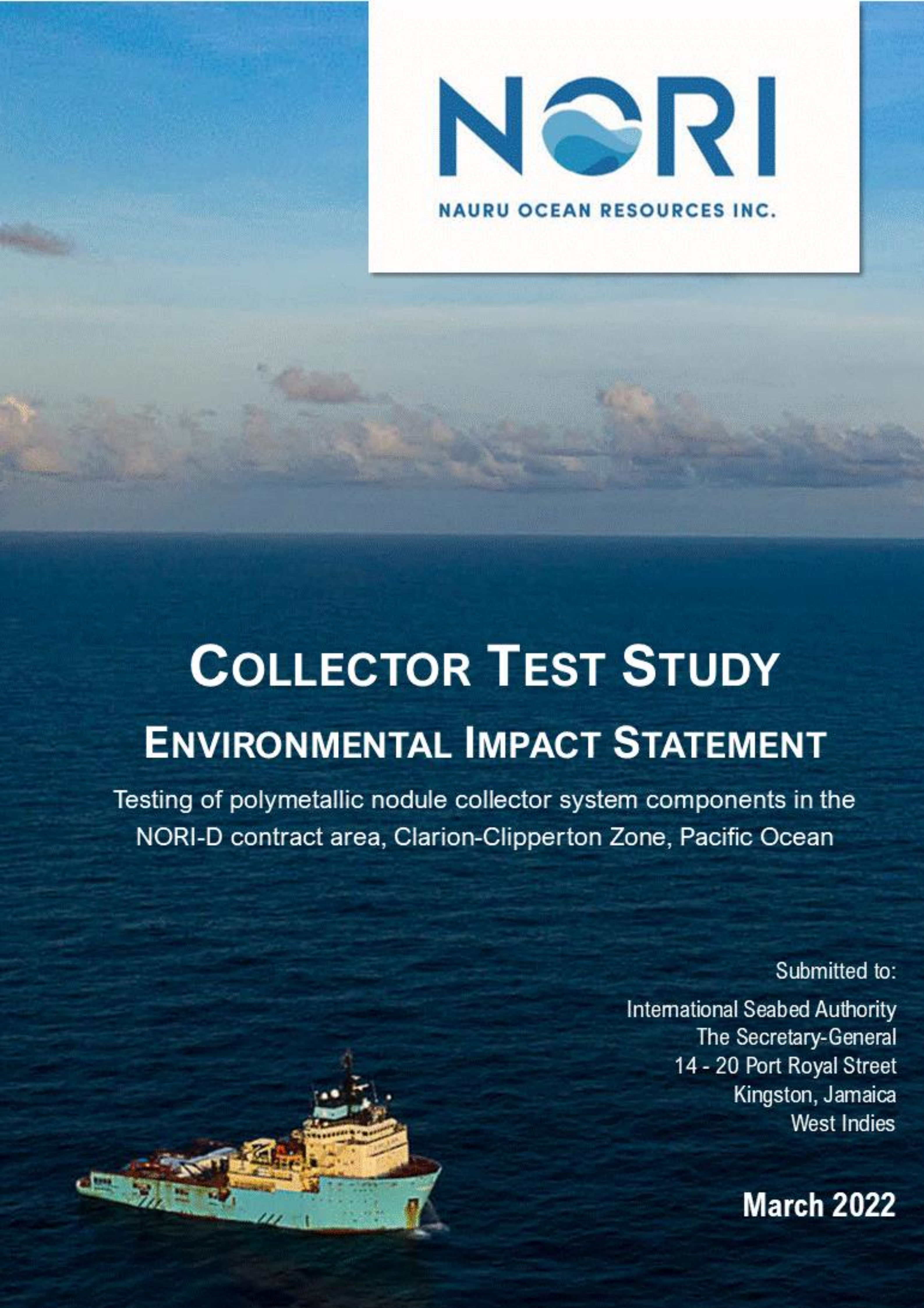

NAURU OCEAN RESOURCES INC.

COLLECTOR TEST STUDY

ENVIRONMENTAL IMPACT STATEMENT

Testing of polymetallic nodule collector system components in the NORI-D contract area, Clarion-Clipperton Zone, Pacific Ocean

Submitted to:

International Seabed Authority
The Secretary-General
14 - 20 Port Royal Street
Kingston, Jamaica
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PREFACE

On July 29th, 2021, Nauru Ocean Resources Inc (NORI) submitted its Collector Test Study Environmental Impact Statement (EIS) to the Secretary General of the ISA for initial review. The document was simultaneously released for public stakeholder review and comment. This updated EIS considers reviewers' comments and incorporates further information that has become available during the interim. In particular, the inclusion and assessment of additional baseline data from completed offshore campaigns which adheres to an established environmental impact assessment (EIA) process of impact identification, significance analysis and risk assessment. This represents a significant advancement in the development of a robust environmental impact statement (EIS) framework for deep sea mining projects.

The inclusion of a Collector Test into the commercial EIA process provides the opportunity to assess the technical performance of the prototype collector system and its potential environmental impacts in the mining lease area which is proposed at a scale and duration of activities that is sufficient to meet the study objectives but of insufficient magnitude to incur any serious harm to the marine environment. As such, the Collector Test is essentially an experiment dedicated to test and refine the technical performance of the equipment and provide empirical (in-situ) environmental monitoring data during and after the test, which is essential to inform impact predictions and to apply best mitigation practices to a full-scale commercial system.

If there were to be no opportunity to carry out the Collector Test, or if it were to be undertaken in un-representative, shallow or nearshore environments, the information collected would be considered of limited application to the actual physicochemical and ecological conditions prevalent in the CCZ. Furthermore, without the Collector Test, there is little other analogous information available at the current developmental stage of deep-sea polymetallic nodule mining. The Collector Test therefore represents a critical component of NORI's studies, as it provides the observations and measurements of the performance and impacts to the seabed and water column that could not be acquired by any other means.

Mining projects in national jurisdictions do not typically include a full (separate) EIS for component testing of equipment or environmental studies because much understanding of the characteristic sources, pathways and impacts of disturbances and emissions already exists from the long history of terrestrial mining activities. In a typical terrestrial EIS, the individual technical studies that make up and support the sequence of environmental investigations and impact assessment steps are incorporated as appendices to the overall commercial EIS, but not as a separate EIS.

The focus of an EIA is to identify significant impacts that have the potential to cause serious harm to the receiving environment – not to mitigate all impacts to zero, as this is both an impossibility and undesirable when the objective of the test is to characterise impacts at a non-commercial scale. The EIS presents the regulator with a description of the residual impacts to the environment that are predicted to remain after all appropriate management and mitigation measures have been applied. Ultimately, the regulator determines whether approval of the project (and hence acceptance of its residual impacts and the associated risks) is justified by the overall benefits to global communities. If a project is approved, the regulator will require comprehensive monitoring to ensure actual impacts do not exceed those predicted and may impose additional requirements such as the need for further environmental studies as a condition of approval.

The requirement for a prior environmental impact assessment and an environmental monitoring programme to be carried out during and after the specific (collector) activity during exploration is given in ISBA /25/LTC/6/Rev.1 (2019) "*Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area*", specifically Section VI. B. (Paragraphs 33[a-g] and 34). The recommended scopes of work are listed in Section VI.

C. (Paragraph 38[a-q]), from which it is evident that the primary inputs and focus to the environmental impact assessment are the baseline, monitoring and impact assessment studies.

Annex III of ISA Recommendations (ISBA/25/LTC/6/Rev.1) states that the assessment of impacts from activities on the seafloor *should be appropriate to the nature and extent* of the activity being considered and should also ensure that no significant harm is caused by the activities conducted during exploration. This Collector Test EIS therefore addresses those issues that are germane to the proposed seabed testing activities. Although it is referred to as an EIS in the recommendations, it is an integral component part of the commercial EIS. It also provides the ISA and stakeholders with a clear description of the Project, the potential environmental impacts, environmental risks and hazards, risk management measures and monitoring programs relating to the Collector Test. These findings will inform the EIS and EMMP for commercial scale mining, socio-economic impacts and aspects common to maritime activities in general will be addressed by the commercial EIA and reported in the commercial EIS for the full-scale operating system.

EXECUTIVE SUMMARY

Introduction

Nauru Ocean Resources Inc. (NORI) plans to carry out testing of a polymetallic nodule collector system (the Collector Test) in the NORI-D lease area (NORI-D) of the eastern Clarion Clipperton Zone (CCZ), Central Pacific Ocean. NORI has commenced an Environmental and Social Impact Assessment (ESIA) in support of an application to the International Seabed Authority (ISA) for a contract to commercially collect deep-sea polymetallic nodules. Testing of a prototype collector vehicle (PCV) and riser system is a pivotal component of the overarching commercial ESIA. The ISA recommends a dedicated assessment of the technical and environmental performance of the prototype system, which is one fifth of the proposed commercial scale.

The Collector Test Environmental Impact Statement (EIS) must be submitted to the Secretary-General of the ISA no later than one year in advance of the activity taking place. The current schedule has the NORI-D Collector Test EIS being submitted Q3/2021 and the test being conducted in Q3/2022, with the overarching commercial EIS to be submitted Q2/Q3 2023.

