CIC Limited's Environmental Management Programme for Cook Islands 2020/2021 Seabed Minerals Tender

8 November 2021

"Responsible Exploration of Seabed Resources of the Cook Islands"

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1. Exploration Management Programme Introduction

CIC Limited (CIC) (Registration #C3864) is a privately held Cook Islands' company formed to pursue seabed mineral exploration opportunities in the Cook Islands. CIC is the entity ('the Applicant') that is applying for exclusive seabed mineral exploration rights in the 2020 Cook Islands Seabed Minerals Tender. CIC's Exploration Management Programme (EMP) draws upon the collective marine and terrestrial mineral exploration and resource management experience of the CIC Consortium (the 'Consortium'), a partnership of individuals, organisations and investors led by CIC that formed an alliance with the purpose of exploring and harvesting (if research indicates that harvesting can be accomplished with no serious harm to the environment) polymetallic (also known as manganese or ferromanganese) nodules within the Cook Islands' Exclusive Economic Zone (EEZ).

2. Exploration Work Programme

2.1 Objectives of the Work Programme

The Exploration Work Programme is designed to achieve the following objectives:

1. Map the deposits within the licenced area comprised of 10 Contiguous Block Groups (CBGs) with sufficient accuracy to identify areas of high nodule abundance, detailed bathymetric data, and critical environmental features.
2. Obtain environmental data and information to allow the completion of a robust Environmental Impact Assessment (EIA) culminating in an Environmental Impact Statement (EIS), including physical oceanography with respect to currents and sediment plumes, collection of baseline oceanographic, geologic, and biological data and samples to determine the interaction of biota, and whether nodule harvesting can be undertaken without serious harm to the environment.
3. Validate and define the extent, abundance, and mineral content of the polymetallic nodules in the CBGs.
4. Deliver sufficient samples for the development of metallurgical processing system design.

2.2 Description of the Geology and Topography of the CBGs

Areas targeted for exploration consist of abyssal seafloor of low slope (<~7°) and low sedimentation rate in the Penrhyn Basin, Aitutaki Passage and Southwest Pacific Basins in the Cook Islands' EEZ at an approximate water depth of 5,000 metres. A fine grain size characterises the primarily inorganic sediments on which the polymetallic (manganese) nodules form. Nodules vary in size but generally average ~4 cm diameter.

Historical data suggest nodule abundances on the order of 30 kg/m^2 may be encountered, with general chemistry of select analytes as follows:

Analytes	% by weight
Cobalt (Co)	~0.45
Nickel (Ni)	~0.33
Copper (Cu)	~0.19
Manganese (Mn)	~15.6
Rare Earth Elements and Yttrium (REE+Y)	~0.16

2.3 CIC Technical Assessment of Cook Islands Nodule Resource

CIC has not conducted a site visit or undertaken initial prospecting in the CBGs. However, desktop prospectivity analysis and review of available results from past exploration campaigns undertaken by external organisations has led to the determination of the CBG Areas of interest. These CBG Areas offer high prospectivity for hosting commercially viable polymetallic nodule resources.

Oceanographic and geologic survey efforts date back to the mid-1970s, with a guided effort to characterise nodule resources in the Cook Islands conducted between 1985 and 2000 during four offshore cruises organised by the Japan International Cooperation Agency (JICA) and the Pacific Applied Geoscience Commission (SOPAC). Additional reporting and publications produced between 2000 and 2015 provided additional insight on the setting and chemistry of potential resources.

The JICA/SOPAC efforts provided numerous sample points including nodule chemistry, physical characteristics and extrapolated abundance. Additionally, a commissioned geospatial data analysis by the Cook Islands' Government and executed by a contract agency (Kenex) examined historical empirical samples and investigated correlations between multiple variables included geology, volcanogenic feature proximity, seafloor slope, bathymetry, the water depth of the carbonate compensation depth (CCD), sedimentation rate and sediment thickness, and geochemistry to determine prospective areas of the Cook Islands' EEZ for nodule exploration.

The Consortium members supporting CIC have been analysing the nodule resource in the Cook Islands since 2014. This understanding has evolved over that span as new data has emerged. Analysis of available historic survey data supports the conclusion that these deposits are patchy with high abundance areas interspersed with areas with minimal or low abundance of polymetallic nodules.

This conclusion has been supported by the following activities that demonstrates CIC's knowledge of the resource and environmental setting:

1. CIC conducted extensive desktop analyses of the Cook Islands' nodule resource. This includes:
   a. Analysis of the data obtained from four specific cruises organised by the Japan International Cooperation Agency (JICA) and the Pacific Applied Geoscience Commission (SOPAC).
   b. Consideration of the low slope low slope (<~7°) and low sedimentation rate in the Penrhyn Basin, Aitutaki Passage and Southwest Pacific Basins in the Cook Islands' EEZ at an approximate water depth of more than 4,000 metres which is critical for nodule mineralisation.
   c. Consideration of other data provided by the SBMA and data published from other research cruises.
2. CIC ran existing sample data through standard geostatistical modeling software.
   a. The primary tool used is cluster analysis, a group of statistical procedures used to separate multivariate environmental variables into distinct groups, or clusters, that share common values. The seabed area examined in the cluster analysis consists of the areas for which satellite derived and transit multibeam data are available and that also have one or more legacy sample stations where nodule abundance (kg/m^2) estimates are available.
   b. A grid of points and associated blocks with 5' X 5' latitude X longitude spacing were created in ArcGIS in the seabed area selected for analysis (not including restricted or reserved blocks). Bathymetry and backscatter values were extracted from the rasters into the study grid point attribute table, and then the grid points lacking complete blocks within the EEZ were eliminated. Values for the other variables used in the analysis were then extracted to the grid points in a similar manner, and the grid attribute table was converted to an Excel table for the cluster analysis. Rows containing missing data for any variable were deleted from the table.
   c. The NCSS Data Analysis statistical software package was used here for the cluster analysis. Medoid Partitioning was used to calculate silhouette width and average distance for each cluster size from two to fifteen. An optimal cluster size of four was selected, based on maximising silhouette width and minimising average distance. The technique of K-means analysis was used to calculate the final cluster compositions and spatial distributions using the entire study grid.

d. The environmental variables considered for the cluster analysis are: nodule abundance in kg/m^2 from legacy sampling data available, using Empirical Bayesian kriging to each grid point; depth in metres from available satellite derived and transit multibeam data in the study grid; slope in degrees determined by the maximum absolute difference between each depth pixel and the eight adjacent pixels; Bathymetric Position Index (BPI) data sets created through a neighborhood analysis function; and aspect in compass degrees which determines the compass direction that the downhill slope faces for each location.

3. CIC incorporated environmental metrics (please see *Attachment: 2a. CBGs and Currents Map*).
4. CIC performed preliminary sample assaying for accurate elemental composition with an industry recognised laboratory partner.

2.4 General Timing and Offshore Operations Description

Offshore exploration operations will be divided into campaigns. Campaigns consist of either a single cruise or multiple back-to-back cruises with each cruise having a duration of approximately 15 - 45 days, depending on the vessel. During the Exploration Licence period of five years, CIC will conduct multiple campaigns, with the first to commence 90 – 120 days after an Exploration Licence is granted, subject to constraints created by the current COVID-19 pandemic and by the availability of ships.

CIC will use the lessons learned from completed cruises to refine future operations to assure offshore work and research activities are effective and efficient. Some offshore work will take place on a large research vessel, most likely calling on American Samoa for shoreside support, unless it can be determined that this vessel can safely and efficiently use the port of Avarua. Another smaller research vessel will also be used and will be operated from ports in the Cook Islands. It is anticipated that this smaller vessel will primarily be used for periodic monitoring of environmental conditions and other marine scientific research in the licenced area.

Whenever possible during the entirety of the Exploration Licence period CIC will preferentially seek services and support from Cook Islands' companies and facilities.

Campaign 1: Multibeam Mapping of CBGs, Box Coring, Dredging, Hi-Resolution Mapping, Environmental Data Collection and Environmental Moorings Deployment

Start:	90 – 120 days following the grant of Exploration Licence
Duration:	Five 30 – 45-day cruises totaling 150-225 days including transit times and port calls
Location / Priorities for Campaign 1:	• All CBGs: Bathymetric mapping; • All CBGs: Intensive focus and comprehensive survey and studies in select areas of the CBGs to complete sufficient mineral and environmental operations to fulfil the objectives. • Surface environmental, sea state, and meteorological observations at all times collected during survey operations.
Offshore Activities:	• Bathymetric mapping of all CBGs. • Box Cores collected in select areas of CBGs per a methodical protocol under direction of project Qualified Person (QP). It is anticipated that between 150 and 300 box cores will be collected in Campaign 1, with the majority of sampling intervals being 15 NM apart. • Less than 100 tonnes of sample collection in select areas of the CBGs covering ≤0.02 km^2. • Deep-tow mapping of select areas of CBGs in both 200 and 400kHz mode and with backscatter processing. • 5 km x 5 km detailed deep-tow survey of areas for environmental moorings. • ROV visual survey of specific locations for environmental moorings. • Installation of moorings of current metres, ADCPs, sediment traps, CTD (Conductivity, Temperature and Density) Water Sampling Carousel and other equipment, and hydrodynamic (plume) modelling with ROV. • Photographic/video transects and biota sampling via ROV and additional methods as necessary use of shovels, scoops, nets, push-cores, slurp gun, use of multi-corer and deeper penetration corers, MAPRs (Mini Autonomous Plume Recorders), Niskin water sampling bottles, moored time lapse cameras, plankton nets and other methods, with laboratory analysis. • 15 NM video transects using ROV between selected newly completed box core sample points. • ROV geotechnical measurements and tests performed on the seafloor using ROV tools and manipulators. • Environmental measurements to be made in select areas of CBGs including but not limited to CTD Water Sampling Carousel with oxygen, turbidity, and other sensors, Mini-Landers, and hydrophones.
Onshore Activities:	Concurrent with Campaign 1, CIC will initiate the community and sea users outreach programmes in the best national interests of Cook Islanders and the environment.

Subsequent Campaigns: Box Coring, Bulk Sampling, Hi-Resolution Mapping, Environmental Data Collection and Environmental Moorings Maintenance and Recovery

Start:	Throughout the five-year period of the Exploration Licence, to be determined after Campaign 1
Duration:	Average of 15 days per month, year-round
Location / Priorities for Subsequent Campaigns:	• Survey of CBGs. • Surface environmental, sea state, and meteorological observations at all times in all areas.
Offshore Activities	• Box Cores collected per a methodical protocol under direction of QP. It is anticipated that between 100 and 150 box cores will be collected in each campaign, with the majority of sampling intervals being 15 NM apart. • 100 - 200 tonnes of sample collection (dependent on results from Campaign 1 and requirements for extraction and processing requirements). • Deep-tow and/or AUV (Autonomous Underwater Vehicle) mapping of select areas of CBGs in both 200 and 400kHz mode and with backscatter processing. • 5 km x 5 km detailed deep-tow and/or AUV survey of areas for any additional environmental moorings deemed necessary. • ROV and/or AUV visual survey of specific locations for environmental moorings. • Installation of moorings of current metres, ADCPs, sediment traps, CTDs and other equipment, and hydrodynamic (plume) modelling. • Photographic/video transects with ROV and/or AUV and biota sampling via ROV, and additional methods as necessary including use of shovels, scoops, nets, push-cores, slurp gun, use of multi-corer and deeper penetration corers, MAPRs (Mini Autonomous Plume Recorders), Niskin water sampling bottles, moored time lapse cameras, plankton nets and other methods, with laboratory analysis. • 15 NM video transects using ROV and/or AUV between selected newly completed box core sample points. • ROV geotechnical measurements and tests performed on the seafloor using ROV tools and manipulators including a Mini Cone Penetrometer. • Environmental measurements to be made in select areas of CBGs including but not limited to CTD Water Sampling Carousel with oxygen, turbidity, and other sensors, Mini-Landers, hydrophones. • Extraction Component Testing. • Geo-technical activities performed in this section will provide critical information for extraction system design
Onshore Activities	On-going community and sea users outreach programmes in the best national interests of Cook Islanders and the environment.

2.5 General technical approach

The general technical approach for survey, sampling and assessment is as follows:

Exploration Technique	Purpose	Description
Hull-Mounted Multibeam Survey	General Bathymetry / Mapping of Large Areas	Geophysical instruments are mounted directly on the ship's hull or pole-mounted on the ship's side. The most common technique used is the multibeam sonar system which emits an array of sound in a fan-like pattern and then measures the time taken for the sound waves to reflect off the sea floor which can then be used to calculate the seafloor depth. By making many measurements at different places a detailed map of the seafloor depth (bathymetry) can be created. These systems emit only low power sound waves and are non-intrusive.
Sound Velocity Profilers (SVPs)	For general 12kHz MBES data collection	Accurate full water column sound velocity profiles are needed every 24 hours to perform real time beam steering and location calculations for shipborne multibeam. These activities are non-intrusive.
Towed Multibeam Survey	Hi-resolution Bathymetry / Mapping of specific target areas	Deep-tow methods employ an underwater sled that is tethered to the ship by a long (fibre-optic) cable. The sled is towed 60-120 metres above the seafloor and operates at depths up to 6,000 metres. Deep-tow system is a Dual Head 7125MB 200/400kHz mapping system. It is used for high-resolution bathymetry mapping, which will allow CIC to map bottom features to 1-5 m grid resolution and provide for backscatter interpretation of nodule presence and abundance. The sonars emit low power sound waves, which are reflected off the seafloor and recorded by receivers on the Deep Tow. These activities are non-intrusive.
AUV (Autonomous Underwater Vehicle)	Hi-resolution Acoustic / Video Mapping of specific target areas	5,000 m rated position tracked untethered vehicle which can survey pre-programmed track lines at low altitudes (5-25 m) above the seafloor. Payloads may include: Reson 7125 400kHz multibeam, Edgetech 120/410Khz sidescan sonar, Edgetech sub-bottom profiler, high resolution 1936 X 1456 pixels optical camera, and other sensors. The sonars emit low power sound waves, which are reflected off the seafloor and recorded by receivers on the Deep Tow. These activities are non-intrusive.

ROV Survey and Sampling Tools	Visual survey and observation (biological communities, Seafloor and near-bottom Megafauna), precision survey data collection, geological and environmental sampling	The 6000 m rated ROV is lowered to the seafloor and surveys are completed and discrete samples can be taken using a suite of tools that it carries. These tools include hydraulic manipulator arms for collecting samples, video and still cameras, and a range of specialised, close-proximity sensing tools for both seafloor and water column survey. The ROV is powered by electricity and is hydraulically controlled from the support ship using an umbilical. Additionally, it is anticipated a Cone Penetrometer for collecting geotechnical data will be deployed via ROV.
Gravity/Box Coring Equipment	Resource estimation, biological sampling, environmental and geotechnical measurements	Box-coring will be undertaken to collect samples for mineral resource estimation, to extract pore water samples to determine the basic chemistry of the sediments, and to collect biological samples for environmental baseline measurement and to collect geotechnical data.
	Sediment coring to determine depth of the oxic/anoxic redox boundary	Gravity corers will be used to sample the upper several metres of sediment to analyse pore fluids to locate the depth of the redox boundaries that will be essential in determining whether the release of toxic metals will be an issue if harvesting operations are permitted.
Bulk Sampling Equipment	Proof of Concept, metallurgical testing	Gathers sufficient nodule sample material to complete initial metallurgical studies.
Vane Shear and Cone Penetration Testing	Measure sub-seabed soil properties (bearing capacity)	To verify that the seabed has sufficient bearing capacity for the mining collector. The seabed properties will be measured in various locations over the area to verify the variability of the properties. Testing is envisaged to be done by a gravity CPT (winch deployed) and a mini-CPT deployed from an ROV.
Water Sampling Carousel / Rosette, CTD (Conductivity, Temperature and Density)	To understand baseline water chemistry conditions in the water column overlying the site targeted for nodule extraction, capturing at least two summer/winter seasons (seasonal studies).	Niskin sampling bottles are arranged in a rosette formation around other sensors (e.g. CTD). The instrument package is tethered to the ship by a long cable and is used to obtain water column samples and profiles in a simple vertical down and up cast. Each bottle can be triggered individually to enable sampling from various locations. A CTD, which is commonly attached to the water sampling carousel, provides profiles of chemical and physical parameters through the entire water column by detecting its conductivity and temperature (which in turn relates to concentration of salt and other inorganic compounds in seawater). By analysing these parameters, inferences about the occurrence of certain biological processes can be made. The rosette commonly houses a variety of sensors, including most importantly dissolved oxygen, turbidity, as well as other sensors.

Deep-Ocean Moorings	To understand the currents around the extraction site over a 12 to 24-month period (depending on the mooring). Study enables modelling the extent and duration of plumes that may be formed during full-scale operations.	Moorings will be anchored to the seafloor and will include instrumentation such as single point current metres, ADCPs, sediment traps, CTDs, transmissometers, and other instruments. It is currently envisaged that three moorings would be installed around the primary site of interest for commercial operations. Moorings will be of multiple lengths and most will focus on bottom-water currents, with at least one envisaged to cover almost the entire water column. Moorings will be retrieved on a ~6 to 12-month basis for data download, equipment maintenance and mooring reinstallation. Following data acquisition, hydrodynamic modelling of plume extent and duration will be performed.
Plankton Nets, Fishing Instruments	To understand baseline plankton conditions within the water column, including baseline metal concentrations. To understand baseline fish populations within the water column and near-bottom (in the benthic boundary layer) that may be impacted by operations (e.g. the operational and discharge plumes).	Nylon mesh net is deployed from winch to collect either vertical or horizontal samples of plankton. Allows for plankton to be analysed both quantitatively and qualitatively. Pelagic monitoring moorings will be deployed opportunistically and will be comprised of a buoyed camera unit to monitor a separate baited/weighted line suspended in the water column.
Marine Biota Observations	To record sightings of marine mammals, other near-surface large biota (such as turtles and fish schools) and bird aggregations, identifying the relevant species and behaviours where possible.	Details to be recorded in transit to and from areas of exploration and on passage between stations. Temporal variability should be assessed.
Moored Hydrophone	To determine the baseline noise levels and estimate impact of mineral harvesting activities.	Hydrophones will be incorporated into the moorings or landers used for physical oceanography studies, or as stand-alone moorings.
Moored (and some Baited) Time Lapse Cameras (TLC)	To understand baseline biological conditions at and immediately above the seafloor and predict the impact of mineral harvesting on biological communities.	Recording device is set up within suitable distance of TLC anchored bait to observe behaviour of demersal scavengers. Likely to be deployed during ROV operations. Time Lapse Cameras may also be implemented onto the Mini-Landers.

Benthic Mini-Landers (MLs)	Continuously monitor physical transport and biogeochemical processes that combine to control distributions of both suspended particulates and dissolved chemical parameters within the benthic boundary layer (BBL).	Time-series measurements of current speed and direction, turbidity, dissolved oxygen (DO), temperature and other relevant parameters from 1 to 25 metres above the seafloor.
Genetic Metabarcoding	Use trace DNA to identify organisms that have come in contact with a defined area.	With the advent of modern, ultra-high throughput sequencing platforms, conducting deep sequencing metabarcoding surveys with multiple DNA markers will enhance the breadth of biodiversity coverage, enabling comprehensive, rapid bioassessment of all the organisms in a sample.

2.6 Technical Team

The Odyssey Operations Team and associated partners consist of leading academic researchers, project managers, ROV pilots, surveyors, geophysicists, subsea engineers, geologists and environmental scientists from all corners of the globe. The team works alongside and in alignment with the CIC Technical Advisory Board (TAB).

Some of the most qualified individuals and experienced professionals in the offshore industry collaborate on Odyssey projects and have done so as a team for over 15 years. From operating, modifying, and maintaining each element of Odyssey's subsea equipment to analysing results and developing new tools, this dedicated team works on a results-driven basis, rather than a group of independent contractors pulled together for a single project. This team approach has resulted in successful outcomes in scores of operations throughout the world that have resulted in many deep ocean record-setting accomplishments and results that have not been achieved by any other company in the world.

2.7 Meeting Good Industry Practise Over the Extent of the Exploration Project

The full extent of the seabed for which mineral exploration rights are granted will be subject to exploration activities. Exploration comprised of sample sites from the entire geographic extent of the CBGs will be necessary to quantify the extent and character of any present mineral resources and to develop environmental baseline data necessary for the generation of an environmental impact report.

The proposed Exploration Work Programme will be conducted in accordance with standard industry practise. Exploration methodologies addressed above detail the methods and equipment considered for exploration and environmental baseline studies. These methods and equipment have been utilised successfully in the past by the Applicant and its supporting organisations for both seabed mineral exploration and environmental data acquisition.

The methods and equipment outlined are those commonly used for exploration in the international seabed area administered by the International Seabed Authority (ISA), including the Clarion-Clipperton Zone (CCZ) Exploration Areas for Polymetallic Nodules. These methods are regarded as good practise within the industry and by industry experts.

