbreaks that have been recorded since the 1970s (see also Section 7.1). In addition, frequent coral bleaching events have been observed since 1991 (Rongo and van Woesik, 2013). After these major disturbances, there is often a reduction in corals and increase in algal cover. From 2006 to 2011, macroalgal turf on Rarotonga increased significantly (Rongo and van Woesik, 2013) raising concerns of ciguatera food poisoning. The potent neurotoxin 'ciguatoxin' has been reported for several years on the island and more macroalgae results in an increase of herbivorous and detritivorous fish which can carry the ciguatoxin. Resulting increased fishing poses a risk to consumers of these fish (Rongo and van Woesik, 2013).

Rarotonga's Muri Lagoon separates part of the island from the fringing reef and is approximately 8 km^2. It is highly frequented by tourists and since 2011 has become a concern for the island after shifting from pristine coral reef to high algal beds of an invasive green algae (*Caulerpa cupressoides*). The phenomenon has largely been attributed to lagoon mismanagement as the it receives excessive levels of nutrient runoff from fertiliser use in crop and livestock farming, animal excrement, and soil run-off from land clearing activities and septic tank seepage. High macroalgal densities and an unpleasant sulphuric odour result which is detrimental to a community so heavily reliant on tourism. Fisheries in the lagoon are estimated to suffer an estimated NZD 534,000/year due to watershed pollution (Hajkowicz and Okotal, 2006).

10.1.2. Fisheries

Rarotonga's coral reefs and lagoons provide locals with marine resources for subsistence fishing (55%), artisanal fishing (35%), and commercial fishing (10%) (Solomona et al., 2009). The traditional marine management practices of *'rā'ui'* have been re-implemented in Rarotonga in 1998 and Aitutaki in 2000 and prohibits the harvesting of nearshore marine species (see also Section 9.5). Initially in Rarotonga this was declared in five coastal areas, but expanded to eight areas by 2002. The extension of these natural resource management concepts is now reflected in the Marae Moana Act (2017).

Subsistence and artisanal fishing has been negatively impacted by the aforementioned ciguatera fish poisoning incidents in Rarotonga (FAO, 2021). Rarotonga has experienced the highest levels of ciguatera poisoning globally, and per capita fresh-fish consumption halved from 149 g/person/day in 1989 to 75 g/person/day in 2006 (Rongo and van Woesik, 2012). Commerical fishing is impacted by Rarotonga's high-cost location for the operation of longline tuna vessels, and scarce labour. The proportion of top predators such as bigeye tuna has reduced, due to high numbers of Fish Aggregating Devices (FADs) in Cook Islands (FAO, 2021). Higher fishing pressure is associated with more populous islands and transect surveys found large fish (>40 cm) were almost absent from nearly all surveyed sites across Rarotonga, Aitutaki, and Palmerston islands (Purkis et al., 2018).

10.1.3. Land Use, Water Quality and Pollution

Air quality is a leading environmental risk factor for disease worldwide (WHO, 2014), and Pacific Island countries share two primary sources of air pollution: diesel-generated energy and waste incineration (Isley and Taylor, 2018). Waste disposal options in Cook Islands are limited and waste burning is often the most hygienic and practical solution (Mataki, 2011). Poor enforcement of bylaws restricting the practise also contributes to its regular occurrence. These factors are of concern for residential and environmental health.

Like its reefs and lagoons, freshwater quality on Rarotonga is impacted by soil erosion and stream sedimentation, runoff from herbicide, pesticides, and fertiliser, livestock and animal waste, septic tank leakages, liquid and solid waste disposal, mosquito outbreaks from stream blockages, and poor waste disposal practices (Hajkowicz and Okotai, 2006).

10.2. Social

10.2.1. Human Health

The declining condition of the Muri lagoon is causing public health concerns as well as environmental issues. There are claims of human illness from consumption of coastal resources and recreational activities.

A reduction in in seafood consumption has been linked to a fear of ciguatera poisoning (Rongo and van Woesik, 2012), the closure of fishing areas due to the establishing of *rā'ui* practices, and meat product availability at a much lower price (Solomona et al., 2009). Cook Islands has become a country with some of the fastest rates of increasing BMI in the world. The increased dependence on imported foods, as well as a genetic predisposition to gain weight, and geographical isolation are identified as some of the key factors leading to dimished human health outcomes (McLennan and Ulijaszek, 2015). Low income and a pressure to put food on the table may have caused the switch away from seafood consumption amidst a declining fish population (Solomona et al., 2009).

10.2.2. Social Issues

The nation is experiencing a decrease in an economically active population. This includes an increase in the 75+ year age group and a decline in the 15–19 year age group. The latter are likely residents who, having completed their secondary education, travel overseas for further job and study opportunities (Cook Islands Government, 2018). Plans exist to improve the schooling system, however limited technology infrastructure, planning and budget limitations, and further training for teachers are cited as issues inhibiting progression (Scott and Newport, 2012). Education issues extending to safe-sex practices and contraception is also a prominent theme across Pacific Island nations. In Cook Islands, motherhood is considered a necessary facet of female adulthood, however, a lack of health education and logistical limitations in accessing healthcare facilities due to the nation's multi-island layout, has contributed to a high rate of teenage and unplanned pregnancy (White et al., 2017).

11. Key Ecological Functions

11.1. Distributions and Biogeography

Healthy ecosystems support distributions of species that fundamentally sustain life cycles and fisheries. Species distributions are generally controlled by physiological limits to environmental condition in concert with factors such as trophodynamics, otogenetic behaviours, and competition. In the benthic environment, pressure (depth), substrate, and productivity are among the key determinants of species distribution. In the pelagic environment, pressure (depth), temperature and water mass distribution, frontal boundaries, vertical stratification, and productivity are among the key determinants of species distribution.

Species distributions at the ocean basin scale are generally stable over time and it is these distributional patterns that establish biogeographic regimes across the oceans. Biogeographic scales are large in ocean basins, as illustrated by the benthic and pelagic biogeographic schema presented in Section 6. Biogeography is central to understanding the spatial distribution of ecological resources and large-area uniqueness/representativeness but it is also directly linked to ecological function as a result of the interaction between fauna and habitats, which dictate trophodynamics and energy flows.

Changes to distributions of marine fauna at ecologically-relevant scales can cause alterations to the ecological function of a place. In the marine environment, experience has shown that such changes may have flow-on effects to overall ecological character and ecosystem health. One example is the significant contraction of kelp forest habitat in California, Australia, and New Zealand, that can be accompanied by an influx of marine pests or over-abundance of native species (in this case sea urchins) as a result of the loss of kelp and the species reliant on this habitat-forming macroalgae. The collapse of the Atlantic northwest cod fishery from over-fishing would be another example of species distribution change that had flow-on ecological function impacts, although fishing-related impacts may prove to be more responsive to management intervention than climate change-driven changes to species distribution.

The large scale of distributions in the deep-sea, and the relatively high stability/buffering capacity of deep-sea habitats, would suggest that alterations to species distributions at ecologically relevant scales would require wholesale alteration to the abyssal seabed (which is not sought or allowable under nodule harvesting regulations) or in the pelagic environment, wholesale alteration of the physicochemical structure of the water column or contamination effects at extremely large scales (which is also not sought or allowable, and perhaps not even possible given the nature of the operation).

Maintenance of species distributions and biogeography is fundamental to biodiversity (see below) and fundamental to marine spatial planning and conservation objectives around nodule harvesting.

11.2. Biodiversity

Maintenance of global biodiversity is a key driver for protected areas and a key pillar of the Marae Moana Act (2017). In the deep-sea environment, factors such as habitat complexity, productivity, and nutrient availability impinge on biodiversity. Deep-sea aspects including pressure, seafloor topography, temperature, oxygen concentration, productivity of surface waters, nutrient flux to the seafloor, and circulation patterns are among the key factors controlling biodiversity. Temperature and oxygen are observed to be critical in determining biodiversity at a large scale, while food supply is more important to biodiversity at a finer scale (Puerta et al., 2020). On a global scale, temperature is positively related with biodiversity, showing a latitudinal increase in species richness from poles to the equator (Lomolino et al., 2006, Beaugrand et al., 2013). Deep-sea benthic species are adapted to relatively low oxygen conditions and the vertical distribution of many infauna species is restricted by sediment oxygen levels. A peak in biodiversity occurs at bathyal depths and temporal fluctuations in oxygen concentrations are likely to have influenced the evolution of deep-sea benthic fauna (Rogers, 2000). As discussed in Section 6.1, benthic biodiversity is generally high in the nutrient limited abyssal zone, but abundance and biomass is generally low, and the supply of phosphates, nitrates, and silicates place limits on biological production (Kinch et al., 2010).

Studies show that species diversity can be high at abyssal depths, while abundance and biomass are low. Size of dominant fauna diminishes with depths, with meiofauna being more abundant than macrofauna, while bacteria abundance is believed to remain relatively constant. The decline of fauna size could be related to the quantity and quality of food available to these species. The limited availability of sinking detritus increases competition in macrofauna while it has limited impact on meiofauna feeding on bacterial carbon (Wei et al., 2010).

In the benthic environment, the CCD impinges on biodiversity (see also Section 6.1.1). Below the CCD, which occurs at ~5,000 m depth in the SPB, the growth of calcareous shells and skeletons are limited by calcite dissolution rates. The depth of the CCD is influenced by circulation, temperature, pressure, and POC flux (Bostock et al., 2011).

Western South Pacific waters are oligotrophic, with high productivity areas limited to equatorial upwelling regions (Dunstan et al., 2020). Forty four species were listed in the IUCN Red List of Threatened species in Cook Islands, among which twenty five are corals. Several groups of species are still undescribed and unassessed, making it difficult to analyse biodiversity in the Pacific region (Kinch et al., 2010).

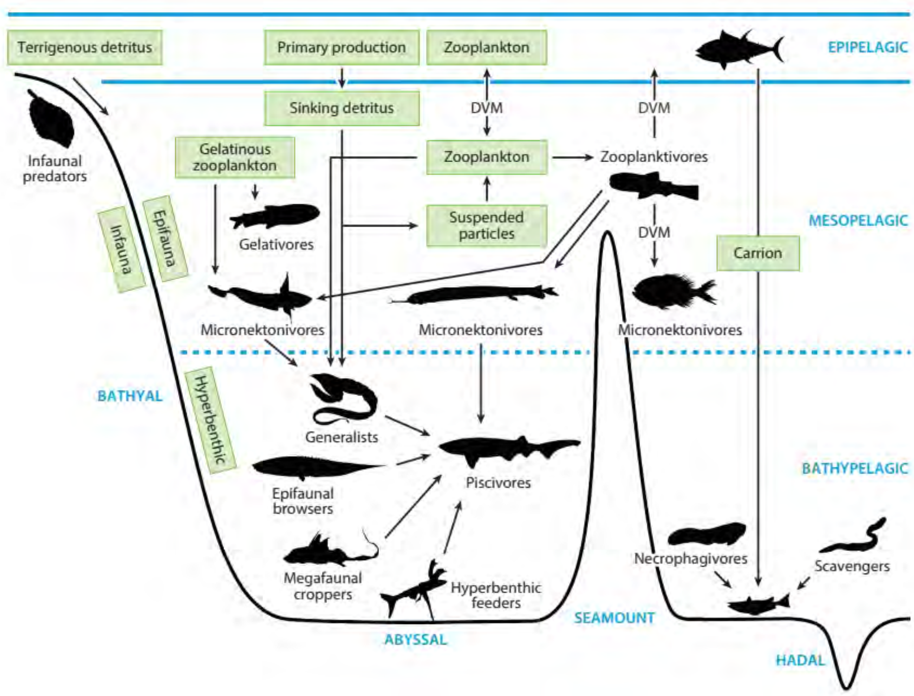
11.3. Food webs

A food web represents feeding relationships within an ecosystem. The structure of a food web is critical to the survival of functional groups and the protection of ecosystem functions. Environmental changes and alterations to a single functional group can lead to the modification of the entire food web, affecting ecosystem functions (Trzcinski et al., 2016; Statmann et al. 2021).

Foodwebs in the oceanic environment are strongly linked to rates of primary production and the establishment of zooplankton-based assemblages at trophic levels 2 and 3, generating a prey field for other fauna. Mobile pelagic fauna and seabirds are adapted to traversing large areas to find productive regions in which to feed. The biological pump operating in the midwater environment and POC flux to the seabed are key foodweb elements. In the mesopelagic zone, the basic structure of the food web consists of zooplankton feeding on suspended particles from sinking phytodetritus, zooplankton is eaten by zooplanktivores and gelativores, and micronektivores prey on zooplanktivores and gelativores (Drazen and Sutton, 2017) (Figure 11-1).

Below the epipelagic zone, primary production is absent and communities are supported by active migration to the surface during the night (DVM) or through the sinking flux of detritus exported from the surface as POC. Sinking POC is remineralised in the upper layers and its abundance is reduced during sinking by microbial decomposition and consumption by zooplankton and fishes.

The role of diving seabirds and large-bodied marine vertebrates in maintaining foodweb functions has recently been appreciated. The foraging behaviour of seabirds contributes to an ecological function of the open ocean by transferring nutrients to coastal environments where higher primary production occurs and, scaled-up to the population across the eastern tropical Pacific, contributes to upper ocean mixing and potentially cloud albedo effect. Diving and feeding behaviour of cetaceans can locally enhance nutrient regeneration and therefore, sustain high productivity.



Source: Drazen and Sutton, 2017.

Figure 11-1 Trophic diagram illustrating primary feeding DOM guilds and fish food sources.

Microbial processes largely influence fluxes of carbon and nutrients in the ocean. In highly productive and nutrient-rich areas, dissolved organic matter (DOM) is produced by photosynthesis, while in oligotrophic, nutrient-poor regions, DOM is produced by microbes through the microbial loop (Kujawinski, 2011). DOM is used by heterotrophic bacteria and transferred to other trophic levels, integrating the microbial loop into the food web and therefore, extending the food chain (Jing et al., 2018). South-west Pacific waters are oligotrophic and nutrients at the surface are largely supplied by mineralisation by bacteria and microbial grazers (Ceccarelli et al., 2013).

The foodweb at abyssal depths includes a larger diversity of feeding habits compared to the zones above Figure 11-1).

Deep demersal fishes are positioned at or near the top end of the deep sea food web and their main guilds are micronektivores, hyperbenthic crustacean feeders, and epifaunal browsers. Due to poor biomass and nutrient availability, scavenging is also included in the trophic behaviour of deep-sea fishes (Drazen and Sutton, 2017).

Filter feeders, detritivores, surface deposit feeders, and carnivores inhabit the benthic habitat (sediments, epibenthic, and BBL). Despite their importance in regulating nitrogen and carbon cycling, information on microbes in the deep sea is limited. Studies in the CCZ showed microbe communities had habitat-specific differences, while regional patterns were not detected (ISA, 2019). Meiofauna are characterised by rapid generation time and metabolic rate and can be used as a proxy for responses of benthic communities to environmental changes and anthropogenic impacts (ISA, 2019). In the CCZ, the majority of macrofaunal species appear to be surface and subsurface deposit feeders, distributed within the top 5 cm of sediment and their abundance varied in response to POC flux and nodule abundance. Infauna taxa contribute to ecosystem functions like respiration, burial of detritus, and bioturbation (ISA, 2019). In contrast to macrofauna, megafauna lives above the seafloor and includes large deposit feeders such as sea cucumbers, sea stars, cephalopods, or sponges. Patterns within this group are associated with food availability, disturbances, and other environmental parameters such as sediment quality. Similarly to macrofauna, megafauna is critical to ecosystem functions such as bioturbation and carbon flow (ISA, 2019).

11.4. Population Connectivity

Population connectivity is the ability of marine organisms to disperse and move through the oceans. It is critical to the maintenance of species distributions, community structure, genetic diversity, and supports biomass and biodiversity. Marine species adopt different strategies to move and disperse to maintain their populations and thus, maintain a healthy ecosystem and preserve ecosystem function. Managers and conservation scientists use information on connectivity to inform spatial management decisions. Spatial management tools are largely applied to protect the marine environment and when connectivity was incorporated in the design of protected areas, they proved to be effective tools to protect biodiversity (Magris et al., 2014, 2016; Krueck et al., 2017).

Pelagic species complete long distance migrations. They migrate and aggregate to reproduce, supporting population connectivity and protecting gene pool diversity. Whales migrate to breeding sites where they mate and reproduce, while fishes aggregate in spawning grounds where they spawn and release larvae. Larval dispersal is a key process of marine connectivity. Gametes are released in the water where external fertilization occurs, subsequently larvae develop and are transported by currents. Larval behaviour influencing larval movements in the water column includes passive dispersal, active swimming, and vertical migration. Larval growth and survival is defined by species-specific life history traits and larvae with a long pelagic larval duration are able to disperse across long distances, promoting colonisation of new areas. Pelagic larval duration might provide an indication of the spatial scale of connectivity, however, realised population connectivity is the result of ocean dynamics, larvae life history traits, and behaviour (Cowen and Sponaugle, 2009).