The Collector Test will take place in international waters and will adhere to the latest recommendations of the ISA (paragraph 38 and Annex III in ISBA/25/LTC/6/Rev.1; 30 March 2020), the governing body that organises, regulates, and controls all mineral-related activities in international waters beyond the limits of national jurisdiction (referred to as "The Area"). This recommendation defines the activities that require an EIA, the form and content of the EIS, and guidance on expectations for baseline studies, monitoring and reporting.

Approach

Annex III of ISA Recommendations (ISBA/25/LTC/6/Rev.1) states that the assessment of impacts from activities on the seafloor should be appropriate to the nature and extent of the activity being considered and should also ensure that no significant harm is caused by the activities conducted during exploration. The proposed work program is underpinned by a detailed risk-based assessment that considers the representativeness of the study area, its dimensions, the duration and sequencing of system testing, and the environmental performance data to be gathered at each stage of the test. The Collector Test will take place over a period of approximately 60 days with all seafloor trials conducted within an $8km^2$ test area.

Research Campaigns

In 2012, NORI commenced a program of research campaigns to develop the environmental baseline for the NORI-D commercial ESIA. As of February 2022, sixteen research campaigns to the NORI leases have been completed. Beginning in 2020, NORI embarked on a program of thirteen environmentally focused campaigns designed specifically to inform the commercial Environmental and Social Impact Assessment (ESIA). This program focussed on the collection of data on the physical oceanography, water chemistry, sediment geochemistry, benthic biota, pelagic biota and ecological processes of the NORI-D lease. The NORI environmental campaign schedule is summarised in the table below.

#	Campaign ID	Start Date	End Date	Focus
1	Campaign 4A	2/10/19	23/10/19	Deployment of three oceanographic moorings within NORI-D to collect continuous metocean data. Water sampling and hydrographic profiling.

#	Campaign ID	Start Date	End Date	Focus
2	Ocean Infinity	23/05/20	30/05/20	Over 25K seabed images collected from PRZ and TMA used for megafauna identification and quantification.
3	Campaign 4D	16/6/20	15/7/20	Serviced the oceanographic moorings deployed at NORI-D during Campaign 4A. Water sampling and hydrographic profiling.
4	Campaign 5A	16/10/20	30/11/20	Collected data on the benthic biology, sediment geochemistry and surface biology of NORI-D using box-core, multicore and floating hydrophones.
5	Campaign 5B	5/3/21	14/4/21	Pelagic biology studies of NORI-D supported by ROV, CTDs, MOCNESS nets and rosette water quality samplers for trace metals.
6	Campaign 5D	27/4/21	12/6/21	Collected seasonal data on the benthic biology, sediment geochemistry and surface biology of NORI-D using box-core, multicore and floating hydrophones.
7	Campaign 4E	6/7/21	29/7/21	Serviced the oceanographic moorings deployed at NORI-D during Campaign 4A. Water sampling and hydrographic profiling.
8	Campaign 5C	21/9/21	2/11/21	Seasonal pelagic biology studies of NORI-D supported by CTDs, MOCNESS nets and rosette water quality samplers for trace metals.
9	Campaign 5E	12/11/21	22/12/21	ROV pelagic and benthic transects and sample collection. Collection of seasonal seabed images collected from PRZ and CTA used for megafauna identification and quantification.
10	Pre/Mid-Collector Test	Q2/2022	TBA	Studies before and during the Collector Test will be conducted during this campaign.
11	Campaign 4F	Q2/2022	TBA	Serviced the oceanographic moorings deployed at NORI-D during Campaign 4A. Conducted additional oceanographic profiling.
12	Post - Collector Test	Q3/2022	TBA	Disturbance studies during and after the Collector Test will be conducted.
13	Campaign 4G	Q2/2023	TBA	Serviced the oceanographic moorings deployed at NORI-D during Campaign 4A. Conducted additional oceanographic profiling.

Selection of Collector Test Area & Test Field

The Collector Test will be conducted within an 8 km^2 Test Field (TF) in a designated 150 km^2 Collector Test Area (CTA). The CTA has been selected to be representative of the primary target mining area represented within NORI-D, based on bathymetry, slope (max. 4°), water depth, nodule type, nodule distribution, and a geoform classification.

Nine potentially suitable TF sites were initially identified for comparison within the CTA. The TF that best met the desired criteria is located in a Level 2 ‘Flatter area’ geoform, which is well represented throughout

NORI-D and the wider CCZ. As Abyssal hills and seamounts have been shown to be higher in species richness and standing stock biomass compared to adjacent areas devoid of topographic variability, the CTA and TF have been purposely positioned in the 'Flatter area' geoform which is assumed to be less species rich and is the largest geoform type represented in NORI-D (8,553.70 km^2).

After the Collector Test has been completed the TF and other impacted areas of the CTA will be designated as Impact Reference Zones (IRZs). A post-test monitoring program for the IRZ will be included in the commercial Environmental Management and Monitoring Plan (EMMP) developed for submission with the application for a commercial contract. Monitoring of the IRZ and control sites will continue for the duration of the contract and closure plan period.

The 8 km^2 TF is the only area that will be directly disrupted by testing and represents 0.09% of the geoform represented on NORI-D. Of the 8km^2 TF only 0.5km^2 will be directly disturbed by the tracks of the PCV, although it is anticipated that the total area that will be subjected to increased levels of sedimentation (≥0.1 mm) after the completion of the Collector Test will be approximately 25.5 km^2.

Collector Test Components

The main components to be tested include the Surface Support Vessel (SSV), a dynamically positioned ship that will accommodate, launch, and recover the PCV and provide all other associated support equipment. The PCV will be constructed at half scale of the proposed commercial size, but otherwise, is a similar tracked vehicle that uses suction technology to collect nodules from the seafloor and will be controlled via an umbilical from the SSV. A riser and return system will transport the collected nodules from the seabed to the surface and discharge water separated from nodules via a return pipe at a trial depth of 1,200m (the outlet to be positioned below the mesopelagic zone). Assistance to the PCV for monitoring, attaching the riser system, visual and sonar surveys etc. will be provided by a Remotely Operated Vehicle (ROV). Umbilicals on both the PCV and the ROV will provide the power and control of all the subsea equipment from the SSV to the seafloor.

A second research vessel will also be on hand as a platform for scientific monitoring during the Collector Test.

Analysis of Alternatives

An Analysis of Alternatives was conducted following a 'narrowing approach' involving a series of logical steps, starting with the high-level alternatives followed by description of more detailed alternatives considered as part of the Project. This approach considers alternatives in the following sequence:

- 'Zero' or 'No Project'
- Conduct the test be conducted in the 'CCZ' or 'elsewhere'
- Situate the CTA in the 'Flatter Area' or 'Other' geoform
- Situate TF in 'Area 6' or 'Other Area' alternative
- Situate BACI control site in 'PRZ' (Preservation Reference Zone) or 'Assign new control area'

The rationale behind key decisions made in the development of the project description is provided.

Collector Test Program

The SSV and scientific support vessel will transit from the port of San Diego, USA, to NORI-D for an estimated 60 days on location. Once the initial field inspection and preparations are complete the PCV will be lowered to the seafloor and the testing sequence will commence with manoeuvrability tests. These will involve straight line and turning tests, obstacle avoidance tests and line tracking tests, taking an estimated 97 hours to complete. This will be followed by nodule pick-up efficiency tests, requiring an estimated 127 hours. During these trials the PCV will still not be connected to the riser system and any nodules collected will be discharged behind the PCV.

The next stage involves the riser installation, commissioning and integration testing (210 hours), followed by system line and manoeuvring test runs, initially without nodule production at slow speeds (0.1 to 0.5 m/s), then with nodule production ramp-up to full capacity (319 hours). Testing will progress to performance test runs to determine nodule production rates and efficiencies under straight line, 180º turning, and contour mining. This will be followed by advanced capacity and slope ability test runs. The trials will end with an emergency shutdown test prior to de-commissioning and site closure.

The estimated total time requirement for system testing is 860 hours, during which the PCV will travel approximately 82 linear kilometres and collect approximately 3600 wet tonnes of nodules.

Physicochemical Environment

General setting

The CCZ is a 4.5-million-km^2 region in the northern part of the Central Pacific Ocean, approximately 1,700 km to the northwest of Mexico. Water depths within NORI-D range from approximately 3,000 to 4,600 m; with isolated seamounts of volcanic origin occurring in the southern half, becoming larger and more prominent towards the southeast. Bathymetric data for the entire NORI-D lease was collected in 2012 from a full-ocean depth multibeam system, with 25,720 km^2 of seafloor mapped.

The climate is dominated by north-easterly trade winds from April to November. Precipitation and cloud cover are sporadic but higher in the northern winter. Hurricane season starts in May, subsiding generally by October or November.

Hydrographic profiles

Three oceanographic moorings have been deployed in NORI-D since October 2019, to collect baseline metocean data throughout the water column in the proximity of the CTA and the PRZ. These are equipped with a range of instrumentation to measure currents, physical water quality parameters, sedimentation, acoustics and a seafloor camera system. Five water quality sampling stations were established in 2019 to collect samples from 16 depths within the water column for analyses of alkalinity, chlorophyll-*a* (for water depths <1,150m), nutrients, trace metals, metalloids, carbon and Total Suspended Solids. In addition, in situ metocean data has also been collected by CSA and the University of Hawaii (UOH) over multiple campaigns.

