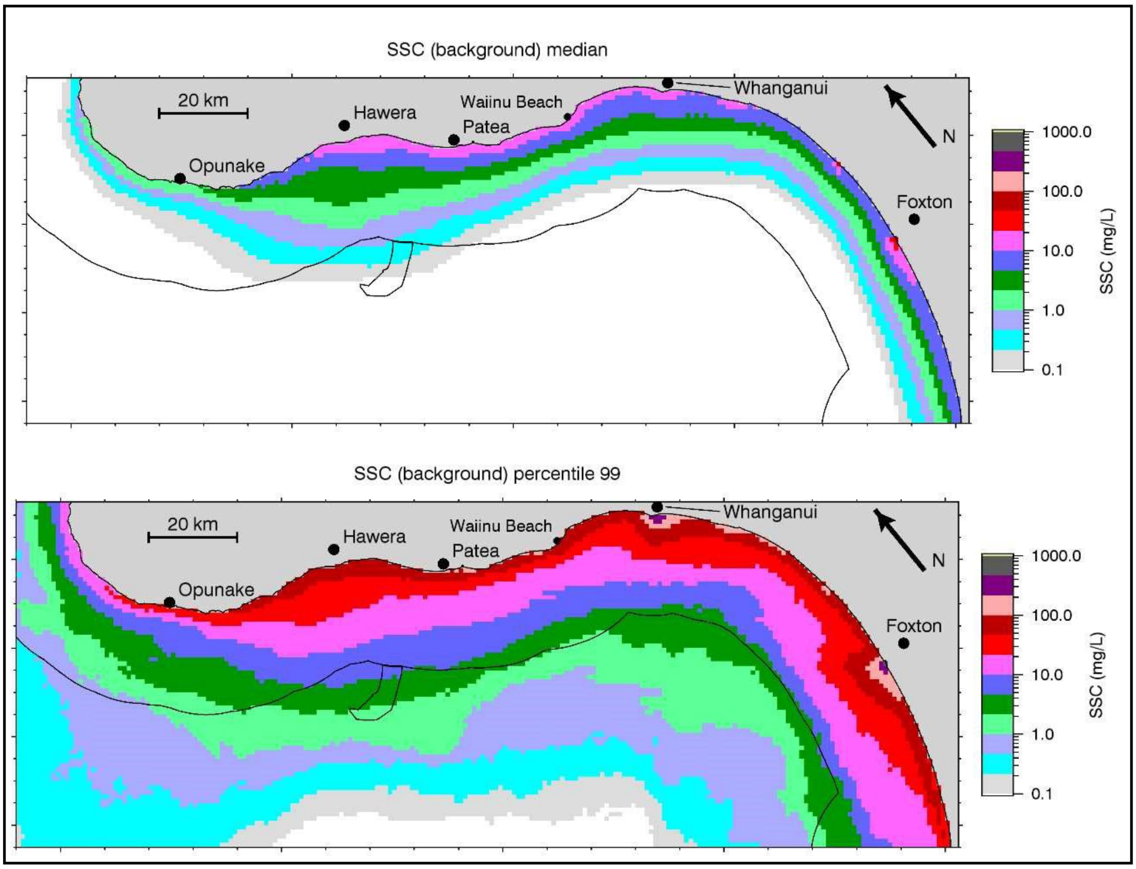
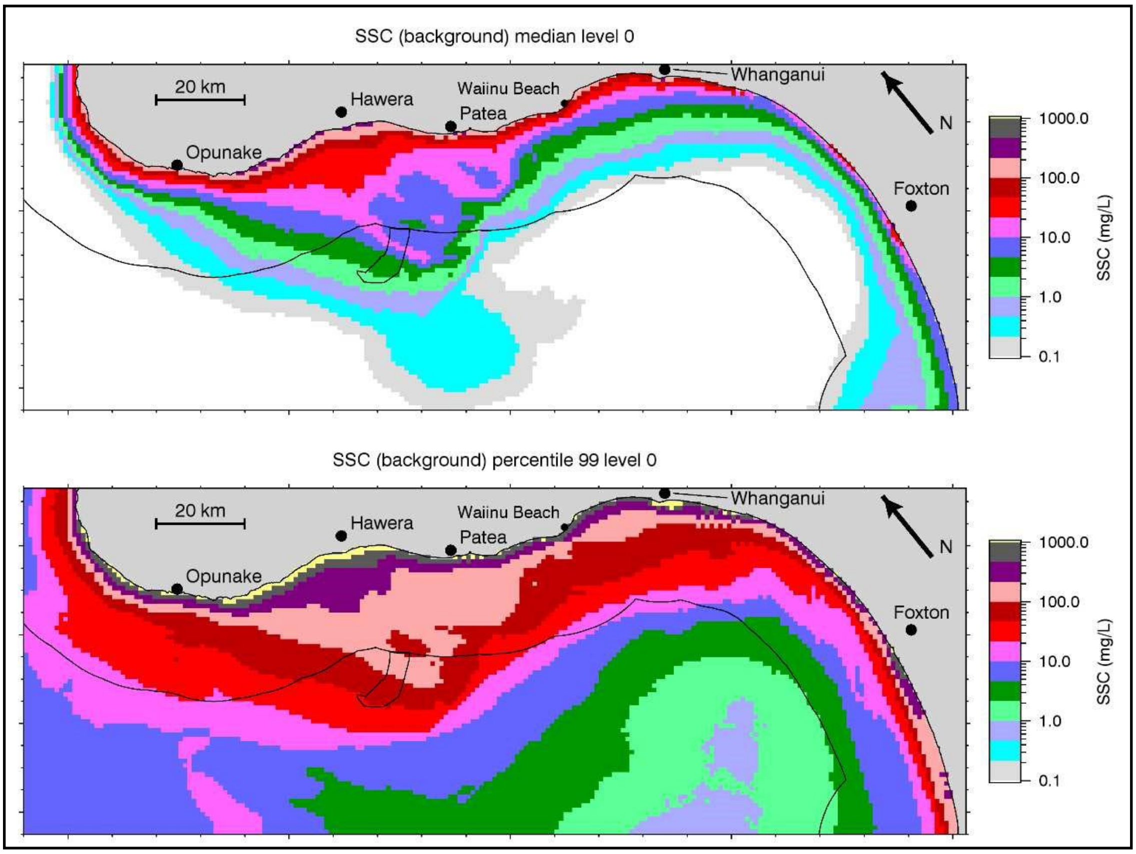
SECTION 5