Exploration, analysis and assessment activities will be overseen by experienced industry scientists and professionals. The mineral resource assessment effort is being supervised by Dr. Morgan to ensure that the assessment is accurate and compliant with mining industry standards (JORC or NI 43-101).

Dr. Morgan has worked on various private and government-sponsored seabed mineral resource assessment efforts for more than 40 years, including extensive studies of the polymetallic nodule deposits in the Clarion-Clipperton region of the North-eastern Tropical Pacific and a formal resource assessment effort, working with the East-West Center of Hawaii, for the nodule deposits in the Cook Islands' EEZ. He is a Registered Member of the Society of Mining, Metallurgy, and Exploration (SME, #4041112) and is a Qualified Person (QP) for the assessment of deep seabed polymetallic nodule resources/reserves.

2.8 Methodology for Establishing Environmental Baselines and Biological Reference Areas

The following table outlines the studies that will be conducted to gather the data required to establish an environmental baseline and define the Biodiversity and Protected areas. These studies will be executed using the technical methods and techniques described above within the term of the Exploration Licence. Studies will be conducted in the areas that feature high nodule abundance as well as candidate Biodiversity and Protected Areas. Reference areas will be chosen such that they are representative in terms of habitat and biota of the areas that would likely be impacted by nodule harvesting, if research indicates that it will not cause serious harm to the environment.

Study Area	Details
Physical Oceanography	Aim: Estimate extent and duration of plumes that may be formed during harvesting full-scale operations and estimate magnitude and direction of predominant surface currents to provide operational constraints for commercial operations and to permit estimation of the dispersion of potential accidental spills from surface vessels. Determine baseline noise levels at the surface, at the seafloor, and within the deep sound channel (~700 – 1,500 m depths) Study requirements: Study of currents, temperature, and turbidity required. Methods and Equipment: Installation of moorings containing current metres, ADCPs, sediment traps, CTDs and other equipment, followed by hydrodynamic (plume) modelling. Deploy untethered lander packages to measure currents, oxygen levels, and other variables over time.
Geology	Aim: Determine heterogeneity of the environment and assist with placement of suitable sampling locations; collect information on the potential for heavy metal and trace element release during mineral harvesting operations. Study requirements: Map the seabed and sample the seabed geology. Methods and Equipment: High-resolution bathymetry, box corers/multiple corers, and laboratory analysis.
Chemical Oceanography	Aim: Understand baseline water chemistry conditions in the water column and within sediment pore water; understand the potential impact of metal release during the harvesting process. Study requirements: Water column: multiple CTD profiles and water sampling efforts over two years, capturing at least two summer/winter seasons (seasonal studies); sample and analyse pore waters. Methods and Equipment: multiple corers, mega corers, laboratory analysis.
Sediment Properties	Aim: To study baseline sediment conditions and predict the behaviour of mineral harvesting on sediment composition to determine the basic properties of the sediment, including measurements of soil mechanics and composition to adequately characterise the surficial sediment deposits which are the potential source of deep-water plume. Study requirements: Acquire adequate samples to determine uniformity in the Exploration Licence area of particle size distribution and various geotechnical parameters. Methods and Equipment: Box corers, multiple corers, and laboratory analysis.

Biological Communities	Aim: Evaluate the effects of activities on biota. Studies to include microfauna, meiofauna, macrofauna, megafauna, demersal scavengers, nodule fauna, video/photo surveys, pelagic community assessment (water column and near bottom), baseline tissue metal concentrations, marine biota observations, temporal variation studies, regional distribution/genetic connectivity studies, etc. Study requirements: Characterise observed and collected flora and fauna and report on species diversity. Measure benthic community respiration rates. Methods and Equipment: Photographic/video transects and biota sampling, use of multiple corer, box corer, hydrophones, moored time lapse cameras (TLC), plankton nets, ROV, *in situ* respirometer and other methods, laboratory analysis.
Bioturbation	Aim: Gather data on the mixing of sediments by organisms and to predict the impact of harvesting activities on biological communities. Study requirements: Determine oxygen profile and flux, directly or by analyses of pore fluids, near and within seabed sediments. Methods and Equipment: Multiple cores, chemistry e.g. ^{210}Pb analysis in core samples.
Fluxes to Sediment (Sedimentation)	Aim: To gather time series data on the flux and composition of materials from the upper water column to the deep sea. To understand baseline sedimentation rates and to evaluate the effects of mineral harvesting activities (especially plumes) on these rates. Study requirements: Spatially distributed sediment traps in terms of water depth and surface area at sites within the region, with site determination approved by Cook Islands government representatives. Methods and Equipment: Moored time lapse sediment traps installed for a minimum of 6 months, and laboratory analysis.

2.9 Minimum Expenditure (Investment) for Stages of the Project

The following table provides estimated projected annual investment for the Exploration Work Programme.

Table for Exploration License Application Section 14:		
ESTIMATE of Expenditures US$	**Year 1**	**Subsequent 12 Month Periods**
Campaign Operations: LARGE SHIP, Research, Laboratory, Reporting, Community Outreach	$15,000,000	$ -
Campaign Operations: SMALL SHIP, Research, Laboratory, Reporting, Community Outreach	$ -	$ 7,500,000
CIC Local Overhead Expenses (CI employees, offices, professional serves, etc..)	$ 900,000	$ 900,000
Total	$15,900,000	$ 8,400,000
ESTIMATE of Expenditures NZ$	**Year 1**	**Subsequent 12 Month Periods**
Campaign Operations: LARGE SHIP, Research, Laboratory, Reporting, Community Outreach	$21,252,479	$ -
Campaign Operations: SMALL SHIP, Research, Laboratory, Reporting, Community Outreach		$ 10,626,240
CIC Local Overhead Expenses (CI employees, offices, professional serves, etc..)	$ 1,275,149	$ 1,275,149
Total	$22,527,628	$ 11,901,388
1.4168 conversion rate.		

The costs and activities stated in the table above are only approximations based on previous experience and analogous exploration work programmes. These are likely to change as the proposed Work Programme is finalised and subject to the ongoing adaptive management protocols and recommendations of the Technical Advisory Board and QP.

Every effort will be made to invest via Cook Islands' businesses during the project.

2.10 Potential environmental impacts and proposed mitigation

The techniques used for mineral and environmental exploration are the same as those used by international marine scientific research organisations and most activities are low or very low impact. Many of the proposed methods and the environmental considerations of their use are summarised below:

Study / Method	**Environmental Impact of normal operations**	**Potential Risks including Potential Sea User Interactions**	**Proposed Mitigation**
Vessel Operations	Standard vessel operations (low impact)	None in addition to vessel operations. Potential interactions with other sea users (e.g. fisheries) during transits.	Ensure relevant local and international regulations are met or exceeded (e.g. MARPOL). Early and regular engagement with other sea users. Standard communications with other vessels during operations.
Hull-Mounted Bathymetry Survey	Negligible. No physical contact made with the seafloor. Sound levels are not of a frequency or intensity high enough to cause serious harm or physical damage to marine biota.	See Vessel Operations	See Vessel Operations
Bulk Sampling	Low to Medium, depending on sampling equipment tow length. Impact to seafloor is typically 2 m wide by 10s to 100s m long. Not expected to impact more than 10,000 m^2.	Winch/wire failure resulting in equipment loss to the environment (small impact). Potential accidental spillage of sample contents into water column upon retrieval.	Learn from other operators in terms of winch and wire type and speed of deployment, use marine scientific research standard sampling procedures.
Opportunistic current profiles, and other casts (e.g. CTD, SVP) and water sampling using carousel / rosette	Negligible, no impact with seafloor, short term presence of wire/instrumentation in the water column.	See Vessel Operations	N/A

High Resolution Bathymetry Mapping (AUV/Deep Tow)	Negligible. No physical contact made with the seafloor. Sound levels that are not of a frequency or intensity high enough to cause physical damage to marine biota.	Accidental collision with the seafloor, disturbing the seafloor at the point of impact. May result in equipment loss.	Instrumentation equipped with tracking beacons.
High Resolution Acoustic and Video Mapping, sampling and geotechnical measurements	Negligible impact from high resolution acoustic and video mapping. Low impact from both sampling and geotechnical measurements. Impact on seafloor for both will likely be less than $1m^3$ per sample site.	Accidental collision with the seafloor, disturbing the seafloor at the point of impact.	Instrumentation equipped with tracking beacons.
Multi-Corer	Varies depending on how many corers, but the diameter of the base of a mega-corer (twelve core tubes) is ~2.8 m. Very small impact, restricted to area where sample is taken.	Winch/wire failure resulting in equipment loss to the environment (small impact).	Learn from other operators in terms of winch and wire type and speed of deployment, use standard procedures.
Box Corer	Maximum area of 0.75 m x 0.75 m with 0.60 m depth penetration per sample if largest known box corer is utilised. Minimal impact restricted to an area where the sample is taken.	Winch/wire failure resulting in equipment loss to the seabed (small impact).	Learn from other operators in terms of winch and wire/rope type and speed of deployment, use standard procedures.
Moored Time Lapse Camera (TLC)	Minimal, confined to area where TLC anchor has contact with seafloor, estimated to be less than 2 m x 2 m.	Accidental mooring release/floating to the surface.	Redundant release systems. Moorings equipped with tracking beacons which trigger upon surfacing.
Plankton Nets/ Fishing Gear	Negligible, no impact with seafloor, short term presence of sampling devices in the water column.	See Vessel Operations.	N/A

Marine Biota and Bird Observations	None	See Vessel Operations.	N/A
Mini-Landers (long term deployments)	Negligible impact – equivalent to size of lander (~1 m x 1 m). Short term (≤1 year) presence of sampling devices on the seabed.	Accidental ballast release/floating to the surface.	Redundant release systems. Landers equipped with tracking beacons which trigger upon surfacing.
Moorings (short and long, long term deployments)	Minimal, confined to area where anchor has contact with seafloor, estimated to be less than 2 m x 2 m. Short- and long-term presence of sampling devices in the water column.	Accidental mooring release/floating to the surface.	Redundant release systems. Moorings equipped with tracking beacons which trigger upon surfacing.

Current plans provide that no single exploration activity which disturbs the seabed will impact an area of the seafloor greater than 10,000 m^2. Should such an activity become required pursuant to the advice of the TAB, a project permit application will be submitted to the Cook Islands' National Environment Service (NES). Any activity requiring consent, or a project permit, will only take place with approval by the NES. Prior to commencement of offshore operations, CIC's TAB will submit to the SBMA a detailed exploration plan outlining the work to be accomplished and the equipment to be utilised. As advised by the SBMA, collaboration with NES and other stakeholders will take place to ensure that CIC is adequately addressing any requirements or concerns pertaining to activities planned for the exploration work.

2.11 Exploration Objectives

The first exploration objective is to identify and map mineral resources in order to determine whether it is economically feasible to justify commercial harvesting. For this purpose, CIC will use the protocols and general guidelines of either the Australasian Joint Ore Reserves Committee (JORC)[1] or the Canadian Institute of Mining, Metallurgy and Petroleum (CIM). The CIM guidelines are defined in the Canadian National Instrument 43-101 – *Standards of Disclosure for Mineral Projects* (NI 43-101).[2]

The second, and most important, exploration objective is to obtain sufficient environmental data to permit the completion of a detailed Environmental Assessment to determine whether seabed mineral harvesting can be accomplished without serious harm to the environment and, if it is determined harvesting can be conducted, development of a comprehensive and effective EMP.

[1] The standards for JORC can be viewed at the following website http://www.jorc.org/

[2] The CIM Definition Standards can be viewed on the CIM website at www.cim.org

The third exploration objective is to recover sufficient samples of polymetallic nodules and sediment to support metallurgical processing development and to provide additional environmental baseline information.

The fourth exploration objective is to complete the necessary geotechnical engineering testing on the seafloor and to collect samples from the seafloor to support development of a nodule harvesting system that can reliably, and with minimal environmental impact, meet the production goals required for a feasible nodule harvesting program from the seabed within the Cook Islands' EEZ.

2.12 Methodology Used

Analysis of available historic survey data supports the conclusion that these Cook Islands' EEZ nodule deposits are patchy with high abundance areas interspersed with areas of minimal or low abundance of polymetallic nodules. CIC is committed to developing an accurate and credible Resource Assessment for the polymetallic nodule mineral resources within the licenced area. To accomplish this goal, industry-accepted exploration multibeam surveys and sampling methodologies will be employed to help determine the deposit characteristics by using standard, accepted scientific sampling methods (e.g. box core collectors) within the coverage of continuous survey techniques (e.g. photographic and high-resolution acoustic surveys of the seafloor). This will enable the quantitative determination of any existing correlations between acoustic and/or photographic coverage of nodules on the seafloor and the samples collected with box cores.

The first surveys will collect sufficient box core samples within the acoustic and photographic survey areas to provide adequate ground-truth data for establishing and verifying the necessary correlations. Subsequent surveys will refine and modify these correlations and quantitatively map the deposits with sufficient accuracy to delineate a specific area for nodule harvesting, including designation of environmental reserve areas where appropriate. The box core and bulk sample collections will provide nodule samples for metallurgical analysis and processing development as well as collection and documentation of important specimens of the flora and fauna that inhabit the seafloor.

The photographic surveys will obtain significant environmental data to help characterise the megafauna (>2 cm) communities within the licence area.

As noted above in order to achieve such an Assessment, CIC will follow the guidelines developed by JORC or the Canadian National Instrument 43-101 (NI 43-101), regulatory frameworks designed to ensure that commercial developers of mineral properties comply with uniform procedures and reporting requirements to establish credible and verifiable evaluations of the mineral resources.

2.13 Why Methodology is Appropriate

CIC and its Technical Advisory Board (TAB) have extensive experience working on the development of the polymetallic nodule resources in the Clarion-Clipperton Zone (CCZ) of the North-eastern Pacific Ocean seabed, and in the case of Dr. Hein, Dr. Morgan and Dr. Usui, significant experience with the evaluation and study of Cook Islands' resources. The methodology for the Exploration Programme has been designed in collaboration with the CIC TAB and takes into account the additional information provided by well-developed databases describing the deposits and provided by the Cook Islands' Government.

3. Narrative of Environmental Component

CIC will assist the Cook Islands to develop their marine mineral resources with a clearly understood responsibility for environmental stewardship. The environmental aspects of this project will remain prioritised at the forefront of each step of the strategic and tactical decision-making processes of the project.

3.1 Objectives of Environmental Data Acquisition

The key objectives of CIC environmental data acquisition are to:

- Conduct environmental baseline studies in order to characterise the existing environment at the seafloor, underlying sediment, and overlying water column;
- Enable the development of an EIA, which will define the expected environmental effects from a nodule harvesting operation which will allow a determination to be made as to whether this can be accomplished with no serious harm to the environment;
- Evaluate and develop strategies to prevent where possible, or otherwise minimise, impacts to the environment from a nodule harvesting operation;
- Allow the development of a robust Environmental Management Plan (EMP) and Monitoring Plan for the Cook Islands in the event they decide to allow a nodule harvesting operation;
- Conduct ongoing environmental monitoring to ensure that no serious harm is caused to the marine environment from activities during exploration;
- Address the critical environmental points that Gerald McCormack has articulated in his publication *Cook Islands Seabed Minerals: A Precautionary Approach to Mining*, including *inter alia*:
    - Application of the precautionary approach at every stage of exploration;
    - Comparing the seafloor environment (biomass, biodiversity, seafloor morphology, ecosystem, physical properties and much more) within the license area, EEZ, South Pacific region, and other regions of the world;
    - Plume management, including determination of relevant sediment properties, long-term measurement of benthic current velocities and modelling of plume dispersion;
    - Constraint of water and sediments to their respective stratified layers;
    - Extensive regional mapping of species distributions throughout the licenced area;
    - Representative Biodiversity and Protected Areas established where no impacts from exploration or harvesting activities will ever occur.

3.2 Methodology Used

The International Seabed Authority (ISA), the governing body for the mineral resources of the international seabed area, has established seven recommended avenues for the baseline studies and EIAs: Physical Oceanography, Geology, Chemical Oceanography, Sediment Properties, Biological Communities, Bioturbation, and Fluxes to Sediment.

The protocols have thus far been developed through a transparent process and multi-stakeholder approach, and the ISA is setting a world-recognised standard for deep-water EIA requirements.

To ensure that CIC takes an approach consistent with leading global standards, CIC, under the supervision of the Environmental Chief Scientist and Qualified Person (QP) Dr. Morgan and the CIC Technical Advisory Board (TAB), will take into consideration the most up-to-date template that the ISA has provided for baseline studies and EIA development.

A summary of the ISA recommended baseline studies and their objectives is presented in Table 3.1. Of these, Physical Oceanography, Chemical Oceanography, Biological Communities, and Sedimentation involve long-term field studies with one to three years of data collection. CIC will make every effort to collaborate with other sea users who may be interested in forming partnerships to complete, for example, the seasonal and/or regional studies.

More details about each of these studies and the methodologies to be used can be found in *Attachment: 3a. List of Environmental Baseline Studies and Approaches.*

Sampling technology and methodology will be used to acquire baseline information for the EIA, in line with both current science and thorough, accurate data collection practises.

3.3 Why Methodology is Appropriate

Over the past 40 plus years, there has been a significant body of information obtained on polymetallic nodules and the environmental impacts of recovering nodules from the seafloor. A summary of the key studies is provided in *Attachment: 3b. Key Environmental Impact Assessment Work for Nodule Provinces in the Deep Sea.* The work conducted to date highlights the complexity associated with conducting research in the deep sea and supplies valuable guidance for future exploration activities.

The methodology described in *Attachment: 3a. List of Environmental Baseline Studies and Approaches* has been developed through a transparent process and multi-stakeholder approach, which included scientific experts, regulators, sponsoring states, contractors (developers), and NGOs (non-governmental organisations), among others.

Table 3.1: Summary of ISA Recommended Environmental Baseline Studies

Study Area	Details
Physical Oceanography	Aim: Estimate extent and duration of plumes that may be formed during full-scale operations and estimate magnitude and direction of predominant surface currents to provide operational constraints for commercial operations and to permit estimation of the dispersion of potential accidental spills from surface vessels. Determine baseline noise levels at the surface, at the seafloor, and within the deep sound channel (~700 – 1,500 m depths). Study requirements: Study of currents, temperature, and turbidity required. Methods and Equipment: Installation of moorings of current metres, ADCP (Acoustic Doppler Current Profiler), sediment traps, CTDs (Conductivity, Temperature and Density) and other equipment, followed by hydrodynamic (plume) modelling which are at-sea requirements. Deploy untethered lander packages to measure currents, oxygen levels, and other variables over time.
Geology	Aim: Determine heterogeneity of the environment and assist with placement of suitable sampling locations; collect information on the potential for heavy metal and trace element release during full-scale mineral operations. Study requirements: Map the seabed and sample the seabed geology. Methods and Equipment: High-resolution bathymetry, box corers/multiple corers, and laboratory analysis.
Chemical Oceanography	Aim: Understand baseline water chemistry conditions in the water column and within sediment pore water; understand the potential impact of metal release during the harvesting process. Study requirements: Water column: multiple CTD profiles and water sampling efforts over two years, capturing at least two summer/winter seasons (seasonal studies); sample and analyse pore waters. Methods and Equipment: multiple corers, mega corers, laboratory analysis.
Sediment Properties	Aim: To study baseline sediment conditions and predict the behaviour of mineral harvesting on sediment composition to determine the basic properties of the sediment, including measurements of soil mechanics and composition to adequately characterise the surficial sediment deposits which are the potential source of deep-water plume. Study requirements: Acquire adequate samples to determine uniformity in the Exploration Licence area of particle size distribution and various geotechnical parameters. Methods and Equipment: Box corers, multiple corers, and laboratory analysis.

Biological Communities	Aim: Evaluate the effects of activities on biota. Studies to include microfauna, meiofauna, macrofauna, megafauna, demersal scavengers, nodule fauna, video/photo surveys, pelagic community assessment (water column and near bottom), baseline tissue metal concentrations, marine biota observations, temporal variation studies, regional distribution/genetic connectivity studies, etc. Study requirements: Characterise observed and collected flora and fauna and report on species diversity. Measure benthic community respiration rates. Methods and Equipment: Photographic/video transects and biota sampling, use of multiple corer, box corer, hydrophones moored time lapse cameras (TLC), plankton nets, ROV, *in situ* respirometer and other methods, laboratory analysis.
Bioturbation	Aim: Gather data on the mixing of sediments by organisms to predict the impact of harvesting activities on biological communities. Study requirements: Determine oxygen profile and flux, directly or by analyses of pore fluids, near and within seabed sediments. Methods and Equipment: Multiple cores, chemistry e.g. ^{210}Pb analysis in core samples.
Fluxes to Sediment (Sedimentation)	Aim: To gather time series data on the flux and composition of materials from the upper water column to the deep sea. To understand baseline sedimentation rates and to evaluate the effects of mineral harvesting activities (especially plumes) on these rates. Study requirements: Spatially distributed sediment traps in terms of water depth and surface area at sites within the region, with site determination approved by Cook Islands government representatives. Methods and Equipment: Moored time lapse sediment traps installed for a cumulative minimum duration of 12 months, and laboratory analysis.