Temperature - A near-continuous long-term record of temperatures has been acquired from instruments attached to the three moorings located within the NORI-D block over a three-year period. Short-term temperature variations (i.e., days) were observed in records collected within water depths of 284 m (~0.5°C variation; Figure 5 11A) and 1,999 m (0.1°C variation). Short-term temperature variations were not as apparent in deeper waters, with near-seafloor temperatures consistently stable at approximately 1.5°C. Evidence of seasonal temperature variation was observed within records collected within the upper half of the water column. At 1,999 m, the temperature decreased by 0.3°C between May and November in 2020, and a similar trend seems evident in the shorter-term 2019 and 2021 records.

Salinity - A near-continuous long-term record of salinities has been acquired from instruments attached to the three moorings located within the NORI-D block over a three-year period. Salinity at all recorded depths throughout the deployment period remained steady at approximately 34.7 PSU. These results indicate uniformity and consistency in salinity values across NORI-D regardless of depth or location.

Dissolve oxygen - A near-continuous long-term record of DO has been acquired from instruments attached to the three moorings located within the NORI-D block over a three-year period. DO concentrations at 1,999 m ranged from 2.3 to 3.1 mg L-1 and typically had short-term (i.e., daily) variations of 0.1 mg L-1, except for between November 2020 and March 2021 where the short-term variation increased to approximately 0.5 mg L-1. Near-seafloor dissolved oxygen concentrations were consistently between 4.7 and 5.0 mg L-1 at all mooring locations.

During Campaign 5B UOH sampled DO at 11 sites across the CTA and the PRZ. They found that the boundaries of the oxygen minimum zone (OMZ), as defined by dissolved oxygen concentrations of about 45 µmol/kg (Karstensen et al. 2008), extended from about 100 to just below 1000 m.

Turbidity - A near-continuous long-term record of turbidity has been acquired from instruments attached to the three moorings located within the NORI-D block over a three-year period. Turbidity through most of the water column rarely exceeded 0.2 NTU (i.e., 0.2 to 1 mg/L; using 1:1 to 1:5 conversion ratios (DOER, 2000)).

Turbidity recorded near the seafloor was highly variable, with singular very short-term peaks (i.e., hours) exceeding 10 NTU (i.e., 10 – 50mg/L) near the seafloor at all mooring locations. A running median of turbidity values near the seafloor indicates median values generally ranged from 0.1 to 0.5 NTU (i.e., 0.1 to 2.5 mg/L) for the majority of the deployment period. Increased turbidity values at the near-seafloor during the short-term peaks are likely due to the occasional resuspension of sediments.

The mean turbidity values are in the order of 0.17NTU (0.2 to 0.9 mg/L) across the 3 instruments, with a standard deviation of 0.13NTU (0.1 to 0.6 mg/L). With an observed relatively high standard deviation in the Turbidity data, it is reasonable to conclude that the biological receptors are unlikely to be sensitive to incremental concentrations less than 0.1mg/l.

Currents - A near-continuous long-term record of current speed and direction has been acquired from instruments attached to the three moorings located within the NORI-D block over a three-year period.

Mid water - Current speeds at 2000m averaged 2.6 ± 1.4 cm s^{-1}. The highest average current speeds were recorded in July (3.6 ± 1.9 cm s^{-1}) and the lowest average current speeds (~2.3 cm s^{-1}) were recorded from September through November.

Average current speeds were frequently higher in July, where 30% of recordings measured current speeds between 3.6 and 5.7 cm s^{-1}. Conversely, average current speeds were frequently lower in October, where 47% of recordings measured current speeds between 0.0 and 2.1 cm s^{-1}.

Current direction at 2,000m generally flowed towards the southwest over the course of the full mooring deployment. However current direction did vary monthly, sometimes trending northwest (January) or northeast (March).

Seabed - At 4,321 m current speeds near the seafloor averaged 2.6 ± 1.6 cm s^{-1}. The highest average current speeds were recorded in June (3.8 ± 1.6 cm s^{-1}) and the lowest average current speeds were recorded in October (2.5 ± 1.3 cm s^{-1}).

Average current speeds were frequently higher in June where 41% of recordings measured current speeds between 3.6 and 5.7 cm s^{-1}. Conversely, average current speeds were frequently lower in April where 41% of recordings measured current speeds between 0.0 and 2.1 cm s^{-1}.

Current direction at the near seafloor generally flowed towards the northwest over the course of the full mooring deployment. However current direction did vary monthly, sometimes trending northeast (March) or south (June).

Sedimentation - A near-continuous long-term record of sedimentation has been acquired from traps attached to the three moorings located within the NORI-D block over a three-year period.

Total mass flux values and trends were similar among the sediment traps located in a water depth of 2,000 m at the Long Mooring Site and those located 500 m above the seafloor (~3,800 m water depth).

77 valid sediment trap data sets are available from the near bed zone over the period October 2019 to June 2022 from which a deposition density of 180kg/m^3 is estimated. This yields background

sedimentation rates with mean of 0.08mm/year with a standard deviation of 0.09mm/year. Sedimentation is characterised by persistent low sedimentation rates with a median in the order of 0.05mm/year, but with a number of high sedimentation events, with the highest event 5 standard deviations above the mean.

Particle size - During Campaign 5B UOH sampled DO at 4 sites across the CTA and the PRZ. There were clear depth distributions in the particle size distribution (PSD) slope with mid-water scattering layers having higher contributions in the large particle sizes, presumably indicative of sedimenting particles with a mode of ~ 6 µm as opposed to the mode of the PSD in surface waters of 4 µm.

pH - During Campaign 5B UOH sampled DO at 11 sites across the CTA and the PRZ. The pH at all sites ranged from 7.61 in the OMZ to 8.04 in the surface mixed layer. The variation in pH in the upper 60 m at similar depths at each station is greater than measured reproducibility at 1000 m and represents environmental changes in pH with depth. These differences between stations can be attributed to depth of sample collection, which was different at each site as well as differences in the balance between photosynthesis and respiration at each site. Variation in pH within the OMZ (~100-1000 m) shows differences between sites that is most likely related to intensity of suboxic and anoxic respiratory processes. Variation in pH in the deepest samples within the benthic boundary layer (~5-10 m above the seafloor), ranges from 7.88 to 7.95 and most likely results from the release of CO2 from respiration from abyssal deposit feeders and benthic infauna, which can be very patchy on the seafloor.

Nutrients - During Campaigns 4A and 4E CSA measured average nutrient concentrations for nitrogen, phosphorous, and silica compounds. All nutrient concentrations were lowest within the surficial mixed layer at the 30 m sampling depth, and most nutrients were highest at the lower boundary of the oxygen minimum zone at water sampling depth of between 950 and 1,500 m. The highest average silicon dioxide concentration was located at a sampling depth of 2,500 m. Nutrient concentrations were generally similar at all depths, implying temporal stability of seawater nutrient concentrations within the NORI-D block. Nutrient concentrations measured during both campaigns were also very similar to vertical profiling trends reported elsewhere within the generalized deep-water Pacific Ocean (MBARI, 2021).

During Campaigns 5B UOH measured the vertical distribution of phosphate, nitrate plus nitrite, and silicate at 11 sites across the CTA and the PRZ. Comparison traces for the full water column depth shows similar patterns across the PRZ and CTA. The 0-200m profiles show consistently low concentrations at the surface (<50 m) and a transition to nutrient-rich waters between 50 to 100 m. The top of the nutricline roughly coincides with the deep chlorophyll maximum. Both the nutricline and the deep chlorophyll maximum are shallower than at the NPSG time-series site, Station ALOHA, but distributions of nutrients are otherwise consistent with historical data at this subtropical time-series site.

The physical properties and nutrient data described have been compared with historical data from the WOCE, CLIVAR, and GO-SHIP programs. The data from NORI-D has excellent comparison to the historical datasets.

Trace elements **–** Seawater samples were collected using trace metal clean procedures established by the International GEOTRACES Program at 11 sites across the CTA and PRZ during Campaign 5B.

Total dissolved mercury (THg) and dissolved lead (dPb) were both at concentrations far below toxic drinking water levels, which is typical for open ocean seawater. At all areas sampled, THg was <1 pM in surface waters and increased to a maximum >1 pM in 13°C Water near 100m depth. In the OMZ, concentrations were variable, with a minimum in the heart of the OMZ at the CTA but maxima in the OMZ at the other two sites. Concentrations steadily increased with depth, showing excellent agreement across the 3 sites at intermediate depths.

Dissolved Pb, in contrast, showed a more typical “scavenging-type” profile shape with low surface concentrations, a maximum at 100m in the 13°C Water, and then decreasing concentrations with depth.

The PRZ showed higher dPb concentrations than the other two sites in the 13°C Water, which could be a spatial difference.

The dissolved Zn, Ni, and Cd profiles showed classic nutrient-like profile shapes that emulated the macronutrients. While several datapoints are still undergoing QA/QC, there was overall little spatial variability observed across the three sites for Zn, Ni, or Cd.

At the CTA, Mn demonstrated a surface maximum, as is typical when particulate Mn(IV) is photo-reduced to dissolved Mn(II) in sunlit waters. Dissolved Mn concentrations then typically decrease with depth, except where there is a secondary dMn maximum coincident with the OMZ between 500-700m depth.

Dissolved Al data showed profile shapes consistent with the rest of the global ocean, with a surface maximum decreasing to low concentrations at depth due to scavenging onto sinking particles.