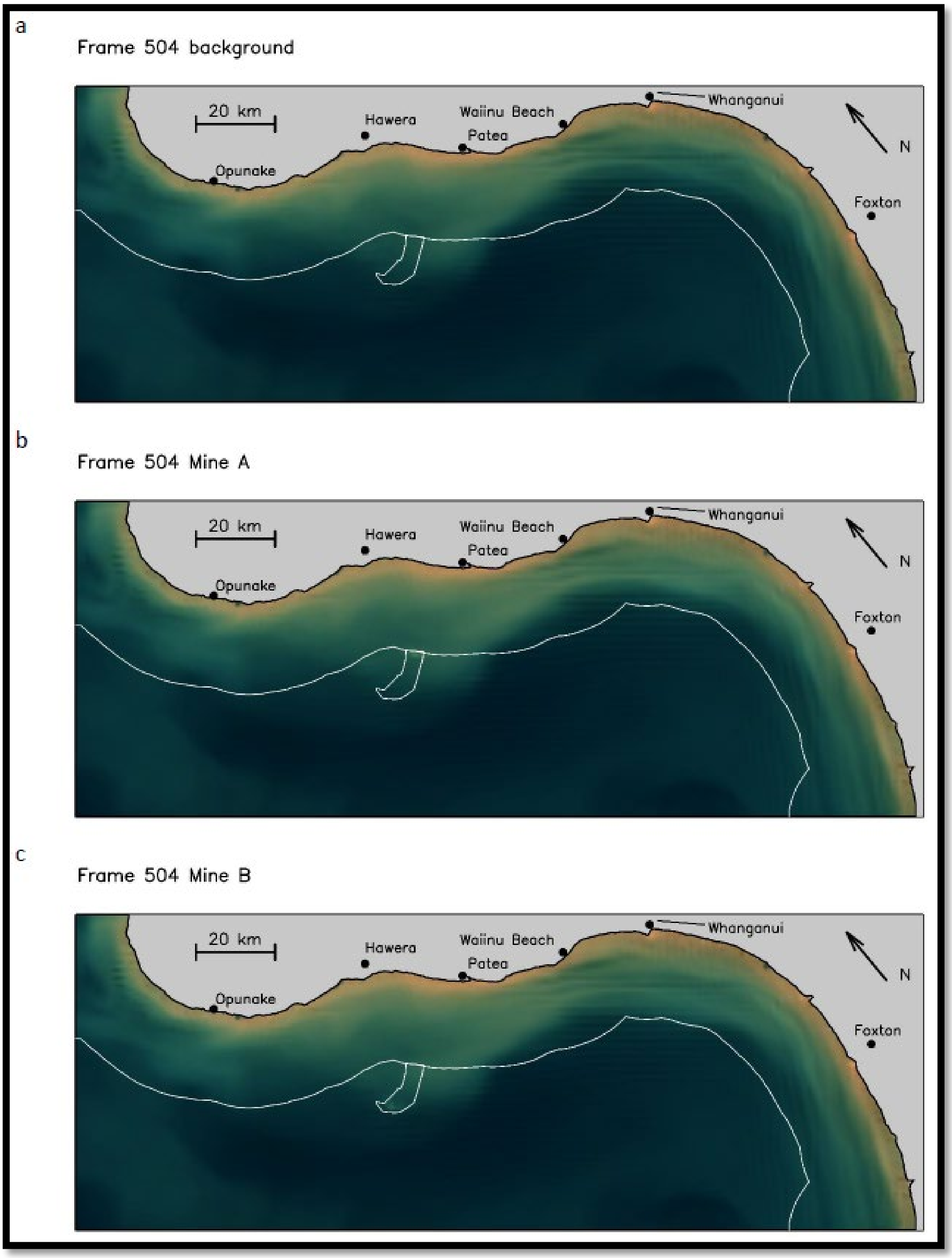
ASSESSMENT OF EFFECTS SECTION APPENDICES



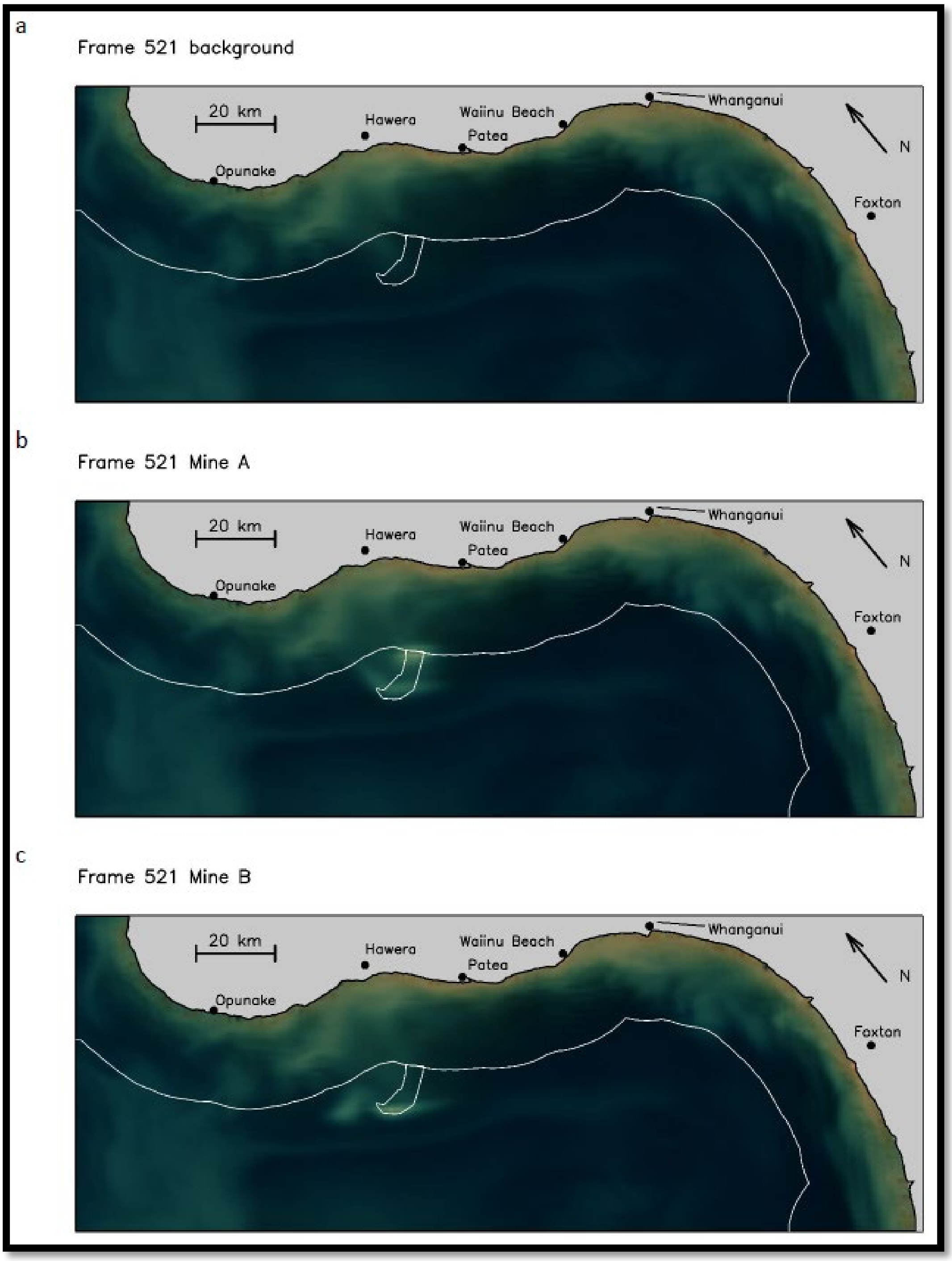
Appendix 5.1: Background near-surface concentration of suspended sediment. (top panel) Median SSC; (bottom panel) 99th percentile SSC.



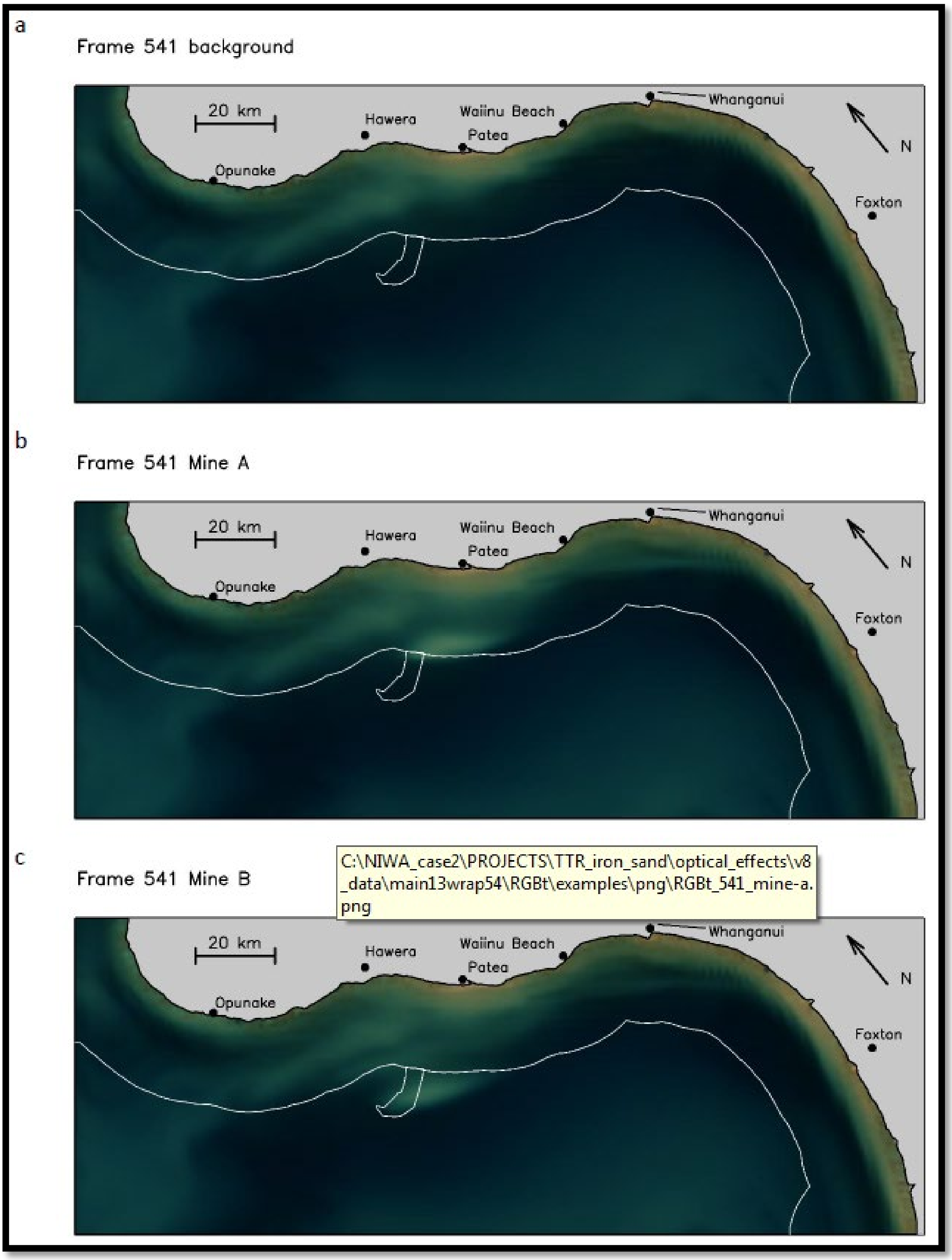
Appendix 5.2: Background near-bottom concentration of suspended sediment. (top panel) Median SSC; (bottom panel) 99th percentile SSC.