ROV = Remotely operated vehicle; ADCP = Acoustic doppler current profiler, CTD = Conductivity, temperature, density with additional environmental sensors

3.4 How Proposed Work Relates to Advancement of Knowledge for Recovery Operations and Ecological Setting

By conducting thorough baseline studies of the seafloor, water column and surface waters at various locations throughout the proposed CBGs, CIC will provide a detailed understanding of the environment and an in-depth assessment of the impacts that would be expected from nodule harvesting. This will allow CIC, along with the Cook Islands' Government and other key stakeholders, to develop strategies to help avoid or otherwise minimise impacts.

Detailed baseline studies will be conducted at the proposed mineral harvesting sites (once they have been identified through exploration work) and at other sites in order to establish a reference area, or areas, as needed, separated from the impact of nodule harvesting.

The purpose of these reference areas is two-fold: (1) to study natural variability in harvesting areas with no extraction activity and (2) to ensure the protection of habitats and biota representative of what may be lost or impacted due to harvesting.

CIC is partnering with world-leading scientists to review and develop environmental plans, conduct baseline studies, and progress towards an EIA, including developing and testing methods to mitigate and minimise environmental impacts. Collaborating academic research scientists will be free to publish their findings, ensuring that CIC is transparent and is prioritising the contribution to the body of knowledge of environmental studies, biodiversity and ocean processes. Additionally, CIC will collaborate with appropriate Cook Islands' Government ministries and other stakeholders to interpret and share with the public environmental data acquired during exploration.

4. Technical Capability

Mr. Greg Stemm, the founder of CIC, has assembled a world-class group of technical experts to guide and manage the technical aspects of the Cook Islands' Exploration Programme.

In addition to broad access to the technical capabilities and resources of the Consortium, CIC is underpinned by a Technical Advisory Board which provides guidance, detailed reviews and approves all technical aspects of the project. The TAB will also scrutinise:

1. JORC or NI 43-101 compliance on resource and reserve estimates.
2. QP review and signoff of geological and environmental reports.
3. CIC and its supporting companies with regards to methodologies, processes and procedures assuring they meet and exceed international industry and environmental standards.

4.1 Technical Advisory Board (TAB)

The TAB will report directly to the executive management of CIC and their work product will be incorporated into all reports to the Cook Islands' Government to help provide assurance that the project is being conducted with the highest possible level of technical integrity that can be achieved.

The TAB recognises that responsible environmental stewardship is placed at the forefront of all project activities and has a remit to reinforce this value.

Currently the members of the TAB include:

- **Dr. James Hein** – 48 years of experience as a marine geologist at USGS, author/co-author of 560+ papers, abstracts and books; associate editor of Marine Geology and Marine Georesources and Geotechnology. Past scientific advisor to the Department of State and was part of their delegation to the International Seabed Authority.
- **Dr. Charles Morgan** – 20 years as an Environmental Planner in Hawaii with a focus on permitting and environmental impact assessments for renewable energy projects and past President of the International Marine Minerals Society and past Chairman of the Underwater Mining Institute.
- **Mr. Robert Goodden** – A deep-sea drilling pioneer and subsea mining consultant with 30+ years at the forefront of new technologies in seabed excavation and drilling with an eye for what works in that environment both practically and commercially.
- **Dr. Mark Luther** – Associate Professor of Physical Oceanography, USF-CM and Director of the Ocean Monitoring and Prediction Lab at USF-CM. Dr. Luther's research involves the combination of real-time ocean observations with numerical models of ocean currents and processes and their application to various problems ranging from maritime safety and security to water quality in estuaries to variability in large-scale ocean circulation and its relation to climate change.
- **Mr. David Weight** – Past President of the Cobalt Institute with involvement in the metals mining industry for 40+ years with 20 years focused on providing technical and commercial services to one of the world's largest refined copper and cobalt producers, Zambia Consolidated Copper Mines Ltd.
- **Dr. John Wiltshire** – Professor Emeritus, University of Hawai'i at Manoa: School of Ocean & Earth Science & Technology. Exploration geologist for Noranda Mines, Chevron and Petro-Canada. Ocean Resources Manager for the State of Hawaii in the Department of Business, Economic Development and Tourism and Director of Hawaii Undersea Research Laboratory (HURL).
- **Mr. Jean-Noel Calon** – Founding Member of Blue Fish and Project Manager for Boulogne Seafood Cluster (Boulogne sur Mer, France), Europe's most important seafood cluster and leading logistics hub, focused on identifying drivers for consistent promotion and monitoring of safe sustainable fishing practices.
- **Dr. Akira Usui** – Professor, Kochi University, Japan. 40 years at the Geological Survey of Japan focused on the field of geology, geochemistry, and mineralogy of marine ferromanganese deposits. Published more than 100 scientific papers and maps jointly with domestic and international colleagues, based on numerous shipboard investigations.
- **Mr. Tom Albanese** – The former Chief Executive Officer of Vedanta Resources plc and Rio Tinto - two of the world's leading mining and natural resource companies. Mr. Albanese brings 40 years of global experience in the mining industry with a career focused on developing innovative modern mining systems, supply chain, corporate management and government relations. He has a history of best practise with stakeholders and environmental management groups. Mr. Albanese is also a recipient of the SW Mining Hall of Fame award in the United States.

- **Mr. Jonathan Gardner** – A Professor of Marine Biology at Victoria University of Wellington. Much of his work is focused on using molecular tools to better understand connectivity in marine species. This research is multi-disciplinary and involves ecologists and physical oceanographers and has a very applied focus to deliver management outcomes in conservation (i.e., coastal and deep-sea marine protected areas), in biodiversity studies and phylogeography, management of bioinvasions, and in aquaculture and fisheries.

In addition to the TAB, CIC, through the members of the Consortium, have direct access to and continual support from the following experts, all of whom will be directly and actively involved in the oversight and execution of the Exploration Work Programme:

Andrew Craig, Director of Marine Operations, Odyssey Marine Exploration

- 20+ years' experience in mechanical engineering and recovery operations using remotely operated vehicles, with significant experience managing operations to depths of 6,000 metres.
- Responsible for the management and acquisition of Odyssey's high-tech deep-ocean tools as well as leading operations aboard vessels.
- Directed the crew during the search and recovery phases of the cargo from SS *Gairsoppa* and the recovery of cargo from the SS *Central America* 2014 expedition.
- Participated in the operations for the SS *Republic,* Balchin's HMS *Victory* and the ET409 airliner wreckage search and recovery operations.
- Prior to joining Odyssey, Mr. Craig was the Operations Manager for Sub-Surface Engineering, where he mobilised and executed hydrographic and topographic surveys, diving operations, and ROV inspections. Mr. Craig has also worked as a commercial and recreational dive instructor.
- Bachelor of Sciences, with High Honours, in Underwater Studies with Hydrography from Plymouth University and a Higher National Certificate in Mechanical Engineering from Lackham College.

Ernie Tapanes, Senior Project Manager, Odyssey Marine Exploration

- 20+ years' offshore project management, sonar imaging and survey expertise, including specialisation in deep-water vehicle and remotely operated vehicle deployment, with significant experience managing operations to depths of 6,000 metres.
- Directs operations aboard Odyssey's research and survey vessels, as well as client and chartered project vessels.
- Led the Odyssey search teams responsible for the *SS Republic*, Balchin's HMS *Victory*, SS *Gairsoppa* (4,700 metres water depths), SS *Central America* and ET409 airliner wreckage search and recovery operations.
- Manages project planning for ExO's Phosphate Resource (phosphate sand) and Aldama (Manganese nodule) mining exploration projects off Mexico.
- Shared managerial duties during Neptune/Dorado Ocean Resources Seabed Mineral research programme throughout South Pacific.

- Led Chatham Rise project, including four separate phosphorite nodule exploration cruises.
- Previously, President for ADC International, where he managed the company's underwater survey operations, in which his team was responsible for locating the USS *Maine*, a 19th-century American warship.
- Bachelor of Computer Science from Carleton University, Ontario, Canada.

4.2 Experience in Deep-Sea Exploration, Oceanographic Data Acquisition and Environmental Operations

Odyssey Marine Exploration (Odyssey)

Odyssey will carry out CIC's Exploration Work Programme. The company has vast experience that is directly applicable to the Cook Islands Nodule Exploration Programme.

For over 20 years, Odyssey has combined tools, team and technology to search for, study and recover a variety of marine seafloor assets and resources. Work has ranged from extensive mineral assessments to robotic archaeological excavations of shipwreck cargoes. These operations were conducted in water depths up to and exceeding those found in the nodule fields of the Cook Islands' EEZ.

The company has conducted search and recovery of base and precious metal cargos from extremely deep shipwrecks. Search operations were performed using a high-resolution dual-head towed multibeam and an ROV with depth rating of 6,000 metres. Once the recovery portion of a project commenced specialised tools including a hydraulic shear, grab, hot stab and deck plate remover were used to surgically cut open steel ship hulls and access cargo. Custom-fabricated robotic tooling was designed and constructed to recover cargos of metal ingots from the interior of the wreckage.

During the past decade, Odyssey has managed and completed over 24,000 hours of complex deep ocean ROV operations at depths between 4,500 and 6,000 metres.

Additionally, Odyssey has planned and executed offshore mineral operations for projects such as ExO's Phosphate Resource, which have demanded the application of available and custom-designed technology to determine mineral resources as well as environmental and oceanographic parameters pertaining to their setting. The extent of the phosphate resource off the western coast of Mexico in 80 metres of water was determined through bathymetric survey and ore matrix sampling.

Offshore operations and subsequent management of sample description, assay and analysis led to the production of a resource statement formatted to JORC or NI 43-101 standards which outlines a geological resource of 588 million tonnes of measured, indicated and inferred phosphorite ore as empirically ground-truthed from 6-metre vibracore acquisition and the associated chain of custody procedures, laboratory assay and Quality Assurance / Quality Control (QA/QC) protocols.

Combined with geotechnical data acquisition, the project required the gathering of environmental baseline data to support engineering and environmental impact analysis.

This analysis included deployment of current metres, CTD and sediment traps, and commissioning plume modelling, ecotoxicology, and sound propagation studies.

Odyssey also conducted multiple operations on South Pacific Seabed Mineral projects. Odyssey's vessels, equipment and technical personnel were deployed to conduct ship-mounted multibeam echosounder survey, side-scan sonar, Tow-Yo water chemistry, geologic and ROV multibeam, video surveys and sampling at depths ranging from <1,000 to 3,000 metres in South Pacific jurisdictions, including those of multiple Secretariat of the Pacific Community (SPC) member states.

University of South Florida College of Marine Science (USFCMS) and University of North Carolina-Chapel Hill (UNC-CH)

In addition to the technical experience Odyssey brings to the Exploration Programme, CIC has also partnered with the University of South Florida College of Marine Science (USFCMS - USA) and the University of North Carolina – Chapel Hill (UNC-CH - USA) for collaboration on physical oceanographic, environmental and other aspects of the project.

Project participants from this team have over a century of combined experience in oceanographic data collection and modelling, with applied experience from the Atlantic/Gulf of Mexico, Pacific and Indian Oceans. Dr. Mark Luther (USF-CMS) and Dr. Chris Martens (UNC-CH) will be leading the effort.

Activities will include modelling oceanographic currents, collecting data on sedimentation rates, ambient turbidity, sound, water current velocity and dissolved oxygen, as well as predicting sediment plumes which would occur in future nodule recovery operations.

Dr. Luther, the team member overseeing current and plume modelling, is a director of the Coastal Ocean Monitoring Prediction System, a founding member and past board chairman of the Alliance for Coastal Technologies and is presently the chairman of the International Seakeepers Society Science Advisory Council. USF-CMS, Dr. Luther's home institution, is a leader in integrated marine sciences, with research activities spanning the globe. The institution was an active member of the Gulf of Mexico Research Initiative, an independent research programme established following the Deepwater Horizon oil spill; through the programme, USF-CMS established the Centre for Integrated Modelling and Analysis of Gulf Ecosystems (C-IMAGE), an international Consortium of academics, researchers and students representing 19 collaborating institutions. The initiative studied geological, biological, chemical and physical aspects of environment and ecosystems over the span of a decade.

Additionally, CIC will be working cooperatively with academic experts from The University of the South Pacific (Rarotonga), Eckerd College (USA), The University of Hawai'i (Manoa), Kochi University (Japan), The International Marine Minerals Society (IMMS), The United States Geological Survey (USGS), The Natural History Museum of London (UK), and The National Oceanography Centre at the University of Southampton (UK) as well as other institutions.

4.3 Odyssey Operates Under a Robust Set of Risk Management Systems and Policies

The following is a summary of the company's Risk Assessment Programme, which is a subset of the company's comprehensive Risk Management Programme. An Exploration Programme Specific Risk Management System and Policy will be provided to the SBMA for dissemination prior to the commencement of offshore operations.

Introduction

Risk Assessments are important tools used to identify significant hazards and manage risks associated with an operation. A hazard is something that has potential to cause damage or harm to personnel, equipment, the environment and/or the reputation of the company or its clients and stakeholders.

The operation may be a routine task or a one-off project activity. However, risks within each operation must be assessed to ensure that adequate control measures have been put in place to ensure the safety of the operation and that no harm will come to personnel, equipment or the environment.

Risk Assessment Methodology

Odyssey undertakes risk assessments in line with industry best practises established within the '*Step Change in Safety Task Risk Assessment Guide'*.

Risk Assessment Form & Library

QHSE-3000A is the Odyssey Task Risk Assessment template which is based on the Step Change in Safety model format. A Master Library of Risk Assessments is stored on the company's Information Management System (IMS).

Project Assessments

Prior to mobilisation of any offshore project a Project Risk Assessment will be generated as part of the review of project specific operations and constraints. The Project Risk Assessment may be reviewed in a risk assessment meeting (HIRA) which will include relevant personnel from all organisations and departments involved in the planned operations. Control measures will be identified within the Project Risk Assessment and the project manager will be responsible for ensuring that these are implemented.

The Risk Assessment Process

The purpose of the Risk Assessment Procedure is to provide tools that evaluate new risks as they arise and ensure that any changes can also be adequately assessed. Thus, helping to ensure that all reasonable, foreseeable hazards for non-routine tasks are identified and the risks are assessed and reduced to the lowest level (as low as reasonably practicable or ALARP).

The Risk Assessment process commences with an analysis of the task to allow any associated hazards to be identified. This may simply be done by listing all the activities of the task, the substances and equipment involved and any environmental conditions that may be appropriate. From the various components of the task, the hazards may be identified, analysed and then risks assessed and reduced to ALARP.

The outcome may require modification to the procedures, equipment, process, or a more detailed analysis. These in turn may require further evaluation prior to final closeout. The Risk Assessment shall be suitable and sufficient for the level and likelihood of potential damage and/or injury to personnel.

Tolerability Criteria

The Risk Assessment process is a compilation of the "qualitative" views of the risk assessment team. The risk values given are agreed as part of the risk assessment process. They are categorised as follows:

- High Risk (RED): Task must not proceed. It should be re-defined or further control measures put in place to reduce risk. The controls should be re-assessed for adequacy prior to task commencement.
- Medium Risk (YELLOW): Task should only proceed with approval of a line manager. Where possible, the task should be redefined to take account of the hazards involved or the risk should be reduced further prior to task commencement.
- Low Risk (GREEN): May be acceptable; however, review task to see if risk can be reduced further.

4.4 Baseline Environmental Data

CIC is committed to taking an inclusive, transparent multi-stakeholder approach to environmental planning. This will include studies to acquire, analyse and compile sufficient baseline data for a robust EIA.

CIC will consider the ISA's most up to date template for baseline studies and EIA development, as this framework has benefited from input provided by a large stakeholder pool from various sectors over the course of several decades.

In addition, CIC will partner with international and local scientific experts, where appropriate, to design and conduct the studies required to establish an environmental baseline and EIA. The company will cooperate with the Cook Islands' Government as well as other stakeholders to develop impact minimisation and mitigation strategies and responsible environmental management measures. Unless advised by the Cook Islands Government that another approach is preferred, CIC will take into consideration the EIA template of the draft ISA regulations, issued in March 2020 (ISBA/25/LTC/6/Rev.1), modified as appropriate by the ISA draft mining regulations (ISBA/24/LTC/WP.1, Annex IV) when it prepares its EIA.

CIC recognises that the Cook Islands' National Environment Service (NES) has the authority to require either consent or a project permit for any activities. CIC will work collaboratively with the NES throughout the programme and will satisfy all requirements necessary before engaging in any exploration activities.

5. Impact on Other Sea Users

CIC will collaborate with the public, Cook Islands' Government departments, local businesses, and NGOs to identify all the key sea user stakeholders to ensure appropriate engagement and a clear path of communication. Suggestions or proposals from Cook Islands' stakeholders and communities will be solicited to help design an Exploration Plan that avoids issues with tourism, commercial/artisanal fisheries, submarine cable projects, marine scientific research, navigation, and other sea users.

Proposed regulated activities will seek to avoid, resolve and mitigate interference with respect to their interests and ensure that any issues relating to offshore activities will be resolved quickly and efficiently while achieving the stated goals of the Exploration Work Programme.

CIC understands that the oceans are the home and lifeblood of the people of the Cook Islands. The culture, industry, and infrastructure of the Cook Islands naturally depend on the ocean surrounding them and all will be respected accordingly.

The offshore activities will occur at a minimum of 50 nautical miles from any coastline, with a majority of the work being conducted much farther offshore. The research that will result from exploration activities will provide important new data that should be useful to a number of commercial and artisanal fishing groups as well as other stakeholders throughout the Cook Islands. While some licenced areas partially overlap known productive areas of fishing, CIC anticipates that exploration work in these overlapping areas can be planned around their respective fishing patterns, and in some cases, during off-seasons to mitigate any potential interference.

CIC also anticipates engaging with representatives from various governmental departments, local communities including churches, schools, local businesses and other stakeholders to better understand the concerns and ideas they have regarding how CIC might work collaboratively to maximise the benefits that can be derived from exploration.

Over the past three years, CIC has already had face-to-face meetings with representatives from Marae Moana, the National Environment Service (NES), the Te Ipukarea Society (TIS), Korero O Te 'Orau, the Cook Islands National Heritage Trust, as well as other key stakeholders for preliminary discussions.

Examples of organisations and stakeholders to be engaged include but are not limited to:

- Marae Moana
- Te Ipukarea Society (TIS)
- Korero O Te 'Orau
- Pacific Islands Conservation Initiative (PICI)
- Secretariat of the Pacific Regional Environment Programme (SPREP)
- Cook Islands Fisheries Field Office (CIFFO)
- Pacific Islands Forum Fisheries Agency (FFA)
- The Secretariat of the Pacific Community (SPC)
    - Pacific Islands Tuna Industry Association (PITIA)
    - Western & Central Pacific Fisheries Commission (WCPFC)

5.1 Fisheries

Exploration activities are not expected to have any measurable impact on any of the Cook Islands' fisheries. While some CBGs partially overlap known productive areas of fishing, CIC anticipates that through effective communication with communities and fishing organisations, exploration work in these overlapping areas can be planned around their respective fishing patterns and in some cases during off-seasons to mitigate any potential interference.

Pelagic fisheries have been a staple of the Cook Islands' marine resources throughout its history. The variety of tuna species that regularly migrate through the Cook Islands' EEZ have given the country international recognition as one of the premier locations for commercial and artisanal tuna fishing. Understanding commercial and artisanal fishing grounds and annual periods of greatest production is critical for avoiding any problematic interaction between CIC's exploration operations and the Cook Islands' fishing vessels.

With this knowledge, CIC will develop the Exploration Work Programme and offshore operations in collaboration with fisheries to ensure fishing and mineral exploration can successfully co-exist.

Longline and purse seine vessels represent the two major commercial methods used for pelagic fisheries within the Cook Islands' EEZ. Skipjack, albacore, yellowfin, and bigeye tuna are the species primarily targeted by commercial vessels licenced to fish within the Cook Islands' EEZ.

One exploration technique that will need consultation and coordination with various fisheries stakeholders of the Cook Islands is the installation of the deep-sea moorings. According to the Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations (FAO), the deepest longline and purse seine operations reach a maximum water depth of 300 metres.

The longest oceanographic mooring will extend from the seafloor to a ~500-metre water depth, giving a 200-metre buffer between the deepest predicted fishing operations and the top of the longest subsea mooring. This is an example of an opportunity for CIC to work

collaboratively with other sea users to ensure there is no interference with or disruption to their activities.

Active outreach to fishing organisations and local communities will take place in advance of exploration activities to pre-empt and mitigate the risk that CIC's offshore operations interfere with any commercial, cultural, or artisanal fishing activity throughout the Cook Islands. The following is a synopsis of the company's understanding of the primary fisheries of the Cook Islands.