Dissolved Fe concentrations showed classic nutrient-type profile shape. Surface concentrations were depleted, suggesting strong nutrient uptake/recycling. The dFe profiles at all three trace metal stations were very similar, suggesting that spatial variability was negligible.

Trace element concentrations from NORI-D were compared Pacific historical datasets. All the dissolved metals studied on Campaign 5B showed profiles similar to their literature values for the tropical/subtropical Pacific, with some exceptions that may in fact relate true spatial variability (since the historic data are from locations quite far from NORI-D).

Sediment geochemical properties

Sediment particle size – Sediment samples for geochemical analysis were collected at 14 sites on Campaign 5A and 16 sites on Campaign 5D across the CTA and PRZ.

Examination of sediments collected on Campaign 5A reports no notable differences in the grain size or porosity of sediment between local sample sites or between the CTA and PRZ. The average grain size was 11 ± 3 µm (n = 139) and average porosity was 0.87 ± 0.03 which is to be expected for deep sea pelagic clay rich sediment.

Porewater nutrients – Analysis of samples from Campaign 5A have been completed for silicate (SiO_2), phosphate (PO_4), nitrate (NO_3), nitrite (NO_2), ammonia (NH_4), alkalinity, and ex-situ dissolved oxygen (O_2). Concentrations of all analytes were broadly within the range of values published previously for the closest CCZ sediments to NORI-D.

Preliminary results indicate no discernible difference in the linear spatial trend of nutrient concentrations either at a local scale (i.e., between sites) or between the CTA and the PRZ. Individual sites do exhibit concentration variability with profile depth that is in the range of expected concentrations. There was also a difference in nutrient concentrations between bottom waters (i.e., <0 depth) and porewaters (i.e., >0 depth) with lower nutrient concentrations observed in bottom waters.

Porewater oxygen (ex-situ) and alkalinity – The sediment O_2 concentrations recorded are consistent with those reported for other areas of the CCZ. And there was no clear evidence of sediment O_2 concentrations differing discernibly either spatially (i.e., CTA vs PRZ), with nodule type (i.e., Type 1 vs Type 2), or with geoform (i.e., Abyssal Plain vs Abyssal Hill).

Alkalinity concentrations were constant across all sites at 2.8 ± 0.2 mM to a maximum depth of 22 cm, suggesting negligible change in carbonate chemistry across the sediment water interface and with depth.

Sediment TOC, IC, Bulk N and associated stable isotope analysis – The concentration profile of TOC with depth across all Campaign 5A sediment cores is similar with low TOC content typical of deep-sea sediments and within the range of previously measured TOC values in the CCZ (0.2-0.7 wt %). Profiles show the highest concentrations of TOC in surface sediment decreasing with depth typical of deposition of organic matter in surface sediments which is degraded by microbial respiration with burial in the sediment. The highest TOC concentrations in the NORI-D claim area are ~0.6 % which is the same as the adjacent BGR claim area.

Depth profiles of IC generally increased with depth except for two sites. Whilst IC values and the profile shape appear to be similar within the CTA, 2 sites from outside the trial mining area had the highest IC concentrations in the top 10 cm and the sites with the lowest concentration were those with type 2 nodules. This variability could be related to the abundance of calcifying forams at different sites and/or the depth of the sediment surface relative to the calcite compensation depth (CCD) of the water column.

There is no notable difference in bulk N content of sediment between different sample regions or nodule types. There is, however, a strong correlation between bulk N and TOC. This indicates that the vast majority of N in sediments is associated with organic matter in the sediments. Stable isotope data also showed no notable differences between the CTA and PRZ.

Sediment total metals and Fe mineral extractions - Total metals data indicate negligible differences in metal content of sediments between the CTA and PRZ. Key mineral forming metals (Mn, Fe, Al) show a gradual decrease with depth at both sites. This is in agreement with published Mn data and NORI-D Mn concentrations appear similar to that measured in other areas of the CCZ (0.05-1.09 wt %). Elevated Mn concentrations (4 wt %) were observed at one site at the same depth as sub-surface nodules were collected from the core. Indicating either that nodule fragments had broken off during sediment sampling or the presence of increased Mn minerals which may have contributed to nodule growth. Both Al and Fe concentrations were at the lower end of the range previously reported for CCZ sediments (3.7-6.1 wt % Fe and 5.9-9.8 wt % Al).

The majority of Fe was associated with the Fe_{mag} fraction suggesting most of the Fe in sediments are present as Fe minerals with a mixed oxidation state (Fe2+/Fe3+). Variability in Fe_{mag} increased with depth and this could reflect variability in Fe mineral content between sites. Fe_{carb} and Fe_{ox} were similar between sites. Fe_{ox} concentrations show negligible change with depth except two subsurface peaks in concentration which could be related to sub-surface nodules. Fe_{carb} decreased with depth indicating that the Fe associated with this fraction is either lost to porewaters or other mineral phases during sediment diagenesis.

Biological Environment

Studies are currently ongoing to characterize the various biological communities represented in NORI-D as part of the commercial ESIA. This involves a comprehensive program of benthic and pelagic sampling, including box coring, multi coring, video transects from robotic and autonomous vehicles, MOCNESS nets, benthic landers and free-floating pelagic samplers. Results will provide a baseline for the BACI monitoring studies that will be ongoing through the operational monitoring phase of the project.

The Collector Test is considered essential to fully understand the magnitude of environmental impacts from polymetallic nodule collection and the sensitivities of the impacted biota. This information will be available to inform the commercial ESIA.

A summary of the key findings from the biological baseline studies completed to date is provided below.

Benthic habitat

The nodule provinces found in the CCZ typically provide hard substrates in the form of the nodules and soft substrates in the red clays that surround them. Thus, there are organisms that live in the sediment, on the sediment, attached to the nodules and those that are free swimming.

The benthic habitat represented by the CTA and TF is classified as a Level 1 'Abyssal plain' and Level 2 'Flatter area' geoform on which sediments are overlain with medium-sized (1 to 10 cm) and densely packed nodules (termed Type 1 nodules). Many nodules are in contact with their neighbours and cover over 50% of the seafloor.

Benthic fauna

Megafauna - Data collected to date indicate that metazoan megafauna density is relatively homogenous across NORI-D, ranging between 0.93 – 1.08 specimens per meter square of seabed. In contrast. substantially different xenophyophore test densities were found between study areas, as significantly higher densities of these thecae were found at the PRZ site. As expected from other CCZ studies, nodule-free areas at NORI-D appeared to harbour a lower megafaunal density, both in metazoan megafauna and xenophyophore test occurrence.

Scavenging megafauna - The most abundant scavenging megafauna in attendance at baited traps were the rattail Coryphaenoides sp. followed by the cusk eel *Barathrites iris* and the eelpout *Pachycara nazca*. The large Aristeidae shrimp, *Cerataspis monstrosus* and the Solenoceridae shrimp *Hymenopenaeus nereus* were also in attendance.

Macrofauna - To date, DNA has been extracted from 545 specimens, from which 338 sequences have been generated. So far, 293 specimens have been assigned to species based on genetic data (199) or morphological data. These represent 106 species from 6 different Phyla (Cnidaria, Echinodermata, Annelida, Brachiopoda, Arthropoda, and Mollusca), with annelids representing the most diverse so far (57 species). From the 106 species identified, only 18 represent described species. The remaining species represent undescribed species that, at this stage, are only comparable using genetic data. For the 103 delimited species for which we have generated genetic data, 47 have only been found at NORI-D, and 56 have been found in other areas. Species with wide distributions such as Bathyglycinde cf. profunda, the cosmopolitan *Porcellanaster cereulus* and *Pelagodiscus atlanticus*, as well as the widespread *Styracaster paucispinus* and *Silax daleus* were also found within the NORI-D samples.

Preliminary analysis of mud-dwelling macrofaunal communities from the CTA suggests dominance by deposit feeding annelids and crustaceans as is expected for the CCZ. While the species identification is still ongoing, most polychaete worms have been identified to family level. Looking at compositional assemblages of polychaete families these are roughly similar; with none of the families dominating any of the three areas within the CTA.

Nodule macrofauna abundance was similar between regions, the relative abundance of different phyla being consistent between sites. However, sponges (Porifera) represented nearly half of the samples collected in the PRZ, where annelid worms were less abundant than in the other areas. This is strongly suggestive that the PRZ is different in community composition to the other sites, not was unexpected given the distances involved and observational reports from the Campaign field teams.

Meiofauna - A total of 21 higher taxa of meiofauna have been observed from NORI-D. Total meiofauna density per cores (0-5 cm) across NORI-D ranged 26.0 – 204.3 ind. 10cm^2, averaging 70.0 ± 42.0 ind. 10cm^2. These average values are relatively low compared to similar other studies, possibly linked to the variability in presence and density of nodules and sediment conditions such as the very high amounts of silicious remains of radiolarians and diatoms, and biogeochemical conditions.

A total of 116 nematode genera have been documented from NORI-D, which is similar to other studies in different license areas and lies within the expectations considering the 156 genera observed from four different license areas and the APEI-3 area. Despite the observed diversity, the communities are characterized by a high abundance of a limited number of taxa, with many low-abundance genera making up most of the community, and rare genera with only a few occurrences across all the samples.