Life histories largely influence dispersal strategies and therefore, connectivity structure. Broadcast spawners like marine invertebrates and corals release gametes and develop planktonic larvae. These larvae are small, produced in large numbers, have long larval durations, and great dispersal potential. Many fish species and some benthic invertebrates release larger eggs and produce nonfeeding lecitotrophic larvae, with shorter larval duration and intermediate dispersal potential, while brooders taxa such as vent-inhabiting polychaete species brood their eggs, keeping them in a protected environment and therefore, have limited dispersal potential (Foggo et al., 2007; Lucey et al., 2015). Colonial invertebrates such as bryozoans use other dispersal strategies and disperse via fragmentation, forming subcolonies from the edges of the parent colony or breaking off the substratum. These fragments float away from the colony and release larvae that may settle in another location (Winston, 2012)

In the deep-sea, information on connectivity is limited, due to the paucity of information on the life history of deep-sea fauna. However, recent research has increased our understanding of deep sea connectivity, with a particular focus on hydrothermal vents. Hydrothermal vents may appear like isolated habitats and communities, however genetic data revealed a mixed genetic pool in hydrothermal vent populations, suggesting that population connectivity is an important process of these ecosystems. Larval dispersal modelling of the hydrothermal vents of the western Pacific showed that hydrothermal vent fields within back-arc basins could be well connected, whereas basin-to-basin dispersal is unlikely to occur as a consequence of dispersal barriers and ocean current directionality (Mitarai et al., 2016). Seamounts are generally considered to be geographically isolated habitats, where individual replacement is supported by larval retention which leads to highly specialised endemic taxa (Meerhooff et al., 2017). Currents may ensure connectivity between seamounts and larval dispersal simulation models provide evidence of potential larval connectivity (Crochelet et al., 2020). Information on connectivity on abyssal plains is limited, however, there is an indication of geographic and genetic connectivity in abyssal plains in the CCZ (Bribiesca-Contreras et al., 2021).

Benthic species are generally sedentary or have limited movement capability. Population connectivity for these species relies mainly on larval dispersal. Larvae are released by benthic species from source habitats, planktonic larvae reach the competent stage during which they are able to settle, and settlement occurs when larvae sense chemical and physical cues. This process allows benthic sedentary species to disperse and therefore, protect genetic diversity. Larval transport is controlled by near-seabed currents, which in the deep waters are believed to be slow, although there is some indication that currents in the CIEEZ may be stronger than those measured in the CCZ. Some benthic fauna are egg-brooders which have more localised recruitment and are therefore considered to have more restricted connectivity.

12. Key Ecosystem Services

Section 9 discusses some of the human interactions with, and ecosystem services provided by, the natural environment. This section discusses all of the ecosystem services that are provided by the marine environment that have been screened for inclusion in the ESIA process, and their significance to Cook Islands where this information is available.

12.1.1. Supporting and Regulating Services

12.1.1.1. Circulation, Nutrient Cycling and Climate Regulation

The vast volumes of cold deep-sea water masses below 1000 m are isolated from the atmosphere. They circulate globally, create a buffer for the carbon and nitrogen cycles, and regulate climate. Ocean circulation is a supporting and regulating service due to the connection between water mass structure and movement, nutrient cycling, and climate regulation and CO^2 exchange (Thurber et al., 2014).

The biological pump is the primary source of energy to the abyssal seafloor in the open ocean. This process involves the sinking of POC generated in the productive sunlit ocean surface waters, as well as the progressive degradation of labile compounds, and transport of materials to the seafloor. The processes of upwelling and DVM of zooplankton and micronekton is another way nutrients are re-suspended back into the surface and sub-surface layers. At abyssal depths and other areas where surface primary production is low, the quantity of carbon and quality of nutrition is generally low, limiting the benthic biomass able to be sustained. The deep-sea water column and seabed, therefore, provide both supporting services (e.g., facilitating the production of biomass) and regulating services (e.g., sequestering carbon and cycling nutrients).

12.1.1.2. Primary and Secondary Production

Primary production is a process that is limited to the sunlit surface waters of the ocean; however, it occurs on a vast scale and drives many of the trophic interactions of human value (e.g., sustaining foodwebs that support fisheries and megafauna). Primary production can reach the seabed 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. Recently, a new appreciation exists for the amount of primary chemosynthetic production generated below the sunlit waters of the open ocean water column by microbes feeding on the vast pool of dissolved inorganic carbon. This process of chemosynthetic production also uses other compounds which are provided by the progressive degradation and repackaging of sinking POC.

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 therefore, the deep-sea provides a notable regulating service. Seabirds play a major role in ingesting and transporting production from the ocean’s upper layers to terrestrial environments (Otero et al., 2018). The presence of large seabird colonies in Cook Islands may indicate that these predators play a significant role in open ocean processes. Furthermore, there has been recent insight into the importance of production enhancement and nutrient mixing via the feeding whales, dolphins, tunas, and other large-bodied predators (Roman and McCarthy, 2010).

12.1.1.3. Waste Absorption and Detoxification

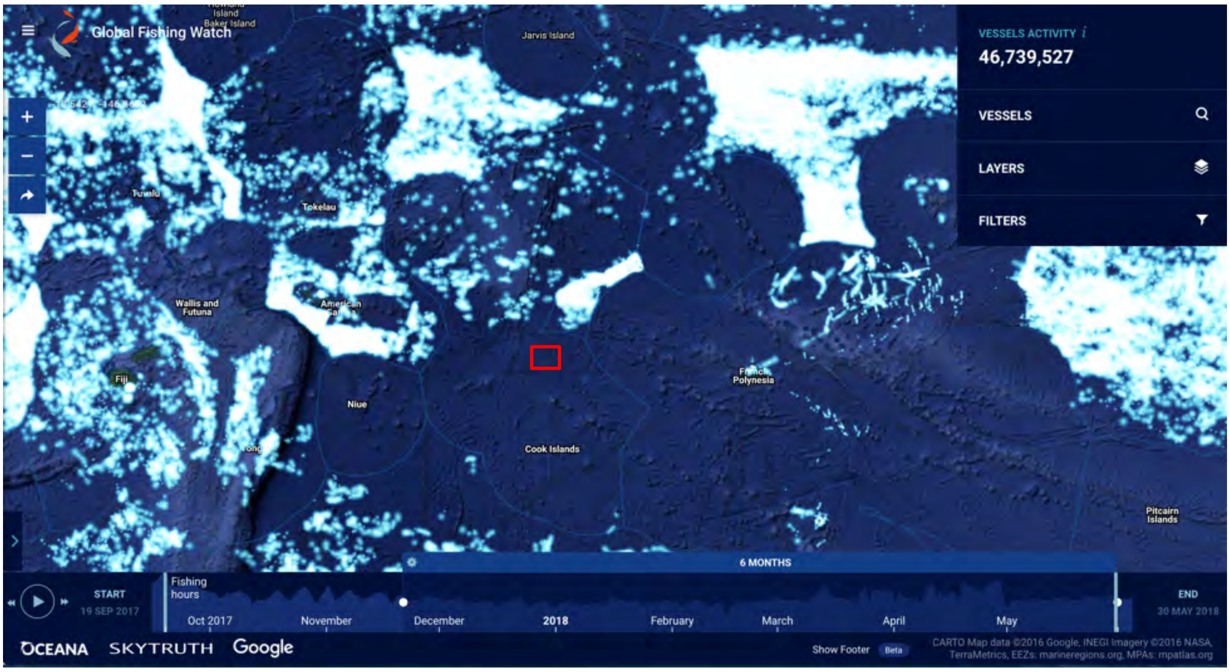
Waste products in the deep-sea can be stored and sometimes detoxified through natural processes. The deep-sea is an ecosystem far removed from human interaction, however, human waste products including disused chemical weapons and discharge from mining processing plants (e.g., deep-sea tailings deposition) are intentionally left on the deep-seabed. Transport and absorption of waste from effluent sources closer to continental shelves and areas of human habitation is recognised as a regulating ecosystem service. Bioremediation involving benthic microbial communities has been reported for hydrocarbon spills and releases. This service can indicate negative impacts in the forms of pollution, contamination, and bioaccumulation. To our knowledge, the CIEEZ has not experienced these forms of deep-sea waste dumping.

12.1.2. Provisioning Services

12.1.2.1. Offshore Fisheries

Harvested species include yellowfin tuna, albacore tuna, skipjack tuna, and bigeye tuna, as well as mahi mahi, wahoo, and billfishes (Anon 2000). On January 1, 2017, quotas for albacore tuna (total allowable catch of 9,750 t) and bigeye tuna (3.500 t) fished from Cook Island waters were implemented. There has been a ban on the commercial fishing of shark within the CIEEZ since 2012. Local and foreign vessels (primarily from Japan, Korea, and Taiwan) target tuna mainly by longline for the export sashimi market and canneries, particularly those in American Samoa and Fiji. In 2017, 45 foreign flagged vessels (from two Chinese companies operating out of Pago Pago, Suva, Papeete, and Kosrae (Federated States of Micronesia)) were authorised to operate in the CIEEZ (the vessels were not permitted to fish within the 12 NM limit of all islands and within the 24 NM limit of Rarotonga). These limits are imposed for foreign vessels as to not interfere with artisanal fishing closer to land (Anon 2000). Three Rarotonga-based longliners catch albacore tuna in addition to other species, mainly to cater for the local market with some exports to Japan. These vessels are around 20 m long and operate within 100 NM of Rarotonga (MMR, 2018).

Relative to other areas in the South Pacific, commercial fishing intensity in the CIEEZ is relatively low (Figure 12-1). Commercial fishing activity appears to be negligible near Moana's Licence Area.

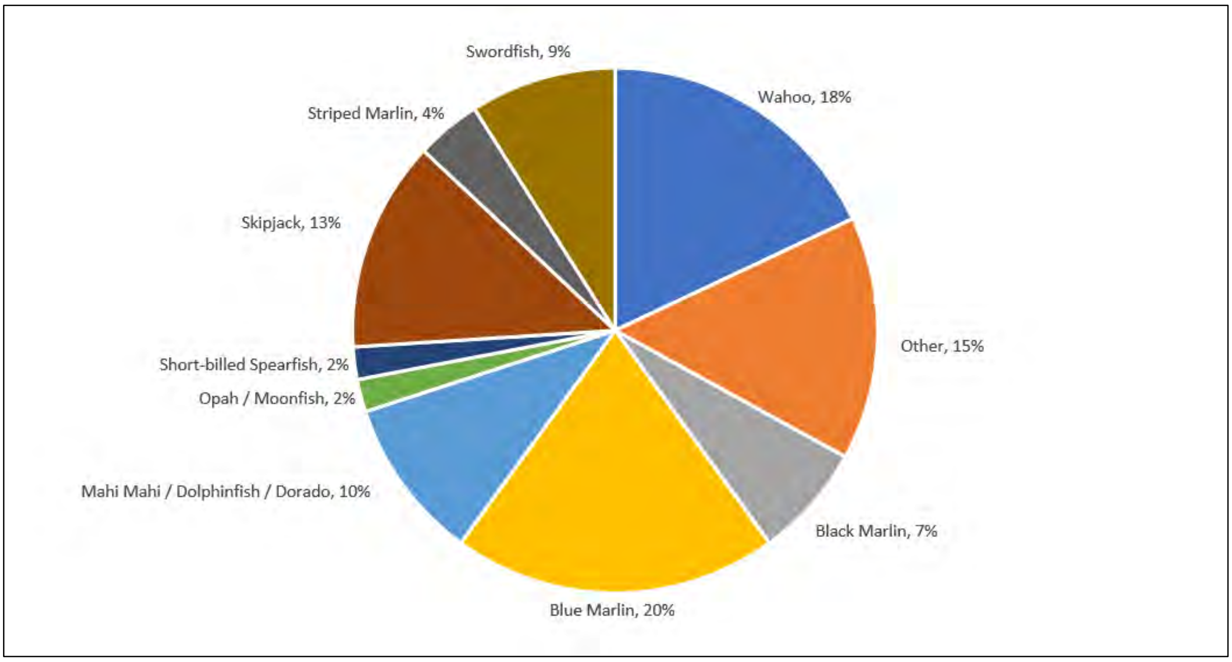


Source: Global Fishing Watch, globalfishingwatch.org/map.

Figure 12-1 Commercial fishing intensity in the CIEEZ (data range = 6 months to 30 May 2018). Red square shows approximate location of the Moana Licence Area, not to scale.

Seasonal trends dictate the catch rates in Cook Islands' longline fisheries. Generally, first and fourth quarter catch rates and total catch are low, signalling the off-season. Second and third quarter catches are the peak of the fishing season. The southern extent of the longline fishery is typically ~15 °S, however recent longline fishing effort has extended further south. In 2017, 45% of key tuna species were caught below 15°S. Bigeye tuna is predominantly caught in the northernmost part of the CIEEZ, above Penrhyn and closer to the equatorial belt. Albacore tuna were taken mostly south of 15°S, towards Aitutaki and south of Mangaia. Albacore tuna is the dominant species caught overall, totalling ~3,552 t and accounting for 65% of total catch composition in 2017. Yellowfin tuna contributed 18% to the longline catch (971 t) and bigeye tuna was 5% (227 t). The remaining 12% is comprised of blue marlin (123 t), skipjack tuna (79 t), wahoo (107 t), swordfish (54 t), and mahi mahi (59 t) among others (Figure 12-2).

The purse seine fishery in the CIEEZ is a surface fishery targeting schooling skipjack tuna in the tropical waters of the Western and Central Pacific Ocean. Catches are unloaded at canneries in Pago Pago, American Samoa (MMR, 2018). It operates in the northernmost waters of the CIEEZ, north of 13 °S which is also north of Moana's Licence Area.



Source: MMR, 2018.

Figure 12-2 Long line fishery species composition of species in the 2017 catch.

The fishery uses the Vessel Day Scheme (VDS) to monitor the days fished within the CIEEZ and therefore, regulate fishing effort. A fishing day can be either a set (deploying the purse net), when the vessel is actively looking for a school, or deploying a FAD (MMR, 2018). Cook Islands has a declared purse seine limit of 1,250 vessel days available annually, of which 350 are reserved for US vessels under the US Treaty (US vessels fished 456 days in the CIEEZ in 2017 and 76 days were fished by non-US operators) (MMR, 218). 2017 was the third year that Cook Islands arranged bilateral arrangements to licence purse seine vessels in addition to vessels under the US Multilateral Treaty with Pacific Island States (US Treaty). In 2017, an additional 15 vessels from Korea, Kiribati, and Spain became licenced to fish in the CIEEZ. All purse seine vessels are prohibited to fish within 24 NM of any island and 48 NM of Rarotonga.

A SFPA with the EU was signed in October 2016 and came into force in May 2017. Two Spanish purse seine vessels were also authorised to fish under the EU SFPA, with a capped total of 7,000 t from a national tonnage limit of 30,000 t. Under these regulations, the Spanish vessels caught 650 t and were present in the CIEEZ for 13 days in 2017.

The total purse seine catches for 2017 comprised skipjack tuna (90%), yellowfin tuna (8%), and bigeye tuna (2%). 95% was taken from 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. This indicates the reliance on FAD sets for the viability of the fishery in Cook Islands waters. There is a strong seasonal trend in catch rates for the purse seine fishery, with the first and fourth quarters being the peak season. 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, prohibiting the setting of nets on FADs (MMR, 2018). Bycatch composition from this fishery (available from observer data coverage) in 2017 indicates that silky sharks are the largest component, followed by blue marlin, rainbow runners, and mahi mahi (MMR, 2018).

12.1.2.2. Nearshore Fisheries

Pelagic and reef-associated fish species in the coastal zone are important to subsistence, artisanal, and small-scale commercial fisheries in Cook Islands. Nearshore fisheries operate away from commercial fishing as mandated by the 50 NM commercial fishing exclusion zone around all islands in the Marae Moana Act (2017). Majority of nearshore fishing occurs in the coastal zone (Gillett, 2016) and not in the oceanic environment over the SPB. The Cook Islands artisanal fishery operates from all inhabited islands, primarily targeting tuna and pelagic species. In 2017, there were 265 active artisanal vessels reporting on the artisanal database. These included small-powered boats with outboard motors (96%), recreational sport charter vessels (tourist operators) (3%), and unpowered canoes (1%).

Artisanal catch data was recorded from the islands of Aitutaki, Atiu, Mangaia, Manihiki, Mitiaro, Mauke, Pukapuka, Rakahanga, and Rarotonga. Catch estimates totalled 255 t in 2017. Majority of the reported catch comes from Aitutaki and Rarotonga. Artisanal catches are consumed locally and sold through local markets. The nearshore fishery is viable and different species are known to be seasonally abundant (Anon 2000).

12.1.2.3. Harvesting nodules and other minerals

The presence of polymetallic nodules in the CIEEZ is a major potential provisioning service. The exploration and commercialisation of these nodules provide major opportunities to further understand the relatively understudied Cook Islands deep-sea environment (see also Section 9.4.1.5). Nodule harvesting can also provide alternative sources of revenue and skills development to the people of Cook Islands. No SMS or cobalt crusts have been identified as yet in the CIEEZ. Rare earth element (REE) enriched sediments occur in the deep-sea and this potential mineral resource has been the subject of preliminary prospecting by OML and DRT.

12.1.2.4. Aquaculture

A variety of marine aquaculture projects have been developed and undertaken but none are associated with deep offshore waters in the CIEEZ. Mariculture developments of round pearls using the black-lip pearl shell (*Pinctada margaritifera*) have grown a black pearl industry in Cook Islands. The pearls are commercially cultured in Manihiki and Penrhyn lagoons in the country's north, approximately 600 km from Moana's project area. They have become one of the country's largest exports. There are 210 pearl farms that occupy an area of around 10 km^2 in Manihiki Lagoon and 1 km^2 in Penrhyn Lagoon (Anon 2000). The fishery uses two pearl species, the small pearl oyster (*Pinctada maculate*), which produces a golden pearl and the previously mentioned black lip 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 in Cook Islands are also being made to commercially develop milkfish (*Chanos chanos*) culture and capture fisheries based on trochus shell (*Trochus niloticus*).

12.1.2.5. Energy Production

Oil and gas reserves are found in the deep ocean. Among some of the renewable energy sources the ocean provides are 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. Exploitation of these sources is limited, but are attracting increased scrutiny and interest, much in the same way that deep-sea minerals harvesting interest has grown. This has been driven by increased demand and technological advances in solving some of the early commercialisation problems. To our knowledge, there is no active exploitation of subsea energy in the CIEEZ, although it is recognised that scientific research for Moana's exploration program has the potential foundational significance for a variety of other marine research that may follow.