The summary findings indicate:

1. In most cases the proposed CBGs do not overlap with primary fishing grounds.
2. Commercial fishing is seasonal, allowing management of offshore exploration activities to assure there is no interference between the operations.
3. Permanent and long-term installations of mineral exploration equipment are deeper than fishing gear typically used.
4. Both mineral exploration and fishing vessels move and operate at slow, controlled and predictable speed and direction to easily avoid each other where and when necessary.
5. Offshore exploration activities will have very minimal impact on the seafloor and water column resulting in no commercially measurable impact on fisheries; fish stocks will not be harmed from deep-sea mineral exploration.

Based on preliminary research into the Cook Islands' fisheries and input from the TAB, CIC is proposing the following measures to ensure that both government and public stakeholders are included and engaged throughout the development of this exploration effort:

- Collaboration with regulating agencies and artisanal fishermen to assist, where possible, in the monitoring of licenced fishing vessels operating in the Cook Islands' EEZ.
- Assistance in the development of Environmental Impact Assessments that could be implemented to help determine the effects of various commercial fishing gear being used in the high seas on artisanal catches.
- Acknowledgement of the absolute, non-negotiable rights of Cook Islands' fishing communities to be involved with any developments at sea, including seabed minerals exploration.
- Commitment to engaging in proactive programmes to support and enhance local knowledge and job opportunities.
- Collaboration with public authorities (Ministry of Education) to achieve high academic standards and foster continuing education aimed at local communities, especially in the field of marine science and environmental studies. Marine research and innovation will benefit from CIC's long-term involvement in the Cook Islands.

5.2 Longline Fisheries

According to the Cook Islands Ministry of Marine Resources 2017 Annual Report, the Cook Islands' longline fleet consisted of 10 Cook Islands-flagged longline vessels operating within the Western and Central Pacific Fisheries Commission - Convention Area (WCPFC-CA). Among these, three domestically based vessels were licenced to fish within the national jurisdiction only.

Eight vessels were authorised to fish within the Cook Islands' EEZ and the High Seas, but rarely fished beyond the waters of national jurisdiction, and three were licenced to fish on the High Seas only. A total of 45 foreign-flagged vessels were licenced and authorised to operate within the Cook Islands' EEZ under charter during 2017. Foreign-flagged longline fishing in 2017 was undertaken by two Chinese companies, with Chinese-flagged vessels operating out of Pago Pago (American Samoa), Suva (Fiji), Papeete (French Polynesia) and Kosrae (Federated States of Micronesia).

In 2017, all longline vessels licenced to fish in the Cook Islands' national jurisdiction were prohibited to fish within 24 nautical miles of Rarotonga and 12 nautical miles of all the other islands. In July 2017, the Cook Islands passed the Marae Moana Act which prevents any type of commercial fishing within 50 nautical miles of all islands. The 50 nautical mile commercial fishing exclusion zones from the Marae Moana Act were implemented in 2018.

There is a strong seasonal trend in catch per unit effort (CPUE) and the calendar fishing year (Figure 5.1). In general, first and fourth quarter catch rates and total catch are low, with this period referred to as the off-season.

Each year, the second and third quarters represent the peak of the fishing season. Catch rates of all three key tuna species steadily decline from August/September onwards, signaling the end of the fishing season.

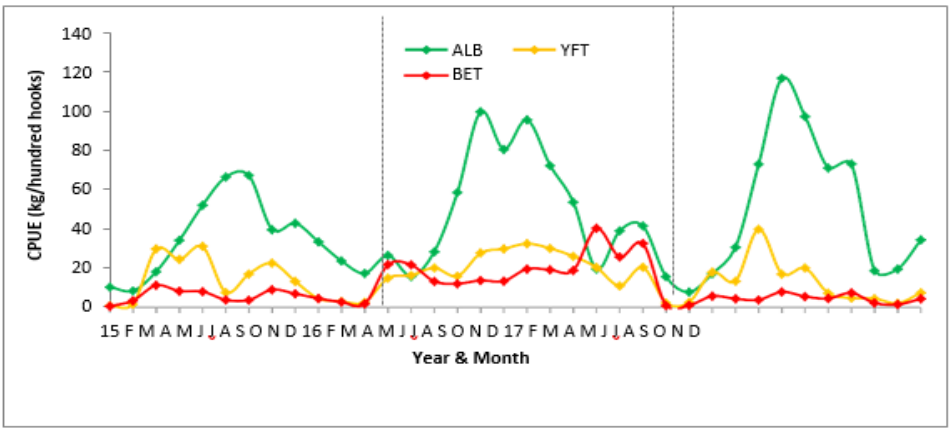


Figure 5.1. Monthly CPUE for albacore (green), yellowfin (yellow) and bigeye tuna (red) from 2015-2018 of all longline vessels fishing within the Cook Islands' EEZ. The dashed lines indicate a new year. Source: CIMMR 2017 Annual Report.

The longline fishery is typically active between 10° and 15° South; however, longline fishing efforts and catches continue to extend further south every year. While albacore is prevalent throughout the entire Cook Islands' EEZ, yellowfin and bigeye have the highest catch rates in the north. The proposed CBGs are mostly located around the central portion of the Cook Islands' EEZ with only three of them having any overlap with longline fishing zones.

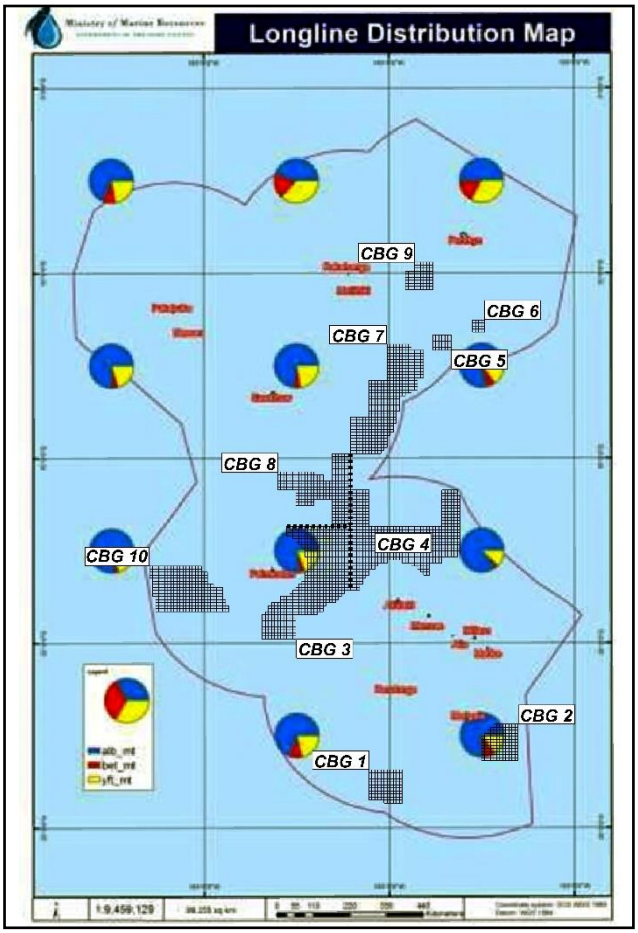


Figure 5.2. Longline fishing distribution of catch in metric tonnes of key tuna species in relation to CBGs. Blue=albacore, Red=bigeye, Yellow=yellowfin. Source: CIMMR 2017 Annual Report

CIC plans to mitigate any longline fishing interference with overlapping CBGs by consulting with fisheries and relevant fishermen, and if there is a concern that cannot be resolved, exploration operations for these areas will be planned during the longline off-season (generally the first and fourth quarters of the year). In addition, CIC intends to undertake community and commercial outreach efforts to better understand the concerns of all stakeholders impacted by the Cook Islands' longline fisheries sector. Understanding these concerns will help shape exploration cruises that avoid and mitigate potential interference with Cook Islands' fisheries.

5.3 Purse Seine Fisheries

The purse seine fishery is a surface fishery targeting schooling skipjack tuna in the tropical waters of the Western and Central Pacific Ocean (WCPO). The purse seine fishery operates in the northernmost waters of the EEZ targeting tuna on both free and fish aggregation devices (FAD) associated schools.

2017 was the third year the Cook Islands entered bilateral negotiations to licence foreign flagged purse seine vessels in addition to vessels under the U.S. Multi-Lateral Treaty. An additional 15 vessels from Korea, Kiribati and Spain were licenced to fish in the EEZ of the Cook Islands.

The purse seine fishery is controlled by using the Vessel Day Scheme (VDS), which monitors the days fished in a zone. A fishing day is defined as either a set (deploying the purse net) or when the vessel is actively searching for a school or deploying a FAD. In 2017, the Cook Islands declared a Purse Seine limit of 1,250 vessel days, of which 456 were used by the U.S., 76 by non-US operators and 13 by Spanish vessels.

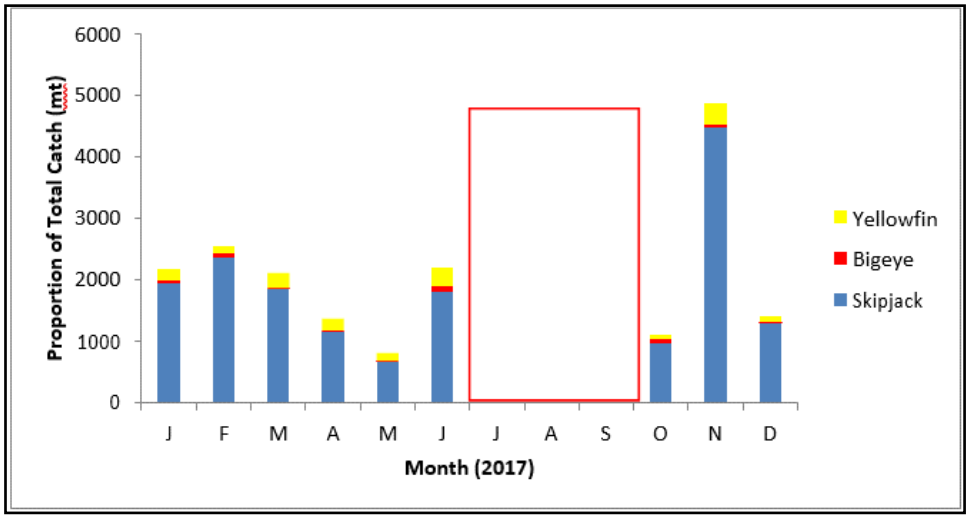


Figure 5.3. Purse seine catch estimates (metric tonnes) of key tuna species by month in 2017. The red shaded area depicts the four-month FAD closure. Source: CIMMR 2016 Annual Report

There is a strong seasonal trend in the purse seine fishery, with the fourth and first quarter of the year highlighting the peak season of the fishery. This is opposite to the longline fishery which operates largely through the winter months. The purse seine fishery is subject to a three-month FAD closure from July to September which prohibits the setting of nets on FADs.

It is especially unlikely that CIC exploration will interfere with purse seine fisheries. The majority of CBG area is in the central or southern parts of the Cook Islands' EEZ except for CBG5, CBG6, CBG7 and CBG9.

CIC will take extra precautions when planning offshore exploration activities in these CBGs to not affect the purse seine fisheries by exploration activities. It should be noted that during years of *El Niño* Southern Oscillation (ENSO) events, purse seine activity shifts toward the eastern tropical portion of the Cook Islands' EEZ (such was the case in late 2015-early 2016).

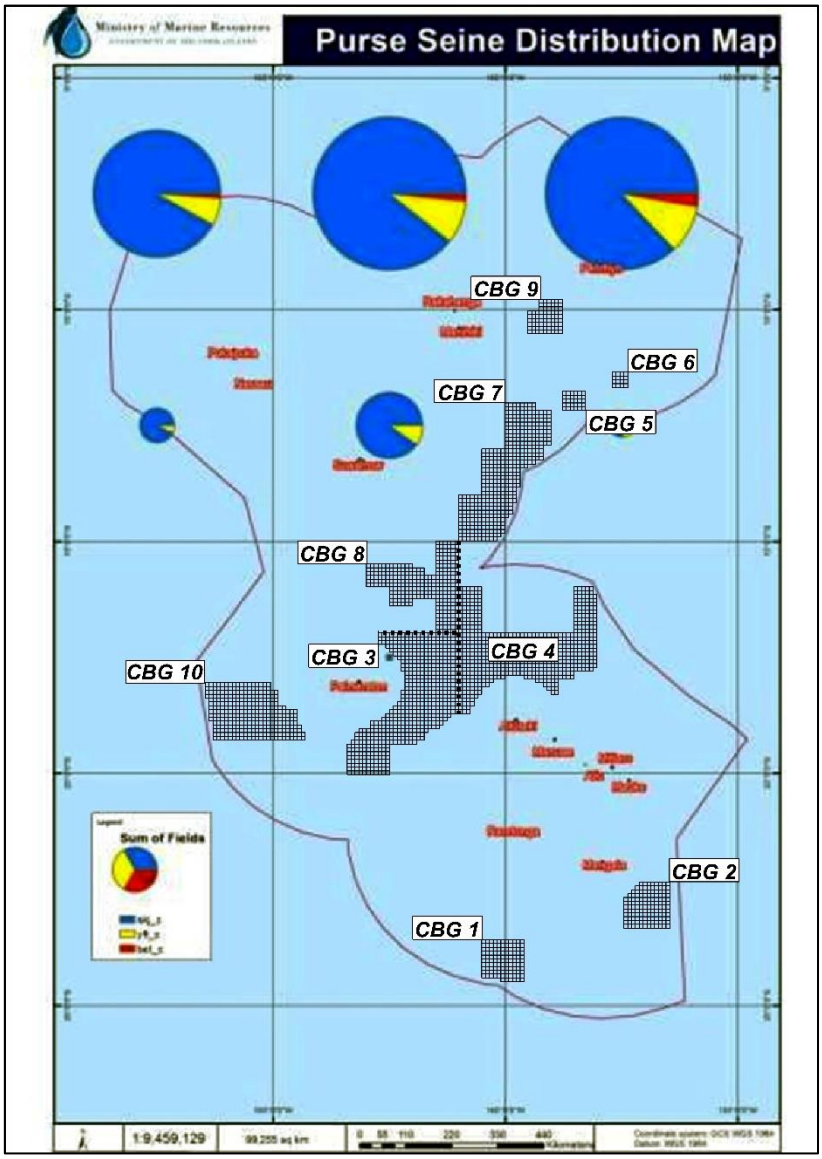


Figure 5.4. Purse seine catch (mt) distribution of key tuna species in relation to CBGs. Blue=albacore, Red=bigeye, Yellow=yellowfin. Source: CIMMR 2017 Annual Report

5.4 Artisanal Fishing

The Cook Islands' artisanal fishery occurs on all inhabited islands, primarily targeting tuna and pelagic species. In 2017 there were 265 active artisanal vessels reported, of which 96% were small, powered boats with outboard motors, 3% were sport or recreational vessels, and 1% were unpowered canoes. While small, powered boats are generally known to fish for subsistence, recreational/sport fishing boats target selling fishing charters and tours to tourists.

Trolling is the main fishing practise used to target billfish, tuna, and other pelagic species. Charter trolling generally takes place within 10 nautical miles of the islands' coasts, ensuring that exploration activities will not cause any interference.

Rarotonga and Aitutaki lead the rest of the islands in infrastructure, population, and tourism which in turn explains the exponential difference in artisanal fishing hours spent throughout 2014, 2015, and 2016 (Figure 5.5). The fishing charters that exist throughout the Cook Islands are primarily based out of Rarotonga, with a few exceptions in Aitutaki. All CBGs are at least 50 nautical miles from Aitutaki and Rarotonga.

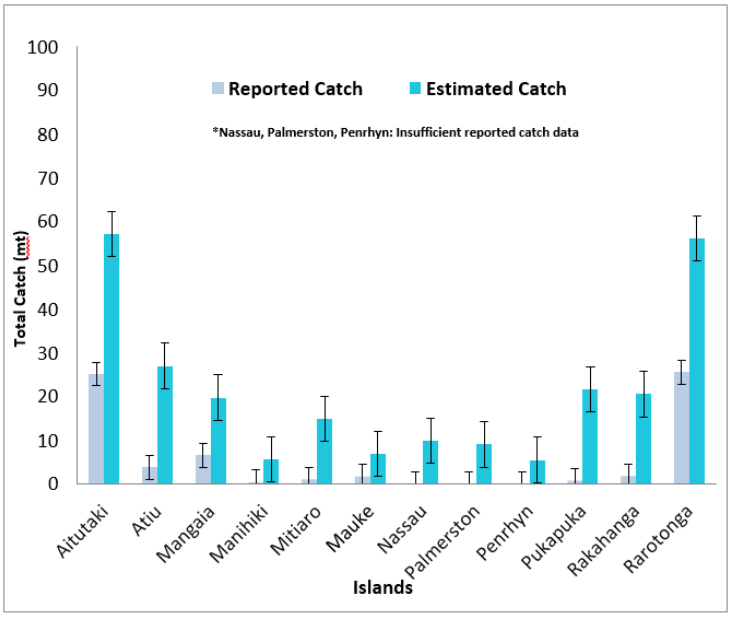


Figure 5.5. Artisanal reported and estimated catch totals (metric tonnes) per island for 2017. Source: CIMMR 2017 Annual Report

5.5 Submarine Cabling

Exploration activities will not interfere with submarine cabling. Detailed project planning assures that exploration operations conducted in the proposed CBGs will not interfere with the installation, maintenance, or positioning of any submarine cable.

CIC is aware that a regional fibre-optic cable system was installed in 2019 which currently is planned to connect Rarotonga and Aitutaki to high-speed broadband internet.

It is highly unlikely that CIC will encounter any conflicts with the work proposed for cable maintenance throughout the Cook Islands. The physical impact to the seafloor is extremely minimal and limited. In fact, the survey data collected during exploration will benefit the design of cable routes that may be installed in the future and will provide useful high-resolution bathymetric data to the Cook Islands that will potentially be useful in cable route surveys. CIC intends to plan exploration in coordination with any submarine cable contractors, so the activities do not impact or interfere with maintenance of submarine cable operations.

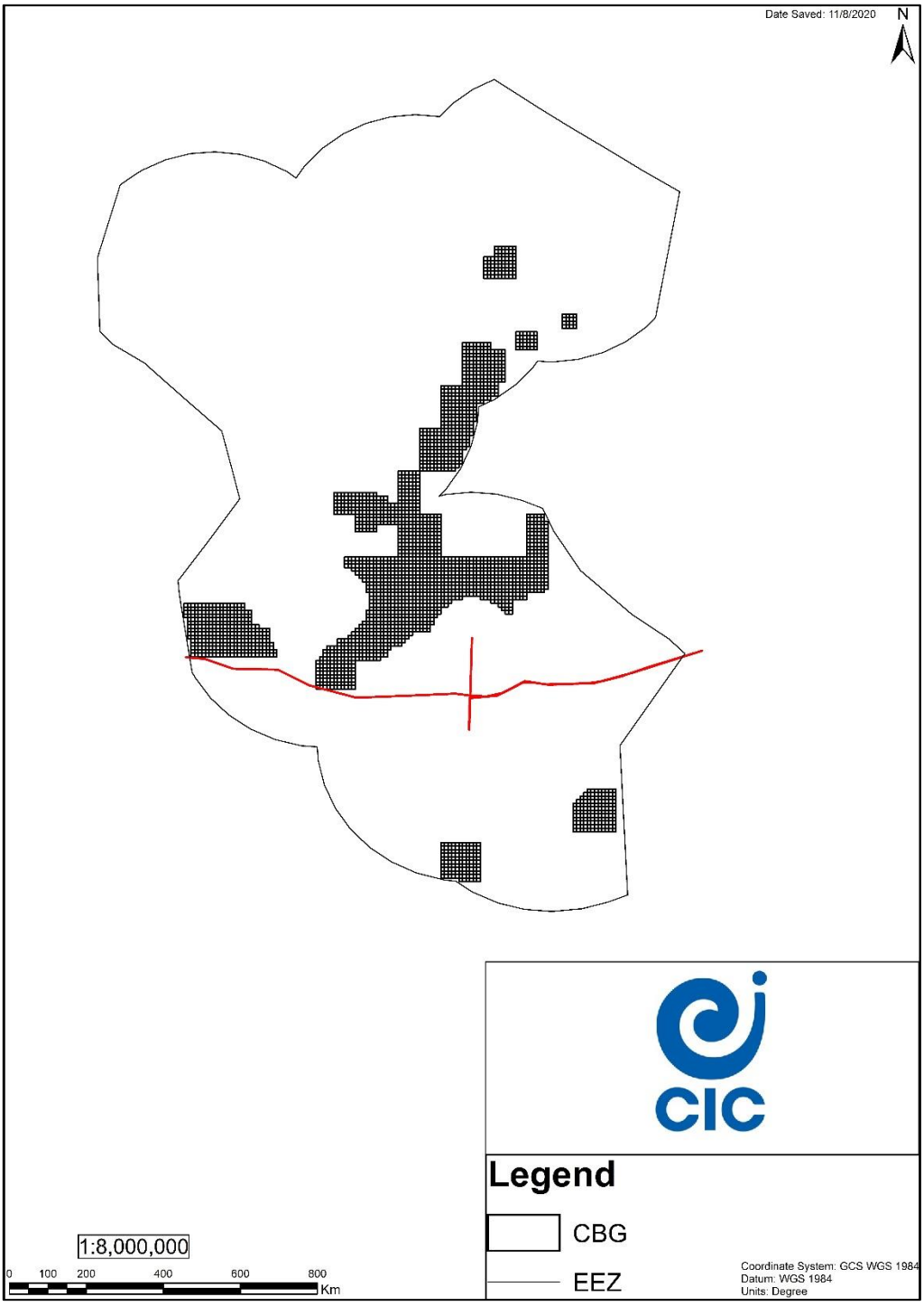


Figure 5.6. Map showing the approximate cable route (red lines) in relation to CBGs proposed for exploration.