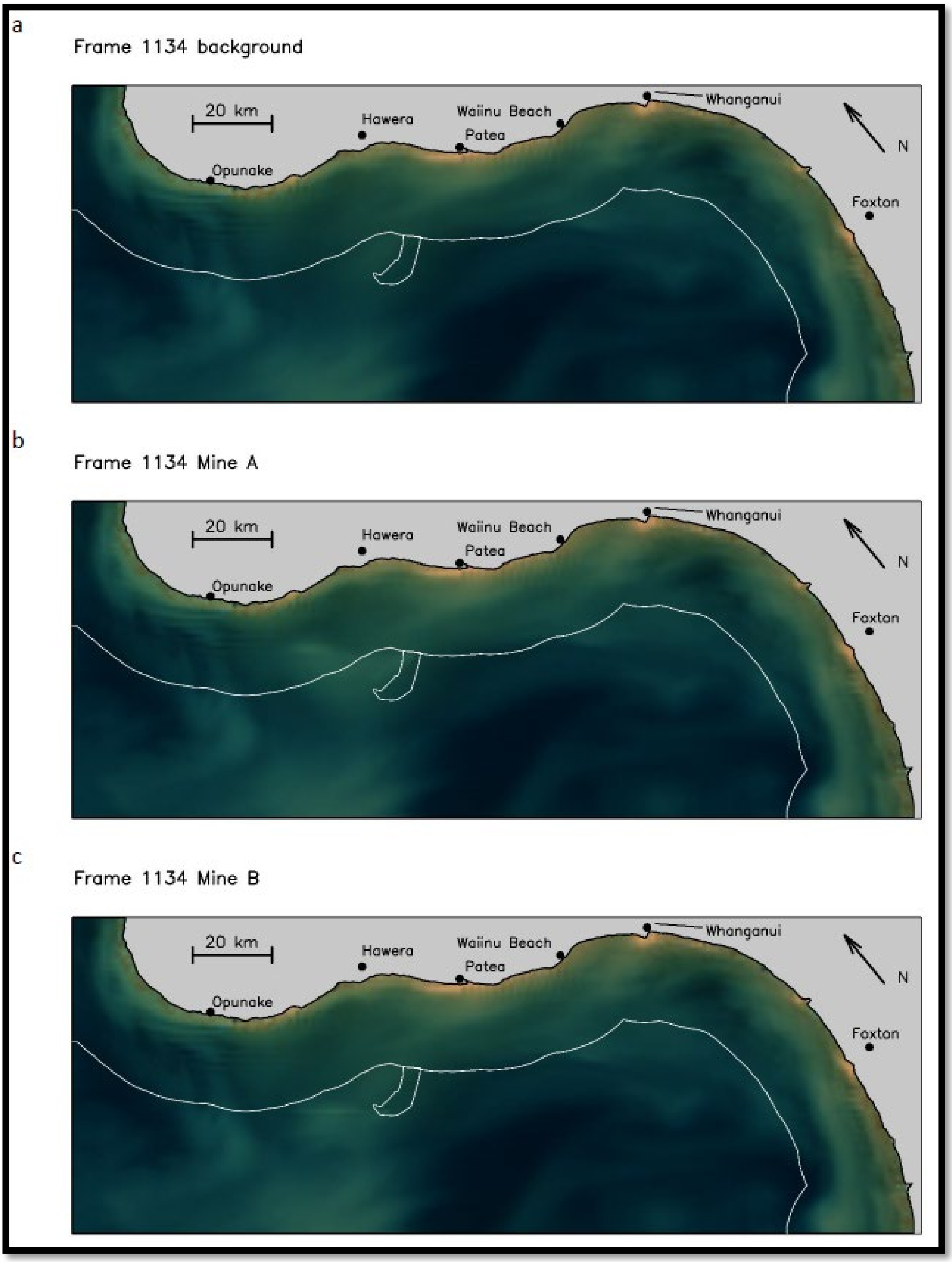
Appendix 5.3(1): Bird Eye Sediment Plume modelling. Explanation: This simulation follows 2.5 days of westerly winds (the dominant wind direction), the plume cannot be clearly discerned but the area to the east of the mining site is more strongly coloured in (b) and (c) compared to (a).



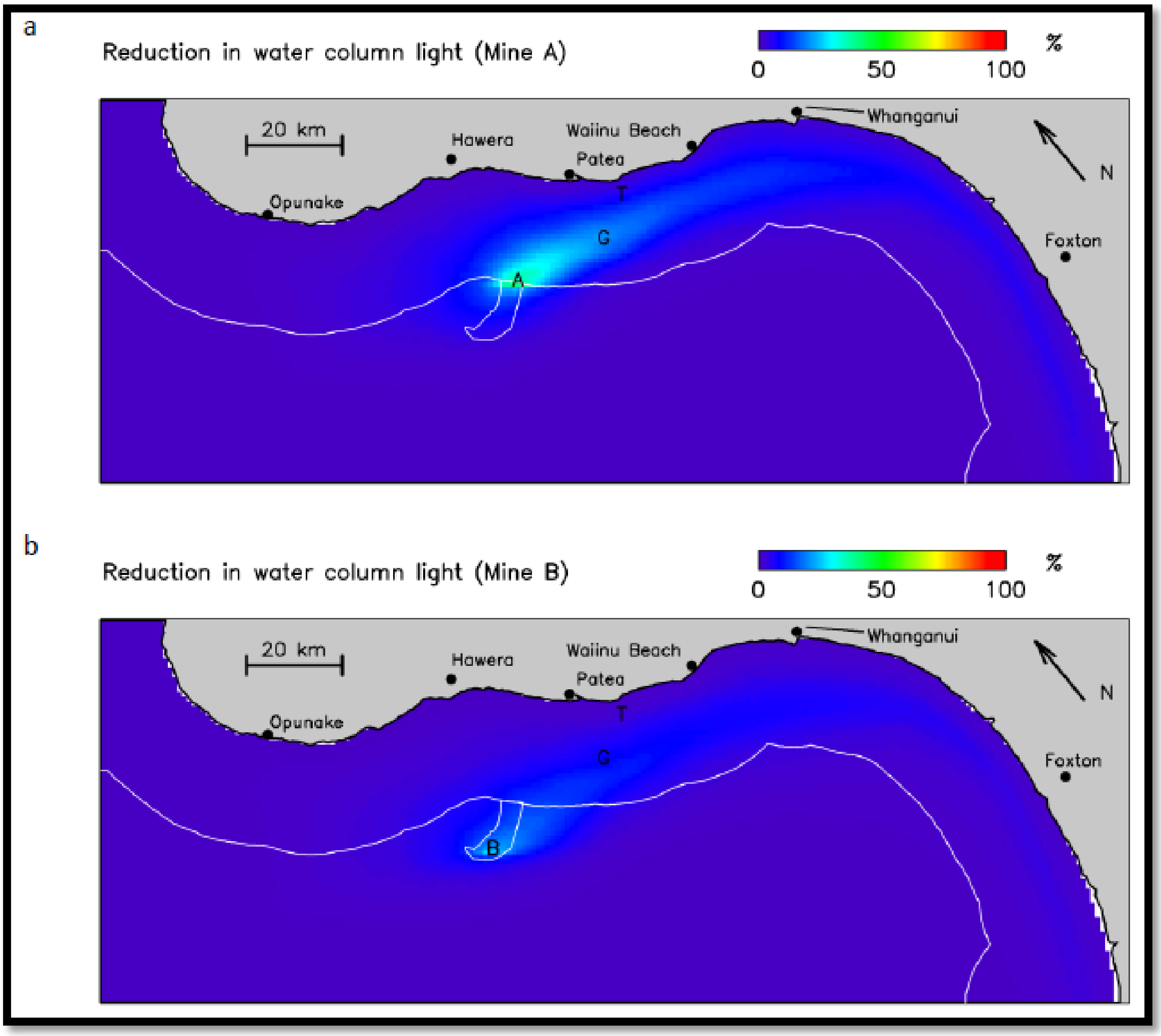
Appendix 5.3(2): Bird Eye Sediment Plume modelling. Explanation: This simulation follows a period of very little wind and shows discharged sediment "pooling" near the project area.