12.1.2.6. Bioprospecting

The deep-sea is considered a potential source for novel natural products containing pharmaceutical properties. These products would be of potential value to biomedicine and cosmetic industries. Notably, 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, no active bioprospecting exists in the CIEEZ, however, it is recognised that scientific research for Moana's exploration program could generate the foundational significance for a variety of succeeding research.

12.1.2.7. Communications

The deep-sea provides a provisionary service by hosting telecommunications infrastructure in the form of subsea cables. In Cook Islands, the Manatua cable come to shore at Rarotonga and Aitutaki and connects to the global internet via Samoa and Tahiti.

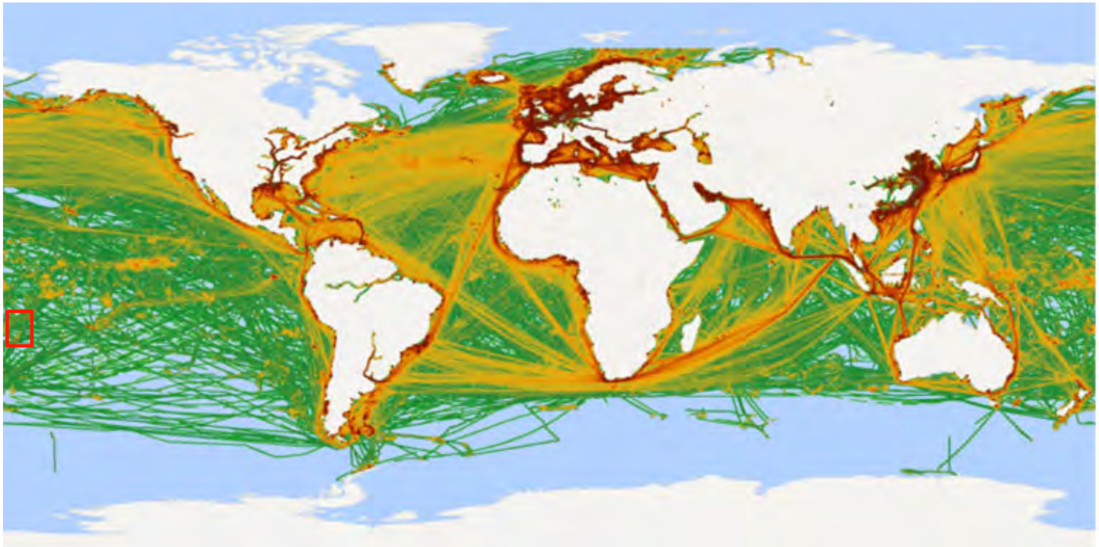
12.1.2.8. Military

Military activities occur in the deep-sea environment. The extent of these activities in the CIEEZ is unknown but expected to be generally lower than the Pacific continental shelf and continental slope locations, as well as the deep-sea locations that are closer to major military bases (e.g., Hawaii). It is conceivable that there are interrelationships between seabed mineral explorations, particularly seabed mapping, and military use (e.g., identification of navigable deep-sea routes). However, it is recognised that the scale of this exploration in the CIEEZ is very minor compared to the existing military resources.

12.1.2.9. Shipping

On a global scale, shipping and total vessel traffic in the CIEEZ is generally low (Figure 12-3) but commercial shipping is critical to the delivery of products to Cook Islands and the economy in general.

(a) cargo ships



(b) total vessel density

Source: Wu et al. (2017).

Figure 12-3 Comparative global cargo ship (a) and total vessel density (b). Approximate location of Cook Islands EEZ is shown by red square.

12.1.3. Cultural Services

12.1.3.1. Cook Islands Cultural Heritage, Spiritual Existence and Identity

The open ocean is integral to the origin stories, traditional knowledge, and cultural values of Cook Islanders as discussed in Section 9. The Marae Moana Act (2017) upholds these values, and they are witnessed throughout everyday life. This Scoping Study recognises that this factor will be paramount in the social acceptability of Cook Islands deep-sea minerals harvesting, and that excellent environmental performance will be of utmost importance in gaining that acceptability.

Moana's exploration program will be nested within an Environmental and Social Impact Assessment (ESIA) framework. The social dimension recognises the fact that avoiding negative social impacts and maximising positive social and socioeconomic impacts will be essential to exploration and future commercialisation of the project.

12.1.3.2. Recreation, Leisure and Aesthetic Experience

In Cook Islands, particularly given the high reliance on tourism that capitalises on aesthetic experience, leisure and marine-based recreational activities, the oceanic environment provides a key cultural service in these areas.

There are currently 12 game fishing charter vessels in 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 centred on Raratonga and other islands where the natural values of the marine environment are primary attraction. Diving, snorkelling, charter fishing, whale watching and other water sports and marine-based activities are key to tourism.

There is no information that indicates that the project activities will occur in vicinity of tourism related activities. However, perceptions around experiential use of the marine environment can interact with this ecosystem service.

12.1.3.3. Marine Scientific Research and Education

The oceanic environment in general holds scientific research and education values, many of which will actually be accessed in the deep-sea minerals harvesting exploration program. Cook Islands has limited dedicated marine research facilities. The key centres identified are the Aitutaki Marine Research Centre and the Centre for Cetacean Research and Conservation, Rarotonga. Both facilities provide valuable insight into local marine ecology. The Living Oceans Foundation also runs research projects in the Cook Islands region which focusses on monitoring and mapping of coral reef habitats. The Universtiy of the South Pacific has a campus in Rarotonga.

12.1.3.4. Global Culture

Deep-sea references and awareness of the open ocean's 'wildness' hold an important place in human culture and imagination. In addition to being a wildlife habitat that we admire and wish to preserve, the oceanic deep-sea environment is central to many ancient and modern civilisations, in the form of mythologies, stories and literature, art, music, and technological development. For example, cutting edge underwater robotics uses biomimetics principles to explore efficient designs.

13. Environmental (Effect) Risk Assessment

The Environment (Seabed Minerals Activities) Regulations 2023 (Schedules 1, 2 and 3) describe the tiers of activity that require consent and those that require permitting. The Environmental Risk Assessment described in this chapter addresses project activities that will be carried out as part of the minerals harvesting project. The risk assessment has considered the draft SBMA Guidleine for Environmental (Effect) Risk Assessments and draws upon the project team's experience in undertaking marine impact assessments that date back to the mid-1990s.

The typical risk assessment approach is a three-step process:

1. Review of all Project activities that could impact on the physical, biological and/or social environment.
2. Assessment of the potential hazards or threats that those activities might pose.
3. Assessment of potential impacts of those hazards.

Potential impacts from Project activities are typically assessed in terms of both their likelihood and the potential consequence if that impact were to occur. The risk assessment also typically assumes the effective implementation of proposed avoidance, mitigation and management measures that the Project will implement. It then examines the residual likelihood of a credible impact occurring and the severity of the potential consequences should the impact occur. The approach for this method is shown in Figure 13-1.

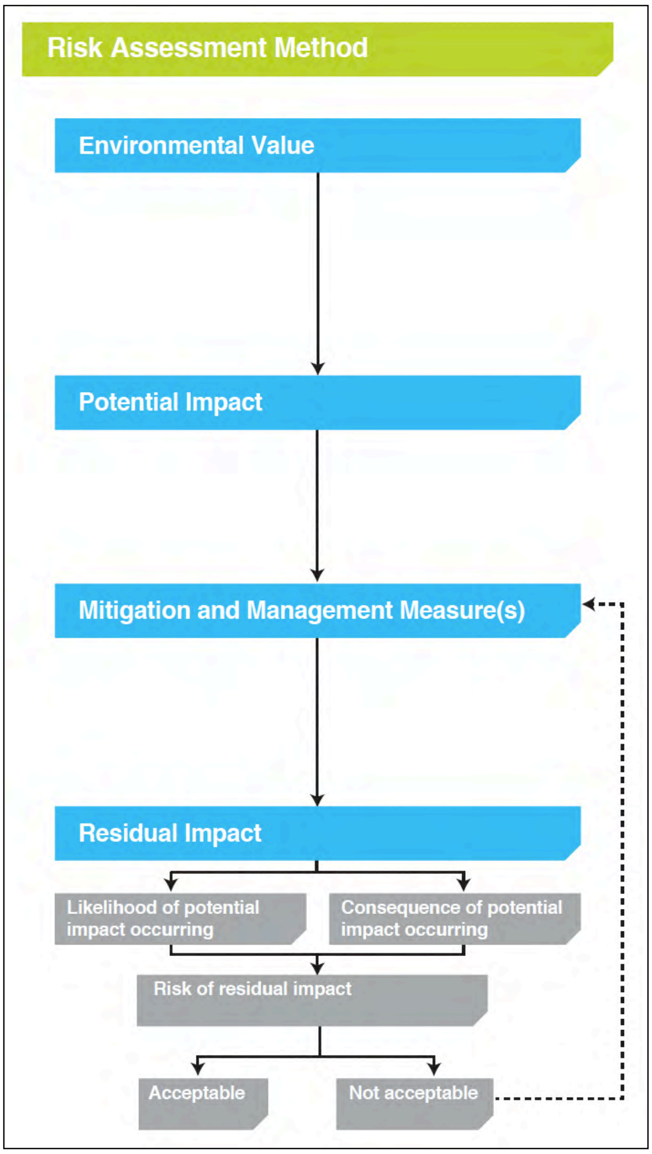


Figure 13-1 Risk Assessment method

At this early stage of the project where preliminary data collection has commenced but core ESIA studies are yet to start and where minerals harvesting engineering design and option selectio are in early stages, it is not feasible to undertake a comprehensive risk assessment that can accurately assess the likelihood and consequence of potential impacts. Such risk assessments will occur at regular phases throughout the ESIA process and will involve input from various subject matter experts, including the ESIA team, design engineers and minerals harvesting engineers.

At this stage of the project, a screening assessment has been undertaken that forms the basis for a future risk assessment. The screening assessment is described in the following sections amd has allowed the idenfication of issues to be addressed in the ESIA. Based upon these ESIA studies, an ESIA studies program environmental risk assssmsent has been undertaken that assesses the risks posed to the environment by these studies. The ESIA studies program environmental risk assssmsent is provided at the end of this chapter.

13.1. Issues Screening

A qualitative screening process was carried out which used the provisional ecosystem model developed for the Exploration Program and the professional judgement of impact assessment practitioners in the areas of ecology, sociology, and cumulative environmental impact.

The screening process addressed the issues which arose from pressure-receptor combinations in the ecosystem model described in Section 13.2 below. Issues have been screened in to or out of the ESIA. If the issue is screened in, it is then determined whether it will be addressed with a specific field baseline study, a desktop study, or a modelling study. The results of the issues screening process are shown in Appendix 1 and the key impact mechanisms are further summarised in Table 13-1. There are several potentially positive impacts of nodule harvesting that are discussed throughout the Scoping Study, but for the purposes of identifying the key impact mechanisms on which to focus ESIA study design, only the potentially negative impact mechanisms are listed in Table 13-1.

The issues and impact mechanisms will be subject to additional workshopping during the Exploration Program and thus are subject to adaptation.

Table 13-1 Summary of the key issues screened in to the ESIA, detailed further in Appendix 1.

Component	Issue	Description
Whole of project	Impacts to cultural ecosystem services	Impacts on cultural/spiritual identity and values, maritime cultural heritage, natural pristine existence value, and other cultural ecosystem services
	Impacts to regulating and supporting ecosystem services	Impacts on regulating and supporting ecosystem services such as climate regulation, ocean and air flows, sequestration, bioremediation, decomposition, waste absorption etc.
	Impacts to provisioning ecosystem services	Impacts to the ability for the oceanic system to support provisioning services, or impacts to the practices of engaging in provisioning services which may result in impacts to things like protein intake, income, traditional knowledge, and customs
		Impact on the ability for the oceanic system to support alternative or future provisioning services
	Impacts to socioeconomics	Impacts on other economic ventures such as tourism
		Operational requirements placing unsustainable pressure on infrastructure, supplies, facilities, and services
		Unrealised socioeconomic benefits in Cook Islands
	Impacts to community structures	Direct social benefits of increased revenue having undesirable effects that change social norms
		Impacts to community cohesion and traditional ways of life
Epipelagic and sea surface	Air emissions	Project Scope 1, 2 and 3 GHG emissions
		Transformation of deep-sea sequestered carbon
	Routine discharges	Water quality impacts from routine discharges at-sea
	Accidents and spills	Water quality and physical impacts from accidental releases of nodules and other materials from the Production Support Vessel, Ore Transport Vessel, and Support Vessels
	Interference with existing activities	Spatial interference with existing commercial fishing and shipping operations
		Biological impacts affecting the distributions, size classes, or biomass of commercially harvested populations
		Water quality impacts affecting food quality of harvested species

		Perceptions of water quality impacts affecting market value and fishing licence revenue
		Overall operational demands channeling limited shipping/port/logistical resources away from other activities
	Noise	Behavioural impacts from noise introduced by surface operations
	Light	Behavioural impacts from light introduced by surface operations
	Structure	Physical interactions between mobile fauna and surface operations
Midwater	Discharges	Water quality impacts from sediment component of midwater discharge
		Water quality impacts from toxicants component of midwater discharge
	Noise and vibration	Behavioural impacts from noise introduced by riser operation
		Behavioural impacts from noise introduced by midwater discharge operation
	Structure	Physical interactions between mobile fauna and riser
	Accidents and spills	Water quality and physical impacts from accidental releases of nodules and other materials from riser and midwater discharge
Seafloor	Physical nodule removal	Alteration of the mosaic of seafloor physical habitat
		Physical obliterative impacts to nodule-attached fauna and sediment fauna
	Sediment disturbance	Physical obliterative impacts to sediment fauna
		Impacts to sediment infauna and ecosystem functioning from the reworking and turnover of productive and temporally stable productive sediment layers altering nutrient, oxygen, and biogeochemical regimes
		Impacts to benthic and demersal fauna and ecosystem functioning from suspended sediment concentration of near-seafloor water column sediment plumes
		Impacts to benthic and demersal fauna and ecosystem functioning from sedimentation of particles in near-seafloor water column sediment plumes
		Impacts to benthic and demersal fauna and ecosystem functioning from particulate and dissolved phase toxicants in near-seafloor water column sediment plumes
	Noise and vibration	Behavioural impacts from noise introduced by operation of collector
	Structure	Physical interactions between mobile demersal fauna and the collector
	Accidents and spills	Water quality and physical impacts from accidental releases of hydraulic fluids, nodules, and other materials from the collector

13.2. Baseline and ESIA Studies

13.2.1. Ecosystem-Based Management Framework (EBM)

EBM is an integrated approach to environmental management which aims to achieve protection balanced against natural resource use. EBM seeks to provide an evidence-base for management decisions including adaptive management processes, whereby the optimal actions for best environmental outcomes can be assessed. Ecosystem components (biological, chemical, physical, social, cultural, and economic) are connected to each other and EBM recognises the importance of maintaining whole-of-ecosystem functions and values to society rather than focusing on a single species or individual habitats (Figure 13-2).

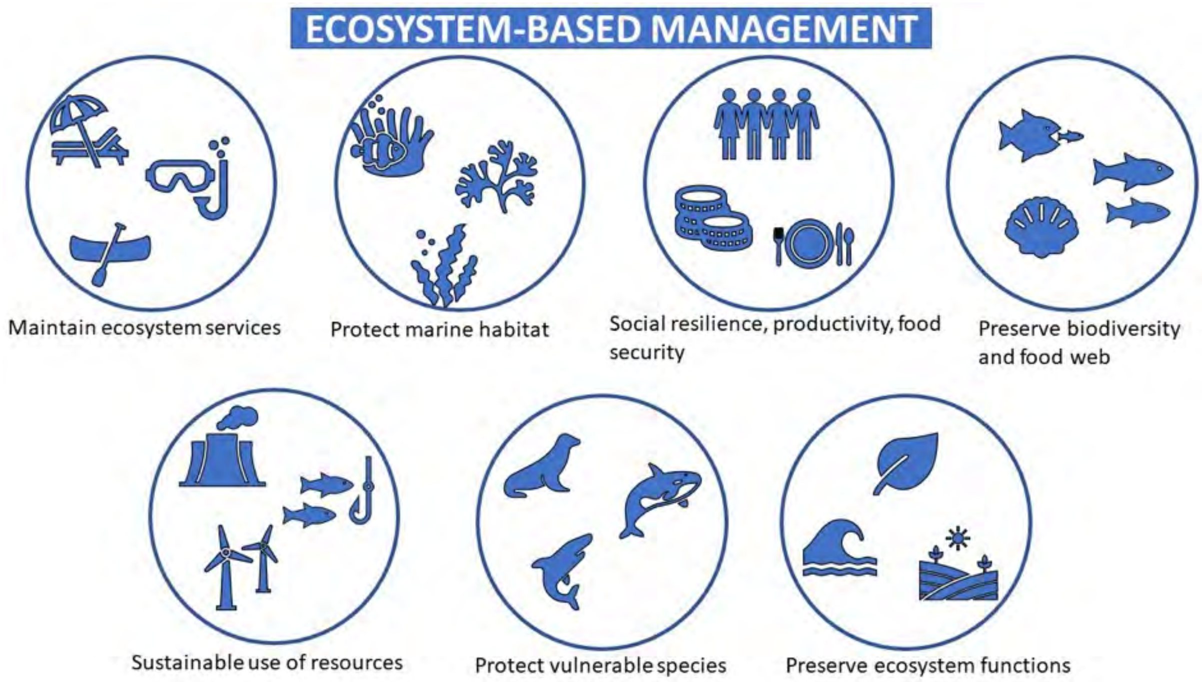


Figure 13-2 EBM key principles.