5.6 Marine Scientific Research

Exploration activities present an opportunity to significantly enhance marine scientific research in the Cook Islands' EEZ. CIC will provide extensive biological, geological, and physical oceanographic data that will contribute to the growth and overall understanding of the Cook Islands' national jurisdiction.

Throughout the term of an Exploration Licence, CIC will provide the Cook Islands (as well as any credentialed academic affiliates) with significant data relating to all fields of oceanographic science. A key CIC goal is to partner with local, regional, and international academic institutions that have performed marine research within the Cook Islands in the past, as well as institutions that want to be involved in the future of the Cook Islands' marine scientific research. Rather than inhibit oceanographic research in the Cook Islands, CIC plans to be a catalyst for local/international scientific institutions to conduct new scientific research in the deep-sea environment.

Additionally, CIC intends to collaborate with the Cook Islands' Government departments to interpret the environmental data acquired during exploration in a way that can be understood and is accessible to all Cook Islanders.

While CIC is currently unaware of any Cook Islands marine scientific research expeditions occurring during the preliminary exploration cruises, adjustments to CIC's Work Programme as well as direct communication with potential research expeditions will take place to ensure that CIC's exploration does not interfere with, and where possible, complements, other marine scientific research.

5.7 Navigation

Exploration vessels and equipment will not impede any shipping lanes or the navigation of other seagoing vessels. CIC has partnered with Odyssey to conduct exploration operations planned for this Licence. Odyssey has an extensive history of working in coastal waters where it is critical to be aware of shipping routes and other vessels near the vicinity of operations.

Odyssey has performed scores of maritime operations near the following ports with no incidents:

- Auckland, New Zealand
- Wellington, New Zealand
- Port Moresby, Papua New Guinea
- Rabaul, Papua New Guinea
- Honiara, Solomon Islands
- Port Vila, Vanuatu
- Apia, Samoa
- Suva, Fiji
- Pago Pago, American Samoa
- Nuku'alofa, Kingdom of Tonga
- Brisbane, Australia
- Portland, UK
- Bristol, UK
- Falmouth, UK
- Hull, UK
- Cork, Ireland
- San Diego, USA
- Jacksonville, USA
- Charleston, USA
- Praia, Cape Verde

Exceptional navigational compliance and communication was demonstrated while operating in all the listed territorial waters. During its 26 years of operations, Odyssey has never had an accident resulting from impeding other vessels.

It should be noted that research vessels, fishing vessels, and cargo ships move and operate at controlled and predictable speeds and directions making it logistically easy to avoid each other. Nonetheless, communication of planned offshore work and shoreside logistics with the Cook Islands' Ports Authority (as well as the Cook Islands' Ministry of Transport) will take place to ensure that all maritime navigational conflicts are avoided.

5.8 Tourism

CIC's exploration activities are located well away from any tourism interests (a minimum of 50 nautical miles from any island). Furthermore, there will be no measurable environmental impact to tourism areas from exploration activities. CIC understands that tourism is vital to the Cook Islands' economy; the pristine lagoons and ocean surrounding them draws tourists from around the world to experience numerous water activities including:

- Snorkeling
- Boating/Cruising
- Paddle boarding
- SCUBA Diving
- Whale watching
- Diving with Sea Turtles
- Kitesurfing
- Surfing
- Fishing
- Lagoon Cruises

While most tourism activities take place within the islands' sheltered lagoons, away from the open seas of the Pacific Ocean surrounding them, CIC acknowledges the interconnected relationship between these lagoons and the ocean. The company plans to incorporate the precautionary approach and will maintain a priority of environmental awareness throughout all phases of its seabed minerals work to avoid negatively affecting the ocean or lagoons.

5.9 Marae Moana

The implementation of Marae Moana in 2017 was a significant accomplishment by the Cook Islands that will help ensure the preservation and sustainability of its national waters. It is currently the largest commitment by a single country for integrated conservation management from ridge to reef and reef to ocean.

CIC recognises the foresight of the Cook Islands in their proactive approach to protecting its oceans. CIC intends to develop a strong relationship with representatives from Marae Moana to understand and adapt operations as needed to meet the organisation's goals and the standards set in the legislation relating to this marine park.

All exploration activities are outside of the defined 50 nautical mile Marae Moana exclusion zones and so these activities will have negligible - if any - environmental impact within the exclusion zones. Furthermore, research garnered from the exploration activities will accrue to a greater understanding of the surrounding ocean systems and will contribute to future Marae Moana spatial planning and management.

CIC will carefully and responsibly adhere to the nine principles of ecologic sustainability outlined in the Marae Moana Act 2017 and listed below (Table 5.1).

Table 5.1: CIC Measures to Follow Marae Moana Nine Principles of Ecologic Sustainability

Marae Moana Principles of Ecologically Sustainable Use	Examples of Compliance by CIC
1. Principle of protection, conservation, and restoration	The extensive Exploration Programme being proposed by CIC will collect essential baseline environmental data to help establish measures and protocols that can be implemented to protect and conserve marine biodiversity within the Cook Islands' EEZ as well as develop future measures for monitoring and managing seabed areas affected by deep-sea nodule harvesting.
2. Principle of sustainable use to maximise benefits	The primary goal of CIC is to assist the Cook Islands in developing a successful and environmentally sustainable Seabed Mineral Harvesting Project that not only contributes to realising the economic benefits of the nodule resource, but also serves as the catalyst for collecting critical environmental data needed for the continued development of Marae Moana spatial planning that will ensure a healthy ecosystem and pristine waters for future generations of Cook Islanders.

3. Precautionary Principle	CIC is completely committed to the precautionary approach and is in full agreement that it is essential that this approach is at the forefront of every stage of the project, including the baseline environmental data collection that will take place during exploration. CIC recognises the work and research that went into the publication of *Cook Islands Seabed Minerals: A Precautionary Approach to Mining* by Gerald McCormack and has developed the environmental data collection and monitoring portion of the Work Programme to align with both Mr. McCormack's considerations as well as suggested areas of environmental study by the ISA.
4. The Principle of Community Participation	CIC understands that for a successful seabed mineral project to take place within the Cook Islands, it must inform and include all stakeholders at every stage of the project. The licencing process implemented by the SBMA does an excellent job of including the comments and opinions of community representatives and a wide array of stakeholders before any Exploration Licences are granted. CIC believes this is an important first step in abiding by this principle but is also aware that it is the responsibility of the contractor to continue engaging and informing stakeholders once an Exploration Licence is granted and the Work Programme has been initiated.

5. The Principle of Transparency and Accountability	The robust tender process announced by the SBMA in October 2020 is the first step in assuring that this principle is being adhered to by not only the contractors submitting applications, but also the Cook Islands' Government. By having all Tender Exploration Applications reviewed by various government agencies, independent technical experts as well as the Advisory Committee, CIC is confident that it will uphold this principle. Similarly, to the Principle of Community Participation, it will be CIC's responsibility to perpetuate transparency throughout the proposed Work Programme by collaborating with the relevant Cook Islands Government departments to distribute and share data collected throughout the exploration campaigns. CIC understands how critical these data are for better scientific understanding of the Cook Islands' marine environment and that they will play a large role in assisting legislation such as the Marae Moana Act to designate areas for certain marine activities throughout the Cook Islands' EEZ.
6. The Principle of Integrated Management	From the onset of lodging CIC's Application, various government, non-government, and external partners will be involved with its review and scoring. If an Exploration Licence is granted to CIC, engagement with all these groups will be continued throughout the Exploration Licence term as variations to the proposed Work Programme are contemplated and project design continues to develop.
7. Principle of Investigation and Research	The methodology proposed for the exploration Work Programme being presented by CIC is essentially standard marine scientific research with the exception of a few geotechnical techniques that will give additional clarity and confidence in the resource as well as provide data for the engineering of a harvesting system that minimises environmental impact. The data collected throughout the Exploration Licence term will help the Cook Islands introduce the needed regulations and policies prior to any commercial harvesting of nodules.
8. Principle of Ecosystem-Based Management	A critical part of the Exploration Work Programme will be identifying the biodiversity, physical properties and chemistry of the deep-ocean environment to contribute knowledge to this relatively new ecosystem and implement measures and effective preservation zones that minimise the impact on these ecosystems prior to commercial harvesting of nodules.

9. Principle of Sustainable Financing	CIC is a privately owned, Cook Islands' company that has the financial and technical support needed to help the Cook Islands develop an economically feasible and environmentally responsible Seabed Mineral Exploration Programme. Each investor, partner, advisor and manager has been thoroughly vetted and approved by the Cook Islands Business Trade Investment Board (BTIB) to ensure that CIC is bringing the highest quality of expertise and financing to assist the Cook Islands in developing their seabed minerals sector.

5.10 Marine Life

When planning all exploration activities, CIC will give special consideration to ensure that marine life is not exposed to serious negative impacts during the operational stages.

CIC recognises that the entire Cook Islands' EEZ is a designated whale sanctuary and plans to pay special attention to the whale migration route through the Cook Islands. A variety of different species of whales including humpback, sperm, and beaked whales have annually been observed migrating north up to Rarotonga and Aitutaki during early July, then departing via a route west/northwest by late October toward Samoa, Tonga, and Fiji.

While some of the proposed licenced areas may overlap with known whale migration routes, the research that will be done in these areas during the Exploration Licence term will primarily be standard marine scientific studies for which impact to whales is already known to be minimal.

No activities are planned that will cause significant emissions of acoustic energy within the Deep Sound Channel (~700 – 1,500m water depths). A detailed description of each exploration campaign will be provided to the NES and technical experts for review prior to the commencement of any exploration activities.

The multibeam echosounder equipment used to map the seabed poses no harmful impact to whales and is operated at both a frequency and intensity considered safe for marine mammals.

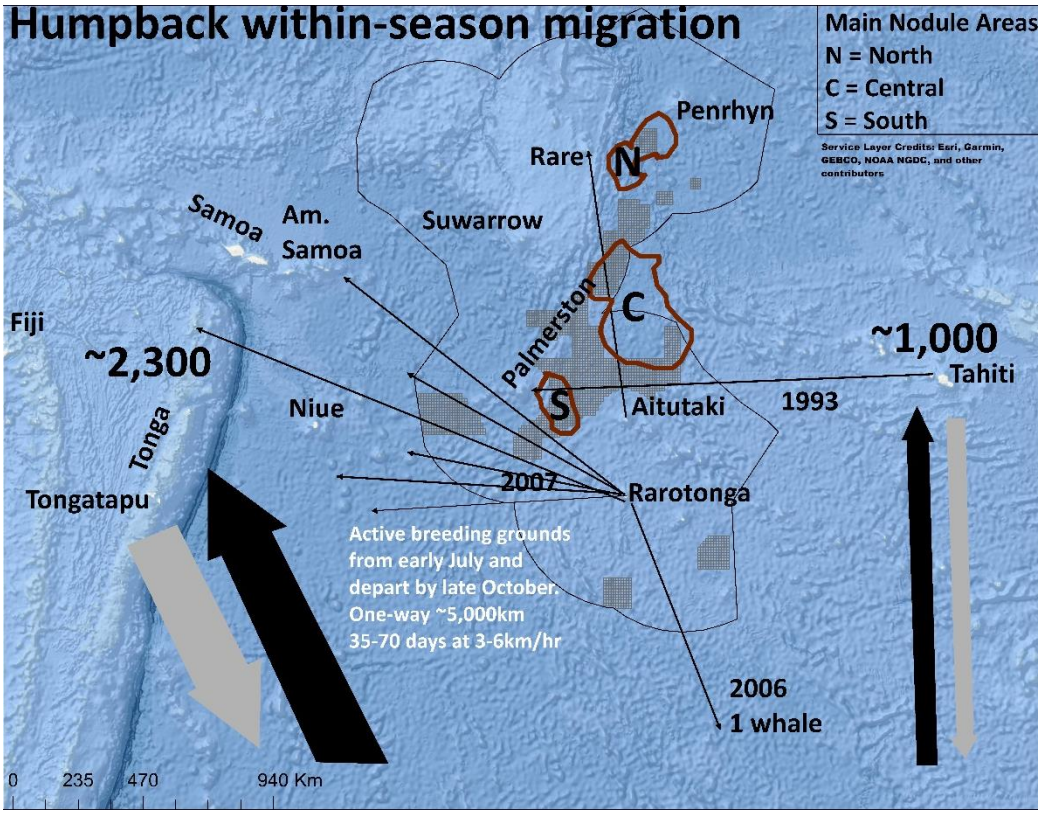


Figure 5.7. Map of Cook Islands' EEZ showing the approximate whale migratory patterns (thin arrows) in relation to CBGs (hash marks). Image adapted from Cook Islands Seabed Minerals: A Precautionary Approach to Mining by Gerald McCormack 2016.

Marine biota and bird observations, including the opportunistic recording of whale sightings and behavioural observations, will be an important component of all offshore exploration activities. All activities will be designed to avoid generating any significant noise within the deep sound channel (~700 m – 1,500 m water depths) to minimise any potential impacts to cetacean communication.

Additionally, environmental data collection will include the use of hydrophones in both the sound channel and near the seabed to establish a baseline of ambient acoustic levels.

Sea turtles have also been known to inhabit the open seas and lagoons as well as nest throughout the Cook Islands. The most commonly observed sea turtles in the Cook Islands' EEZ are Hawksbill (endangered) and Green Turtles (threatened). Both species are known to nest on Manihiki, Pukapuka, Penrhyn, Nassau, Suwarrow (December to February), and Palmerston (May to August). In Rakahanga only Green Turtles are known to nest.

Most of these are part of the Northern Group of islands (with the exception of Palmerston) giving sea turtles ample distance from the concentration of exploration activities that will take place. The most commonly frequented islands for turtle nesting are the Palmerston and Penrhyn atolls. Palmerston is approximately 50 nautical miles and Penrhyn is approximately 64 nautical miles from the closest licenced areas.

Currently there is not enough available data to determine precisely how many sea turtles regularly inhabit the Cook Islands' EEZ for nesting, feeding, and resting. The most recent data and observations however suggest that turtle populations are declining on most of the islands. CIC is confident that exploration operations, which will occur outside of the Marae Moana 50 nautical mile exclusion zones, will result in no significant environmental impact on sea turtles. The company looks forward to engaging with the Cook Islands' Government and relevant stakeholders to assist wherever possible with turtle protection measures and programs.

Offshore exploration activities are not expected to interfere with seabird migratory routes or feeding grounds as the vessel is generally well offshore and in motion during operations. Observations of seabirds will be logged as part of standard operating procedures during exploration.

In addition to the precautions geared towards avoiding interference with whales, sea turtles and seabirds, CIC will collaborate with Cook Islanders, scientists and other technical experts to avoid interference with seasonal migratory patterns of any other marine species that may not have been mentioned in this section.

5.11 Ports

Prior to initiation of exploration cruises, communication will be established between Odyssey and the Cook Islands' Ports Authority to ensure there is a clear understanding of the scheduling and location of where exploration activities will occur and what those activities will entail.

For exploration operations, CIC plans to take a collaborative approach with regard to interfacing with Cook Islands' offshore support businesses. Where commercially reasonable and in line with both the Cook Islands' and the community's interests, every effort will be made to support and utilise the services of Cook Islands' businesses.

While Pago Pago (American Samoa) has the closest suitable infrastructure to provide Odyssey's exploration work with a location for port calls of large vessels, mobilisation, crew changes, provision/fuel, and de-mobilisation, CIC intends to incorporate Cook Islands' landside support to whatever extent Cook Islanders deem it appropriate, logistically possible, and acceptable.

While undertaking operations with the large multibeam vessel, Avatiu Harbour (Rarotonga) and Arutanga Harbour (Aitutaki) may only be utilised in the case of transporting specialised technical scientists, priority parts needed for operations, and medical emergencies unless it can be determined that the large vessel can safely utilise the services of Avatiu Harbour. CIC intends to collaborate with communities and representatives of the Cook Islands to better understand the level of involvement Rarotonga and Aitutaki communities desire in terms of interface with the vessel during exploration activities.

All landside port support will seek to pay close attention to sensitive cultural issues and concerns between ship operators and the port communities.

In Phase Two of research expeditions, CIC is planning on the constant presence of a smaller research vessel (30-50 metres) that will mostly operate out of Avatiu Harbour, availing itself of the port facilities there. This smaller vessel will be undertaking year-round research expeditions of an average of 5 to 15 days per month, which enables it to accommodate shorter expeditions and to provide a research platform for guest scientists from around the world. It may also call on different islands in the Pa Enua for educational purposes, for public outreach, and to transport people and supplies as may be required or requested by the government.

5.12 Proposed Mitigation for Exploration

CIC will use available data and suggestions or proposals from Cook Islands' stakeholders/communities to help design an exploration plan that avoids conflicts with commercial/cultural fisheries, submarine cable projects, marine scientific research, navigation, and other sea users.

The following approaches will be incorporated into all exploration cruise plans to attempt to avoid any conflict with other sea users within the Cook Islands' EEZ and to provide valuable information to assist in their growth and management:

1. Focus exploration in CBGs to avoid any activities that interfere with the most productive commercial fishing zones (both longline and purse seine), as well as any whale migration routes.
2. Collaborate with the Ministry of Marine Resources (MMR) as well as local communities while formulating exploration cruises to minimise potential interference from CBGs that are overlapping with known and expected fishing zones.
3. Stay outside 50 nautical miles exclusion zones to ensure that the islands, fisheries, tourism, shipping traffic, and marine life surrounding them will not be affected by exploration work.
4. Share and facilitate communication of biological, geological, and physical oceanographic data that will contribute toward a better understanding of the ocean environment within Cook Islands' EEZ.
5. Cooperate with authorities to monitor and report international fishing vessels that may be conducting unauthorised and unlicenced activities within the Cook Islands' EEZ, if requested by the Cook Islands' authorities.

6. Engage in open and proactive communications with the Cook Islands' Government and submarine cable contractors to ensure exploration work does not interfere with the submarine cable maintenance and upkeep, and potentially provide access to CIC's ships and equipment, if necessary, for cable maintenance and monitoring.
7. Engage in open and proactive communication with any academic institutions that wish to conduct marine scientific research to ensure exploration work proposed does not interfere with, and where possible complements and extends scientific research.
8. Engage in open and proactive communication with the Cook Islands' Ports Authority and Ministry of Transport to ensure exploration work and shoreside logistics do not interfere with existing or future shipping schedules, and potentially offer access to CIC's research vessels for transportation of supplies and people to the Pa Enua (outer islands).

6. Risk Assessment

CIC presents general statements related to risks and benefits of the Exploration Programme to the Cook Islands. Areas considered include social/cultural, environmental, and economic/financial. The following table is by no means exhaustive and will be expanded collaboratively with the SBMA and with interested parties, including sea users, during early-stage outreach programmes.

Table 6.1: Risks, Mitigation and Benefits Overview

Risk Area	Risks	Mitigation	Benefit
Social / Cultural	• Community concerns about subsea mineral exploration.	• Investment in community and sea user outreach and collaboration programmes. • Prioritisation of transparent and meaningful, effective communication with the public and stakeholders about the Exploration Programme.	• Early, frequent and on-going engagement with Cook Islanders intended to create an environment where the community is engaged in the Exploration activities undertaken by the contractor, the data it is generating and ways to use that data to better understand the marine environment.

Environmental	• Concerns that Ecosystem health and function may be adversely impacted.	• Employ only proven methodologies for Exploration Programmes and minimally invasive interaction with the seabed. • Partner with the scientific community, including objective deep-sea ecology experts, to conduct studies and design environmental programmes. • Open sharing of environmental data.	• Significantly increase the Cook Islands' data and knowledge regarding their EEZ environment.
Economic / Financial	• Concerns that the programme may negatively affect core economic drivers including tourism and fisheries. • Concerns that investment in the Cook Islands (businesses and employment of people) may not meet expectations.	• Nothing from the proposed Exploration Work Programme will have any measurable impact on tourism or fisheries. All work being proposed will take place at least 50 nautical miles away from any island. • CIC is committed to finding a variety of ways to employ, train and provide valuable data to Cook Islanders throughout the entire Exploration period.	• In addition to the value-based commitment of CIC to engage businesses, there is a budget commitment to this endeavour as well as a Trust that has already been established to invest in local traditional, cultural and educational programmes.