The average foraminiferal density from all sites was 392 stained and complete individuals per 5 cm^2 with a range of 255 to 743 individuals per 50 cm^2. The average density of individuals in the CTA region was 393 individuals per 50 cm^2 with a range of 255 to 654 individuals per 50 cm^2. The average density of individuals in the PRZ region was 411 individuals per 50 cm^2 with a range of 338 to 484 complete individuals per 50 cm^2. Over half of all foraminifera species found (>250) in the NORI-D samples were considered monothalamous forms. This is consistent with previous studies from the UK-1, OMS, Kaplan East, and APEI-6 regions where monothalamids were largely dominant

Microbial Metabolic Activity - Bacterial carbon uptake rates ranged from 0.055 mg C m-2 d-1 at the CTA, to 0.035 mg C m-2 d-1 at the PRZ. Statistically significant differences between all locations cannot be yet determined due to sample size. However, bacterial C uptake appears to not significantly differ between sample sites. C-uptake rates were approx. 10% of the total DIC production values, which is consistent with trophic transfer efficiency in ecological food webs.

Average rates of bacterial carbon uptake, an indicator of benthic metabolic activity, decrease from shallower to deeper sediment. Bacterial carbon uptake appeared to not significantly differ between sample sites (e.g., CTA vs. PRZ), but were lower than microbial metabolic rates measured in the nearby OMS and UK-1 sites. Nutrient fluxes were not found to significantly differ between background and algal addition experiments, suggesting no change in organic matter remineralisation processes in response to phytodetrital inputs, which together with the findings of much lower bacterial C-uptake rates in NORI-D relative to the UK1 and OMS sites indicate a rather inactive microbial community at NORI-D.

Fluxes of all nutrients between deployment locations showed no clear spatial patterns and a high degree of heterogeneity across the PRZ and CTA within NORI-D. In contrast to nutrient flux data, the total DIC production rates did not appear to vary that greatly between deployment locations, suggesting a consistent pattern across the license area. However, this needs to be confirmed with further sampling.

Pelagic fauna

Mid-water ecosystems have been studied very little in the CCZ, in part due to a focus on the specific effects of nodule collection on the seafloor habitats and communities. However, nodule collection and processing activities may have a variety of potential effects on biological communities in the ocean's mid-waters or pelagic realm.

Studies of meso- and bathypelagic zooplankton and micronekton have been conducted around the CCZ but not within. Zooplankton and micronekton assemblages have been characterized in some areas of the central Pacific, including around Hawaii, in the equatorial region south of Hawaii and in the Costa Rica Dome region to the east of the CCZ. Although these studies provide useful information for the wider Pacific region, they are location, taxon and/or size class specific and reveal only a partial assessment of communities.

The mid-water studies implemented during Campaigns 5B and 5D are the first to be conducted in the CCZ

Microbial communities - The composition of microbial communities varied with depth and was consistent with long term observations from the North Pacific Subtropical Gyre. The most abundant taxa in the surface waters were in the family Prochloraceae, particularly the widespread photoautotrophic genus Prochlorococcus comprising an average of 32% of the community in the euphotic zone. Additional abundant taxa in the surface waters included the SAR11 Clade I, Flavobacteriaceae, Actinomarinaceae, and the SAR86 clade. Below the euphotic zone the most abundant taxa were in the family Nitrosopumilaceae, autotrophic Archaea that oxidize ammonia. Additional abundant taxa in the deeper waters included the SAR324, SAR406, SAR11 Clade II and the Gammaproteobacteria Alteromonadaceae and Pseudoalteromonadaceae. Abundant taxa throughout the water column included the Marine Group II and III Archaea, the Alphaproteobacteria Rhodobacteraceae, and various families within the order Oceanospirillales. The SAR202 and SUP05 clades were most abundant in specific depth horizons in the mesopelagic and oxygen minimum zones, respectively.

Phytoplankton communities in the epipelagic zone - Net community production was derived from O_2/Ar measurements. The deviation of O_2/Ar from equilibrium, ΔO2/Ar, represents the O_2 saturation anomaly due to biological processes, and its sign indicates whether the system is net autotrophic (positive values) or net heterotrophic (negative values). The samples collected during Campaign 5B showed high variability in $\Delta O_2/Ar$. At the PRZ site, mean $\Delta O_2/Ar$ for each cast ranged from near equilibrium (0.01%) to up to up to 0.5% whereas the two casts conducted at the CTA site showed highly different mean values, -0. 6% and 0.1%.

Diel changes in the concentration of dissolved O_2 within the mixed layer are largely driven by biological processes. Dissolved O_2 concentrations at the two sites displayed clear diel cycles with maxima near sunset and minima near sunrise, consistent with the variability expected from biological processes. Preliminary estimates of gross oxygen production and community respiration in the mixed layer were obtained daily. Net community production, determined as the difference of mean gross oxygen production and community respiration values, is 0.38 ± 0.39 mmol O_2 m-3 d-1 for PRZ and 0.13 ± 0.16 mmol O_2 m-3 d-1 for CTA (± propagated standard deviation), indicating net autotrophic conditions during the time of sampling. There is a significant positive correlation between gross oxygen production and community respiration (r2 = 0.85, p = 0.0087), indicating a tight coupling between photosynthesis and respiration in this ecosystem.

Zooplankton communities – Upper ocean (0-1500m) zooplankton biomass results, although quite preliminary, largely follow observations reported from other areas of the eastern tropical Pacific (ETP). The overall vertical structure of biomass showed distinct features in association with the OMZ hydrographic structure. Observations of high biomass in the upper thermocline, at the top of the upper oxycline, and also in the lower oxycline are consistent with observations from sites to the east (Costa Rica Dome) and north (Tehuantepec Bowl) of the NORI-D region, although the specific depths at which these hydrographic features occurred was variable between areas.

A very deep penetration of diel vertical migrators, with some animals moving to the 700-800m lower oxycline (LO), or even lower at the PRZ (down to 1000m), for their daytime resting depth, was observed. While this pattern has been reported before, the NORI-D has a particularly deep LO, and most prior studies focus on areas with a LO in the range of 500-600, closer to the daytime resting depth for deep migrating taxa in regions without OMZs. To our knowledge this is the first-time sampling has been conducted into the upper bathypelagic (1000-1500m) and results from this region of the water column are particularly novel, and relevant to the discharge depth.

From these preliminary results, there is no evidence of significant differences in zooplankton biomass between the PRZ and the CTA, despite higher net community production at the PRZ. There is however high variability among tows, in particular at the PRZ, and ongoing analyses on all tows, may provide a better understanding of spatial variability.

Abyssal zooplankton community composition in the NORI-D is dominated by copepods and their nauplii, as found in all other areas of the CCZ, animal abundance in the NORI-D is higher than regions in the eastern CCZ but north of our sampling sites (OMS, UK1) and in regions to the west (APEIs 4 & 7). Currently, these differences in abyssal zooplankton density look very pronounced; and it is expected that these abundances are correlated with high POC flux to the seafloor. Overall community composition of the larval assemblage specifically is broadly comparable to organisms found at other sites, including gastropods, bivalves, benthic polychaetes, bryozoans, and echinoderms. There does appear to be some spatial variability in the larval assemblage with 6X higher larval polychaete abundance in the CTA in comparison to the PRZ.

Gelatinous zooplankton communities do not appear to differ appreciably in overall species diversity at the CTA and PRZ sites, though the specifics of their vertical distribution show some differences.

Micronekton community (small fishes, squids and shrimps) – Micronekton abundance and biomass in NORI-D is similar to other oligotrophic regions in the North Pacific. With regard to vertical distributions, it was somewhat surprising to find high fish biomass within the OMZ core during the day. Other studies have suggested that plankton and other taxa avoid the OMZ core. Given the strength and shallow depth of the OMZ in the NORI-D region it is likely that the migratory fishes must enter it during the day to avoid visual predators. Below the OMZ there are peaks in the abundance of *Cyclothone* spp., crustaceans and cephalopods.

In relation to collector test preparation, it is important to note that there is a significant biomass of micronekton at the depths of the planned midwater discharge. This may be partly the result of deep distributions caused by the strong OMZ but actual drivers are unclear at this time. Often abundance is lower at these depths compared to shallower but biomass is higher. This suggests the presence of older, larger and possibly more reproductively mature individuals residing at depth. Studies have shown that large fishes and squids can be found deeper and it may be that the reproductive output of deeper populations is critical to population maintenance.

There are differences in the micronekton community between the PRZ and CTA. There is inherently a lot of variability in net collection data. However, the dominant fish *Cyclothone* spp. are more abundant and have greater biomass in the CTA. These are largely nonmigratory fishes living at or just above the planned discharge depths. Other taxa (e.g. Melamphaidae) are more abundant in the PRZ. Further an analysis of community composition also found differences between the two sites. The nighttime communities, thus non-migrators, were different between the two sites at OMZ depths (450-700m). Daytime communities in the upper oxycline (70/90 to 450m) were also different between the sites. The reasons for differences between the PRZ and CTA are not clear at this time but may be related to slight differences in OMZ characteristics or due to mesoscale eddies.