EBM is implemented in sustainable fisheries management and in MPA design (Babcock et al., 2005). Recent implementations of EBM have focused on incorporating traditional knowledge into EBM practices to support decision-making toward resilience and sustainability in social-ecological systems (Stori et al., 2019). An EBM approach was applied by the US EPA (Environmental Protection Agency) to restore the coastal and estuarine environment of Florida Keys and Dry Tortugas where an integrated conceptual ecosystem model was developed through a participatory system, which incorporated the input of scientists, agency resource managers, and environmental organisation representatives (Ault et al., 2012; Kelble et al., 2013).

In Australia, EBM principles are applied to large area marine spatial planning directives and coordinated research objectives in the state of Victoria (DELWP, 2017; 2020) and the Great Barrier Reef Marine Park (Anthony et al., 2013). EBM frameworks have also been applied to the coordinated management of large areas with industrial development priorities impinging on natural values, such as the Port of Gladstone.

In New Zealand, the Sustainable Seas Challenge[14] brings together researchers, environmental groups, Māori, Government, industry, and communities working towards preserving a healthy marine ecosystem that provides value to New Zealanders.

EBM does not focus on protecting the single species, rather it prioritises the conservation of biodiversity. Maintaining high biodiversity and species richness has several benefits such as regulating and protecting water and biological resources and therefore, supports ecosystem services and food security, as well as preserving a functional food web (Worm et al., 2006).

13.3. Ecosystem Model

13.3.1. Background

Ecosystem models are fundamental tools to support EBM. They are used to support decision-making and are commonly employed to assess management scenarios. An ecosystem model should use a modelling framework that incorporates all ecosystem components such as populations and functional groups and should adequately describe ecosystem processes (Geary et al., 2020). Ecosystem models are generally complex, although models can have different levels of detail. Conceptual ecosystem models are largely used in natural resource management to provide information on linkages in ecological systems and identify management priorities. Ecosystem models can be parametrized using field and experimental data or can be informed by expert opinion (Geary et al., 2020). As such, very well studied ecosystems, such as an ecosystem supporting a fishery that has volumes of sampling data (e.g. see Townsend et al., 2019), can be highly parameterised and quantitative, allowing the exploration of things like trophic mass balance.

DPSIR (drivers-pressures-status-impact-responses) modelling frameworks have been adopted by several agencies and institutions. Examples include the Florida Keys marine ecosystem (Kelble et al., 2013) and management of United Kingdom coastal habitats (FGDC, 2012). The model framework represents the connections between natural and human Drivers, the Pressures they generate, and relates them to the Ecosystem compartments, features, trophic groups, and functions. In a DPSIR model, the ecosystem is linked to the Ecosystem Services provided by that ecosystem, thus representing social and cultural dimensions. Pressures, Ecosystem, and Ecosystem Services are linked to appropriate Status indicators, which include measurable parameters used to monitor the condition of the ecosystem receptors or the intensity of pressures. DPSIR models aim to identify the most effective management responses to preserve the ecosystem and related ecosystem services. The DPSIR holistic approach has the flexibility and potential to be applied to all types of environmental problems. It provides a powerful tool for risk assessment and risk management, and it is also a stakeholder-inclusive communication tool useful in implementing an EBM approach (Patrício et al., 2016).

13.3.2. A Model Framework for the Moana 1 Project

To inform this Scoping Study, a DPSIR conceptual ecosystem model was constructed to depict a generalised nodule harvesting project in relation to the Cook Islands ecosystem and

[14] https://www.sustainableseaschallenge.co.nz/

ecosystem services. The model was constructed by reviewing a large body of literature available and is intended to provide an *a-priori* framework to inform scoping and a basis for further development. Throughout the ESIA, additional models may be nested within this general structure to describe relevant interactions.

Nodes used in our ecosystem model were acquired from the existing MSFD framework as a starting point, and additional nodes were incorporated that were specific to nodule harvesting as an Activity and specific to the open ocean and abyssal seafloor environment (Table 13-2). Terminologies used in the mode were aligned to the concepts described in the MSFD and the scientific literature. An innovative aspect of this model is the addition of several categories of studies connecting to Status Indicators (Table 13-2). This allows the studies to be closely tied to the ecosystem model and provides a central logic to the selection and prioritisation of studies.

Nodes were organised according to a hierarchical system, where Level 1 represents broad categories to Level 6 representing the maximum level of detail (see Table 13-3). This hierarchical structure allows for the use of the model at different levels depending on the level of information available. For communication purposes, a low level of detail may be sufficient, while more details are required for analyses or discussion of technical details.

The DPSIR model described in this report aims to represent the Cook Islands ecosystem and the relationships with pressures linked to nodule harvesting. Nodes included in the conceptual ecosystem model were selected and defined based on an extensive review of the literature and technical documents describing the deep-sea environment, ecology, and nodule harvesting activities. Additional review of the Cook Islands environment, economy, and society was completed to define nodes specific to this region.

Drivers consist of nodes describing natural drivers including climate, currents, geology, and natural events. Activities related to nodule harvesting and deep-sea research were included so that the model can also be used to assess impacts of scientific research should that be required.

Pressure nodes specific to the activity of nodule harvesting are included which cover the water column and benthic compartments. A screening of the material provided by the ISA and research related to nodule harvesting was completed to define nodes to the best available scientific knowledge. Nodule harvesting pressures may be caused by nodule removal from the seabed, the release of plume containing contaminants in the deep and mid-water environment and the impact of harvesting operations and vessels at the ocean surface including increased levels of noise, vibration, and light.

Table 13-2 Ecosystem model DPSIR themes and node categories.

Drivers	Pressures	Ecosystem	Status indicators	Ecosystem services	Responses	Studies
Natural	Chemical	Functions	Seafloor integrity	Provision	Spatial planning	Geological studies
Human activities	Physical	Features	Hydrographic conditions	Regulation	Technology	Habitat structure and function
	Biological	Trophic relationships	Biodiversity	Habitat	Regulatory	Toxicology
		Habitat	Food web	Cultural	Monitoring	Physical oceanography
		Environment	Environmental contaminant			Water column structure
			Seafood			Noise
			Energy			Air quality
			Light			Water quality
			Electromagnetic radiation			Sediment quality
			Marine litter			Sediment biogeochemistry
						Ecological function
						Classification
						Biodiversity, community, biomass
						Spatial planning
						Ecosystem services
						Climate and meteorology
						Climate change
						Plume modelling
						Noise modelling
						Hazard assessment
						Ecosystem-based management

Table 13-3 Example of the hierarchical structure of nodes for each DPSIR category in the ecosystem model.

DPSIR category	Node hierarchy
Driver	1. Driver 2. Activity 3. Extraction (and disposal) of non-living resources 4. Deep sea minerals harvesting 5. Deep sea minerals harvesting operations 6. Nodule harvesting
Pressure	1. Pressure 2. Pressure group 3. Physical damage 4. Habitat structure changes - removal of substratum 5. Removal of nodules
Ecosystem	1. Ecosystem 2. Lower abyssal seafloor 3. Sediment epibenthic 4. Epibenthic layer feature 5. Nodules - macrofauna 6. Polychaeta
Status indicator	1. Status indicator 2. Seafloor integrity 3. Physical disturbance of seabed 4. Sediment reworking
Ecosystem service	1. Ecosystem service 2. Regulating service 3. Climate regulation 4. Reduction of greenhouse concentrations
Response	1. Response 2. Improve technologies 3. Reduce nodule removal impact 4. Optimize plume intensity/extent
Study	1. Study 2. ESIA and Baseline Studies 3. Environmental studies 4. Physical oceanography 5. Ocean currents 6. Acoustic Doppler Current Profilers

Ecosystem services nodes were based on the ecosystem services described in this report and were classified according to the traditional groups adopted in the literature (regulating, provisional, and cultural). Cultural ecosystem services were developed to include Cook Islands cultural heritage values and socio-economic factors. An important application of this model is to understand the potential impacts of nodule harvesting not only on the environment, but also on Cook Islands society.

The Response group consist of nodes describing monitoring and management decisions such as actions and measures taken in environmental management systems, to reduce the adverse effects of pressures and restore the condition of ecosystems. Responses were targeted to deep sea environmental management, including spatial planning decisions like deep sea protected areas (PRZs and BPAs) and harvesting-specific measures, including reducing plume or modifying harvesting patterns and locations.

The final group consist of Studies, which are described in Section 13.4.

Data collected during the ESIA studies can be used to parameterise the model, advancing from a conceptual modelling framework to an evidence-based, operationalised model. When new information is available, further revisions of the model are valuable contributions to an adaptive management process, allowing for the interrogation of the model and to provide ecosystem-based recommendations to managers and inform decision making.

13.4. Information Requirements and Studies

The EBM and modelling approach applied to the Exploration Program has identified required ESIA studies (Table 13-4).

Table 13-4 Study description in the hierarchical structure of the ecosystem model.

level	theme	label	description
2	ESIA	ESIA and Baseline Studies	Studies to inform Environmental and Social Impact Assessment and establish a pre-minerals harvesting baseline for monitoring comparisons
3	Geological studies	Resource and geological studies	Studies on the geological basis for the resource and the distribution, abundance, typology, mineralogy of nodules and sediments
4	Geological studies	Seafloor geotechnical studies	Studies to investigate the geotechnical characteristics of the seafloor, including porosity, vane strength, and other parameters. Informs on geological basis of nodule deposits, design criteria for minerals harvesting tool design, and environmental habitat structure and function (e.g. geotechnical stability)
4	Habitat structure and function	Nodule type	Nodule type classification
4	Habitat structure and function	Nodule abundance	Studies to quantify nodule abundance in the Licence Area
4	Habitat structure and function	Nodule distribution	Studies to classify nodule types and map their abundance distribution
5	Habitat structure and function	Seafloor acoustic mapping	Acoustic bathymetric mapping of the seafloor to map terrain and detect backscatter indicators of nodule abundance (seafloor hardness)
5	Habitat structure and function	Seafloor image groundtruthing	Optical mapping of the seafloor to ground-truth acoustic mapping and models of nodule distribution, and measure nodule type/abundance and benthic habitats/fauna
4	Toxicology	Nodule chemisty	Studies to determine the chemical composition of nodules with respect to target minerals, deleterious metals and potential contaminants
4	Toxicology	Sediment chemistry	Studies to determine the physicochemical composition of sediments with respect ot potential minerals of interest, physical characteristics for plume studies and potential contaminants
3	Environmental studies	Environmental studies	Environmental studies from the perspectivie of characterising the existing physical, chemical, and biological environment, the background spatial and temporal variability and technical studies to examine potential impacts
4	Physical oceanography	Physical oceanography	Physical oceanography studies involving investigations of currents, water mass physical structure, and spatial and temporal patterns in these parameters
5	Habitat structure and function	Ocean currents	Studies of ocean currents as input to plume models, pelagic habitat categorisation, engineering design, and biological oceanograhy
6	Habitat structure and function	Acoustic Doppler Current Profilers (ADCPs)	Deployment of ADCPs in upward and downward-looking orientations to detect current speed and direction in target water column strata (layers), using multple frequencies
6	Habitat structure and function	Single-point current meters	Deployment of single point current meters to detect current speed and direction at target points in the water column, typically used in combination to ADCPs to obtain full water column coverage
4	WC structure	WC structure	Studies to investigate the physicochemical structure of the water column. Typically achieved through sensors on CTD (conductivity-temperature-depth) rosettes achieving continuous profiles, but may be supplemented by physical sampling.
5	Habitat structure and function	pH	pH
5	Habitat structure and function	Dissolved oxygen	Dissolved oxygen
5	Habitat structure and function	Temperature	Temperature
5	Habitat structure and function	Salinity	Salinity
5	Habitat structure and function	Irradiance	Irradiance
5	Habitat structure and function	Transmissivity	Transmissivity
5	Habitat structure and function	Turbidity	Turbidity
5	Habitat structure and function	Fluorometry	Fluorometry
4	Noise	Noise measurements	Noise measurements
5	Habitat structure and function	Baseline underwater soundscape	Measurement of the soundscape to characterise underwater noise. Biological sounds may be measured in these studies but measurements in this study are not targeted to the detection of marine mammal vocalisation
4	Air quality	Air quality	Studies to investigate the baseline air quality
4	Water quality	Water quality	Studies to investigate the physicochemical structure of the water column. Typically achieved through sensors on CTD rosettes but may be supplemented by physical sampling.

5	Habitat structure and function	Water physical parameters	Measurement of water physical properties including temperature, salinity, pH, suspended solids concentration, oxygen concentration, etc.
5	Habitat structure and function	Water nutrients	Measurement of the concentration of nutrients in the water column. At fine scales, water nutrients will also be studied in the pelagic ecosystems theme.
5	Habitat structure and function	Water contaminants	Measurement of the concentration of metals, organics, and other contaminants in the water column. Informs ecotoxicological risk assessment.
4	Sediment quality	Sediment quality	Studies to investigate the physicochemical structure of the seabed. Informs on chemical, biological, toxicological, and biogeochemistry components.
5	Habitat structure and function	Sediment physical parameters	Measurement of sediment physical properties including grain size, mineralogy, pH, but may also include physical attributes associated with bioturbation, such as waste caste/burrows via MRI scanning technology.
5	Habitat structure and function	Sediment nutrients	Measurement of the concentration of nutrients in sediment. At fine scales, sediment nutrients will also be studied in the sediment biogeochemistry theme.
5	Toxicology	Sediment contaminants	Measurement of the concentration of metals, organics and other contaminants in sediment. Informs ecotoxicological risk assessment.
4	Habitat structure and function	Habitat mapping and condition	Studies to define benthic and pelagic habitat structure and its condition. Typically advanced prior to availability of in-situ biological data, these studies typically rely on physical and chemical remote sensing. These studies map the distribution of abiotic habitats in a hierarchical fashion so as to make preliminary judgements about planning studies, information spatial conservation management etc. This category includes condition metrics that can be applied at this level, related to the integrity, stability, variability, and functioning of habitats.
5	Classification and spatial planning	Benthic habitat classification	Benthic terrain, geoform and subsrate classification
5	Classification and spatial planning	Benthic habitat texture and condition	Epibenthic sediment texture, fine scale geomorphology and condition. Involves acoustic and optical mapping to assess furrows, blanketing, sedimentation, accumulation, scraping.
5	Classification and spatial planning	Pelagic habitat classification	Water column hydrographic and biological oceanographic structure that is informative for the definition of water masses, frontal zones, theremoclines, oxyclines, isoclines, etc. that define the structure of the pelagic habitat and nest it within a biogeographic realm.
4	Sediment biogeochemistry	Sediment biogeochemistry	Sediment biogeochemistry studies
5	Ecological function	Nutrient supply and recycling	Supply and nutritional content of particulates reaching seafloor
5	Ecological function	Sediment organic matter	Sediment organic matter composition
5	Ecological function	Sediment oxygenation	Sediment oxygen profiles, redox state, sulfur reduction
5	Ecological function	Sediment respiration	Respiration rates of sediment infauna and epifauna
5	Ecological function	Sediment composition	Grain texture, mineralogy, bioturbation, waste casts etc which determine binding, recolonisation potential, and are indicative of impacts of change sediment compaction
4	Benthic ecosystem	Benthic ecosystem	Studies into the epibenthic fauna and infauna and ecological function of the seafloor environment
5	Biodiversity, communities, biomass	Megafauna diversity and community composition	Studies of megafauna, generally defined as organisms > 2cm and visible to the human eye in high quality underwater imagery, to investigate biodiversity. Biodiversity studies can include traditional taxonomic and genetic studies and encompass biodiversity and community composition and distribution
5	Toxicology	Megafauna ecotoxicology	Ecotoxicology of benthic megafauna, involving biomarker measurements of exposure to metals and other contaminants such as tissue metals concentrations, endocrine disruptors, DNA markers of contaminant stress etc.
5	Biodiversity, communities, biomass	Macrofauna diversity and community composition	Studies of megafauna, generally defined as organisms retained on a 300 mm sieve to investigate biodiversity. Biodiversity studies can include traditional taxonomic and genetic studies and encompass biodiversity and community composition and distribution
5	Toxicology	Macrofauna ecotoxicology	Ecotoxicology of benthic macrofauna, involving biomarker measurements of exposure to metals and other contaminants such as tissue metals concentrations, endocrine disruptors, DNA markers of contaminant stress etc.
5	Biodiversity, communities, biomass	Meiofauna diversity and community composition	Studies of meiofauna, generally defined as organisms < 300 mm and retained on a 32 µm sieve, to investigate biodiversity. Biodiversity studies can include traditional taxonomic and genetic studies and encompass biodiversity and community composition and distribution