The Exploration Work Programme uses standard and proven methodologies for mineral exploration and environmental baseline data collection and assessment with limited risks and defined mitigation programmes. Even so, a detailed risk assessment will precede each offshore campaign to ensure appropriate risk management occurs and that risks are minimised as reasonably practicable at every stage of project development. This approach to risk management, along with the work done to understand the baseline environment and expected impacts, accrues to the application of the precautionary approach for extraction programme development.

CIC proposes that an annual risk review process be established, in line with the Seabed Minerals Authority's Annual Reporting requirement, to assess overall risks of the project at regularly scheduled intervals. These reviews will consider both the work that has been done on the project and the upcoming Work Programme. The reviews will seek to incorporate new ways to mitigate risks in all aspects of the project.

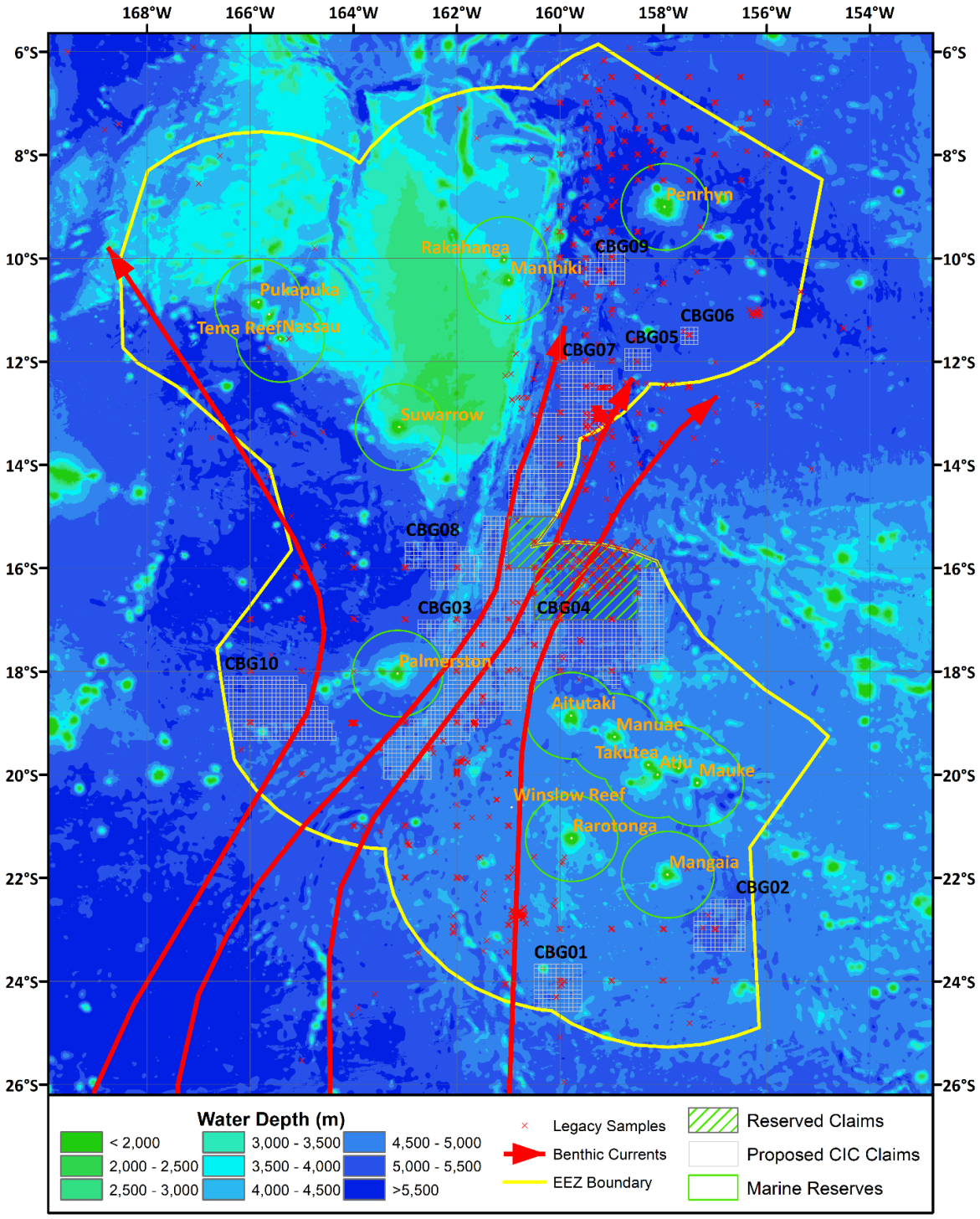
Conclusion

CIC looks forward to working with the Cook Islands' Government, local communities, businesses and organisations to further refine this Environmental Management Plan (EMP). The CIC Exploration Work Programme being proposed will align with the Cook Islands' desire for a world class-exploration programme to responsibly and effectively learn more about the potential mineral resources and the marine environment in the Cook Islands' EEZ.

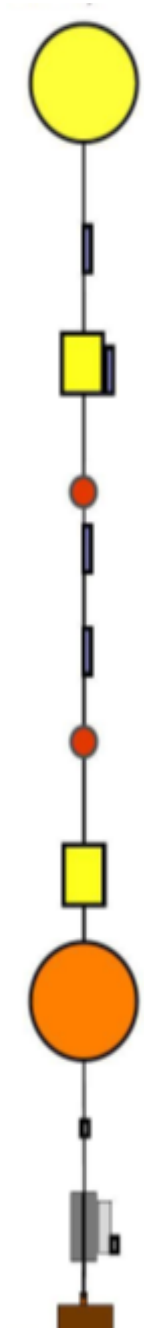
List of Attachments

- 2a. CBGs and Currents Map
- 3a. List of Environmental Baseline Studies and Approaches
- 3b. Key Environmental Impact Assessment Work for Nodule Provinces in the Deep Sea

Attachment: 2a. CBGs and Currents Map

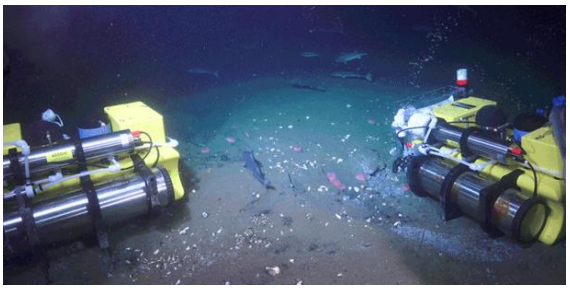


Attachment: 3a. List of Environmental Baseline Studies and Approaches

Study Area: Physical Oceanography (Long-term Studies)		
 (example only, not to scale)	**Platform**	**Multiple moorings installed on the seafloor**
	Study Objective	To understand the currents around the extraction site and to estimate the natural levels of sedimentation over a 12 to 36-month period (depending on the mooring). Study enables modelling the extent and duration of plumes that may be formed during full-scale operations.
	Technique Description	Moorings will be anchored to the seafloor and will include instrumentation such as single point current meters, acoustic doppler current profilers (ADCPs), sediment traps, CTDs, transmissometers, and other instruments, along with buoyancy devices. Moorings will be of multiple lengths and most will focus on bottom-water currents, with at least one envisaged to cover almost the entire water column (example shown). Moorings will be retrieved on a ~6 to 12-month basis for data download, equipment maintenance and mooring reinstallation. Following data acquisition, hydrodynamic modelling of plume extent and duration will be performed.
	Project Stage	EIA – Environmental Impact Assessment
	General Comments	Moorings are usually anchored using scrap metal or cement blocks. The moorings will be affixed to the anchor with dual acoustic releases, which are triggered from the ship using a "Deck Box" when equipment retrieval is necessary.
	Area Disturbed	Small, corresponds to size of the anchor which is typically less than 2 m x 2 m.
	Environmental impact[1]	Very low. Note that the depth of the shallowest instrument will need to be determined in consultation with the Cook Islands government and local fisheries to ensure there is no chance of entanglement with fishing nets or lines.
	Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups and environmental agencies.

Photos and specifications for moorings and equipment are courtesy of RDSea International.

[1] Environmental impact beyond standard vessel operations.

Study Area: Physical Oceanography (Near-term and Long-term Studies)	
 	
Platform	**Benthic Basic Mini Landers**
Study Objective	To understand the currents around the extraction site and to estimate the natural levels of turbidity, as well as near-seabed dissolved oxygen, water temperature, and conductivity (as a proxy for salinity). Study enables modelling the extent and duration of plumes that may be formed during full-scale operations.
Technique Description	Landers are unmanned and deployed from a research vessel. They collect data for a defined period of time and then shed their ~90kg ballast after which they float to the surface. The units are retrieved aboard the research vessel and collected data is obtained from the Lander's sensors.
Project Stage	EIA – Environmental Impact Assessment
General Comments	These offer an expeditious means to acquire valuable data on currents and other parameters near the seabed. They complement data collected from moorings and their deployment/retrieval requires fewer logistical considerations than moorings.
Area Disturbed	Small, corresponds to size of the unit which is a footprint of about 90 x 90 cm.
Environmental impact	Very low
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups and environmental agencies.

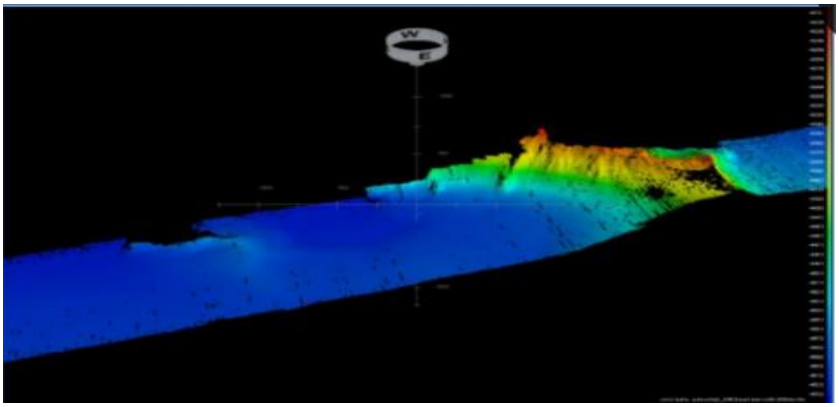
Photos and specifications for Mini-Landers are courtesy of UNC-CH.

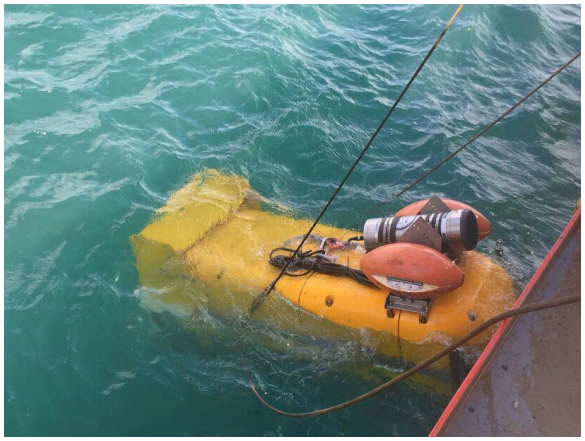
Study Area: Physical Oceanography (Opportunistic Current Profiles)	
 	
Platform	**L-ADCP (Lowered Acoustic Doppler Current Profiler)**
Study Objective	To understand the currents above and around the extraction site at a single point in time – will help to 'calibrate' the long-term moorings over a larger area of study. Study enables an estimate of the extent and duration of plumes that may be formed during full-scale operations.
Technique Description	A Lowered-Acoustic Doppler Current Profiler (ADCP) is tethered to the ship by a long cable and is used to obtain water column current (speed and direction) profiles in a simple vertical down and up cast.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Data needs to be carefully processed following collection to remove interferences from ship movements and deployment method (i.e. the movement associated with the instrumentation traveling through the water column).
Area Disturbed	Nil. No physical contact made with the seafloor.
Environmental impact[2]	None. No physical contact made with the seafloor.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

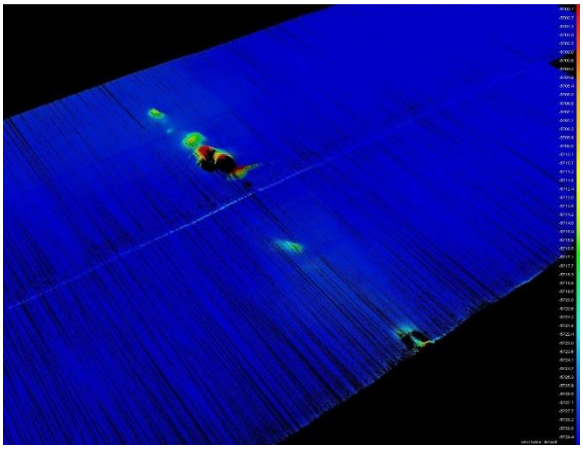
Photo #1 Courtesy of Teledyne Marine
Photo #2 Courtesy of Census of Marine Life

[2] Environmental impact beyond standard vessel operations.

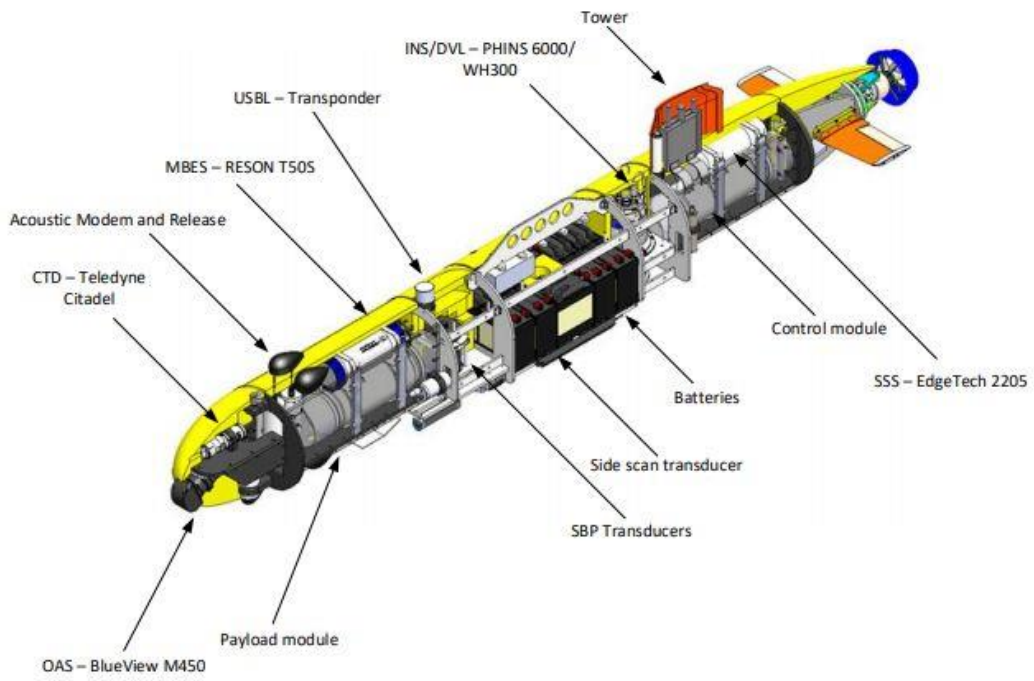
Study Area: Geology (High Resolution Bathymetry)

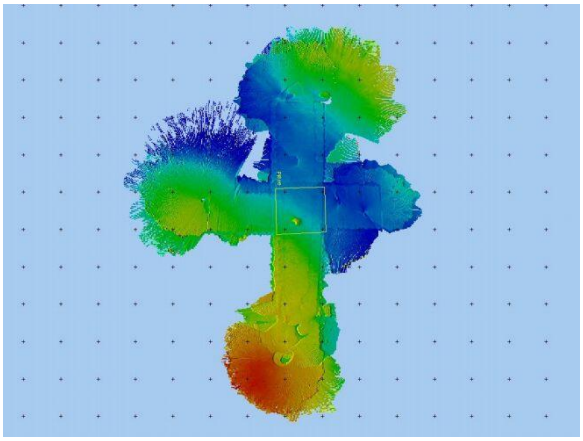


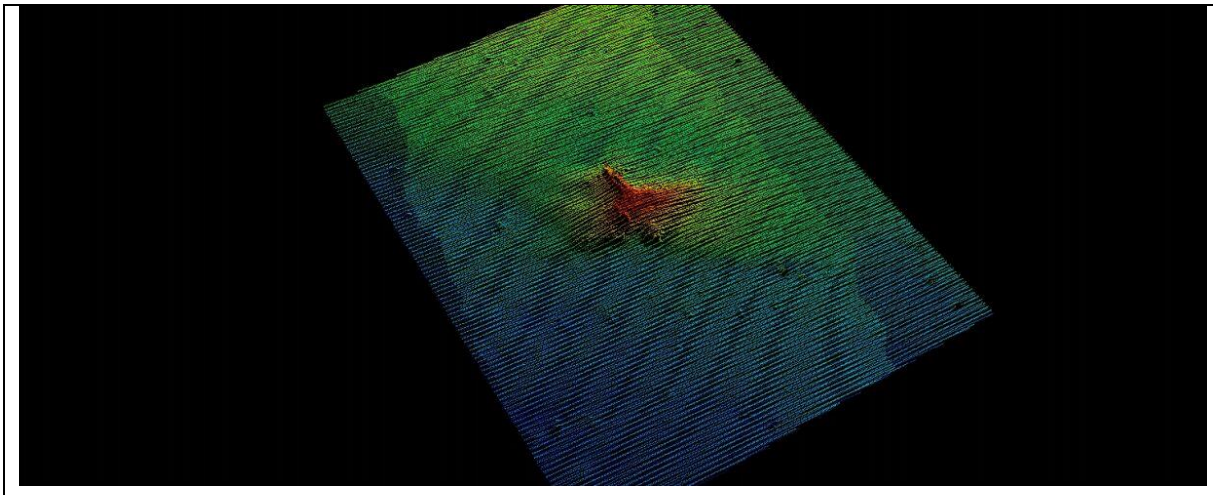




DeepTow images and 200kHz multibeam data images collected courtesy of Odyssey Marine


Tower
INS/DVL – PHINS 6000/
WH300
USBL – Transponder
MBES – RESON T50S
Acoustic Modem and Release
CTD – Teledyne
Citadel
Control module
SSS – EdgeTech 2205
Batteries
Side scan transducer
SBP Transducers
Payload module
OAS – BlueView M450





SeaRaptor AUV images and 400kHz multibeam data images collected courtesy of Teledyne Gavia ehf

Platform	**Deep Tow / AUV**
Study Objective	To produce Geographic Information System regional maps with high resolution bathymetry showing major geological and geomorphological features to assess the heterogeneity of the environment. These maps will be produced at a scale appropriate to habitat variability. This information will also assist with the placement of study locations and mooring installations.
Technique Description	The Deep Tow method employs an underwater sled that is tethered to the ship by a long (fibre-optic) cable. The sled is towed several meters above the seafloor and can be up to 5700 m behind the vessel. A typical deep-tow method uses two side-mounted sonars to map the seafloor on each side of the instrument. The sonars emit low power[3] sound waves, which are reflected off the seafloor and recorded by receivers on the sidescan instrument.
Project Stage	Early Exploration
General Comments	Deep Tow: sled can remain in the water for up to 2 days at a time. A typical survey area may take several weeks to complete.
Area Disturbed	Nil. No physical contact made with the seafloor.
Environmental impact[4]	Negligible. No physical contact made with the seafloor. Sound levels not high enough to cause physical damage to marine biota.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

[3] Power and frequency levels dependent on specific technique used.
[4] Environmental impact beyond standard vessel operations.

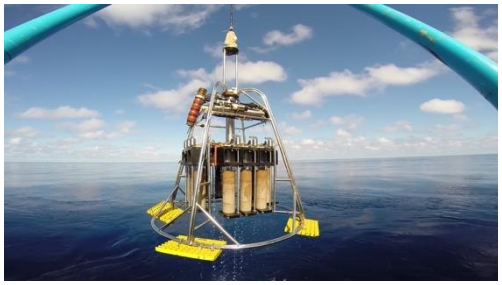
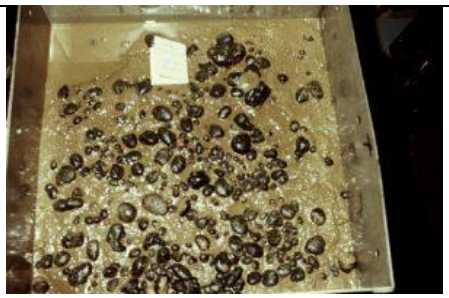
Study Area: Geology (Heavy Metals and Trace Elements)	
  	
Platform	**Multiple-Corers (Multi-Corers) or Mega-Corers**
Study Objective	To collect information on the potential for heavy metal and trace element release during full-scale mineral extraction operations, and their concentrations.
Technique Description	A multi-corer is a bottom sampling tool used for sampling in chemical, geochemical and biological applications. The coring head is hydraulically damped to ensure undisturbed samples. It is deployed from a research vessel with a deep-sea wire. The design of the system allows for multiple cores to be retrieved from a single deployment/retrieval cycle, increasing the chances of successful core retrieval in areas of difficult seabed terrain (i.e. hard bottom, seamounts, and undulating bathymetry). Cores are brought up to surface, sectioned and preserved following best practise technique.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Multi-corers generally have between four and twelve individual corers that will separately penetrate the seafloor once contact is made. Multi-corers can be outfitted with additional instrumentation such as altimeters, CTDs, and penetrometers. Casts are usually completed within several hours.
Area Disturbed	Varies depending on how many corers, but the diameter of the base of a mega-corer (twelve core tubes) is ~ 2.8 m.
Environmental impact[5]	Very small, restricted to area where sample is taken.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #1 courtesy of Natural Resources Defence Council

[5] Environmental impact beyond standard vessel operations.