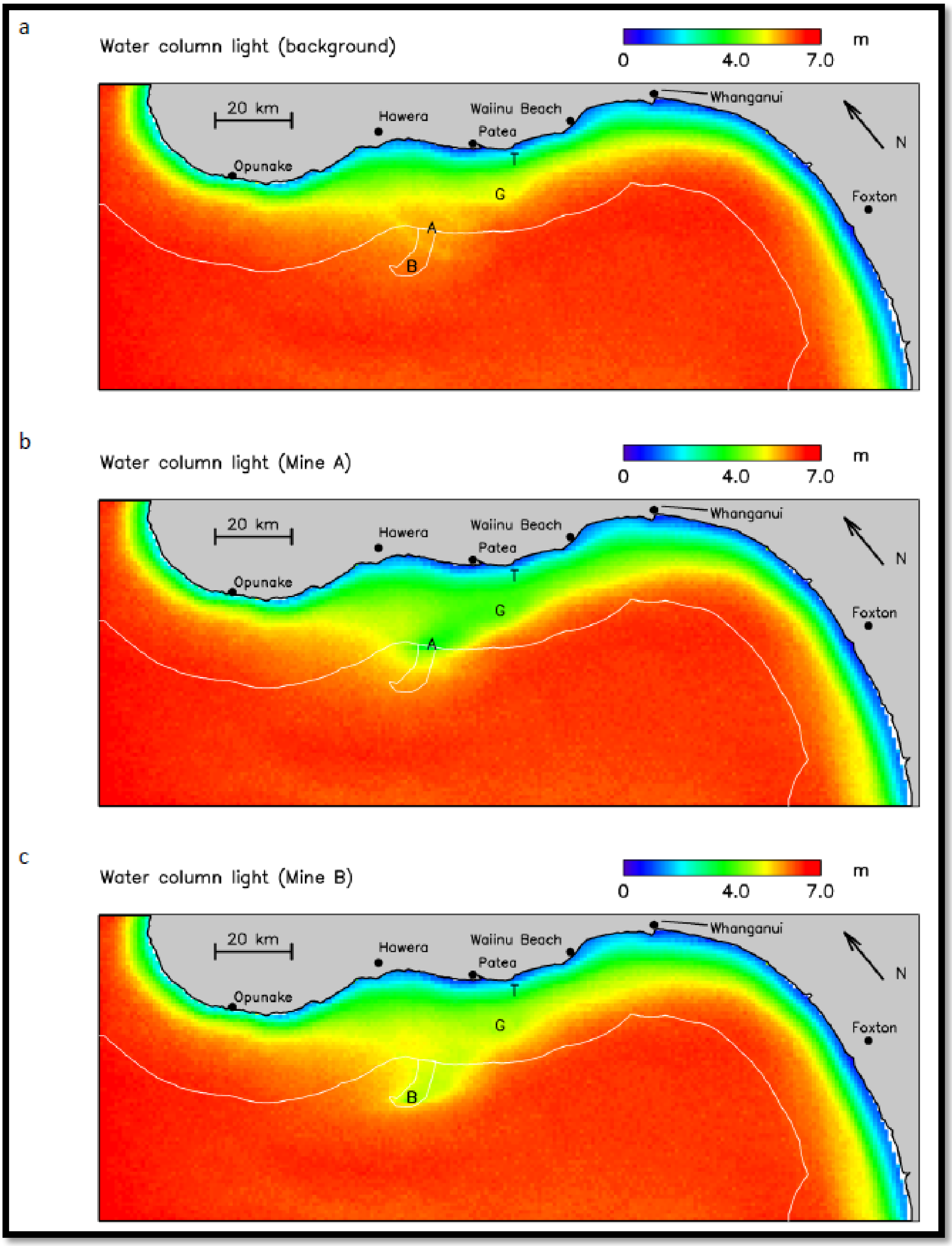
Appendix 5.3(3): Bird Eye Sediment Plume modelling. Explanation: This simulation follows 2.5 days of northerly winds and shows the plume moving to the east of the project area.



Appendix 5.3(4): Bird Eye Sediment Plume modelling. Explanation: This simulation follows 2.5 days of south-easterly winds and shows the plume dispersing predominantly to the west of the mining site.



Appendix 5.4: Modelled change in water column light at Location A (top panel) and Location b (bottom panel).



Appendix 5.5: Modelled water column light at Background Levels (top panel), Location A (middle panel), and Location B (bottom panel).

Appendix 5.6: Draft Baseline Environmental Monitoring and Management Plan

SOUTH TARANAKI BIGHT OFFSHORE IRON SAND EXTRACTION AND PROCESSING PROJECT

BASELINE ENVIRONMENTAL MONITORING PLAN

DRAFT – WITHOUT PREDJUDICE – FOR CONSULTATION PURPOSES ONLY

August 2016

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GLOSSARY OF TERMS

ADCP	Acoustic Doppler Current Profiler
ANOSIM	Analysis of Similarity
AWAC	Acoustic Wave and Current
BAG	Before After Gradient
BEMP	Baseline Environmental Monitoring Plan
chl-a	chlorophyll-a
CPCe	Coral Point Count with Excel Extensions
CTD	Conductivity, Temperature and Depth
DISTLM	Distance-based Linear Models
DoC	Department of Conservation
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EMMP	TTR's proposed Environmental Monitoring and Management Plan
EPA	Environmental Protection Authority
GIS	Geographic Information System
HAT	Highest Astronomical Tide
HSE	Health, Safety and Environment
IA	Impact Assessment
IMV	Integrated Mining Vessel
Iron sand extraction	Sediment excavation and the subsequent deposition of tailings
IUCN	International Union for the Conservation of Nature
KRG	Kaitiakitanga Reference Group
LSST	Laser In-Situ Scattering and Tranmissometer
MBES	Multi-beam Echo Sounding
NIWA	National Institute of Water and Atmospheric Research
nMDS	Non-Multidimensional Scaling
NTU	Nephelometric Turbidity Units
NZTCS	New Zealand Threat Classification System
ORP	Redox Potential
OSPM	Operational Sediment Plume Model
PAR	Photosynthetic Available Radiation
PERMANOVA	Permutational Multivariate Analysis of Variance
Project	TTR Iron Sand Extraction and Processing Project
Project Area	The 66 km^2 from which iron sand extraction is proposed
PSD	Particle Size Distribution
SIMPER analysis	A statistical method to determine similarity between samples
SSC	Suspended Sediment Concentration
SSS	Side-Scan Sonar
STB	South Taranaki Bight
TFS	Total Free Sulphide
TOC	Total Organic Carbon
TRC	Taranaki Regional Council
TRG	Technical Review Group
TTR	Trans-Tasman Resources Limited
TSS	Total Suspended Solids

1 INTRODUCTION

1.1 Background

Trans-Tasman Resources Limited (**TTR**) is a privately owned New Zealand company, established in September 2007 to explore, assess and uncover the potential of offshore iron ore deposits off the west coast of the North Island of New Zealand.

TTR is seeking marine consents under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (the **EEZ Act**) to undertake iron ore extraction and processing activities in a total Project Area of no more than 66 square kilometres (the **Project Area**), located between 22 and 36 kilometres (12 and 19 nautical miles) offshore in the South Taranaki Bight (**STB**) (**Figure 1**).