5	Biodiversity, communities, biomass	Microfauna diversity	Studies of microfauna, defined as prokaryotes (bacteria and archaea)
5	Ecological function	Benthic ecosystem structure and function	Studies to integrate benthic biological data into ecosystem structure and ecological function assessment. Involves integrating taxonomy studies into model trophic guilds, reproduction and turn over, distributions, biomass
3	Ecological studies	Ecological studies	Ecological studies
4	Abyssopelagic and benthic boundary layer ecosystem	Abyssopelagic and benthic boundary layer ecosystem	Studies of the fauna and function of the abyssopelagic zone and the BBL
5	Biodiversity, communities, biomass	Abyssopelagic scavenger diversity and community composition	Studies of the diversity of invertebrate scavengers
5	Toxicology	Abyssopelagic scavenger ecotoxicology	Ecotoxicology of abyssopelagic scavengers, involving biomarker measurements of exposure to metals and other contaminants such as tissue metals concentrations, endocrine disruptors, DNA markers of contaminant stress etc.
5	Biodiversity, communities, biomass	Abyssopelagic fishes diversity and community composition	Studies of the diversity of abyssopelagic fishes
5	Toxicology	Abyssopelagic fishes ecotoxicology	Ecotoxicology of abyssopelagic fishes, involving biomarker measurements of exposure to metals and other contaminants such as tissue metals concentrations, endocrine disruptors, DNA markers of contaminant stress etc.
5	Biodiversity, communities, biomass	Benthic boundary layer zooplankton	Studies of the diversity of zooplankton in the BBL, including larvae
5	Ecological function	Benthic boundary layer structure and function	Studies to integrate BBL biological data into ecosystem structure and ecological function assessment. Involves integrating taxonomy studies into model trophic guilds, reproduction and turn over, distributions, biomass
4	Pelagic ecosystem	Pelagic ecosystem	Studies into the fauna and infauna and ecological function of the water column environment
5	Ecological function	Primary production	Rates of primary production, spatiotemporal variability, environmental limitations
5	Biodiversity, communities, biomass	Microbial	Midwater microbes that span the phyto- and zooplankton classes
5	Biodiversity, communities, biomass	Phytoplankton	Community composition of phytoplankton and ecosystem function
5	Biodiversity, communities, biomass	Zooplankton	Community composition of zooplankton, from nano, pico, micro to macrozooplankton, distributions and biomass
5	Ecological function	Particulate organic matter	Concentrations, nutritional content and trophic role of POM in the water column
5	Ecological function	Particulate flux	Rates of POM sedimentation in the water column
5	Biodiversity, communities, biomass	Micronekton	Community composition of micronekton, distributions and biomass. Generally described as fauna < 20 cm, but functionally defined as pelagic free-swimming organisms that are sampled in slow-moving scientific midwater trawl nets
5	Ecological function	Pelagic ecosystem structure and function	Studies to integrate pelagic biological data into ecosystem structure and ecological function assessment. Involves integrating taxonomy studies into model trophic guilds, reproduction and turn over, distributions, biomass. In the pelagic environment, this will involve biological oceanography to understand connectivity, scales of pattern and process
4	Surface ecosystem	Surface ecosystem	Studies into the fauna and infauna and ecological function of the sea surface environment, generally defined as the epiplegaic zone and the air above and thus includes cetaceans, seabird, tuna, billfishes etc. despite some of these organisms interacting with the mesopeagic zone in deep foraging excursions
5	Biodiversity, communities, biomass	Megafauna distributions and movements	Desktop and tagging studies of the movements and migrations of surface megafauna
5	Biodiversity, communities, biomass	Megafauna observations	Surface megafauna observation studies
5	Biodiversity, communities, biomass	Megafauna acoustic sensing	Acoustic sensing of marine mammals
6	Biodiversity, communities, biomass	Low frequency hydrophone	Low frequency acoustic hydrophones targeting baleen whales, large toothed whales, and dolphin clicks
6	Biodiversity, communities, biomass	High frequency hydrophone	High frequency acoustic hydrophones targeting beaked whales

5	Ecological function	Surface ecosystem structure and function	Studies to integrate surface biological data into ecosystem structure and ecological function assessment. Involves integrating taxonomy studies into model trophic guilds, reproduction and turn over, distributions, biomass. In the pelagic environment, this will involve biological oceanography to understand connectivity, scales of pattern and process
4	Nearshore ecosystem	Nearshore ecosystem	Studies of the nearshore coastal and marine environment as it relates to the minerals harvesting infrastructure and potential areas of influence
5	Habitat structure and function	Nearshore terrestrial environment	Studies of the nearshore coastal environment
5	Habitat structure and function	Nearshore marine environment	Studies of the nearshore marine environment
4	Spatial planning	Spatial planning	Spatial planning studies that integrate minerals harvesting influence with spatial distributions of biological communities, habitat qualities, and conservation measures to define use zones and specific sites. Spatially planning can be done at multiple levels, and may involve regulators and stakeholders at the contract scale.
5	Classification and spatial planning	Exploration zones	Establishment of zones for minerals harvesting exploration activities
5	Classification and spatial planning	Preservation reference zones	Establishment of preservation reference zones
5	Classification and spatial planning	Sampling designs	Establishment of sampling designs
5	Classification and spatial planning	Mine planning	Establishment of minerals harvesting designs and plans
4	Ecosystem services	Commercial fisheries	Studies of commercial fishing to monitor interference of impact or deep-sea minerals harvesting on the commercial fishing industry
5	Commercial fisheries	Commercial catch and effort	Monitoring of commercial catch and effort
5	Commercial fisheries	Commercial spatial interaction	Monitoring of spatial distribution of commercial fishing activity to investigate interference
5	Commercial fisheries	Commercial market value and satisfaction	Assess commercial fishing market values and acceptance to monitor perceived or real market economic interference
4	Ecosystem services	Artisanal and recreational fisheries	Studies of artisanal and recreational fishing to monitor interference or impact of deep-sea minerals harvesting on the sector
5	Artisanal and recreational fisheries	Artisanal catch and effort	Assessment of artisanal and recreational catch and effort
5	Artisanal and recreational fisheries	Artisanal spatial interaction	Assessment of spatial distribution of artisanal and recreational fishing activity to investigate interference of the deep-sea minerals harvesting sector. Includes dimensions customary rights and access.
4	Ecosystem services	Marine tourism	Studies of marine tourism to monitor interference of impact or deep-sea minerals harvesting on the sector
5	Marine tourism	Tourism activity	Monitoring of spatial distribution of marine tourism activity to investigate interference of the deep-sea minerals harvesting sector
5	Marine tourism	Tourism value and satisfaction	Assess marine tourism market values and acceptance to monitor perceived or economic interference of the deep-sea minerals harvesting sector
4	Ecosystem services	Cultural services	Studies of the non-fisheries related services and cultural heritage components to monitor interference or impact of deep-sea minerals harvesting on the sector
5	Cultural heritage and traditional knowledge	Cultural heritage and traditional knowledge	Assessment of the marine cultural heritage and traditional knowledge values of the marine environment. Dimensions include values, beliefs, customs, and traditions that relate to the marine environment, custodianship and connection with modern society and traditional identity, important cultural features in the minerals harvesting area (e.g. seafaring routes, fauna migration routes)
3	Social studies	Social studies	Social impact assessment studies
4	Socioeconomics	Socioeconomics	Socioeconomic studies
5	Economic impact	Economic impact study	Assessment of the potential positive and negative economic impact of minerals harvesting on the Cook Islands economy as it relates to socioeconomics, services, opportunities, limitations of supply and capacity, and social well-being
5	Subsistence	Subsistence and livelihoods	Quantification of the socioeconomic basis for subsistence/artisanal resource use. Related to the ecosystem service studies above, but differentiated on the basis of economic and nutritional values. Dimensions include rates, seasonality and income of subsistence/artisanal fishing and other harvesting, relative contributions of harvested protein to diets.
3	Technical and modelling studies	ESIA technical studies	Technical and modelling studies that integrate various other scientific studies to support the assessment of environmental and social impacts
4	Toxicology	Ecotoxicology	Ecotoxicology assessment that integrates bioaccumulation studies above with additional testwork and modelling to assess ecotoxicological risk
5	Toxicology	Elutriate tests	Elutriate tests to investigate leaching, porewater, and sediment factors generated by seafloor sediment disturbance

5	Toxicology	Ecotoxicological evaluation	Gradient of bioavailability assessment, contaminants of concern assessment, and ecotoxicological tests to investigate toxicological risk
5	Toxicology	Nodule ecotoxicological risk	Ecotoxicological tests on nodules
5	Toxicology	Sediment ecotoxicological risk	Ecotoxicological tests on sediments
4	Climate and meterology	Climate and meteorology	Studies of climate and meteorology to inform impact assessment but also engineering design aspects of minerals harvesting development
5	Climate and meterology	Wave, current and wind climate	Studies of waves, currents and winds
5	Climate and meterology	Meteorology	Synoptic studies of meteorology
5	Climate and meterology	Air quality	Air quality studies
4	Climate change	Climate change	Studies to inform an assessment of impacts of minerals harvesting development on global climate change
5	Climate change	Atmospheric emissions	Studies of the atmospheric emissions of minerals harvesting development. May extend to terrestrial processing aspects in addition to the offshore aspects
6	Climate change	Greenhouse gas emissions	Studies of greenhouse gas emmisions
6	Climate change	Air pollutant emissions	Studies of air pollutants
5	Climate change	Ocean sequestration and release	Studies of carbon sequestration and release
6	Climate change	Sediment carbon storage	Assessment of levels of carbon storage in deep-sea sediments in minerals harvesting areas
6	Climate change	Blue carbon capture	Assessment of carbon capture in deep-sea ecosystems
5	Climate change	Ocean acidification	Assessment of potential for ocean acidification impacts from deep-sea minerals harvesting
4	Plume modelling	Plume modelling	Plume modelling studies
5	Plume modelling	Midwater plume modelling	Modelling of plumes associated with midwater discharges
5	Plume modelling	Benthic plume modelling	Modelling of plumes associated with seafloor disturbance
4	Noise modelling	Noise modelling	Modelling of underwater noise introduction and propagation
5	Noise modelling	Vessel noise	Modelling of underwater noise introduction and propagation associated with surface vessel activity
5	Noise modelling	Rise noise	Modelling of underwater noise introduction and propagation associated with nodule riser operation
5	Noise modelling	Collector noise	Modelling of underwater noise introduction and propagation associated with seabed minerals harvesting tools
4	Hazards assessment	Hazards assessment	Assessment of hazards
5	Hazards assessment	Hazardous materials	Hazardous materials assessment
5	Hazards assessment	Waste management	Waste management assessment
5	Hazards assessment	Extreme natural events	Extreme natural events hazard assessment
5	Hazards assessment	Accidental events	Accidental events hazard assessment
3	Ecosystem-based management	Ecosystem-based management	Studies to support minerals harvesting operation-wide ecosystem-based management. Refers to a suite of practices that lead a proponent through a process of applying ecosystem-based and evidence-based decision making in planning, execution, and assessment
4	Ecosystem-based management	Ecosystem model	Development of an ecosystem model, in qualitative or quantitative form, that represents an evidence-based representation of the ecosystem and causal links between pressures and receptors
4	Ecosystem-based management	Indicator and threshold setting	Setting of status indicators and safe operating thresholds. Setting of thresholds can be based on statistical inference and should link to pressures, multiple ecosystem features, and ecosystem services parts of the ecosystem model.
4	Ecosystem-based management	EMMP	Development of an Environmental Monitoring and Management Plan that is tuned to the ecosystem model outcomes and baseline data concurrent with the ESIA studies to ensure concordance and transition from baseline to monitoring in a unified system
4	Ecosystem-based management	Adaptive management framework	Development of a corporate adapative management framework to address operational direction modifications that may be required as a result of the findings of the environmental and social studies program

Footnote: "level" relates to the hierarchical level of the model structure and thus the table represents parent-child listing

The studies as defined here are able to be linked to the ISA's recommendations for exploration in the CCZ (ISBA/25/LTC/6/Rev.1). The ISA recommendations are listed more in terms of scientific discipline, pressure, or species groups than the ecosystem model language used in this Scoping Study (Table 13-5).

Table 13-5 ISA recommendations for exploration in the CCZ and study descriptions scoped in the present study.

ISA Study Recommendation	Moana Study Theme (Level 4 of the model hierarchy)
Physical oceanography	Physical oceanography
Chemical oceanography	Physical oceanography Water column structure Toxicology
Geological properties	Habitat structure and function
Biological communities	Benthic ecosystem
Demersal fishes and scavengers	Abyssopelagic and benthic boundary layer ecosystem
Phytoplankton and primary productivity	Pelagic ecosystem
Zooplankton	Pelagic ecosystem
Gelatinous zooplankton	Pelagic ecosystem
Nekton	Pelagic ecosystem Surface ecosystem
Mesopelagic micronekton	Pelagic ecosystem
Large mesopelopelagic taxa	Pelagic ecosystem
Fishes	Pelagic ecosystem Surface ecosystem
Noise	Noise Noise modelling
Vertical migration	Pelagic ecosystem
Trace metals and potential toxic elements	Toxicology
Marine mammals, birds, turtles, and sharks	Surface ecosystem
Bioturbation	Benthic ecosystem
Fluxes to the sediment	Benthic ecosystem Sediment biogeochemistry
Data management	Data management
Cooperative research	Environmental and Social Impact Assessment
Environmental Impact Assessment	Environmental and Social Impact Assessment
	Ecosystem services
	Climate and meteorology
	Climate change
	Ecosystem-based management
	Hazards assessment
	Social and cultural heritage

13.5. Specification of Key ESIA Field Studies

Field studies identified in the sceening study to be undertaken to support the ESIA for minerals harvesting listed as follows:

- **Physical oceanography**, including ocean currents, water column structure, noise and biological sounds, sediment flux using oceanographic moorings and Conductivity, Temperature, Density (CTD) casts.
- **Benthic habitat structure and function**, including acoustic surveys, imaging surveys and seafloor sampling.
- **Pelagic habitat structure and function**, including water column structure and water quality.
- **Toxicology**, including sediment and nodule physicochemistry, water quality, sediment toxicological risk and nodule toxicological risk.
- **Benthic ecosystem**, including megafauna and benthic ecology imaging surveys and seafloor sampling.
- **Abyssopelagic and benthic boundary layer ecosystem**, including abyssopelagic plankton and particulates, abyssopelagic fishes, scavengers and other megafauna, and opportunistic sensors.
- **Pelagic ecosystem**, including primary production, midwater particulates, midwater zooplankton and midwater micronekton.
- **Surface ecosystem**, including megafauna observations, cetacean acoustic sensing and megafauna movements and migration.
- **Ecological function**, including distributions and biogeography, biodiversity, food webs and population connectivity.

13.5.1. Socioeconomic Studies

Socio-economic studies to support the ESIA include the following:

- **Economic impact study**, including revenue, other benefits, industry impacts, gender and disadvantaged cohorts.
- **Subsistence and livelihoods**, including subsistence/artisanal marine resource use and contribution to nutrition.
- **Cultural heritage and traditional knowledge**, including values, beliefs, customs and traditions that relate to the marine environment and mapping of important cultural features (e.g., seafaring routes, fauna migration routes).

Stakeholder engagement and informal interviews, desktop assessment, environmental field studies and some modelling/projections (economic analysis) will be used to execute these studies.

Ecosystem services will be addressed and will include a study and analysis of provisioning services (commercial and non-commercial fisheries), cultural services, climate regulation and GHG.

13.5.2. Technical Studies

A number of technical studies will be undertaken as follows:

- **Ecosystem modelling**, including model components and definitions, indicators and thresholds.
- **Habitat mapping and spatial planning**, including geoform mapping, substrate mapping, biotope mapping and spatial planning.
- **Noise modelling**, including establishing project noise sources, project targets and modelling.
- **Plume modelling**, including plume model design criteria, project targets and modelling the behaviour and fate of project-derived subsea plumes.
- **Hazard assessment and oil spill modelling**, including natural hazard assessment, identification of upset events and modelling.
- **Greenhouse gas emissions and climate change** that will assess the project's potential effect on climate change.

13.6. Workshopping and Refinement

Through this desktop Scoping Study, the connections between the provisional ecosystem model, status indicators, and studies have been established to the extent that allows for the idenitifcation of study themes. It is envisaged that the design logic and studies will be presented to the SBMA and key stakeholders so that they can be further workshopped and refined.

The structure built around the study design requires that new issues or studies raised by regulators, researchers, and all stakeholders need to be inserted back into the model and supported by evidence and reasoning. Using the model as a 'screening' tool requires the linkages to be made between a pressure and an ecosystem response, description and linkage of status indicators, before the design of a study.

13.7. Collaboration Opportunities

The environmental program will need to maintain an adaptive management approach to respond to emerging opportunities that are currently unforeseen and that could arise as a result of the commencement of offshore research by multiple contractors. The Scoping Study has identified the following areas that are particularly suited to collaboration:

Multi-contractor funding of Saildrone, Argo, and other remote/drifting sensor arrays that provide data on the pelagic environment. These require disproportionately high mobilisation/start-up costs for a single contractor but, once mobilised, have very high data yields.

Platform-sharing of multibeam bathymetry surveys which, if mobilised by a third-party international provider, require disproportionately high mobilisation/start-up costs for a single contractor but, once mobilised, can complete multiple surveys.

Habitat mapping standardisation to provide SBMA and stakeholders with standardised classifications and understandings at the CIEEZ scale of the distribution of benthic habitat types.

Nodule classification standardisation to provide SBMA and stakeholders with standardised terminologies for nodule types at the CIEEZ scale.

Research including animal tagging studies on species that are wide-ranging, such as humpback whales.

13.8. ESIA Studies Program Environmental Risk Assessment

A risk assessment relating to the exploration program was undertaken in 2021 and assessed environmental sampling activities, sampling devices and instruments that will be used during the ESIA studies program. These activities will interact with the sea surface, atmosphere, water column and seafloor. During the ESIA studies, it is expected that interaction with the seafloor will cause negligible disturbances at the scale of the contract area and abyssal environment.

13.8.1. ESIA Studies Activities

At this stage, ESIA studies are expected to disturb an area of the seafloor less than 10,000 m^2 and will therefore be defined as Tier 2 activities that have low environmental risk. The Tier 2 exploration activities and the receiving environments are listed in Table 13-6.

Table 13-6 Tier 2 ESIA Studies Activities and Receiving Environment(s)

Activity type	Activity	Receiving Environment(s)
Vessel Operations	Mobilisation and demobilisation	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

13.8.2. Potential Environmental Risks

The potential risks of the ESIA studies program are identified in Table 13-7. 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 expeditions to the exploration area over the period 2019 to 2023 and those under 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 ESIA studies program are associated with the potential for Positive Impacts. The ESIA work program has the potential to create tangible positive impacts with respect to travel, accommodation and support services of vessel crew and scientists and we acknowledge the potential importance of this injection into the local economy in a post-COVID-19 recovery phase.