Study Area: Geology (Heavy Metals and Trace Elements)	
  	
Platform	**Box Corers**
Study Objective	To collect information on the potential for heavy metal and trace element release during full-scale mineral extraction operations, and their concentrations.
Technique Description	Bottom sampling tool designed for minimum disturbance of sediment and overlying features. It is deployed from a research vessel with a deep-sea wire. Upon contact with seafloor, the outer shovel is released, and the sample taken.
Project Stage	Early Exploration, EIA – Environmental Impact Assessment
General Comments	Box cores typically have an area of approximately 2500 - 5625 cm^2. Retrieval and deployment time depends on winch capabilities and water depth; however, total time generally does not take more than several hours at depths of ~5000 m. Box corers can be outfitted with additional instrumentation such as altimeters, CTDs, and penetrometers.
Area Disturbed	Maximum area of 0.75 m x 0.75 m with 0.65 m depth penetration per sample if largest known box corer is utilised.
Environmental impact[6]	Very Low.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photos #1 and #3 and specifications for Box Corer courtesy of Ocean Instruments.
Photo #2 courtesy of NOAA

[6] Environmental impact beyond standard vessel operations.

Study Area: Chemical Oceanography (Water Column Chemistry)	
  	
Platform	**Water Sampling Carousel / Rosette, CTD**
Study Objective	To understand baseline water quality conditions in the water column overlying the site targeted for nodule extraction, capturing at least two summer/winter seasons (seasonal studies).
Technique Description	Water sampling bottles (or "Niskin" bottles) are arranged in a rosette formation around sensors (e.g. CTD). The instrument package is tethered to the ship by a long cable and is used to obtain water column samples and profiles in a simple vertical down and up cast. Each bottle can be triggered individually to enable sampling from various locations. A CTD, which is commonly attached to the water sampling carousel, provides profiles of chemical and physical parameters through the entire water column by detecting its conductivity and temperature (which in turn relates to concentration of salt and other inorganic compounds in seawater). By analysing these parameters, scientists can make inferences about the occurrence of certain biological processes.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Casts are usually completed within several hours.
Area Disturbed	None. No physical contact made with the seafloor.
Environmental impact[7]	Negligible. No physical contact made with the seafloor.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups to characterise water chemistry of the deep sea.

Photo #1 courtesy of Sea Catalog
Photo #3 courtesy of Heraeus Group

[7] Environmental impact beyond standard vessel operations.

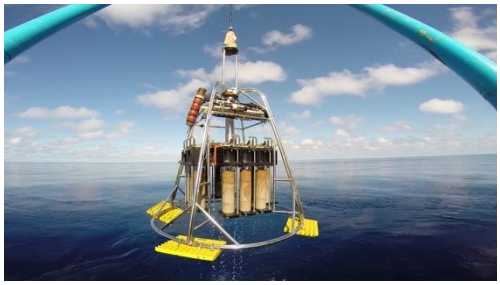
Study Area: Chemical Oceanography (Sediment Pore Water)	
  	
Platform	**Multiple-Corers or Mega-Corers**
Study Objective	To understand baseline water chemistry conditions in sediment pore waters. To collect information on metal and other elements that may be released during the nodule extraction process.
Technique Description	A multi-corer is a bottom sampling tool used for sampling in chemical, geo-chemical and biological applications. The coring head is hydraulically damped to ensure undisturbed samples. It is deployed from a research vessel with a deep-sea wire. The design of the system allows for multiple cores to be retrieved from a single deployment/retrieval cycle, increasing the chances of successful core retrieval in areas of difficult seabed terrain (i.e. hard bottom, seamounts, and undulating bathymetry). Cores are brought up to surface, sectioned and preserved following best practice technique.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Multi-corers generally have between four and twelve individual corers that will separately penetrate the seafloor once contact is made. Multi-corers can be outfitted with additional instrumentation such as altimeters, CTDs, and penetrometers. Casts are usually completed within several hours.
Area Disturbed	Varies depending on how many corers, but the diameter of the base of a mega-corer (twelve core tubes) is ~ 2.8 m.
Environmental impact[8]	Very small, restricted to area where sample is taken.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #1 courtesy of Natural Resources Defence Council

[8] Environmental impact beyond standard vessel operations.

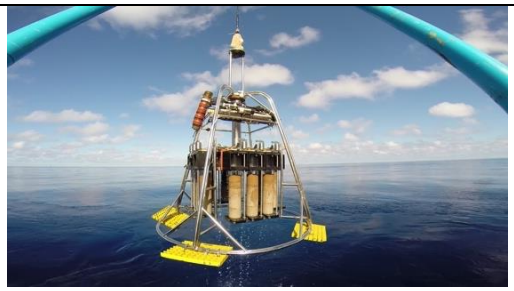
Study Area: Sediment Properties	
  	
Platform	**Box Corers, Multiple-Corers**
Study Objective	To study baseline sediment conditions and predict the behaviour of mineral extraction on sediment composition. To determine the basic properties of the sediment, including measurements of soil geotechnical properties and composition to adequately characterise the surficial sediment deposits which are the potential source of deep-water plume.
Technique Description	See *Heavy Metals and Trace Elements* study for Box coring techniques. See *Heavy Metals and Trace Elements* and *Sediment Pore Water* studies for multi-corer techniques. Sediment to be sampled taking into account the variability of the seabed.
Project Stage	EIA – Environmental Impact Assessment
General Comments	See Box corer methods. See Multi-corer methods.
Area Disturbed	Small, area equivalent to the size of the box corer (typically 0.25 to 0.56 m^2 per deployment) or multi-corer (base diameter ~2.8m).
Environmental impact[9]	Very small, restricted to area where sample is taken.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #1 courtesy of Natural Resources Defence Council

[9] Environmental impact beyond standard vessel operations.

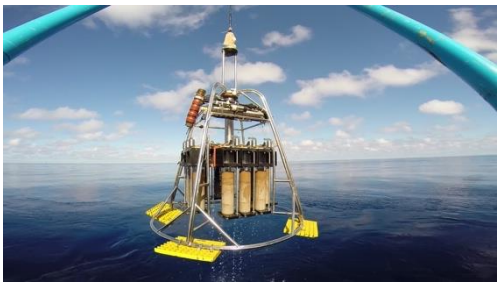
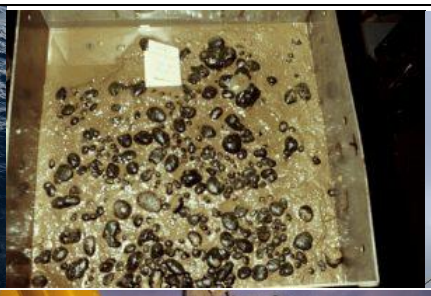
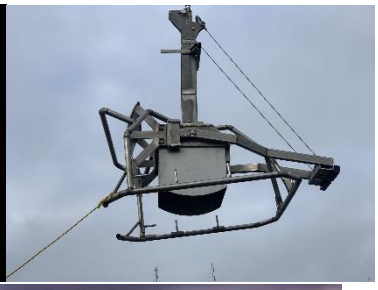
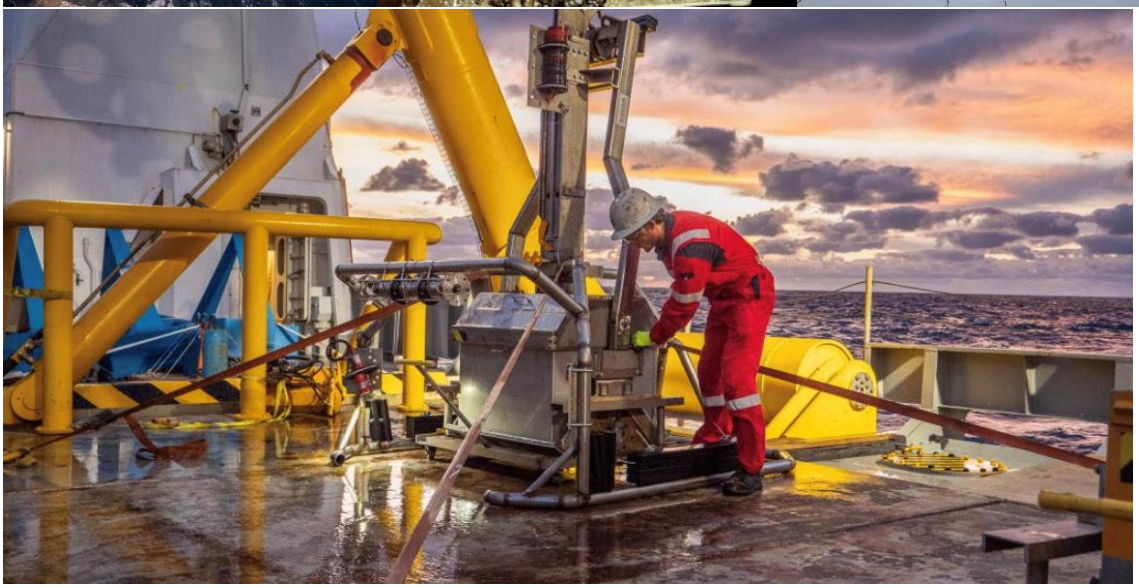
Study Area: Biological Communities - Meiofauna [32-250 micron], Microfauna [<32 micron]	
  	
Platform	**Multiple-Corer**
Study Objective	To understand baseline biological conditions within the seafloor sediments and predict the impact of mineral extraction on biological communities. Samples of fauna to be representative of variability of habitats, bottom topography, depth, seabed and sediment characteristics, abundance and mineral resource being targeted.
Technique Description	See *Sediment Pore Water* study for a description of the sampling technique. Meiofauna: One complete core to be dedicated to metazoan meiofauna (sieved through a 32-micron mesh), a second core for molecular meiofauna analysis with the top 0-5 cm processed. A separate core should be provided for foraminiferal meiofauna, sliced into 1-cm thick layers down to 5 cm depth. Microfauna: Microbial metabolic activity should be determined using adenosine triphosphate or other standard assay. In soft sediment, vertical profiles should be obtained with suggested intervals for sampling as follows: 0-0.5, 0.5-1.0, 1-2, 2-3, 3-4, 4-5 cm. Samples should then be preserved as appropriate.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Multi-corers generally have between four and twelve individual corers that will separately penetrate the seafloor once contact is made. Multi-corers can be outfitted with additional instrumentation such as altimeters, CTDs, and penetrometers. Casts are usually completed within several hours.
Area Disturbed	Varies depending on how many corers, but the diameter of the base of a mega corer (twelve core tubes) is ~ 2.8 m
Environmental impact[10]	Very small, restricted to area where sample is taken.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #1 courtesy of Natural Resources Defence Council

[10] Environmental impact beyond standard vessel operations.

Study Area: Biological Communities - Macrofauna [250 micron], Nodule-associated Fauna

Platform	Box Corer
Study Objective	To understand baseline biological conditions within the seafloor sediments an on hard substrates and predict the impact of mineral extraction on biological communities. Samples of fauna to be representative of variability of habitats, bottom topography, depth, seabed and sediment characteristics, abundance and mineral resource being targeted.
Technique Description	See *Heavy Metals and Trace Elements* study for a description of the sampling technique. Macrofauna: information obtained on abundance, species structure, biomass and diversity. Vertical profiles with a suitable depth distribution (i.e. 0-1, 1-5, 5-10 cm) should be obtained. Where possible, whole box core samples should be used and should not be sub-cored or divided. Nodule Fauna: information obtained on abundance, biomass and species structure should be determined from nodules taken from the top of the box corers.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Box cores typically have an area of approximately 0.25 m^2 – 0.56m^2. Retrieval and deployment times depend on winch capabilities and water depth; however, total time generally does not take more than several hours at depths of ~5000 m. Box corers can be outfitted with additional instrumentation such as video cameras, altimeters, CTDs, and penetrometers.
Area Disturbed	Maximum area of 0.75 m x 0.75 m with 0.65 m depth penetration per sample if large box corer is utilised.
Environmental impact[11]	Very Low.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photos #1, #3 and #4 as well as specifications for Box Corer courtesy of Ocean Instruments.
Photo #2 courtesy of NOAA

[11] Environmental impact beyond standard vessel operations.

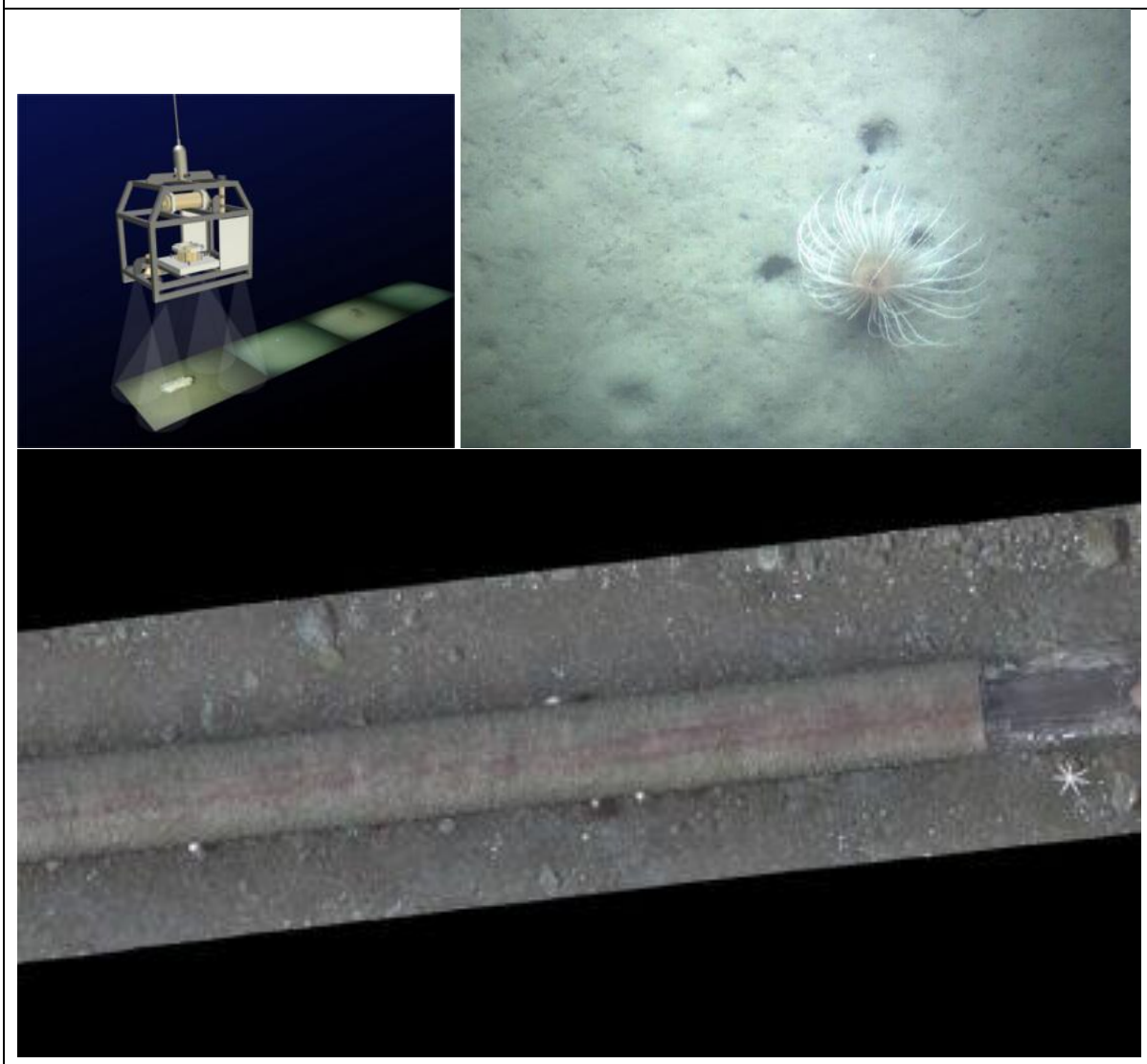
Study Area: Biological Communities – Fauna Sampling by ROV (Megafauna [>2 cm]

Platform	ROV
Study Objective	To understand baseline biological conditions of visible fauna (megafauna - 2 cm and bigger) at the seafloor and predict the impact of mineral extraction on biological communities. Samples of fauna to be representative of variability of habitats, bottom topography, depth, seabed and sediment characteristics, abundance and mineral resource being targeted.
Technique Description	Select target species, combined taxonomy and genetic studies (study to be confirmed – possibly not practical due to low numbers of biota expected in nodule provinces).
Project Stage	EIA – Environmental Impact Assessment
General Comments	The ROV is lowered to the seafloor and surveys are completed and discrete samples can be taken. The ROV is powered by electricity and is hydraulically controlled from the support ship using an umbilical. ROV is typically underwater for 6 to 12 hours at a time, depending on whether or not samples need to be recovered to surface.
Area Disturbed	None – very little contact with seafloor, if any
Environmental impact[12]	Very low, confined to limited removal of individual biota.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

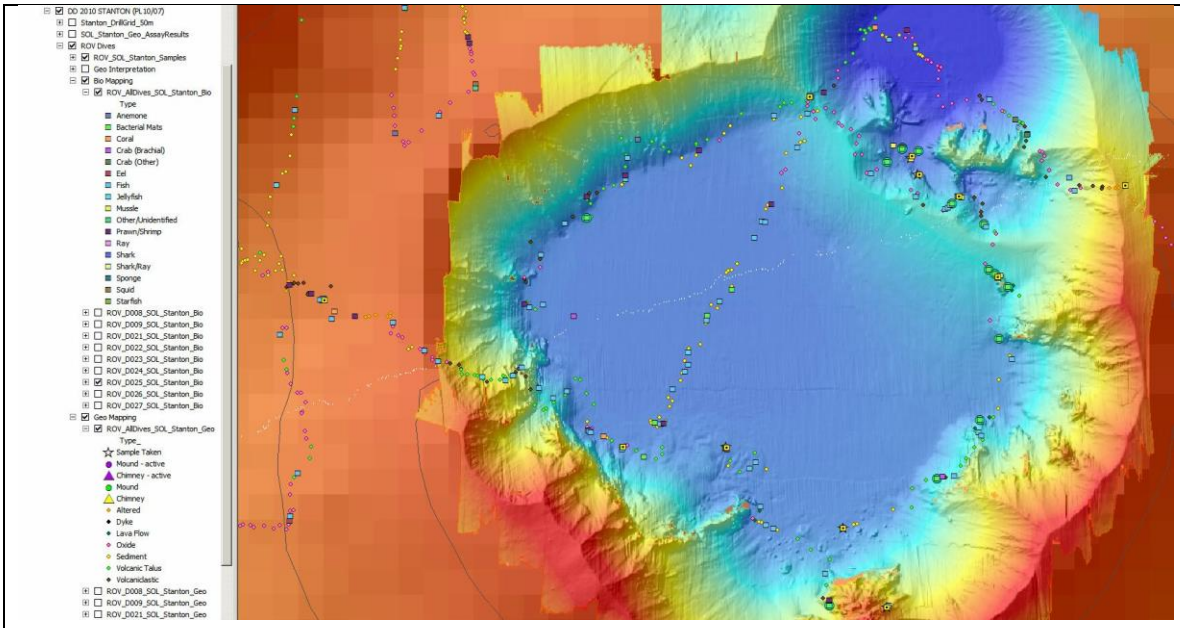
Photos courtesy of Odyssey Marine Exploration, Inc.

[12] Environmental impact beyond standard vessel operations.

Study Area: Biological Communities – Photo/video Transects (Seafloor and Near-Bottom Megafauna)



Images courtesy of Fugro



Example of biota mapping completed with ROV (courtesy of Odyssey Marine)

Platform	**ROV/AUV/Towed Camera System (TBC)**
Study Objective	To understand baseline biological conditions at and immediately above the seafloor and predict the impact of mineral extraction on biological communities.
Technique Description	Follow pre-established transect lines and record observed biota. Assess density and biodiversity of megafauna (biota >2 cm).
Project Stage	EIA – Environmental Impact Assessment
General Comments	See ROV, AUV, and Towed methods
Area Disturbed	None – no contact with seafloor
Environmental impact[13]	None – no contact with seafloor (see ROV)
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

[13] Environmental impact beyond standard vessel operations.