The TTR Iron Sand Extraction Project (the **Project**) involves the extraction of up to 18 million cubic metres per year (up to 50 million tonnes per year) of seabed material containing iron sand, for processing on-site utilising an Integrated Mining Vessel (**IMV**). Around 10% of the extracted material will be processed into iron ore concentrate and stored by a Floating Storage and Offloading Vessel (**FSO**) before being exported by a bulk carrier. All residual sediment (approximately 45 million tonnes per year) will be returned to the seabed as de-ored sediment via a controlled discharge at depth below the IMV. This extraction, and the subsequent deposition of residual sediment, is herein referred to as '**iron sand extraction**'.

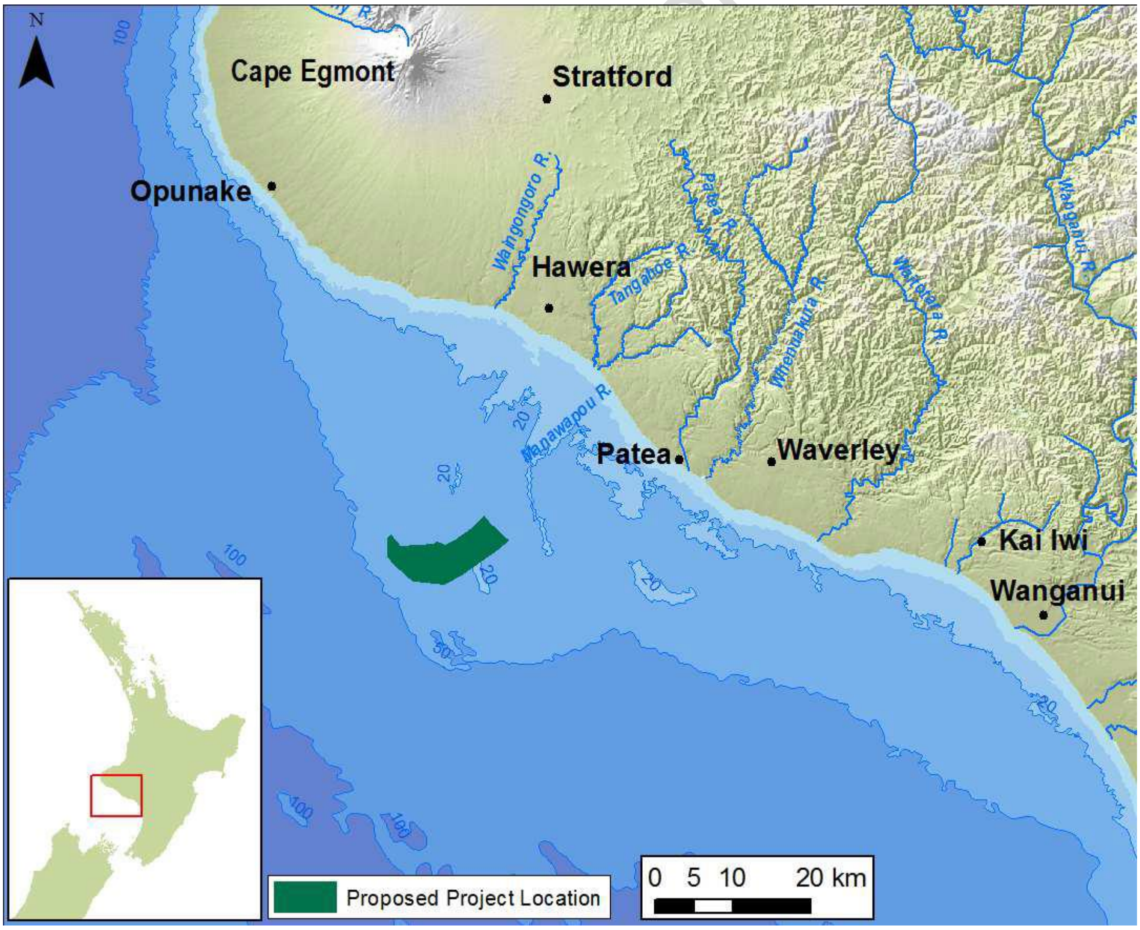

Figure 1 Proposed iron sand recovery area in the South Taranaki Bight.

The marine environment around the Project Area was characterised as part of the Impact Assessment (**IA**) prepared in support of TTR's application for marine consent. The IA also predicted the potential effects that the iron sand extraction would have; with the main impacts[1] of the planned activities being the physical removal of benthic species within the Project Area and the effects of increased suspended sediment concentration (**SSC**) on habitats and biota from the controlled discharge or de-ored sediment. With regard to the potential impacts, the IA predicted that the following ecological receptors would be at greatest risk:

- Subtidal communities inhabiting soft and hard substrata that include invertebrates living on or within bottom sediments and on reef formations within 20 km of the proposed operational area;
- Planktonic and primary producers (i.e. phytoplankton, zooplankton, etc.); and
- Fish and marine mammals in the STB.

Environmental monitoring to document and manage any project-related impacts is a fundamental part of the TTR application for marine consent. To this end, an Environmental Monitoring and Management Plan (**EMMP**) has been drafted and will be submitted to the Environmental Protection Authority (**EPA**) for approval prior to any iron sand extraction activities commencing. However, in order to quantify any project-related impacts a thorough understanding of the baseline environment is required to which comparisons with monitoring results during iron sand extraction can be made. Baseline monitoring is therefore critical to the Project and must include the spatial and temporal variation which exists within the STB. The collection of specific baseline ecological data will occur for a minimum of two years in line with this Baseline Environmental Monitoring Plan (**BEMP**). The BEMP will also serve to validate information in the IA and to refine the methodologies and 'Response Limits' and 'Compliance Limits' proposed in the EMMP.

1.2 Purpose of this Document

The purpose of the BEMP is to:

- Establish a baseline set of environmental monitoring data that identifies natural background levels while taking into account spatial and temporal variation;
- Confirm the current understanding of the seasonality and natural variability of environmental parameters that will be monitored during iron sand extraction activities;
- Provide data to validate the background data used in the Operational Sediment Plume Model (**OSPM**), which predicts the sediment transportation processes in the STB;
- Provide data to verify that the 'Response Limit' and 'Compliance Limit' values are appropriate following the validation of the OSPM;
- Confirm that the chosen sampling locations are the best suited for the proposed EMMP;
- Satisfy the objectives of the BEMP;
- Confirm that the parameters being monitored and the chosen design, location and methodology is the best suited for the environmental monitoring during iron sand extraction activities; and
- Ensure compliance with all regulatory requirements and guidelines.

[1] A through appraisal of all potential impacts is provided in the IA

1.3 Scope of this Document

This BEMP sets out TTR's approach to ensure sufficient baseline information is available on which subsequent actions to avoid, manage or mitigate adverse environmental impacts from iron sand extraction can be based by enabling comparisons between baseline monitoring results and monitoring results collected once iron sand extraction activities have commenced. Accordingly this BEMP:

- Identifies key environmental components for attention in respect of baseline monitoring;
- Presents details for each component by way of an individual baseline monitoring programme; and
- Provides a monitoring programme that will allow the validation of the OSPM and collects data to confirm the appropriateness of Response and Compliance Limits.

The individual baseline monitoring programmes outline:

- The objectives for the baseline environmental monitoring;
- The parameters to be monitored, including sampling design, methodology, frequency, duration and monitoring locations;
- The data analysis and processing for all parameters being monitored; and
- The report methods for all parameters being monitored.

The individual monitoring programmes outlined within this document have been developed to provide robust baseline data such that changes to baseline conditions can be detected, assessed and managed accordingly.

This BEMP has been prepared by TTR to comply with the proposed marine consent conditions to ensure that a baseline set of data is collected over a two year period that takes into account both temporal and spatial variation, to validate the OPSM, confirm that the Response Limits and Compliance Limits are appropriate and, following a review, provide any recommendations to be incorporated into the EMMP.

This BEMP provides an overview of the Baseline Environmental Monitoring Programme (**Section 2**), before addressing each of the individual monitoring programmes as set out in **Table 1**.

Table 1 Baseline Environmental Monitoring Programme Synopsis

Monitoring programme	BEMP Section
Water quality and sedimentation	**Section 3**
Model validation	**Section 4**
Oceanography	**Section 5**
Primary productivity	**Section 6**
Zooplankton	**Section 7**
Subtidal benthos	**Section 8**
Subtidal and intertidal reefs	**Section 9**
Marine mammals	**Section 10**
Underwater noise	**Section 11**
Recreational fishing	**Section 12**

1.4 Plan Review

A Technical Review Group (**TRG**) will be established at least three months prior to the commencement of the baseline monitoring programme. As a minimum the TRG will consist of one suitable representative from the TTR, Taranaki Regional Council (**TRC**), Sanford Limited, the Kaitiakitanga Reference Group (**KRG**), Te Tai Hauauru Regional Fishing Forum and the Department of Conservation (**DOC**).