Table 13-7 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 (<10 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. Total spatial footprint of sampling will be less than 10,000 m^2 in area over the life of the exploration program.
		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,	Seafloor impact and substrate removal	NEGLIGIBLE Area of seafloor impact per deployment (~1 m^2) negligible compared to total abyssal habitat.

		removal of nodules and sediment		Volume of nodule and sediment removal per deployment (<1 m^3) negligible compared to total abyssal habitat. Total spatial footprint of sampling will be less than 10,000 m^2 in area over the life of the exploration program.
		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 OMs past interactions and experience of the SBMA 2020 stakeholder engagement process indicates low risk of negative perceptions.

13.8.3. Avoidance, Mitigation and Management Measures

Scientific sampling will be subject to Standard Operating Procedures that will be subject to a full Risk Assessment accompanying annual work plans prior to expeditions to assess the risks of the detailed scope of work.

Most Tier 2 activities of the exploration program are of negligible to low significance (see Table 13-7) and therefore preclude the need for specific mitigation measures. However, specific avoidance and management measures of the program will include:

- Use of state-of-the-art technologies and methods to track sampling equipment interaction with the seabed and clear documentation of cumulative area sampled/disturbed.
- Sharp look-out for cetaceans and other marine fauna while transiting and operating, including:
    - 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 behaviours 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.

- The following measures will be taken to maximize the potential positive impacts of the ESIA work program:
  - Maintaining a Rarotonga office, establishing business connections and staffing with individuals who can interface with stakeholders.
  - Provision of cargo and passenger services between islands.
  - Actively supporting regulator observer attendance.
  - Actively supporting training and education.
  - Producing data and reports for public dissemination and fostering evidence-based decision making.

13.8.4. Accidents and Emergencies

Accidents and emergencies will be avoided by the implementation of best international practice in offshore operations. 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 13-8 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

14. Stakeholder Engagement

A key requirement of the ESIA is obtaining not only the environmental permit for nodule harvesting, but also to obtain a social licence to operate. Best practice stakeholder engagement, structured within the ESIA framework, is one tool for obtaining that social licence.

Successful stakeholder engagement in an ESIA context seeks to ensure that by the time the EIS document is delivered, decision-makers and stakeholders:

- Already have an understanding of what the key environmental and social issues are for nodule harvesting and how they've been addressed.
- Already have an understanding of what the conclusions are, what the levels of impact are predicted to be, and have already considered whether those impacts are acceptable.
- Can easily understand the material and the logic to how the conclusions were reached.
- Have confidence that international best practice has been applied and a high quality product is presented.
- Can identify the connection between environmental and social matters and can identify the value of the new scientific knowledge generated.
- Can recognise their prior inputs and consultative input in the final product and therefore, identify with the document.

This chapter outlines the main components of the engagement approach and processes to achieve these objectives.

14.1. Engagement Objectives and Principles

Stakeholder engagement and participation is central to ESIA and EBM. The proposed approach to stakeholder engagement outlined below recognises the breadth of stakeholders that may have an interest in, or be affected by harvesting operations, including Government , NGOs and authorities, cultural authorities, and industry partners. The proposed approach also recognises the rights of Cook Islanders as 'principal rights holders' and 'resource owners' (or custodians) rather than simply stakeholders.

Moana's approach to stakeholder engagement reflects the principles within the Cook Islands National Seabed Minerals Policy 2014, which states that to minimise social impacts associated with seabed harvesting:

> *"…we will require that Title holders develop a participatory and collaborative approach to the planning and development of Seabed Mining Activities relating to their Title, taking into account the needs of Cook Islanders".*

Further, an objective of the Seabed Minerals Act is to:

> *"..promote a co-operative approach to the management of the seabed minerals of the Cook Islands involving government and island communities."*

The approach is also underpinned by the Marae Moana Act (2017), which provides a framework to promote sustainable development by balancing economic growth interests such as tourism, fishing, and nodule harvesting, with conserving core biodiversity and natural assets, in the ocean, reefs, and islands. The Act incorporates a 'principle of community participation', which 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".*

Therefore, the objectives of stakeholder engagement are to:

- Inform Cook Islanders and other relevant stakeholders about harvesting operations, including its potential impacts and benefits.
- Map and understand the different views, concerns and interests of the Cook Islands community and other stakeholders.
- Ensure that Cook Islanders are supported to participate in the ESIA process.
- Provide a framework to assess, screen, and manage stakeholders' concerns, expectations, and issues.
- Build, maintain, and enhance Government and community relationships.
- Identify the key social and environmental issues that need to be addressed in the ESIA, feeding those issues back into the overall ecosystem model and study design.
- Inform proposed impact mitigation and management measures as well as the initiatives to deliver socio-economic benefits.

To effectively deliver these objectives, the following engagement principles apply:

This Scoping Study has identified the stakeholders listed in Table 14-1. This list is not exhaustive and will be updated throughout the scoping and planning phases as additional stakeholders are identified.

Table 14-1 Relevant stakeholders.

Stakeholder	**Interest/influence**
Cook Island Government	
Seabed Minerals Authority (SBMA)	The *Seabed Minerals Act 2019* establishes the SBMA as a statutory agency of the Government of Cook Islands. The SBMA is responsible for the licensing of exploration and exploitation activities. 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 Cook Islands, and additional members as required. The SBMA is responsible for issuing an Exploration Permit and must ensure that the principles of the *Environment Act 2003* are upheld; i.e., controlling the permitting of activities that have the potential to cause significant environmental impacts.
National Environment Service (NES)	The Cook Islands NES is the agency responsible for permitting, monitoring and enforcing environmental laws under the *Environment Act 2003.* The NES also plays an important role in research and stakeholder engagement in the area of sustainable development of seabed minerals harvesting in Cook Islands. The NES is responsible for approving the EIA and setting conditions of the environment permit.
Marae Moana Council	The Cook Islands *Marae Moana Act 2017* establishes the entire CIEEZ 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. The Marae Moana Council (MMC) and its Technical Advisory Group (TAG) and Coordination Office are responsible for the zoning of the marine environment and any associated regulations. The Council is chaired by the Prime Minister and comprises the opposition lead, representatives from the private sector, traditional leaders, the NGO sector, the religious sector through the Religious Advisory Council, as well as a representative from the Southern Cook Islands and a representative from the Northern Cook Islands. The TAG is comprised of representatives from the Office of the Prime Minister, NES, MMR, SBMA, Ministry of Transport, House of Ariki or Koutu Nui, and NGOs with marine science and social policy expertise. The Coordination Office sits within the Office of the Prime Minister and coordinates implementation of the Policy, any revisions required, and the development of the Marae Moana Action Plan. On Rarotonga, the MMC oversees implementation of the Marae Moana Policy (2016 – 2020) and associated Action Plan relating to the Rarotonga coast as well as offshore throughout Cook Islands.
Ministry of Marine Resources (MMR)	The MMR is a Government department tasked with ensuring the sustainable development of the living and non-living marine resources for the benefit of the people of Cook Islands. The marine environment contains many of the nation's major exploitable natural resources. Currently, marine resources are exploited through aquaculture (black pearls), offshore fishing (tuna and other pelagic species), and coastal reef fisheries (trochus, aquarium fish, reef fish etc).

Stakeholder	**Interest/influence**
House of Ariki	The House of Ariki is a parliamentary body made up of high chiefs that is tasked with representing the best interests of the people of Cook Islands. They advise Government on traditional matters such as land ownership and custom. In Parliament, the House of Ariki may be asked to respond, through expression of opinion and/or to make recommendations to the elected Parliament on matters that may affect the welfare and/or interests of the people of Cook Islands. The composition includes one Ariki from each of the inhabited outer islands with Rarotonga represented by six Ariki.
Koutu Nui (Council of Traditional Leaders)	In 1972, the House of Ariki Act was expanded to make room for a second national body of traditional leaders: the Koutu Nui. Its legal function is to consider and make recommendations to Parliament and the House of Ariki on matters 'relating to the customs, traditions (and usages of the indigenous people) of the Cook Islands'. Recommendations or resolutions are conveyed by the Koutu Nui to the House of Ariki's through the Clerk of the Parliament or to the Government of Cook Islands through the Prime Minister. Any (undisputed) Titleholder can choose whether or not they want to become part of the Koutu Nui.
Religious Advisory Council (RAC)	The Cook Islands RAC was founded in 1968. Established to discuss vital religious issues, it comprises six church denominations: the Cook Islands Christian, Roman Catholic, Church of Latter Day Saints of Jesus Christ, Seventh Day Adventist, Assembly of God and Apostolic Church. The Cook Islands Government may refer religious matters for the Council to review, seek views from the RAC perspective, when public reaction over statements or programmes made through the news media, TV, radio, and community has religious connotations.
Ministry of Finance and Economic Management (MFEM)	The MFEM is a Government agency responsible for advising the Government on financial and economic issues. The MFEM publishes regular economic forecasts and reports, including social and economic statistics. The MFEM has recently (2021) published a National 10-year Economic Development Strategy that establishes five priorities to drive economic development.
Ministry of Transport (MoT)	The MoT (maritime section) is responsible for the administration of the *Maritime Transport Act 2008* and associated rules and regulations. The marine section is also responsible for ensuring obligations under international maritime laws and conventions are met. In addition, the section has responsibilities related to aids to navigation and maritime safety information. The MoT also regulates civil aviation.
Ministry of Marine Resources (MMR)	The MMR will be interested in offshore biological assessments and will hold data on fisheries resources that will be used in the ESIA.
Cook Islands Ports Authority (CIPA)	The Port Authority will have an interest in any development in and/or use of the port facilities and a mandate to ensure sustainability of existing services in Rarotonga.
Cook Islands Ministry of Cultural Development	The Ministry may have an interest in informing the assessment of potential impacts on tangible and intangible cultural heritage.
International Bodies	
New Zealand Government and Governments in Oceania	The New Zealand Government in particular is expected to have a keen interest in the development of deep-sea minerals harvesting in Cook Islands. From the perspective of environment and social impacts, but also from the

Stakeholder	Interest/influence
	perspective of financial, legal and technical advice provisioning and facilitating some of the Governments' sustainable development objectives such as repatriation and training. Furthermore, Pacific Island transboundary issues and cooperation will be expected. Indeed, Australia has already played a role in providing due diligence advice through the Exploration Licence tendering process and such financial, legal, and technical interaction may occur throughout. Many of these interactions may be outside of Moana's direct influence of mandate, but they should be noted.
International Seabed Authority (ISA)	While outside the ISA jurisdiction, there will likely be 2-way feedback between the ISA and Cook Islands. The SBMA and NES will be expected to look to The Area to gauge best practice and leverage existing knowledge as to how to handle things like regional environmental management and data sharing. The ISA will likely look to Cook Islands to see how processes and findings of their processes can inform the way things are handled in The Area.
Cook Islands Industry/Business Sector	
Training providers	Training providers in Cook Islands and Oceania will play a role in providing services to support the Government's capacity-building and training objectives, which will require interaction with Moana and other contractors to establish those requirements and standards.
Commercial fisheries	The commercial fishing sector may have an interest in the studies and potential interactions with the commercial fishing fleet. Commercial fisheries data will also be sought for use in the ESIA through the MMR.
Marine tourism operators	The marine tourism sector may have an interest in potential interactions with tourism vessels and potential environmental impacts that could indirectly affect tourism activities and/or marketing.
Business sector representatives/peak bodies/unions	Businesses that seek to benefit from the development of the minerals harvesting, or pivot their operations to provide services to operations, may have an interest in, for example, setting standards and industry cooperation guidelines.
Media	Television and newspaper services in Cook Islands are important avenues for information dissemination locally. There is likely to be considerable interest from Cook Islands News Limited in particular and media representations need to be carefully managed and handled by individuals with appropriate training and experience.
Conservation Organisations	
The Living Oceans Foundation (LOF)	The LOF runs research projects in the Cook Islands region which focus on monitoring and mapping of coral reef habitats.
Te Ipukarea Society	Te Ipukarea Society is an environmental organisation based in Cook Islands and formed to help look after the country's Ipukarea, (heritage). They are members of the IUCN and Birdlife International and a member of the MMC's TAG.
Secretariat of the Pacific Regional Environment Programme (SPREP)	The SPREP is a regional organisation comprising 21 Pacific Island member countries and territories. It is guided by its vision for the future: "a resilient Pacific environment, sustaining our livelihoods and natural heritage in harmony with our cultures", and is charged with protecting and managing the environment and natural resources of the Pacific.
Pacific Islands Association of NGOs (PIANGO)	PIANGO strengthens and builds the capacity of the civil society sector through giving the sector a voice in policy formulation and development and

<table>
<tr><th>Stakeholder</th><th>Interest/influence</th></tr>
<tr><td></td><td>strengthening the National Liaison Unit or the umbrella organisations in the 23 member countries of the Pacific.</td></tr>
<tr><td>Aitutaki Conservation Trust</td><td>The ACT was formed in 2007 and aims to protect Cook Islands’ land, lagoon, and culture through education and positive action. The ACT runs school excursions to their Marine Research Centre and Lagoon ‘rā’ui’ areas (protected moratorium areas); to teach our children about the importance of our local fisheries and waterways.</td></tr>
<tr><td>Pew Charitable Trusts</td><td>Pew’s ocean work includes efforts to create large marine reserves; end illegal fishing; protect key species such as penguins, sharks, tuna, and foraging fish; and establish policies that protect, maintain, and restore the health of marine ecosystems.</td></tr>
<tr><td>Ocean Foundation</td><td>The Ocean Foundation’s mission is to support, strengthen, and promote those organizations dedicated to reversing the trend of destruction of ocean environments around the world.

The Ocean Foundation runs a ‘Deep Sea Mining Campaign’, which is an association of NGOs and citizens from Australia, Papua New Guinea, and Canada concerned about the likely impact of deep-sea minerals harvesting on marine and coastal ecosystems and communities. The goal of the campaign is to develop an active, broad-based and informed Civil Society response to Deep Sea Mining in the Pacific region. In particular, the aim is to achieve Free Prior and Informed Consent (FPIC) from affected communities and the application of the precautionary principle in decision-making about deep-sea minerals harvesting.</td></tr>
<tr><td colspan="2">Research Organisations</td></tr>
<tr><td>Research agencies</td><td>Several research agencies have a footprint in Cook Islands and will likely have an interest in the Moana 1 Project from the perspective of conductive research, supplying students and interns, but also from the perspective of advising Government as to acceptability of risk or generating position papers.

Agencies include:
South Pacific Whale Research Consortium National Institute for Water and Atmospheric Research (NIWA)
The Crawthorn Institute
University of the South Pacific
CSIRO Australia
South Pacific Applied Geoscience Commission (SOPAC)
Aitutaki Marine Research Centre
Centre for Cetacean Research and Conservation</td></tr>
<tr><td colspan="2">Community Stakeholders</td></tr>
<tr><td>Cook Islands Community</td><td>Those not aligned with or part of the above groups, but who may have some interest in minerals harvesting, e.g., what benefits, or impacts may affect them personally (e.g., job or training opportunities, public spending, identity, and stewardship).</td></tr>
<tr><td>Affected communities</td><td>People or communities directly affected by minerals harvesting activities. This could include those people who have customary rights to areas impacted by development, or where subsistence activities and livelihoods are affected by minerals harvesting activities.</td></tr>
</table>

14.2. Engagement Approach

14.2.1. Project Positioning

Moana acknowledges that nodule harvesting is an emerging industry, and while there have been multiple studies of its viability since the 1970s, there are no existing operations today. Therefore, there is a recognition that there will be uncertainty, concerns, voices of support, and opposition. The engagement approach will therefore need to carefully balance emerging concerns with maintaining focus, while at the same time correcting potentially impactful misinformation.

Moana is committed to evidence-based decision making and sustainable development of nodule harvesting. Through a process of transparency in the ESIA and active engagement and participation, Moana is committed to working closely with stakeholders throughout the EIA process. The ecosystem model approach, which resolves to ecosystem services, places people within the ecosystem and reinforces the linkages between natural resource exploitation and people.

In a practical sense, Moana will maintain a strong local presence though an operations base and office. Information and feedback mechanisms will be established to manage stakeholder contact and enquiries.

14.2.2. Levels of Participation

The IAP2 Spectrum of Public Participation (IAP2, 2018) is a global best practice model that sets out five levels of increasing influence that the public can have on an outcome or decision. From 'Inform' to 'Empower' the Spectrum sets out goals and commitments at each level.

The IAP2 model was used to define appropriate engagement methods for engagement, based on the level of stakeholder influence and potential impact, the purpose of engagement, and their role (i.e., regulator/decision-maker, group or umbrella organisation, individuals personally affected etc). Figure 14-1 outlines the IAP2 public participation model that underpins stakeholder engagement.