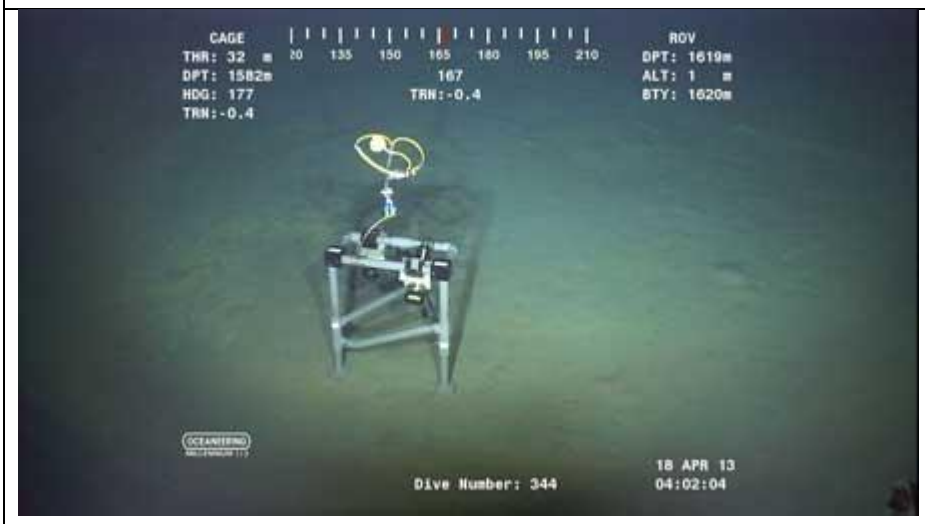
Study Area: Biological Communities (Demersal Scavengers)	
	
Platform	**Moored Time Lapse Camera(s), Baited Time Lapse Cameras**
Study Objective	To understand baseline biological conditions at and immediately above the seafloor and predict the impact of mineral extraction on biological communities.
Technique Description	Recording device is set up within suitable distance of time lapse camera (TLC) anchored bait to observe behaviour of demersal scavengers.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Likely to be deployed during ROV operations
Area Disturbed	Minimal, confined to area where TLC anchor has contact with seafloor, estimated to be less than 2 m x 2 m.
Environmental impact[14]	Negligible.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Image courtesy of Oceaneering International, Inc.

[14] Environmental impact beyond standard vessel operations.

Study Area: Biological Communities (Pelagic Communities)	
  	
Platform	**Plankton nets, fishing gear, etc.**
Study Objective	To assess the pelagic communities in the water column and near-bottom (in the benthic boundary layer) that may be impacted by operations (e.g. the operational and discharge plumes) and to assess their baseline metal concentrations.
Technique Description	Pelagic monitoring moorings will comprise of a buoyed camera unit to monitor a separate baited/weighted line suspended in the water column
Project Stage	EIA – Environmental Impact Assessment
General Comments	Pelagic monitoring rigs will be deployed opportunistically See Plankton net methods
Area Disturbed	Nil if suspended in water column.
Environmental impact[15]	Negligible.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #1 courtesy of Deep-Sea News
Photo #2 courtesy of Microcosmos

[15] Environmental impact beyond standard vessel operations.

Study Area: Biological Communities – Marine Biota Observations	
	
Platform	Ship
Study Objective	To record sightings of marine mammals, other near-surface large biota (such as turtles and fish schools) and bird aggregations, identifying the relevant species and behaviours where possible. Details to be recorded in transit to and from areas of exploration and on passage between stations. Temporal variability should be assessed.
Technique Description	Opportunistic sightings. Use binoculars where possible. Marine Biota Observation Log filled out on the bridge of the ship. Pelagos system currently under development by OML will be considered to encourage uniformity of the observations made
Project Stage	EIA – Environmental Impact Assessment
General Comments	All crew of research vessel will be instructed to notify onboard environmental contractor of all sightings of marine biota while at sea. Sightings will properly be recorded by qualified personnel.
Area Disturbed	None.
Environmental impact[16]	None.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

[16] Environmental impact beyond standard vessel operations.

Study Area: Biological Communities (Connectivity)	
  	
Platform	Ship
Study Objective	To assess the regional distribution of species and genetic connectivity of key species.
Technique Description	Samples taken as per methods described above (e.g. ROV, box corer, multiple-corer) and specimens are processed, preserved and analysed appropriately.
Project Stage	EIA – Environmental Impact Assessment
General Comments	See above for the relevant technique.
Area Disturbed	See above for the relevant technique.
Environmental impact[17]	See above for the relevant technique.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #2 courtesy of KC Denmark
Photo #3 courtesy of NOAA

[17] Environmental impact beyond standard vessel operations.

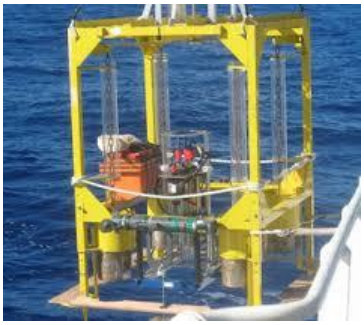
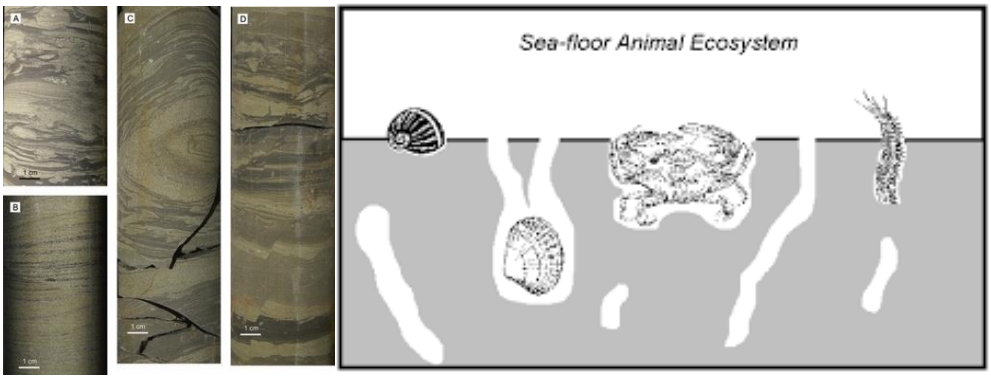
Study Area: Biological Communities (Oxygen Consumption Experiments)	
 	
Platform	**Lander**
Study Objective	To understand baseline biological activity within the seafloor sediments and predict the impact of mineral extraction on biological communities.
Technique Description	Landers are used to measure the sediment-water exchange of nutrients by placing a chamber over the sediment and taking water samples with syringes from the chambers at fixed moments in time. The oxygen concentrations in the chambers are also measured. This gives us an idea of the uptake of oxygen by the sediment. We can compare this measured oxygen uptake to that calculated from profiles of oxygen measured in sediment cores.
Project Stage	EIA – Environmental Impact Assessment
General Comments	N/A
Area Disturbed	Small – equivalent to size of lander (~2 m x 2 m)
Environmental impact[18]	Negligible.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photo #1 courtesy of NOAA
Photo #3 courtesy of http://sea.wreia.us/

[18] Environmental impact beyond standard vessel operations.

Study Area: Bioturbation	
	
Platform	**Multiple-Corer**
Study Objective	To gather data on the mixing of sediments by organisms and to predict the impact of extractive activities on biological communities.
Technique Description	See multiple-corer methods. Rates of bioturbation (i.e. the mixing of sediments by organisms) must be measured to analyse the importance of biological activity prior to a mining disturbance and can be evaluated from profiles of excess ^{210}Pb activity in the cores. Excess ^{210}Pb activity should be evaluated on at least five levels per core (suggested depths are 0-0.5, 0.5-1.0, 1-1.5, 1.5-2.5 and 2.5-5 cm).
Project Stage	EIA – Environmental Impact Assessment
General Comments	
Area Disturbed	None – no contact with seafloor.
Environmental impact[19]	Negligible.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

[19] Environmental impact beyond standard vessel operations.

Study Area: Fluxes to the Sediment (Sedimentation)	
  	
Platform	**Moored Time Lapse Sediment Traps**
Study Objective	To gather time series data on the flux and composition of materials from the upper water column to the deep sea. To understand baseline sedimentation rates and to evaluate the effects of mineral extraction activities (especially plumes) on these rates.
Technique Description	It is currently envisaged that time lapse sediment traps will be incorporated into the moorings used for physical oceanography studies (see above), or as stand-alone moorings. Measurements will be focused near the seafloor. Traps will be in place for a minimum of 6 months to obtain seasonal data. Besides weight/volume, the material collected in the traps will also be analysed to determine nutrient and trace element transport to deep sea environments.
Project Stage	EIA – Environmental Impact Assessment
General Comments	In addition to providing sedimentation data, analysation of trace elements can help with understanding local upwelling phenomena.
Area Disturbed	None – no contact with seafloor.
Environmental impact[20]	Negligible.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR groups.

Photos #1 and #2 and specifications for sediment traps are courtesy of RDSea International.
Photo #3 courtesy of KC Denmark

[20] Environmental impact beyond standard vessel operations.

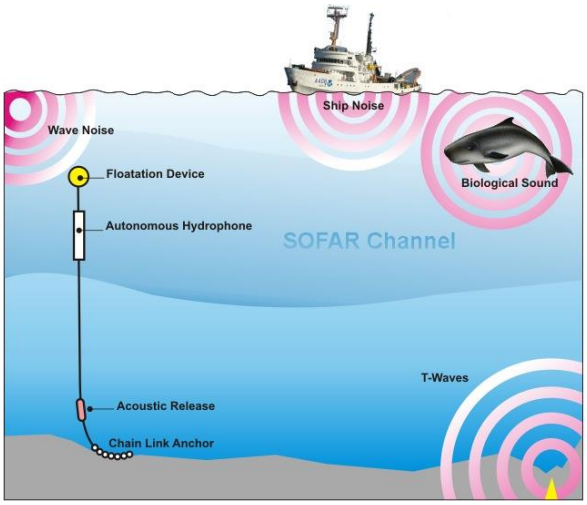
Study Area: Noise	
	
Platform	**Moored Hydrophones**
Study Objective	To determine the baseline noise levels, for example from marine mammals and shipping, and estimate impact of mineral extraction activities.
Technique Description	It is currently envisaged that hydrophones will be incorporated into the moorings used for physical oceanography studies (see above), or as stand-alone moorings.
Project Stage	EIA – Environmental Impact Assessment
General Comments	Hydrophones for this application are not off the shelf. Some design development will likely be needed and may represent a collaboration opportunity.
Area Disturbed	Very little. Possibly the area of an anchor to keep it in place on seafloor (0.5-1 m^2)
Environmental impact[21]	Negligible.
Technique used in Marine Scientific Research (MSR)	Yes. These are standard techniques used by MSR and environmental agencies in shallower waters.

Photo courtesy of Kompasiana

[21] Environmental impact beyond standard vessel operations.

References

Brockett T, Richards CZ. 1994. Deep sea mining simulator for environmental impact studies. *Sea Technology* 35(8):77–82.

Khripounoff A, Caprais J-C, Crassous P, l'Etoubleu J. 2006. Geochemical and biological recovery of the disturbed seafloor in polymetallic nodule fields of the Clipperton-Clarion Fracture Zone (CCFZ) at 5,000-m depth. *Limnology and Oceanography* 51(5):2033–2041.

Morgan CL, Odunton NI, Jones AT. 1999. Synthesis of environmental impacts of deep seabed mining. *Marine Georesources and Geotechnology* 17:307–356.

Attachment: 3b. Key Environmental Impact Assessment Work for Nodule Provinces in the Deep Sea

Study Name (location, year)	Entity	Key Focus Areas	Objectives/Findings
DOMES (CCZ, 1970s)	USA	Baseline studies, impact prediction	DOMES identified three key future EIA study areas: i) benthic community impacts due to nodule removal, ii) near-surface biota impacts due to plumes from discharge water (assumes surface discharge), and iii) benthic community impacts due to deposition of suspended sediments. The study suggested test harvesting was needed to confirm predictions made.
ECHO-1 (CCZ, 1983)	USA	Revisited DOMES Site C post-test mining in 1978	Objective was to examine benthic recolonisation using box core samples following small-scale test mining by OMA some five years earlier. No significant differences were found between macrofauna and meiofauna from mining tracks and a nearby control area. Dick and Foell (1985) [cited in Morgan et al. 1999] determined that the tests were inconclusive due in part to the techniques used, which had low positional accuracy.
Acute Mortality Experiment (CCZ, ca. late 1980s)	USA	Studied impacts of sedimentation on fauna	Known amounts of sediment were added to corers positioned on the seabed with the expectation to learn the amount of sedimentation required to smother or entomb benthic biota. This project experienced technical difficulties with core recovery from the sea floor. General conclusions were that there was little evidence of serious disturbance to macrofauna when subjected to burial <1 cm of sediment, while burial under 4 cm of sediment appeared to cause entombment of 25% to 50% of the macrofauna in six days.
Quagmire II Expedition (CCZ, 1990)	USA	Revisited DOMES Site C post-test mining in 1978	Examined benthic recolonisation using precision sampling techniques (RUM-III vehicle) following small-scale test mining by OMA in 1978. Carried out a critical-dose experiment to determine the sensitivity of benthic fauna to sedimentation levels. The major cruise objectives were not achieved.

DISCOL (Peru Basin, 1989 to 2015)	Germany	Large-scale disturbance-recolonisation experiment (Peru Basin)	The work involved baseline data gathering, plowing ~11 km^2 of the sea floor using a "plow-harrow" down to 10 to 15 cm depth. ~20% of the area was affected by the plow harrow, ~70% was covered by various thicknesses of sediment, and ~10% remained unaffected. Following the disturbance, studies were conducted immediately after the impact, after six months, then at three and seven years to determine the rate of recolonisation of the impacted areas. Due to the impact, the abundances of all fauna decreased significantly, then three years after the impact, densities of major faunal groups significantly exceeded what had been found during baseline studies, although diversity was lower. After seven years, the tracks remained clearly visible. The undisturbed areas remained more or less constant. For the megafauna, biota that depend on hard substrates (nodules) remained absent while more mobile biota dominated. A further offshore study at the DISCOL site was conducted in 2015, some 26 years post disturbance (as part of MIDAS and JPIO; jpio-miningimpact.geomar.de). The researchers noted that while the faunal densities of most taxa recovered rather quickly, and were almost back to pre-disturbance conditions after seven years, the diversity and community composition had not recovered 26 years after the impact. The study highlighted that to minimise large-scale impacts, there is a need for marine spatial planning, including the establishment of set-aside areas. It should be noted that no impact minimisation, mitigation, or restoration activities were trialled as part of the original disturbance experiment.
Benthic Impact Experiment; BIE (CCZ, 1993)	Collaboration between Russia, USA, and Japan	Studied the effects of sediment re-deposition on benthic fauna	Work included baseline studies (including current meters, box cores and sediment traps), then blanketing an area with sediment by towing through an area 150 × 3,000 m in a NE–SW direction, resulting in the suspension of ~4,000 m^3 of sediment. Bulk of sediment travelled north and settled quickly as a sediment-laden fluid flow. Of the 71 macrofaunal families analysed, only two appeared to be impacted by sediment re-deposition. Overall species diversity remained unaffected by sediment re-deposition. However, the resultant sediment thickness was not attainable due to wide dispersion causing no measurable significant accumulation outside the disturbance area. Therefore, no relationship between faunal succession and sediment was accomplished.

Japan Deep-Sea Impact Experiment; JET (CCZ, 1993)	Japan	Studied the effects of sediment re-deposition on benthic fauna	Used the same device as BIE in a western CCZ location. Samples before and after disturbance were collected and then collected again after 1 year. Abundances and vertical distributions of meio- and microfauna were studied. Again, there was no quantification of the re-sedimentation thickness. The extended effects of disturbance on the abundances of each faunal component were different. Changes in abundance in total fauna were greatest in the upper layers of sediment.
Interocean-metal Joint Organization Benthic Impact Experiment; IOM-BIE (CCZ,1995, 1997, 2000)	IOM, COMRA (China)	Studied the effects of sediment redeposition on benthic fauna	IOM-BIE monitored ecosystem changes following a sediment disturbance. Immediately following the disturbance, intense feeding activity by megabenthos was observed, presumably due to additional availability of food sources. Meiobenthos abundance decreased and their vertical distribution was altered. During the 2000 campaign, the results collected indicated the abyssal meiobenthos in the control area had been affected by (assumed) natural processes. By 2000, abundances at the 10M site had reverted to control area levels.
Indian Deepsea Experiment; INDEX (CIOB, 1997 to 2007)	India	Studied the effects of sediment re-deposition on benthic fauna (Central Indian Ocean Basin; CIOB)	INDEX utilised the Deep-Sea Sediment Resuspension System (Brockett and Richards 1994) to resuspend >6,000 m^3 of sediment over a nine-day period. Monitoring over a decade showed that the CIOB has highly heterogeneous environmental conditions in terms of spatial variation. India reported at an ISA workshop held in 2010 that the monitoring of environmental conditions after the benthic disturbance experiment indicated the benthic conditions were steadily moving towards restoration and the effects of disturbance are waning with time.

Kaplan Study (CCZ, 2002 to 2007)	International; USA, UK, Japan, France (JM Kaplan Fund and ISA funded)	Baseline Studies (biological)	The Kaplan study was designed to study biodiversity, species ranges, and gene flow in the abyssal Pacific nodule province, with specific reference to predicting and managing the impacts of deep seabed mining. The Kaplan study aimed to i) estimate, using molecular methods and rigorous statistical techniques, the number of polychaete, nematode and foraminiferal species at three stations spaced at 1,500 km intervals across the Pacific nodule province; ii) evaluate species overlap and rates of gene flow; iii) communicate findings and make specific recommendations on minimizing the risks to biodiversity resulting from mining. Based on the data collection and analysis, the researchers recommended that the ISA establish a network of MPAs across the CCZ to safeguard biodiversity that could be affected by mining activities. This eventually led to the establishment of APEIs within the CCZ.
EqPac (JGOFS EqPac) (CCZ, 1992)	USA	Equatorial Pacific Process Study; Baseline studies	The EqPac process study was conducted along 140°W. Four process cruises took place, with a fifth benthic cruise and sediment trap legs adding to the overall study. The scientific objectives of this study were to determine the fluxes of carbon and related elements, and the processes controlling these fluxes between the Equatorial Pacific euphotic zone and the atmosphere and deep ocean.
NIXO/NIXO 47 (CCZ, 2004)	France	Studied long-term effects of physical disturbance made by a dredge (OMCO) in 1978	This study compared surface sediments in and outside a dredge track. 26 years after the dredging event, the track was still visible. The physical and chemical properties of the disturbed sediment sampled in the track had not changed significantly over time and had not shown any recovery since the disturbance. On the other hand, the biological activity measured in the track with a respirometer did not differ from the unperturbed site, which suggests that the benthic fauna have completely recovered, as have nutrient fluxes at the water–sediment interface (Khripounoff et al. 2006).
NaVaBa Program (CCZ, 1996 to present)	China	Natural variability baseline studies	10 cruises were conducted from 1998 to 2010, focusing on environmental baseline work for the COMRA contract area. Initial studies examined spatial variability/heterogeneity and functional relationships between fauna.
Deep CCZ Biodiversity Synthesis	International	Summary of Friday Harbor Biodiversity Workshop	Comprehensive update of CCZ biodiversity research, sponsored by the ISA and the Pew Charitable Trusts

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Deep-Sea Mining Plume Mitigation: Sequestration and Treatment (2020 to present)	USA	Mitigation of miner plume impacts	Laboratory studies of natural sediments to investigate potential for using electrocoagulation to mitigate plume dispersion (Steven Rizea, Underwater Mining Conference 2020)

CCZ = Clarion-Clipperton Zone; DOMES = Deep Ocean Mining Environmental Study; EIA = Environmental Impact Assessment; OMA = Ocean Mining Associates ; BIE = Benthic Impact Experiment; IOM = Interoceanmetal Joint Organization; MPA = Marine Protected Area; COMRA = China Ocean Mineral Resources Research and Development Association; CIOB = Central Indian Ocean Basin; OMCO = Ocean Minerals Company.

References

Brockett T, Richards CZ. 1994. Deep sea mining simulator for environmental impact studies. *Sea Technology* 35(8):77–82.

Khripounoff A, Caprais J-C, Crassous P, l'Etoubleu J. 2006. Geochemical and biological recovery of the disturbed seafloor in polymetallic nodule fields of the Clipperton-Clarion Fracture Zone (CCFZ) at 5,000-m depth. *Limnology and Oceanography* 51(5):2033–2041.

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