Each representative was selected due to relevant expertise in the key environmental, ecosystem, matauranga maori and engineering components being monitored. The formation of the TRG provides TTR with assistance to manage, supervise and monitor the exercise of the marine consent activities for the duration of the marine consent.

The TRG will review the BEMP prior to it being certified to ensure the environmental monitoring parameters are appropriate as well as reviewing the Response Limits and Compliance Limits that have been determined.

The TRG shall meet annually to review baseline monitoring programme results following the completion of each year of monitoring and will provide technical advice on the environmental management and make a recommendation to TTR of any future actions. Minutes of these TRG meetings shall be taken and provided to the TRG members and the EPA within 10 working days of each meeting being held.

1.5 Plan Certification

The BEMP shall be submitted to the EPA for certification at least three months prior to the commencement of the baseline monitoring programme.

Following initial certification, the BEMP may be reviewed and amended at any time based on the monitoring information collected or following advice from the TRG. The amended BEMP must be re-certified prior to any of the amendments being implemented.

Minor amendments to the BEMP can be made immediately to address unforeseen circumstances in the field provided the effects of such amendments are no greater than those associated with the certified BEMP. However, re-certification from the EPA shall be sought as soon as practicably possible after the fact.

2 BASELINE ENVIRONMENTAL MONITORING PROGRAMME OVERVIEW

2.1 Introduction

The baseline monitoring programme must:

- Be practical;
- Be robust;
- Account for natural variability in time and space; and
- Be sufficiently detailed to provide the means by which any potential impacts can be quantified during activities.

TTR's baseline monitoring programme has been designed to capture the spatial and temporal aspects of the Project at geographic and ecological scales appropriate for the subsequent assessment of potential effects during iron sand extraction. Monitoring locations have been proposed for the environmental parameters being monitored within this BEMP, with the intention that these same monitoring locations will be included in the EMMP; allowing for direct comparisons between baseline data and data collected during iron sand extraction. However, if after the two year baseline monitoring programme it is found that the proposed monitoring locations are not sufficient or robust, then recommendations to change the relevant monitoring locations will be made following the BEMP review and incorporated into the EMMP.

The two year baseline monitoring programme will be undertaken prior to commencement of iron sand extraction to provide a robust set of baseline data that takes into account seasonal variation to gain an understanding of the natural variability within the STB of all the different parameters that will be monitored. The monitoring results will also validate the OSPM and confirm that the Response Limits and Compliance Limits proposed within the EMMP are appropriate to monitor compliance once the iron sand extraction activities commence.

The proposed individual monitoring programmes within this BEMP are summarised in **Table 2,** including the monitoring objective for each component and a summary of proposed methodologies. The methodologies for each monitoring programme will be finalised during the TRG review process.

The spatial scale of the environmental monitoring (both baseline and ongoing (EMMP)) has been designed in accordance with the results of the OSPM that predicts the potential scale of dispersion of the de-ored sediment plume. The model predicts the extent, gradient and intensity of SSC plumes in terms of turbidity and sediment deposition within the STB. Baseline oceanography data will also assist with the validation of the OSPM.

A number of sensitive sites were identified during the IA process. These sensitive sites have been incorporated into the BEMP, where Response Limits and Compliance Limits have been determined to monitor for compliance at these locations once iron sand extraction is underway. The BEMP will provide monitoring data to ensure that these limits are appropriate to monitor for compliance against, and the monitoring technologies are well established prior to iron sand extraction commencing.

2.2 Monitoring Locations

Monitoring locations are specific for each of the different environmental components that will be monitored; however, a number of the monitoring locations for the different parameters do overlap to enable a full picture of the environmental conditions at that specific location. Each monitoring location has been selected to ensure they are representative and relevant to each of the different environmental components that are being monitored as part of the BEMP (**Figure 2, Figure 3, Figure 4, Figure 5,** and **Figure 6)**.

Each monitoring location has been designated to achieve the objectives of each individual monitoring programme and to provide robust baseline data on the environmental conditions and communities at that specific location. This will provide both temporal and spatial data to enable a comparison to be made between operational monitoring results and baseline monitoring results, as well as monitoring for compliance once iron sand extraction activities commence.

Table 2: Baseline Monitoring Programmes: Objectives and Methodologies

Monitoring Programme	Objectives	Summary of Methods
Water Quality and Sedimentation	• Provide a baseline assessment of water quality in the STB against which potential impacts from iron sand extraction can be measured. • Provide baseline data of SSC in the STB against which potential impacts from iron sand extraction can be measured. • Provide data to inform other components of the monitoring programme, in particular the Model Validation Baseline Monitoring Programme. • Establish telemetry equipment.	Turbidity/moored sensors and profiles Photosynthetically Available Radiation Temperature Conductivity Depth Gross Sedimentation (settlement tubes)
Model Validation	• Provide high quality data for the validation of the Sediment Plume Model used in the IA. This model will be used to inform the development of the OSPM that will be run in hindcast mode during iron sand extraction to differentiate between background SSC levels and project-related SSC. • Provide high quality temporal and spatial resolution of the currents and turbidity characteristics of the STB to understand natural variability of these parameters. • Obtain a time-series of in-situ SSC, particle size distribution and settling velocity data along with current and wave measurements to allow determination of critical shear-stresses for re-suspension and settling.	Turbidity/moored sensors and profiles Sedimentation Currents measurements Waves/moored instruments Particle size and settling velocity/moored instruments and profiles
Oceanography	• Provide a baseline assessment of coastal processes and bathymetry in the STB against which potential impacts from iron sand extraction can be measured. • Provide data to inform the Model Validation Baseline Monitoring Programme.	Deployment of ADCP for measuring waves Deployment of AWAC for measuring currents
Primary Productivity	• Provide a baseline assessment of primary productivity in the STB against which potential impacts from iron sand extraction can be measured.	Phytoplankton community composition, Chlorophyll-a levels in the water column, micro-zooplankton community composition, chlorophyll-a in surficial sediments, Light availability - PAR logger Turbidity - NTU logger

Monitoring Programme	Objectives	Summary of Methods
Zooplankton	• Provide a baseline assessment of zooplankton (biomass, abundance and diversity) in the STB against which potential impacts from iron sand extraction can be measured. • Provide a baseline assessment of water colour and clarity in the STB against which potential impacts from iron sand extraction can be measured.	Zooplankton diversity, abundance and distribution Surface water colour and clarity
Subtidal Benthos	• Provide a baseline assessment of infaunal and epifaunal communities (abundance and diversity) in the STB against which potential impacts from iron sand extraction can be measured. • Provide a baseline assessment of sediment characteristics (sediment grain size, redox potential and pH) in the STB against which potential impacts from iron sand extraction can be measured.	Ecological benthic sampling programme Abundance and diversity of infauna and epifauna Sediment physico-chemical characteristics Microphytobenthos
Subtidal and Intertidal Reefs	• Provide a baseline assessment of subtidal and intertidal reef communities in the STB against which potential impacts from iron sand extraction can be measured.	Intertidal and subtidal ecological surveys using both quantitative and qualitative methods. Drop camera photo-quadrats Diver surveys
Marine mammals	• To conduct surveys to describe the variability of marine mammal relative abundance and distribution in the STB before the commencement of iron sand extraction.	Incidental sightings Aerial surveys Acoustic surveys
Underwater Noise	• Establish baseline underwater noise characteristics in the vicinity of the Project Area, prior to the commencement of iron sand extraction. • Provide data to inform the Marine Mammal Baseline Monitoring Programme	Fixed-point underwater noise surveys
Recreational Fish	• Provide a baseline assessment of recreational fishing (target species and fishing effort) in the STB against which potential impacts from iron sand extraction can be measured.	Catch per unit effort, total abundance, size, Vessel counts