Food web linkages between trophic levels of dominant taxa - The concentrations of particulate carbon (PC), particulate organic carbon (POC) and particulate nitrogen (PN) were measured by sub-sampling filters used on the large volume in situ pumps (McLane Pumps). The concentrations of PC, POC and PN are high at the surface and decrease exponentially with increasing depth. Concentration of PC and POC are higher than that of PN throughout the upper 1500 m at both sites. The concentration of POC is higher than that of PC in the shallowest samples at both stations and at 200 m within the OMZ at the CTA site only, otherwise the concentration of PC and POC are indistinguishable. At both sites, the concentrations of PC, POC and PN are always highest in the 0.7 to 6 µm size fraction. Concentrations of PC, POC and PN in the 6 to 53 µm and >53 µm are nearly equal with the latter slightly higher at shallower depths. This size distribution is particularly important at the proposed plume depths (1000-1500 m) since the discharged sediment is thought to be less than 5 µm, which overlaps with the 0.7-6 µm particle fraction. The concentrations of PC, POC and PN are only about 0.33, 0.27 and 0.03 µmol/L, respectively in the depth range of the discharge plume.

The downward flux of particles was determined using in situ particle interceptor traps (PIT) that were deployed between 70 and 90 m during Campaign 5B on sediment trap arrays. The mass flux of particles ranged from 3.95 to 5.73 g/m2/d. Mass flux is variable at each site. However, the mass flux measured for sediment traps deployed at the same site but at different depths were not significantly different (one-way ANOVA p = 0.92 for PRZ and p = 1.00 for CTA). On the contrary, particle mass flux from the PRZ was significantly greater than that from the CTA (one-way ANOVA, Tukey Test, p=0.003. The flux of PC ranged from 198 to 389 mg/m2/d whereas the flux of PN ranged from 26 to 58 mg/m2/d and did not differ between the PRZ and CTA sites during Campaign 5B. The flux of POC at both sites are still being measured.

To characterize food webs the stable isotopic composition of water column particles, the food of suspension feeders and size fractionated zooplankton, many of which are suspension feeders or omnivores, were examined. Comparison of the δ15Nlys values of zooplankton and 0.7-6 and >53 µm particles can identify the particle size forming the base of the food web. None of the zooplankton measured are obligate grazers – all have a trophic position consistent with omnivores (TP > 2). Since these zooplankton are resident, non-migrating zooplankton, their δ15Nlys values are set by particles forming the base of their food web as well as preying on diel vertically migrating species during the daytime that may carry a very different δ15Nlys value than particles. From the surface to about 100 m, the δ15Nlys values of 1-2 mm zooplankton overlaps with large and small particles. Although 0.7-6 µm particles from the CTA site have yet to be analyzed, at all sites there is overlap in the δ15Nlys values of large and small particles near the surface. It is logical that 1-2 mm zooplankton feed within a shallow food web that base of which is dominated by large and small algae.

Below ~200 m and down to ~500 m, the δ15Nlys values of 1-2 mm zooplankton overlap with those of >53 µm particles. This overlap suggests that the >53 µm particles are important in forming the base of zooplankton food web. However, given that δ15Nlys values do not change appreciably with depth between 150 and 500 m, we cannot eliminate the possibility that carnivorous 1-2 mm zooplankton prey on vertically migrating zooplankton. Zooplankton that feed at night in surface waters inherit a δ15Nlys value of near surface particles and those values can be passed on to resident 1-2 mm carnivorous zooplankton at depth.

Between depth of 500-1250 m, the δ15Nlys values of 1-2 mm zooplankton become closer to the δ15Nlys values of the 0.7-6 µm particles. This change suggests that these smaller particles may become increasingly important at the base of the mesopelagic zooplankton food web and/or that diel vertically migrating prey that feed at the surface at night are not as abundant at these deeper depths.

Within the range of the proposed sediment discharge depths (1200 m), δ15Nlys values of many zooplankton fall between the δ15Nlys values of 0.7-6 and >53 µm particles. This suggests that both particle sizes are important for the zooplankton community. The δ15Nlys values of 0.2-0.5 mm zooplankton at 1150 m overlap or are slightly greater than the 0.7-6 µm particles indicating the importance of this size class of particles to the base of at least some zooplankton. This is noteworthy because the 0.7-6 µm particles overlap with those expected in the midwater discharge.

Ecotoxicology studies in zooplankton and pelagic fish - On Campaign 5B and 5C, micronekton, water, zooplankton and sediment samples were collected for whole effluent toxicity (WET) analyses. This analysis is still in progress and data will become available in the next 12 months as well as data on the baseline heavy metal concentrations, and data on temporal changes in heavy metal concentrations in zooplankton and target mesopelagic taxa.

Marine Mammals, Birds, Turtles, Bony Fish and Sharks – Observations of dolphins, sperm whale, manta ray and acoustic detections of substantial dolphin whistles, minke whale, sperm whale, blue whale, dwarf sperm whale and beaked whales is evidence that these species exist and feed in the NORI-D region.

Beaked whales, sperm whales and dwarf sperm whales are deep-divers that are posited as species of increased concern in terms of interaction with nodule collection activities. The occurrence of these species in the area suggests the presence of a deep prey source comprising fishes and squids that are targeted by these species.

Seabirds are the most abundant predators observed and existing data indicates that the North Equatorial Countercurrent is an important foraging area for piscivorous species, particularly in the western sector (west of 120˚W). The foraging behaviour of seabirds contributes to an ecological function of the open ocean by transferring nutrients to coastal environments where higher primary production occurs and, scaled-up to the population across the eastern tropical Pacific, contributes to upper ocean mixing and potentially cloud albedo effect.

Collectively, the data indicate that the pelagic ecosystem in the NORI-D region is a system that at least periodically supports piscivorous predators. This requires ecological processes that supply regenerated nutrients and primary production that underpins the development of a food chain that supports prey fish and other nekton populations. The local scale biological oceanography is under investigation as part of the broader pelagic research work packages and integration with these studies will further inform the surface biology study.

Impact Assessment

An environmental impact is defined as the effect a project related activity has on the receiving environment; the effect can be positive, negative, or neutral, and range from low-high in extent or duration. A 'significant impact' occurs if an environmental effect causes a change in the receiving environment that is deemed unacceptable by the regulating body or relevant authority. In the context of the ISA recommendations, a significant impact would have potential to cause 'serious harm' to the marine environment (ISBA/25/LTC/6/Rev.1(II)).

For the purposes of this EIA the following process was applied to make an informed determination of significance:

Step 1. Identification of activities associated with the project that may be sources of impact.

Step 2. Identification and characterization of Valued Ecosystem Components (VECs) represented in the receiving environment.

Step 3. Characterization of environmental effects, i.e., points of interaction between project related activities and VECs.

Step 4. Assessment of environmental effects to determine if they are likely to result in significant impacts based on the anticipated magnitude of the impacting activity and the sensitivity of the impacted VEC.

Step 1. Based on the description of the Collector Test operations provided by Allseas the following project related activities were identified as potential sources of impact:

- Transit to Collector Test Area
- Offshore inspection and preparation
  - Pre-dive checks and system verification
  - Deployment of ROV/basket to seabed
  - Deployment of first LBL array beacons subsea positioning verification
  - Deployment of remaining LBL beacons and SLAM
- PCV deployment
  - Parking position
  - Skidding in launch position
  - Lowering the PCV with the cursor winch through the splash zone
  - Disconnect PCV from the cursor frame
  - Subsea lowering
  - PCV touchdown
- Jumper and riser deployment
  - Jumper hose deployment
  - Riser deployment
- Riser commissioning
  - Sensor line routing over drill floor
  - Air pressure hose skidded/hoisted into place and connected

- Leak testing and locking of the pressure hose
    - Hose to connect riser head to dewatering plant is skidded/hoisted/connected
    - Riser head is skidded/hoisted over the end of the riser
- Subsea connection of jumper on PCV
    - Collector placed close to the jumper hose
    - ROV attaches pull-in wire on jumper hose
    - Connector is pulled down
    - Connection is made
    - Pull-in wire is disconnected
    - Disconnect Jumper hose
- Operations
    - Manoeuvrability test runs
    - Pick-up test runs
    - Riser installation and commissioning test
    - System integration test
    - System test runs
- Emergency shutdown testing
- Riser and PCV recovery
    - Jumper hose recovery
    - Riser recovery

Step 2. Based on a comprehensive review of the baseline results and literature relating to the potential impacts of Deepsea mining the following Valued Ecosystem Components were identified:

Physical

- Acoustic quality (noise)
- Vibration
- Air quality
- Water quality
- Light

Chemical

- Sediment geochemistry

Biological

- Birds
- Cetaceans/Turtles
- Fish
- Nekton
- Phytoplankton
- Zooplankton
- Microbes
- Sediment biota
- Nodule biota
- Sediment habitat quality
- Sediment geochemistry
- Nodule habitat quality

Functions

- Ecosystem function (as a result of cumulative impacts)
- Climate Regulation

Step 3. An analysis of the Environmental Effects of the Collector Test identified 34 project related activities and events as potential sources of impact, and 25 Valued Ecosystem Components (VECs), distributed through the atmospheric, euphotic, mesopelagic, bathypelagic, and abyssal zones of the water column and benthic environment. In addition, potential cumulative impacts to ecosystem function and environmental services have also been considered.

A Leopold Matrix is used to evaluate the 850 (34x25) potential interaction points between project activities and VECs; 103 are identified as interactions with potential to cause impact. Where zero interaction was anticipated no further assessment is applied.

The highest number of vulnerable VECs are in the bathypelagic and abyssal zones and most of the potential impacts are associated with nodule production (specifically system test runs). This information is used to focus the EIA on potentially high-risk activities, vulnerable VECs, and areas that may be exposed to multiple and/or cumulative impacts.