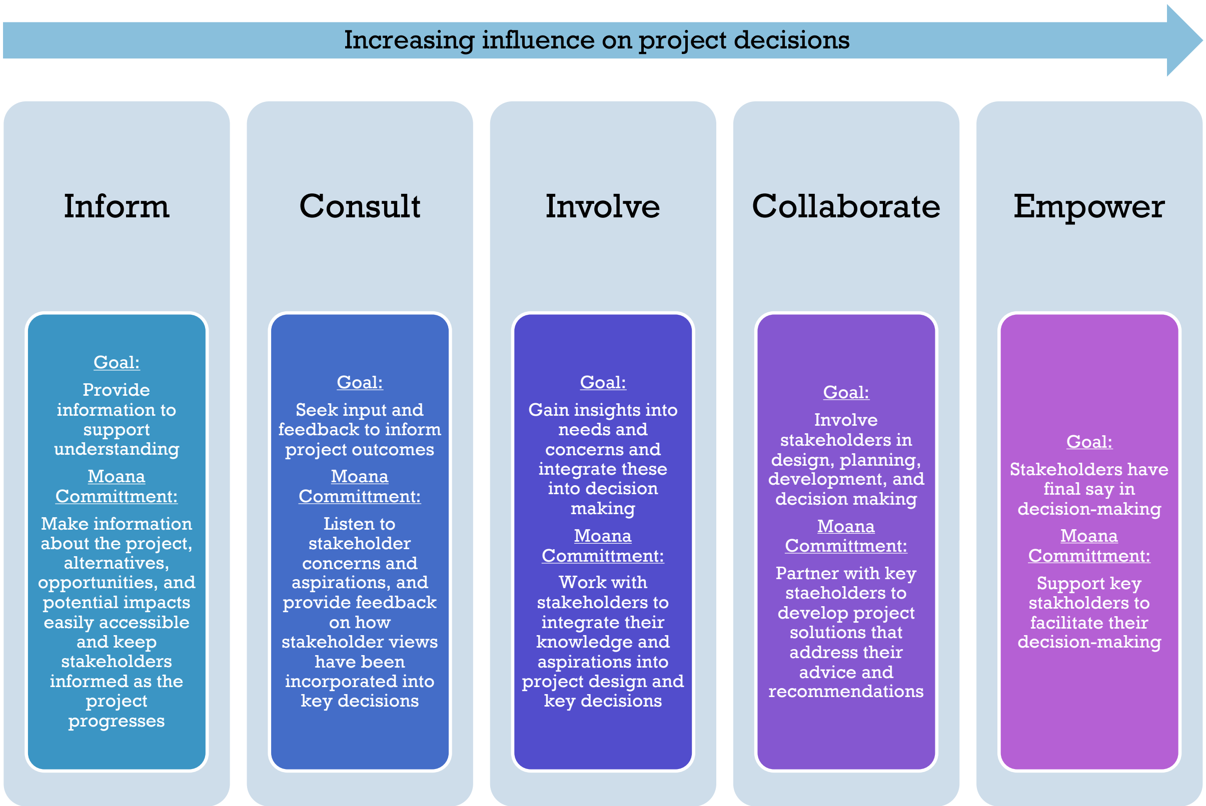


Figure 14-1 Levels of public participation based on IAP2 Spectrum of Public Participation.

14.2.3. Inclusive Participation

Moana acknowledges and understands that communities are not homogenous, and that there are different groups of people (audiences) with different backgrounds (e.g., educational, economic, cultural), access to communication methods, and engagement needs and preferences. The geography of Cook Islands can make it difficult for some Cook Islanders to physically attend meetings or information sessions, or even access information digitally. Others may find it difficult to find time to participate due to work commitments or due to subsistence activities.

Moana is committed to supporting all interested or affected stakeholders to participate in the ESIA process, and therefore, these are considerations that will underpin a future Stakeholder Engagement Plan (SEP). Some of the ways Moana will support inclusive participation include:

- Avoiding technical jargon and acronyms; and using plain English, particularly when describing technical matters.
- Using maps, figures, and pictures where possible to support narratives.
- Breaking down information into smaller ‘bite-sized chunks’ to avoid ‘information overload’.
- Asking stakeholders how they would like to engage (i.e., what methods, when, where, and by whom).
- Utilise established community leaders to support the communication of project information and the collation/representation of community issues or concerns.

- Being clear on the purpose of every engagement, and providing feedback to participants on what was heard, and how it will be incorporated into the project.

As the project progresses, stakeholder feedback will inform the ways that Moana can continue to provide support for inclusive participation.

14.2.4. Engagement Methods

Some of the methods Moana will implement during stakeholder engagement include:

- Engagements to be led by Moana's in-country liasion manager.
- Asking stakeholders how they would like to engage (i.e., what methods, when, where, and by whom).
- Seeking collaboration with the SBMA to support the engagement.
- Travelling to outer islands for engagements and seeking support from the SBMA to establish necessary permissions and processes.
- Avoiding technical jargon and acronyms; and using plain English, particularly when describing technical matters and using maps, figures, and pictures where possible to support narratives.
- Being clear on the purpose of every engagement, and providing feedback to participants on what was heard, and how it will be incorporated into the project.
- Maintaining a register of engagement.

As the project progresses, stakeholder feedback will inform the ways that Moana can continue to provide support for inclusive participation.

Effective engagement requires tailoring methods to the engagement purpose and to the needs or preferences of stakeholders. Table 14-2 details some of the methods that are expected to be applicable during the project.

Table 14-2 Stakeholder engagement methods.

Method	Description
Face-to-face meetings	Meetings will be held with screened and categorised stakeholders
Informal community gatherings	Informal community gatherings help to maintain local relationships and provide an opportunity for interested community members to ask questions and discuss issues or concerns.
Formal community meetings	Formal community meetings will be used to present study findings and seek input to proposed management measures. It is expected that the SBMA will take a lead role in the organisation and administration of these meetings.
Telephone calls and video conferences	Phone and video conferencing will be used where face-to-face meetings are not possible, or as a follow up tool (in addition to email), once a face-to-to face meeting has occurred.
Letters and emails	Letters and emails will be used to disseminate project information and as a feedback mechanism to update stakeholders on how their comments and/or concerns have been considered.
Newsletters and fact sheets	Hard copy and online newsletters and fact sheets will be used to keep stakeholders informed about the status and progress of the project, and to provide information about specific issues or topics.

Method	**Description**
Website	A project website will be developed as a central repository for project information, communications, and to make finding contact details easy. It will be updated regularly to reflect changes in the project or regulatory status.
Community Liaison Officer	A locally based Community Liaison Officer will be available at the Moana Minerals office in Rarotonga to facilitate face-to-face engagement. Contact details will be advertised.
Participation in data collection activities	There will be opportunities for some stakeholders to be involved in the process of collecting data to inform the impact assessment. The project data management mechanism will provide opportunities for 'online dashboard' style interfaces and standard reporting outputs.
EIA process/scoping workshops	Screened stakeholders may be invited to participate in workshops to help scope elements of the project impact assessment, including studies.
Capacity-building/ knowledge workshops	Screened stakeholders may be invited to participate in workshops designed to elicit traditional knowledge and understanding of human-environment relationships relevant to the project, and to facilitate information sharing and capacity building between the local community and the project team.
Community interviews	Interviews may be used to seek detailed information on potential project impacts and management strategies.
Grievances/complaints management	A grievances and complaints procedure will be developed.
Media/newspapers	Media releases will be issued periodically to keep the general Cook Islands and international communities up to date with project activities and findings.
EIA documentation	There will be opportunity for public comment on the ESIA documentation during the assessment process.

15. Permitting and Development Timetable

15.1. Permitting Structure

The Cook Islands Environment Act (2003) is the core legislative instrument controlling environmental permitting and applies throughout Cook Islands, including the territorial sea and EEZ. The Environment Act is enfoced by the NES and is upheld by the Cook Islands Seabed Minerals Act (2019) and the subsequent Seabed Minerals Amendment Act (2020) and Seabed Minerals Amendment Act (2021). Other relevant Cook Islands legislation is listed in Section 2.1.

The Environment Act provides for the following:

- **Parts 1 to 2:** Establishment, powers, and functions of the NES (already provided by the repealed Rarotonga Environment Act) and the Island Environment Authorities.
- **Parts 3 and 11:** Convening of the National Environment Council and the Cook Islands Environment Forum with the purpose of determining policy direction and programs, reviewing compliance and obligations to the Act, and international treaties and protocols.
- **Part 4:** Appointment of National Environment Officers and their powers.
- **Part 5:** Environmental impact assessment (EIA) and environmental planning.
- **Part 8:** Recognition of the most vulnerable areas to development such as the foreshore area, the wetlands, and the sloping lands and therefore, the establishment of protected areas.
- **Part 9:** Establishment of an Environment Protection Fund and its use.
- **Section 70:** Regulations for waste and pollution may be made by the Queen's Representative from time to time by Order in Executive Council.

Moana will conduct an EIA in accordance with the requirements of the Environment Act (2003), the 2023 environmental regulations, other relevant Cook Islands legislation, international agreements to which Cook Islands is a signatory, and international best practice in environmental management.

15.2. ESIA Phases

15.2.1. Environmental Significance Declaration

Under Part 3 of the Environment Act (Permits and Consents) Regulation 2005, an Environment Signficance Declaration Form is to be submitted to the NES along with an assessment fee. This form describes the harvesting operations, environmental setting, and sensitivities. The declaration allows the NES to assess the submission in terms of the potential significance of effects, the activity tier, and therefore, the requirements of the environmental assessment. Pursuant to the Draft Environment (Seabed Minerals Activities) Regulations, Moana's *minerals harvesting* operations will automatically be deemed to be a Tier 3 Activity and will therefore, require an EIA (which Moana is casting as an ESIA).

The present ESIA Scoping Study will form part of the supporting documentation for the Environment Signficance Declaration Form.

15.2.2. Terms of Reference

Under Part 5 of the Environment Act (Permits and Consents) Regulation 2005, a Terms of Reference will be prepared for the proposed minerals harvesting by the NES. The Terms of Reference acts as a guide for the preparation of the EIA and will stipulate the environmental baseline studies to be undertaken, a task that would be aided by this Scoping Study.

The regulations contain considerable detail on the review and consultation process. It is our understanding that the NES-drafted Terms of Reference does not go out for public consultation, but this is an area for further clarification moving forward.

15.2.3. ESIA Studies and EIS Document

15.2.3.1. Environmental Baseline Studies

A key consideration for the environmental baseline studies is the management of expectations from the regulator and stakeholders as to what the baseline studies aim to achieve. Any one ESIA baseline program by any one proponent cannot address all research aspects of the deep-sea or define the full temporal variability. As such, the focus must be on characterising the key features of the environment, defining the key drivers of ecological function, and providing a baseline for the indicators that are relevant to environmental management and monitoring.

In relation to nodule harvesting in the CCZ, there has been considerable effort in ISA-sponsored workshops to address the issue of residual uncertainty in the EIA process. Moana's approach to the environmental baseline will be to:

1. Acknowledge that a level of scientific or ecological uncertainty is inherent in every EIA and cannot be eliminated altogether. The focus will therefore be on reducing uncertainty to levels judged acceptable to regulators, stakeholders, reviewers, based on the best available scientific evidence.
2. Focus the baseline studies on the types of information required for the ESIA.
3. Address residual uncertainty in a transparent manner in a high quality and comprehensive ESIA, and implement ongoing monitoring to confirm predictions.
4. Recognise that the opportunity to collect baseline environmental information does not end at the moment that an Environmental Permit is granted. Rather, baseline data collection will continue in many areas, baseline infill studies may be required as a condition of permit approval. Monitoring requirements will be set out in the Environmental Management Plan and will be ongoing should the project proceed.

15.2.3.2. Environmental Impact Assessment Technical Studies

EIAs rely on technical expertise in impact assessment, with specialisations in various disciplines (e.g., plume modelling, ecotoxicology, benthic biology, etc.). The core EIS technical studies will analyse and interpret data generated in the baseline and link with project engineering development information to inform the impact assessment.

Technical studies will form Technical Appendices of the EIS document and the information will be synthesised into the impact assessment in the main body of the EIS. The EIS Technical

Appendices therefore, form the evidence base for the impact assessment. While most members of the public may not read the Technical Appendices, relying only on the interpretations provided in the main body test of the EIS, expert independent review panel members, and some high-level stakeholders will carefully review the primary data in Appendices.

15.2.3.3. Environmental Impact Statement

Section 63 of the Draft Environment (Seabed Minerals Activities) Regulations 2020 sets out the required content of the EIS.

The EIS will be a multi-volume document comprising: An Executive Summary, EIS Main Report chapters, Technical Appendices (housing baseline data and EIA technical studies). The final EIS document will also be via presentation and information materials intended to communicate the findings.

The EIS is a multi-author document, with a core team from the EIA consultant bringing the document together. EIS chapters are somewhat standardised across the industry and will address the requirements described in Section 63 of the Draft Environment (Seabed Minerals Activities) Regulations 2020.

15.2.4. EIS Submission (Application for a Project Permit)

Section 63 of the Draft Environment (Seabed Minerals Activities) Regulations 2020 sets out the process for EIS submission, which occurs as part of the application for a Project Permit. Section 27 of the regulations state the permit application also requires payment of a fee and submission of a draft environmental management plan and draft closure plan.

Once all aspects of the application are submitted, the NES must, within 20 days, determine whether the application complies with Section 27 of the regulations. If the application is incomplete, it will be need to be completed before resubmission.

EIS submission is a major milestone that will be partnered with in-country personal delivery of the EIS, stakeholder consultation, press release, and other activities.

15.2.5. EIS Public Consultation and Review

Once the Application for a Project Permit is deemed to be complete, the EIS will (within 10 days) be made available on a Government website to the public for comment for a period of 20 days. The NES has the option of extending the public comment period for an additional 20 days.

At the same time as the public comment period, the NES will write to the responsible Minister, the Ministries responsible for marine resources and transport, the MMC and TAG, and any other Crown agency or stakeholder as determined by the Director, seeking comments on the EIS within 20 days. The NES will also consult with the SBMA.

Within 10 days after the closing date for comments, the NES will forward to the applicant a list and a copy of all the comments that it has received in relation to the public notice and all written submissions from Government agencies. The applicant then has 10 days to respond to these comments and submissions.

Within 10 days of receiving responses from the applicant, the NES will summarise all public and Government comments and applicant responses.

Section 30 of the regulations allow the NES to commission an independent review of the EIS. This is normal for major development projects and would be expected to involve engaging either an alternative EIA consultant and/or a panel of experts in the fields of technical specialisations covered in the EIS. Government agencies and academic institutions may be involved in the peer review process. Given the nature of the EIS, it is expected that the review phase will involve high profile academic researchers at some level.

The NES will prepare a report for the Permitting Authority that will include a summary of key issues to be considered, comments received, Moana's responses, any independent peer review, advice from Crown agencies, and other information as required. The report must be submitted to the Permitting Authority within 30 days after the NES has received all comments on the EIS. This NES-draft assessment (recommended decision) report is to be accompanied by the application, EIS, and other relevant information. The report will be made publicly available on the NES website. As such, we identify here the potential for two rounds of public consultation of the EIS material, which is an area for further clarification moving forward. Section 38 of the regulations allow the Permitting Authority to commission an independent review of the NES report to the Permitting Authority.

15.2.6. Permit Approval

Following assessment of the application by the Permitting Authority and assuming the application is acceptable, the Permitting Authority will issue a permit with conditions within 90 days of reveiwing the application. Section 47 of the regulations allow for an additional 30 days to issue the permit.

Permit conditions may include environmental performance requirements, require a bond, prescribe discharge points and discharge rates/volumes, require a revised environmental management plan and closure plan by certain dates.

15.2.7. Environmental Management Plan

Part 6 of the regulations addresses the requirement for an environmental management plan, which state the plan must:

- Be based on the EIA and the EIA report.
- Be prepared in accordance with the applicable standards and guidelines.
- Be consistent with the closure plan and incident response and management plan.
- Set out the environmental performance standards for the control measures.
- Set out the environmental performance outcomes against which the performance of the holder in meeting the environmental management objectives for each environmental factor in the environment plan must be measured.
- Set out the measurement criteria for determining whether each environmental performance objective or outcome and environmental performance standard is being met.

Under Section 74 of the regulations, the Permitting Authority has 60 days to either accept the Environmental Management Plan or request modifications.

Within 10 days after receiving a notification from the NES that the Permitting Authority has accepted the Environmental Management Plan, Moana must submit to a non-technical summary of the plan to be made publicly available on the NES' website.

Once approved, and subject to obtaining the minerals harvesting licence and any other permits, nodule harvesting can commence.