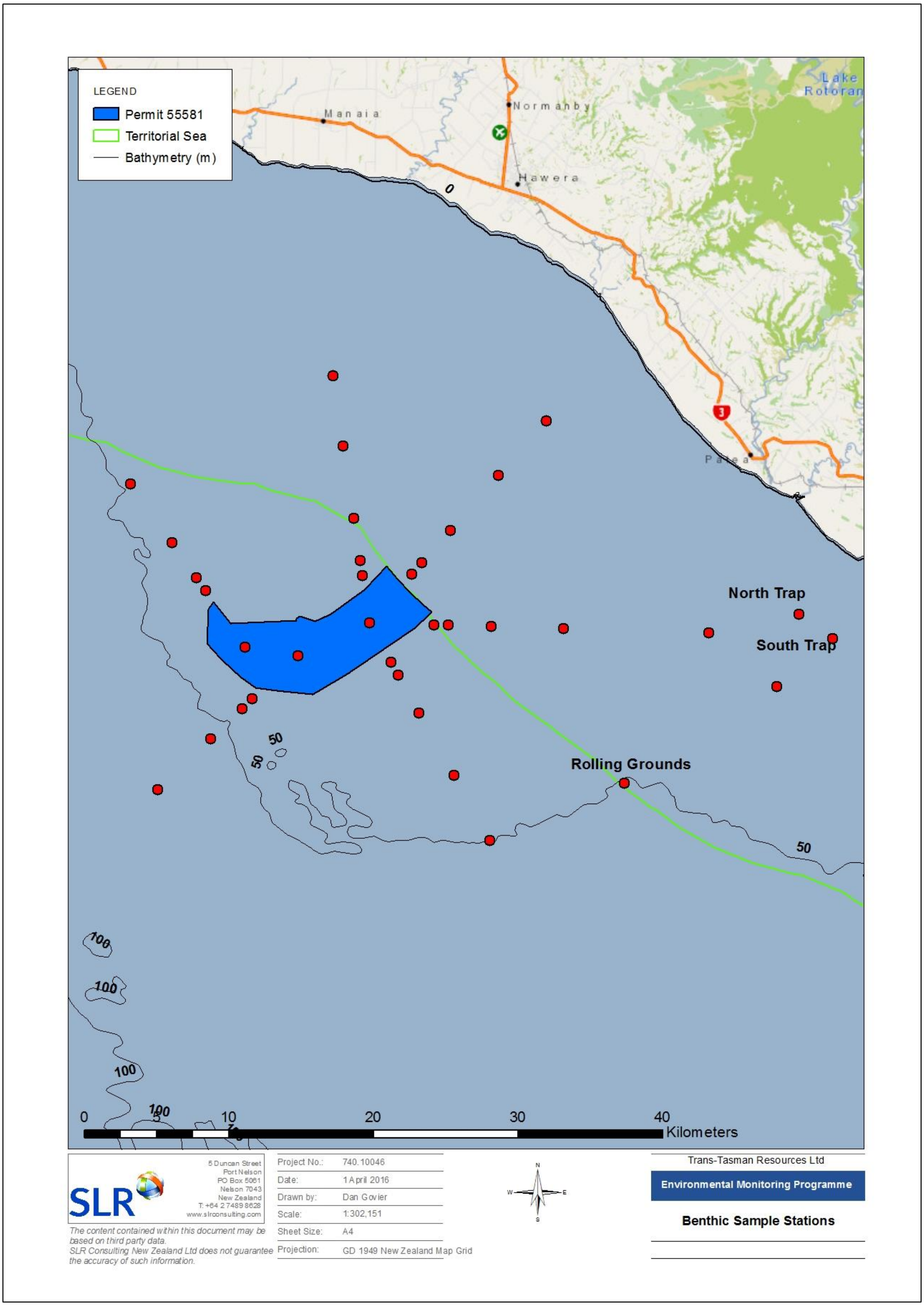

Figure 2: Location of benthic monitoring stations in relation to the Project Area

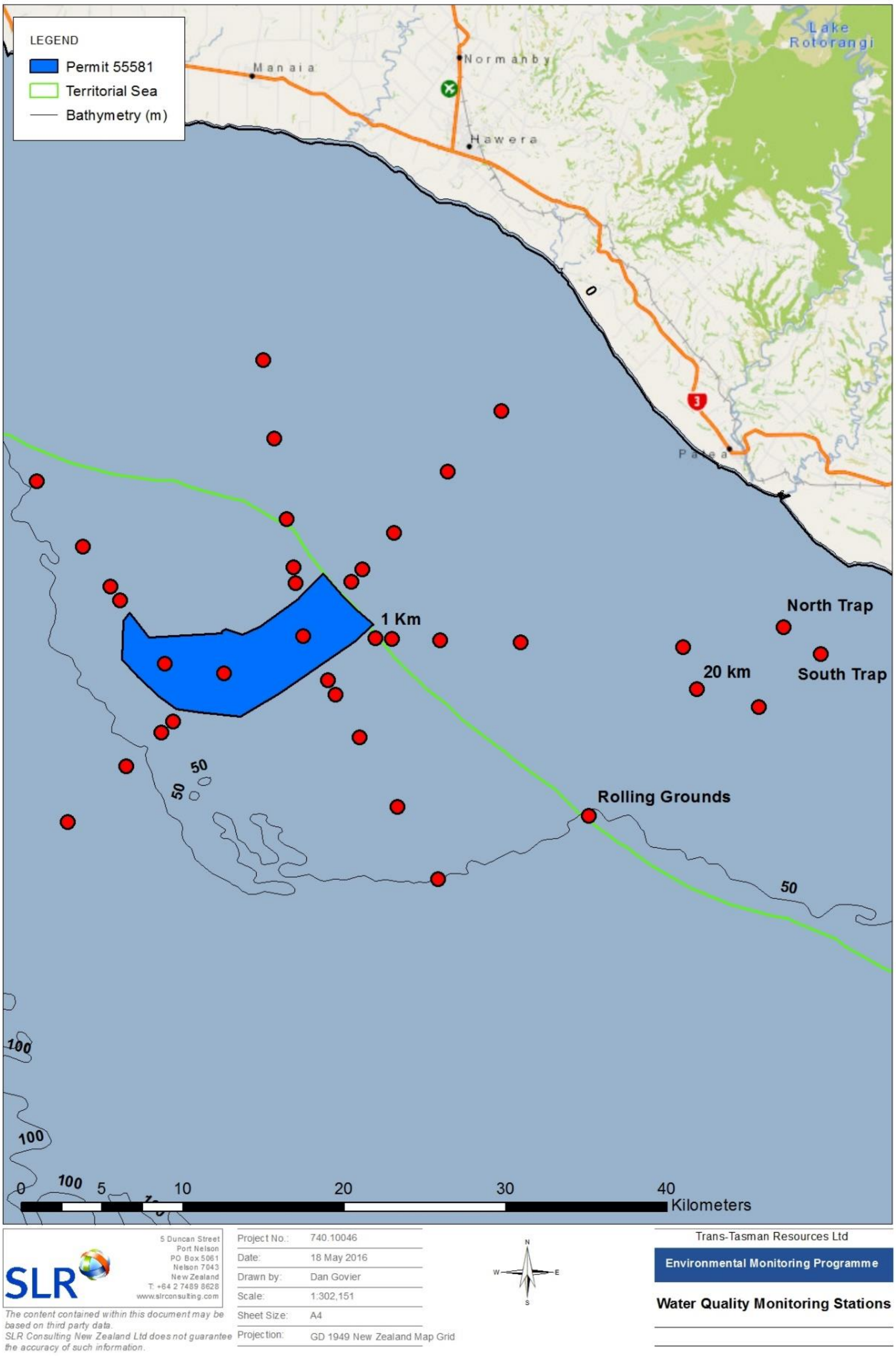

Figure 3 Location of water quality monitoring stations in relation to the Project Area