Step 4. An environmental risk assessment was conducted the results of which indicate that all residual risks can be mitigated to a level of 'negligible' or 'low' with the application of the proposed mitigation measures. The only exception is the potential impact of System Testing to cetaceans and turtles which ranked as a 'medium' residual risk. This is primarily because of the potential impacts from noise levels generated by the newly designed riser system and airlift which will not be well defined until they are measured during the Collector Test. However, a desk top assessment of noise impacts using analogous examples of equipment and known sensitivities of receptors, does not anticipate significant impacts to marine biota; a 'medium' ranking has been assigned to this residual impact consistent with a precautionary approach. Additional project specific controls have been applied in response to this 'medium' risk rating in the form of the addition of a marine mammal observer to the project team.

With the application of the measures described no significant residual risks to the physicochemical or biological components of the receiving environment is anticipated from the Collector Test.

Cumulative Impacts

Existing anthropogenic stressors in the CCZ include occasional sound (shipping, fishing, geological exploration), commercial fishing and gradual rises in temperature and pH associated with climate change. It is assumed that all will continue at their current rate during the Collector Test, but that no new activities (e.g., CO_2 disposal, hazardous waste disposal etc.) will be added.

Previous investigations in NORI-D during the period 2012-2020 have collected 4,770 kg of nodules; completed 259 box cores (each 0.25 m^2); and towed a 1.1 m wide epibenthic sled resulting in aggregate seafloor disturbance of less than 10,000 m^2. Autonomous or remotely operated underwater vehicles, midwater instruments to sample water chemistry or plankton, and mooring or servicing of instruments to measure sound, sedimentation or other parameters are assumed to have had minimal impact.

Within the 150 km^2 CTA, new stressors will be introduced in a directly disturbed 0.5 km^2 portion of the 8 km^2 (2 km x 4 km) TF during 860 hours (35.8 days) of tests that will include driving the PCV 82 km, with 259 hours (10.8 days) at full test operation entailing nodule collection, pumping nodules, water and entrained sediment to the surface, and discharging "waste" water, sediments and fines at 1,200 m depth.

Stressors produced during the Collector Test will include sound (ship, PCV and riser pipe operations), light (ship and PCV operations), sediment disturbance (movement, compaction), sedimentation, increased total suspended solids (TSS), turbidity (benthic plumes, midwater discharge of entrained sediments and fines), extraction of nodules, mobilization of toxins (if any) from sediments, sediment pore water and nodule fines, and local changes in temperature, oxygenation or other physiochemical parameters.

Different combinations of stressors could affect different types and size classes of organisms, and in different ways, but such cumulative effects are still poorly understood. Beyond obviously injurious impacts, non-injurious effects could accumulate to have population-level effects mediated through physiological impacts and probably other mechanisms.

Key stressors expected during the Collector Test period include noise, light and plume generation, nodule removal and disturbance of the benthic habitat and biota. Rational is provided that supports a finding that owing to the limited time and extent of the Collector Test it is reasonable to assume that risk from cumulative impacts to ecological function and the environmental services they support would be low.

Transboundary Impacts

The potential for some of the stressors from the Collector Test to impact across contract zones, water column depth zones, and possibly political boundaries has been evaluated. These stressors include noise, plumes, disruption of ecological function and social or economic impacts. Rational is provided that supports a finding that owing to the limited time and extent of the Collector Test it is reasonable to assume that risk from transboundary impacts are low.

Mitigation Measures

When considering appropriate mitigation measures for the Collector Test it is important to remember that a key objective of the test is to identify and quantify potential environmental impacts of mining at the test scale to inform the development of effective mitigation measures at the commercial scale. To this end it may be counterproductive to mitigate impacts of the Collector Test to the point where the impact signal cannot be identified or quantified. For example, minimisation of the mid-water plume concentration to a level where the plume cannot be tracked would not provide useful information on plume dynamics at a commercial scale. Therefore, mitigation measures have been developed to ensure that impacts are not significant, but not necessarily eliminated.

Mitigation measures include:

1. The Collector Test System is 20% the scale of a full-size commercial system and is considered sufficient to meet the testing objectives while minimizing the environmental disturbance footprint.
2. The Prototype Collector Vehicle is 50% scale of a full-size commercial vehicle and is considered sufficient to meet the testing objectives while minimizing the environmental disturbance footprint.
3. The nozzles of the PCV have been designed to exploit the Coandă effect, (the tendency of a fluid jet to stay attached to a convex surface) to minimize sediment disturbance during nodule pick-up.
4. Nozzle head height adjustment allows for fine tuning of the Coandă effect by changing the relative force of the water jet and suction combination on the seabed. The ability to fine tune in this manner will optimize the efficiency of nodule pick-up whilst minimizing sediment disturbance.
5. The first stage of the nodule processing system is designed to separate nodules from sediment inside the PCV. Special pump equipment is used for separating fines from the nodule flow stream, keeping as much sediment as possible at the seafloor.
6. The PCV tracks will be fitted with water jets, powered by a dedicated pump which will clean sediment from the outer track surface and inner sprocket path prior to ascending to the surface, reducing the amount of benthic sediment transported to the surface.

7. Where possible, all chemicals used in submersible equipment (i.e., ROV and PCV), will be biodegradable and compliant with OSPAR (2009) standards for the protection of the marine environment.
8. The nodule surface separator and storage system has been fitted with a 2-way diverter valve that can send the slurry stream directly to the buffer tank. This provides a protection from sudden unexpected over-load and spill.
9. The depth of the return water outlet has been set at 1,200 m, 200 m below the measured oxygen minimum zone. Due to the particle momentum of the outfall the effective discharge depth may be as deep as 1,280 m.
10. All vessels used during the Collector Test will adhere to MARPOL regulations aimed at preventing both accidental pollution and pollution from routine vessel operations.
11. Use of modern ships and offshore supply vessels that comply with IMO (2014) guidelines, will minimize noise generation.
12. Use of modern and efficient thruster systems and dynamic positioning systems (e.g., DP II in preference to DP I, or DP III in preference to DP II). will minimize noise generation.
13. The of Vertical Transport System (VTS) using airlift riser technology rather than noisier technologies such as risers with multiple slurry pumps or risers fitted with a Subsea Slurry Lift Pump (SSLP) fitted with individual positive displacement pump module displacement pump at its base.
14. The outlet of the return process wastewater pipe will be located at 1,200 m depth, which is below the biologically productive epipelagic zone 90–200 m depth and upper mesopelagic zone (200–1,000 m depth), as well as minimizing activities in the sound-fixing-and-ranging (SOFAR) channel (typically at a depth of ~1000 m in the CCZ) within which low-frequency sound is transmitted over very long distances (hundreds to thousands of kilometers).
15. The GHG emissions for the Collector Test have been calculated and will be offset.
16. All Collector Test operation will be confined to an 8 km^2 TF.
17. The duration of the entire Collector Test is limited to 860 hours, and the duration of system testing (period of maximum plume generation) is limited to 259 hours. Most impacting activities associated with the Collector Test will be temporary, short in duration, and spatially contained.
18. The ROV and all associated equipment will be maintained and inspected for leaks prior to deployment.
19. A specially designed Launch and Recovery System (LARS) for the PCV has been fitted to the side of the Hidden Gem. The LARS affords a very high degree of control for raising and lowering the PCV through the splash zone, allowing the operation to be paused or slowed at any time and minimizing the likelihood of any significant interactions with marine fauna.
20. The area of seabed that will be directly disturbed by the PCV has been contained to just 0.5km^2; considered to be the minimum level of disturbance required to credibly assess the functionality of the system and potential environmental impacts. This represents just under a quarter (23%) of the 2.2 km^2 that was disturbed within the 10.8 km^2 DISCOL experiment in the Peru basin.
21. CTA has been located in the ‘Flatter area’ which is the largest geoform by area (8,553.70 km^2) in NORI-D, rather than in the ‘Abyssal hills’ geoform. This placement is intentional as Abyssal hills and seamounts have been shown to be higher in species richness and standing stock biomass compared to adjacent areas devoid of topographic.
22. The area of seabed experiencing sedimentation rates above the demonstrated natural range of variation (i.e., ≥0.1 mm) is limited to 25km^2. This is considered the minimum level of disturbance required to credibly assess the functionality of the system and potential environmental impacts.

23. Measures recommended by the International Maritime Organisation for minimising the risk of collisions between ships and whales will be implemented during the Collector Test campaign, including: good route planning for transit to the site, keeping watch, continued scientific research into the migratory species that utilize NORI-D.
24. The wet weight of nodules collected during the Collector Test will be restricted to approximately 3,600 tonnes, limiting the impacts of the test due to loss of nodule habitat and direct impacts to benthic biota.
25. Nodules >80 mm in diameter will not be collected. Larger nodules will be left in the TF where they may continue to provide habitat value for nodule obligate biota, if not buried by sediment.
26. Modelling predicts that mid-water exceedances of ≥0.1 mg/l will be laterally contained to 200 - 250 m from the point of discharge and an overall plume dispersal footprint of will be just 16km^2; this is 8% of the 200 km^2 plume footprint generated by the Muñoz Royo et al. (2021) study.
27. A marine mammal observer (MMO) will be present during all offshore operations and to act immediately to protect species of concern should they enter the vessel's exclusion zone prior to and sometimes during operations. The MMO will advise personnel onboard to delay or shutdown operations until the animals are at a safe distance and also to record behaviour and sightings at other times.
28. The air lift will be in operation during the Riser installation and commissioning, System Integration Test and System Test Runs. This is considered to be the minimum operating time required to meet the objectives of the Collector Test and limits exposure to potentially impactful underwater noise to approximately 529 hours.