16. References

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APPENDIX 1

Issue/Impacts Screening Assessment

Project Component	Category	Sub-category	Potential Impact (Negative and Positive)	ESIA Inclusion	Baseline Data Collection Study	Desktop Study	Modelling Study	Comment
Whole of Project	Ecosystem Services	Cultural services	Operation of project (e.g Influx of workers, financial opportunity) negatively affects other ventures such as tourism, cultural/spiritual values, maritime cultural heritage, natural pristine existence value, and other cultural ecosystem services	YES	YES	YES	NO	Baseline program to establish cultural services including traditional belief systems and cultural identity connection to the ocean. ESIA to include assessment of potential impacts to cultural values.
		Regulating and supporting services	Operation of project negatively affects regulating and supporting ecosystem services such as climate regulation, ocean and air flows, sequestration, bioremediation, decomposition, waste absorption and others	YES	YES	YES	NO	ESIA to address the area's capacity for regulating and supporting ecosystem services through the environmental baseline, and assess the impacts to these from project development.
		Provisioning services	Operation of the project negatively affects commerciaor artisanal fisheries or nearshore artisanal fisheries, aquaculture, shipping and other provisioning services	YES	YES	YES	NO	ESIA to establish provisional services potentially impacted by the project with a focus on fisheries.
	Socio-economics and Communities	Socio-economic values	Project generates increased demand for and disruption to social services and infrastructure (e.g. water and energy supply, communications, sewage and waste disposal, fire protection, police, schools, medical care)	NO	NO	NO	NO	Not the mandate of proponent. Cook Islands government has policies and responsibilities for social services to develop as the needs of the community arise. Sustainable development policies are in place in the Cook Islands to ensure the social demands created by the project are met. OML to liaise closely with SBMA and other regulators throughout project to provide industry input to such considerations and to communicate any unexpected project-derived impacts.
			Project generates increased demands on power, communications, and related infrastructure	NO	NO	NO	NO	Any upgrades to existing infrastructure are expected to be negligible and the needs of the project are in-line with existing goods transport processes in Cook Islands. However, it is acknowledged that demand pressure from the project may generate prioritisation conflicts with shipping supply processes. Sustainable development policies are in place in the Cook Islands to ensure the social demands created by the project are met. OML to liaise closely with SBMA and other regulators throughout project to provide industry input to such considerations and to communicate any unexpected project-derived impacts.
			Project generates increased demand for housing/accommodation to accommodate workforce	NO	NO	NO	NO	During operations, there is expected to be minimal workforce housing requirements on land. The mining crew transfer process will utilise existing passenger transport facilities including crew transfer vessel, domestic flights, existing accommodation in Aitutaki and Rarotonga. However, it is acknowledged that demand from the project may add additional pressure. Sustainable development policies are in place in the Cook Islands to ensure the social demands created by the project are met. OML to liaise closely with SBMA and other regulators throughout project to provide industry input to such considerations and to communicate any unexpected project-derived impacts.
			Cook Islands Government focus and resources on deep sea mining, opportunity cost for other development options (e.g. change in industry composition, dominance by foreign entities in a high-tech industry)	NO	NO	NO	NO	Not the mandate of proponent. Deep-sea mining (DSM) development is under government regulatory control and does not preclude other development options. DSM development will be subject to requirements of sustainable development guidelines.
			Benefits of renewable technologies driving deep-sea mining not able to be realised in Cook Islands	NO	NO	NO	NO	ESIA to address overall social impact. Particular issue listed here is the potential for benefits of renewable technologies (principally electric vehicles) to be realised in western economies and not directly transferable to Cook Islands. However, global climate change can disproportionately affect Pacific Island nations, so benefits globally will be realised. Cook Islands zero emissions goals to considered and technological cross-overs are possible to achieve local benefits.
			Project generates increased stress on capacity of ports, roads and the existing transport system	YES	NO	YES	NO	The ESIA will describe the project requirements. The Production Vessel and Ore Transhipment Vessels will not mobilise from the Port of Avarua and are not envisaged to interact with the Port in any way. Supply/support vessels and crew transfer vessels will mobilise from the Port of Avarua and/or Arutanga Harbour at Aitutaki Island. However, Cook Islands government has policies and responsibilities for services to develop as the needs of the community arise. Sustainable development policies are in place in the Cook Islands to ensure the social demands created by the project are met. OML to liaise closely with SBMA and other regulators throughout project to provide industry input to such considerations and to communicate any unexpected project-derived impacts.
			Interference with existing subsea facilities and marine uses	YES	NO	YES	NO	ESIA to address potential interference with existing facilities and users. Telecommunications in the Cook Islands are provided by the Manatua sub-sea cable. The Project will have no interaction with this cable and is not located in an area that could impact future sub-sea cables.
			Project revenue to government	YES	NO	YES	TBD	ESIA and economic impact studies will identify revenue for Cook Islands and the Social Impact Assessment will identify areas for potential consideration. Level of economic modelling required to be dictated by resource modelling and requirements of finance regulator. However, government is responsible for directing expenditure and it is not the manadate of proponent to influence.
			Project generating training or educational opportunities for Cook Islanders	YES	NO	YES	NO	ESIA and project economic studies will identify the ongoing training and educational opportunities. Environmental baseline program will integrate with education agencies to identify best avenues for education and training.
			Direct economic benefits for people and communities	YES	YES	YES	NO	ESIA and project economic studies will identify revenue streams. Government sustainable development policy will direct benefits as required, particularly in the area of jobs and flow-on economy.
			Industry development opportunities	YES	YES	YES	NO	The project will require a number of local supporting services that could be developed (e.g. logistics, equipment fabrication, materials handling and freight, offshore marine crew).
		Community structures	Project generates an activation of or changes to traditional governance structures	NO	NO	NO	NO	Project to operate within government policies and legislation enacted by the Seabed Minerals Authority. Traditional governance is handled at the government level. The project will interact with traditional owners as required, but no additional traditional governance structures such as cultural hierachies or land ownership conflicts are foreseen.
			Project causes an encroachment into existing settlement areas or customary lands	NO	NO	NO	NO	Project to operate within government policies and legislation enacted by the Seabed Minerals Authority. The project will interact with traditional owners as required, but no encroachment onto customary lands is foreseen.
			Project causes an infringement on customs or customary rights	NO	NO	NO	NO	Project to operate within government policies and legislation enacted by the Seabed Minerals Authority and the Marae Moana Act. The project will interact with traditional owners as required, but no infringement of customary rights is foreseen.
			Project causes Restrictions in access to customary areas or restrictions in resource use in customary areas	NO	NO	NO	NO	Project to operate within government policies and legislation enacted by the Seabed Minerals Authority and the Marae Moana Act. The project will no require additional levels of access to restricted areas.

			Project and revenue generates social disruption that causes increase in domestic violence, sexual violence, substance abuse and trafficking, prostitution, change in social norms, pace of change for vulnerable communities	YES	NO	YES	NO	Social Impact Assessment to address these matters, but no specific baseline studies expected. The project will employ both local Cook Islanders and ex-pats, and the terrestrial personnel and infrastructure will be limited, unlike terrestrial mines where these problems area exacerbated. The tourism based economy in Cook Islands means that locals and services are already accustomed to large ex-pat presence.
			Project and revenue generates social disruption that causes impacts to community cohesion	YES	NO	YES	NO	Social Impact Assessment to address these matters, but no specific baseline studies expected. The project will be developed within government sustainable development guidelines and policies.
			Project causes an influx of an external workforce or in-migration to the project area	YES	NO	YES	NO	Social Impact Assessment to address these matters, but no specific baseline studies expected. The project will be developed within government sustainable development guidelines and policies. The influx of personnel will be limited and in-line with existing tourism movements, unlike terrestrial mines where these problems area exacerbated. The specialised nature of offshore work which requires training and certification is expected to limit the levels of in-migration for job-seeking.
			Project causes creation of local jobs/ livelihood opportunities for Cook Islanders encouraging Cook Islanders to stay in-country or for ex-patriots to return to Cook Islands with commensurate skills transfer	YES	NO	YES	NO	Social Impact Assessment to address these matters, and opportunities for retention of youth and transfer of skills exist but no specific baseline studies expected. The project will be developed within government sustainable development guidelines and policies.
			Project and revenue cause negative impact to traditional way of life for outer Islanders, with potential flow-on effects to diet and health	YES	NO	YES	NO	Social Impact Assessment to address these matters, however the impact to traditional ways of life on outer islands is expected to be minimal and in-line with government sustainable development goals and requirements of social acceptance.
			Disproportionate experience of impact and marginalization of vulnerable groups (e.g., women, disabled, aged, ethnic minorities, indigenous, and young), equity in participation and employment	YES	NO	YES	NO	Social Impact Assessment will address these matters. OML policy requires equity in participation and employment.
	Ecosystem Functions	Distributions and biogeography	Operation of project causes measurable changes to the regional-scale distributions of biological communities	YES	YES	YES	YES	Baseline studies to contextualise studies in an ecological function setting. Fundamental to ESIA will be the understanding of ecosystem that underpins ecological function and assessment of the impacts of the project on those functions at the local and regional scale.
		Biodiversity	Operation of the project causes measureable changes in regional-scale biodiversity	YES	YES	YES	YES	Baseline studies to contextualise studies in an ecological function setting. Fundamental to ESIA will be the understanding of ecosystem that underpins ecological function and assessment of the impacts of the project on those functions at the local and regional scale.
		Foodwebs	Operation of the project causes measureable changes to the ability for the ecosystem to support and maintain foodwebs that sustain biodiversity and biomass at the regional scale	YES	YES	YES	YES	Baseline studies to contextualise studies in an ecological function setting. Fundamental to ESIA will be the understanding of ecosystem that underpins ecological function and assessment of the impacts of the project on those functions at the local and regional scale.
		Population connectivity	Operation of the project causes measureable changes to the movements, migration, larval dispersal or exchange of genetic material required to sustain populations and diversity	YES	YES	YES	YES	Baseline studies to contextualise studies in an ecological function setting. Fundamental to ESIA will be the understanding of ecosystem that underpins ecological function and assessment of the impacts of the project on those functions at the local and regional scale.
Terrestrial	Land Use and Displacement	Tailings	Release of mine tailings	NO	NO	NO	NO	Minerals processing outside Cook Islands EEZ. ESIA will consider alternatives, including no-project, terrestrial mining cases.
		Freshwater	Use of scarce freshwater resources	NO	NO	NO	NO	All freshwater for project made on vessel.
		Land Use	Use of scarce arable land	NO	NO	NO	NO	Terrestrial project footprint very limited.
	Air Quality and GHG	Project emissions	Pollutant and GHG emissions impacting air quality and renewalable energy targets	YES	NO	YES	YES	Baseline air quality measurement. ESIA to address project life-cycle Scope 1, 2, 3 GHG emissions.
Coastal and Nearshore	Subsistence and recreational fishing	Project interference	Operation of project spatially or temporally interferring with practice or resulting a change in the practice	YES	YES	YES	NO	No recreational or subsistence fishing in the mining area. Nearshore vessel movements minimal and within scope of normal Port operations. Social Impact Assessment to establish baseline understanding of recreational and subsistence fisheries.
		Harvested populations	Operation of project affects population sizes/availability/age-classes of harvested species	YES	NO	YES	NO	No recreational or subsistence fishing in the mining area. No pathway to impact nearshore resources. ESIA to include desktop assessment of nearshore resources.
		Water quality affecting target species or food quality	Operation of project affects nearshore water quality and/or food quality of target species	YES	NO	YES	NO	No recreational or subsistence fishing in the mining area. No pathway to impact nearshore resources. ESIA to include desktop assessment of nearshore resources.
		Patterns of use	Socio-economic impacts flow-on to affect decrease in recreational/subsistence fishing and a loss of traditional knowledge	YES	NO	YES	NO	Social Impact Assessment to include desktop studies to establish baseline understanding of recreational and subsistence fisheries and potential impacts of changed socioeconomic status.
			Socio-economic impacts flow-on to affect decrease in recreational/subsistence fishing and decrease in protein intake	YES	NO	YES	NO	Social Impact Assessment to include desktop studies to establish baseline understanding of recreational and subsistence fisheries and potential impacts of changed socioeconomic status.
			Socio-economic impacts flow-on to affect increase in recreational/subsistence fishing and increased pressure on resources	YES	NO	YES	NO	Social Impact Assessment to include desktop studies to establish baseline understanding of recreational and subsistence fisheries and potential impacts of changed socioeconomic status.
	Aquaculture	Project interference	Operation of project interferring with commercial pearl aquaculture	NO	NO	NO	NO	No aquaculture in oceanic waters, no impact pathway to pearl aquaculture in Manihiki and Penryhn lagoons. However, aquaculture industry to be engaged in stakeholder consultation.
	Coastal vegetation, mangroves, coral reefs and other nearshore habitats	Habitat loss or degradation	Project infrastructure or operations directly impacting productive coastal and nearshore habitats	NO	NO	NO	NO	No link from project to coastal and nearshore habitat loss or degradation. ESIA will consider existing impacts (e.g. lagoon nutrient loads, infrastructure development, etc.) in development of baseline environment understanding, but no new studies considered necessary.
	Transport	Project interactions	Increased vessel traffic increasing risk of accidents	YES	NO	YES	NO	Additional shipping traffic is minor in context of existing Port operations. Impact Assessment to include desktop studies of existing vessel traffic and hazard assessment and mitigation for project shipping.
			Exclusion from the mining area	YES	NO	YES	NO	Relatively small exclusion area around the mining Surface Production Vessel. Impact Assessment to include desktop studies of existing vessel traffic and hazard assessment and mitigation for project shipping.
Offshore - Surface	Air Quality and GHG	Project air emissions	Pollutant and GHG emissions impacting air quality and renewalable energy targets	YES	NO	YES	YES	Baseline air quality measurement. ESIA to address project life-cycle Scope 1, 2, 3 GHG emissions.
		Project release of sequestered carbon	GHG emissions from conversion and release of sequestered carbon	YES	NO	YES	YES	ESIA to address risks of sequestered carbon conversion to CO2 and release in project GHG emissions.
	Surface Production Vessel operations	Noise	Disruption to animal communication and movement	YES	YES	YES	YES	Baseline noise measurement. Baseline surface fauna assessment. ESIA to include noise modelling from SPV.

		Light	Disruption to animal communication and movement	YES	YES	YES	NO	Baseline surface fauna assessment. ESIA to include assessment of potential impacts of light polluation on behaviour.
			Disruption to foraging - herding prey species causing increased predation pressure	YES	NO	YES	NO	ESIA to include assessment of potential impacts of light pollution on behaviour.
			Disruption to foraging - negatively impacting predatory behaviour	YES	NO	YES	NO	ESIA to include assessment of potential impacts of light pollution on behaviour.
		Accidents and spills	Hydrocarbon and other materials spills at surface	YES	NO	YES	TBD	ESIA to include hazards assessment associated with accidents, natural extreme events etc. Requirement for spill modelling to be determined.
		Routine discharges	Licenced operational discharges	YES	NO	YES	TBD	ESIA to include baseline water quality studies and assessment of impacts associated with licenced discharges from ship operation.
		Swash zone releases	Sediment-laden releases of sediment attached to vehicles in swash zone during launch and recovery	YES	NO	YES	NO	ESIA to include baseline water quality studies and assessment of impacts associated with project operations.
	Transhipment and Transporting operations	Noise	Disruption to animal communication and movement	YES	YES	YES	YES	Baseline noise measurement. Baseline surface fauna assessment. ESIA to include noise modelling from transhipment and transport.
		Light	Disruption to animal communication and movement	NO	NO	NO	NO	No impact pathway for temporary transhipment operation
			Disruption to foraging - herding prey species causing increased predation pressure	NO	NO	NO	NO	No impact pathway for temporary transhipment operation
			Disruption to foraging - negatively impacting predatory behaviour	NO	NO	NO	NO	No impact pathway for temporary transhipment operation
		Accidents and spills	Nodules spill	YES	NO	YES	YES	ESIA to include hazards assessment associated with accidents, natural extreme events etc. Oil spill modelling presumed to be required.
			Hydrocarbon and other hazardous materials spill	YES	NO	YES	YES	ESIA to include hazards assessment associated with accidents, natural extreme events etc. Oil spill modelling presumed to be required.
		Routine discharges	Licenced operational discharges	YES	NO	YES	TBD	ESIA to include baseline water quality studies and assessment of impacts associated with licenced discharges from ship operation.
		Transportable Moisture Limit and ballast management	Discharges and materials handling	YES	NO	YES	TBD	ESIA to include baseline water quality studies and assessment of impacts associated with discharges from ship operation.
	Commercial Fisheries	Project interference	Spatial interference of project operation (e.g. exclusion zones) to commercial fishing activity, fishing licence revenue	YES	YES	YES	NO	ESIA to include studies to establish baseline commercial fishing activity and assessment of impacts associated with project operations.
		Harvested populations	Operation of project affects population sizes/availability/age-classes of harvested species	YES	NO	YES	NO	ESIA to include desktop studies to establish baseline commercial harvesting rates and assessment of impacts associated with project operations.
		Water quality affecting target species or food quality	Operation of project affects water quality and/or food quality of target species, or market perceptions of food quality	YES	YES	YES	YES	ESIA to include studies on foodwebs and contaminant risks.
	Visual Amenity	Amenity	Potential impact of offshore project infrastructure on visual amenity	NO	NO	NO	NO	SPV and ore transhipment vessels lighted at night, but operation > 200 km from nearest land. Screened out of ESIA.
Offshore - Midwater	Riser Systems operations	Noise	Disturbance to animal communication and movement	YES	YES	YES	YES	Baseline noise measurement and cetacean occurrence. Noise modelling. ESIA to include cetacean impact assessment.
		Structure	Disturbance to animal movement	YES	NO	YES	NO	ESIA to include assessment of collision and physical interference risk.
		Accidents and spills	Accidental release of nodules from riser	YES	NO	YES	TBD	ESIA to include hazards assessment associated with accidents, natural extreme events etc. Requirement for spill modelling to be determined.
	Midwater discharge	Sediment	Impacts from midwater discharge sediment plume	YES	YES	NO	YES	Baseline characterisation of receiving environment and midwater plume modelling study.
		Contaminants	Toxicity impacts from midwater discharge	YES	YES	YES	YES	Baseline characterisation of receiving environment and midwater plume modelling study.
		Structure	Disturbance to animal movements	YES	NO	YES	YES	ESIA to include assessment of collision and physical interference risk.
		Noise	Disturbance to animal communication and movement	YES	YES	YES	YES	Baseline noise measurement and cetacean occurrence. Noise modelling. ESIA to include cetacean impact assessment.
	Transit of mining tools	Midwater sediment releases	Sediment-laden releases of sediment attached to vehicles in midwater zone during launch and recovery	YES	NO	YES	NO	ESIA to include baseline water quality studies and assessment of impacts associated with project operations.
		Light	Disruption to midwater animal life history and communication	YES	NO	YES	NO	ESIA to include baseline water quality studies and assessment of impacts associated with project operations.
		Noise	Disruption to midwater animal life history and communication	YES	NO	YES	NO	ESIA to include baseline water quality studies and assessment of impacts associated with project operations.
Offshore - Seafloor	Mining operations	Nodule removal	Physical removal of nodule substrate and physical alteration to seafloor habitats	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Physical impacts to nodule-attached fauna	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Physical impacts to sediment fauna	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
		Sediment disturbance	Physical impacts to sediment fauna	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Reworking and turnover of productive sediment layers and alteration to associated biogeochemistry	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Sediment plume generation - suspended sediment concentrations	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Sediment plume generation - ecotoxicological risk	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Sediment plume generation - sedimentation	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
		Noise	Disruption to non-cetacean mobile megafauna life history and communication	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
		Light	Disruption to non-cetacean mobile megafauna life history and communication	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
		Structure	Disturbance to animal movements	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
		Accidents and spills	Hydraulic fluid spills from collector	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.
			Nodule spills from collector	YES	YES	YES	YES	Impacts to benthic and midwater ecosystem will be addressed in the ESIA through comprehensive baseline studies, desktop studies and modelling studies.