Significance analysis demonstrates that with the implementation of measures to minimize the magnitude of impacts, and the application of a precautionary approach to account for uncertainty, no significant inherent impacts are anticipated from activities associated with any aspect of the Collector Test.

Major Hazards, Mitigations & Emergency Response Plans

The specialised oceanographic vessels that will be commissioned for the Collector Test and environmental monitoring studies are fully equipped for purpose, complete with all documentation of crew qualifications, health and safety procedures, emergency response plans, international maritime and navigational certification, MARPOL compliance, oil spill prevention and response plans, organisational responsibility charts and current records of audits, inductions, training, and drills etc. The existence of, and adherence to, these systems and processes will be confirmed by NORI as part of vessel contractual arrangements, as has been the case for all previous campaigns.

Once the vessel is selected, job-specific operating procedures will be prepared to address the hazards, environmental risks, and mitigations specific to the activities of the contracted scientific staff and points of integration with the vessel's overarching health, safety and emergency response procedures.

The Hazard Identification Risk Assessment (HIRA) used conforms to international principles of risk management, where criteria have been developed in a 5-step matrix to rank the likelihood (from rare to almost certain) and consequence of potential impacts (none to severe), respectively. The consequence of potential project impacts due to major hazards is defined in terms of four aspects – environment, health and safety, business reputation and financial loss.

Risk Prioritisation

The risks posed by predictable impacts and unpredictable events (hazards) have been assessed, based on the current understanding of the activities associated with the Collector Test and receiving environment, no impacts have been assessed as being of 'high' risk. This is primarily due to the routine nature of many of the activities (e.g., operation of surface vessels) and/or the small scale of the Collector

Test. Therefore, it is not considered necessary to develop additional mitigation measures to supplement the management measures described.

Activities and hazards ranked posing 'medium' risk will be prioritised for resourcing and monitoring in the EMMP.

Environmental Monitoring & Reporting

Monitoring of the collector system performance will be conducted over two campaigns currently scheduled for Q3/2022. The monitoring program will follow a pre-, during, and post-test sequence and will focus on the technical performance of the collection system and short-term environmental impacts. The Collector Test provides an opportunity to challenge assumptions made during the development of plume models and collector system design.

The performance of the collector system will be monitored in real-time in the near-field (that is, <200m from the collector system) and far-field (≥200m to the limit of measurable change in an environmental parameter). It is acknowledged that this is a broad definition and that far-field limits will vary depending on the metrics being measured. However, real time measurements of dynamic parameters such as TSS will provide indications of the likely extent of other ecological changes.

For the purpose of monitoring collector system performance, the receiving environment has been divided into the following impact zones based on the expected nature of the impacts and the monitoring methods that will be applied:

- Impact Zone 1 – Atmosphere, Surface Waters and Euphotic zone (0 m - 200 m)
- Impact Zone 2 – Mesopelagic (200-1,000 m) and Bathypelagic zone (1,000 m - 4,000 m)
- Impact Zone 3 – Abyssal (4,000 m - 6,000 m) and Benthic (seabed) zones

Long-term environmental studies will monitor how benthic communities recover following disturbance and will be conducted over years to decades. Details of monitoring methods will be included in the commercial EMMP and results will be benchmarked against the pre-test baseline of the CTA and PRZ. Parts of the CTA designated as IRZs will not be mined any further following the test, and along with the PRZ and other control sites, the areas will be preserved as reference sites for the duration of mining operations.

A Collector Test specific EMMP will also be developed prior to the start of activities, this will include commitments to the requirements for monitoring and validating the main predicted impacts from the Collector Test.

Limitations, Assumptions & Uncertainty

Limitations

- This EIA is only applicable to the Collector Test.
- The plume modelling results only applicable to the Collector Test.
- The findings of this EIA are applicable to the Collector Test activities only and not the operational phase.

Assumptions

The findings of this EIA are based on the following assumptions:

- All direct disturbance of the seabed by the PCV is confined to the TF (8 km^2).
- The overall area of seabed that will be directly disturbed by the PCV is limited to 0.5 km^2.
- The overall area that will be impacted by sediment deposition of ≥0.1mm is limited to 25.5 km^2.

- Collector Test activities will be conducted in accordance with the test plan described.
- All onsite activities associated with the Collector Test will be completed within a 3-month period. The duration of the entire Collector Test is limited to approximately 36 days, and the duration of system testing (period of maximum plume generation) is limited to approximately 12 days. Most impacts associated with the Collector Test will be temporary, of short duration, and spatially constrained.
- The benthic and mid-water plume exceedance models are an accurate representation of plume dynamics.
- Seasonal variations in physical oceanography (e.g., current direction; water temperature etc.) will not cause a material change in the magnitude of TSS exceedances described by the plume models. Any seasonal change in direction of plume drift is inconsequential to the findings of this EIA.

Uncertainty

Uncertainty is almost unavoidable in EIAs as they typically involve situations in which the full range of possible options and their impacts cannot be known. Assumptions then must be made to address knowledge gaps, which introduce uncertainty into the EIA process. It is important for informed decision making that the sources of uncertainty are identified, and treatments proposed.

The main sources of uncertainty in the Collector Test EIA are associated with the plume models which are in the early stages of development and need to be verified by field observations and the preliminary nature of the biological baseline. An uncertainty profile has been developed for the Collector Test which demonstrates that small scale of the Collector Test minimises the potential magnitude of key impacts for which there is high unresolved uncertainty (i.e., plume size, area of sedimentation, area of seabed disturbance).

Consultation & Review

NORI conducted a global stakeholder consultation workshop Q1/2020 to inform both the Collector Test EIA and commercial ESIA. ISA recommendations (ISBA/25/LTC/6/Rev.1/E41(d)) encourage sponsoring states to also conduct stakeholder consultations as part of the Collector Test EIA. This EIS will be made available by Nauru for stakeholder comment.

The Collector Test EIS was submitted to the ISA on 29th July 2021 and released for public comment soon thereafter. A public stakeholder workshop was conducted on 5th October 2021 which described the EIA process; after which written comments were submitted to NORI by 19th November 2021. The current version of the EIS document has been updated in response to public comments provided as part of the stakeholder consultation process.

This document has been reviewed by a Certified Environmental Impact Assessor (EIANZ) who confirms that the EIS methodology and processes are consistent with international good industry practice.

EIS Revisions

NORI submitted the Collector Test EIS to the Secretary General of the ISA on July 29th, 2021. Following the ISA's acceptance that the study complied with the required content for an EIS, it was referred to independent agencies for review. This updated EIS report considers reviewers' comments and incorporates the following further information that has become available during the interim:

- In addition to the PRZ, up to two additional sites have been added to the monitoring design specifically as control sites for the Before-After-Control-Impact (BACI) studies that will be conducted on the IRZ. This addition is in response to inconclusive data from some baseline studies on the comparability of some aspects of the geochemistry and biodiversity of the PRZ and IRZ.

- The physiochemical and biological baseline chapters of the EIS have been revised significantly to incorporate data from over 12 reports that were submitted by the science teams in Q4/2021.
- The impact assessment chapters of the EIS have been revised in the context of the newly acquired baseline data, this has reduced the uncertainty around some aspects of the sensitivity of the biotic and abiotic receptors.
- A desktop noise assessment has been conducted as a precursor to the noise modelling and verification that will be conducted as part of the Collector Test. A preliminary noise assessment report has been included in the Appendix.
- An alternatives analysis has been included which explains the rationale behind key decisions in the design of the Collector Test program.
- A comprehensive assessment of cumulative and transboundary impacts has been added.
- The plume modelling has been updated to include a more conservative estimate of natural rates of sedimentation, and a revised plume modelling report has been included in the Appendix.
- Greenhouse Gas (GHG) emissions associated with the Collector Test have been estimated and an offset commitment made by NORI.
- Additional information has been provided relating to the pre-CCZ testing of the Collector System and processing of the nodules onboard the surface vessel.
- NORI has made a commitment to submit a comprehensive Environmental Management and Monitoring Plan (EMMP) to the Secretary General of the ISA for review prior to the start of the Collector Test activities in the CCZ.

Conclusion & Recommendation

The Collector Test is an essential component of the commercial ESIA. It is necessary to demonstrate the technical, economic, and environmental feasibility of operations proposed for the commercial phase of the project. The Collector Test is an opportunity to demonstrate the feasibility of the nodule collector system and test any assumptions made during its design.

The information presented in this EIS supports the finding that the proposed mitigation measures, additional project specific controls and small scale of the test program sufficiently minimise all physicochemical, biological, and cumulative impacts to non-significant levels. In the absence of significant residual impacts, the risk of the Collector Test resulting in ‘serious harm’ to the marine environment at a regional scale, is ‘Low’.

The Collector Test should proceed under the conditions described in this EIS which will be operationalised in the Environmental Monitoring and Management Plan to be submitted to the ISA prior to mobilization. The learnings from the information gathered during testing should be reflected in the findings of the commercial EIS and applied to the design and operations of the full-scale system to reduce uncertainty and minimise environmental impacts during commercial operations.

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