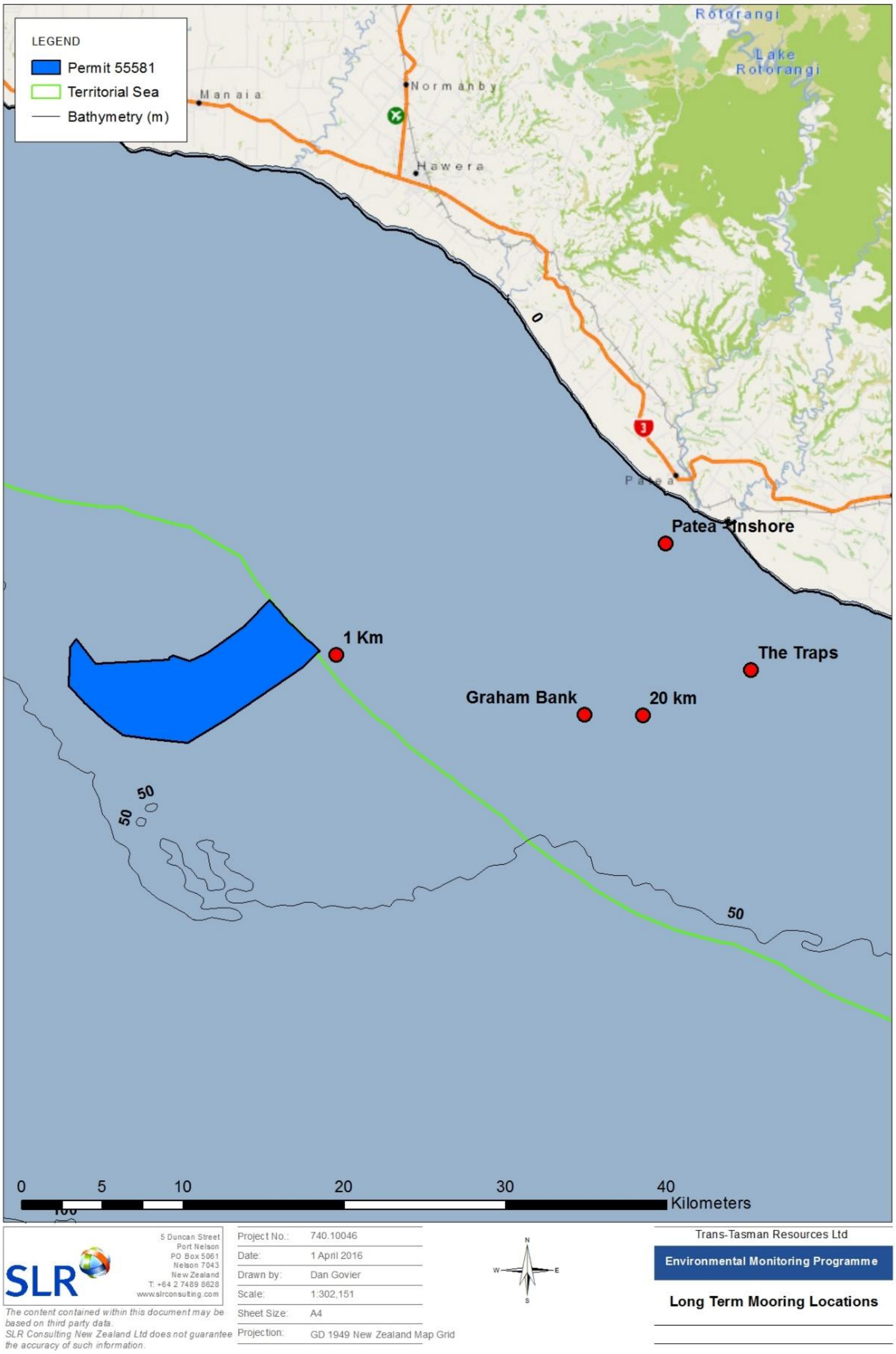

Figure 4 Location of fixed moorings in relation to the Project Area

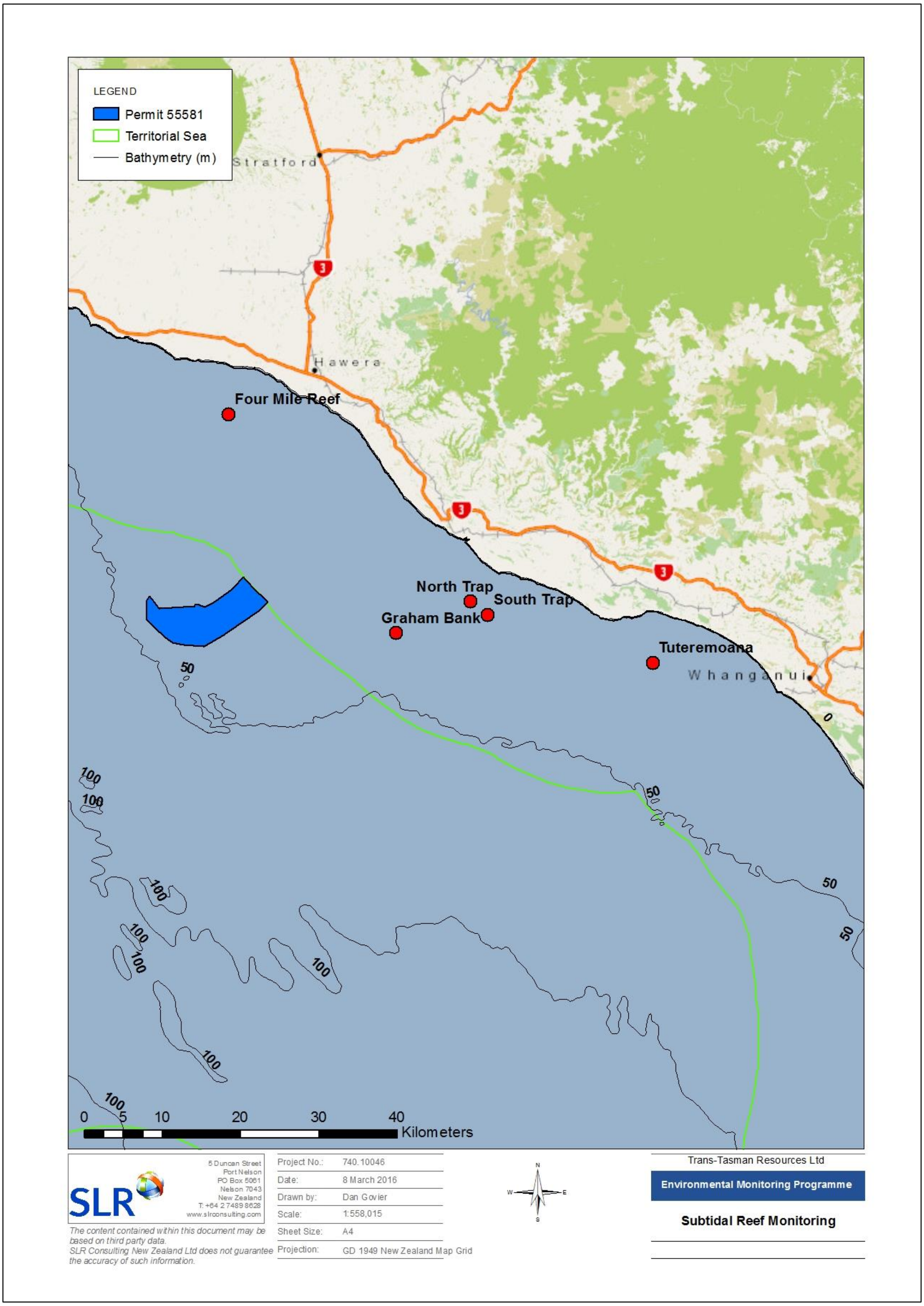

Figure 5 Location of subtidal monitoring sites in relation to the Project Area

Figure 6 Location of intertidal monitoring sites in relation to the Project Area

2.3 Sampling Frequency

During the two year baseline monitoring programme, sampling will typically occur either on a monthly or quarterly basis (however there is some variation across individual monitoring programmes) as this will provide information about seasonal variations on ecological communities and water column characteristics within the STB. A summary of sampling frequency is provided in Appendix X.

2.4 Sampling Design

A 'Before After Gradient' (**BAG**) sample design will be utilised for the following components of the baseline monitoring programme:

- Water quality and sedimentation;
- Primary productivity;
- Zooplankton; and
- Subtidal benthos.

The BAG design was selected primarily on account of its suitability for the ongoing monitoring that will occur once iron sand extraction is underway. It is logical to also adopt this design for the baseline monitoring to facilitate direct comparisons between the baseline period and the operational period.

This design means that sample locations are placed at intervals distributed at variable distances from the Project Area. A BAG design is useful where a disturbance attenuates from a point source (i.e. Project Area). The use of this sampling design is also supported by the fact that no control sites could be selected that are close enough to the disturbance to have comparable natural variability to the disturbed environment and still be far enough away that they are not affected by the disturbance (Ellis & Schneider, 1996). Ellis & Schneider (1996) found that a BAG design was more powerful than a control impact sample design in detecting changes due to anthropogenic disturbances. The BAG sampling design avoided the problem of arbitrarily selecting control sites and the results from a gradient layout design enabled chemical, physical and biological changes to be assessed as a function of distance from the disturbance area.

Modelling indicated the primary concentration gradient of the expected sediment plume. Sample stations will be placed along this axis of deposition out to at least 20 km from the Project Area. Sample locations have also been placed along secondary axes radiating away from the Project Area to enable a full assessment of the surrounding area. The spatial layout of the monitoring components that will utilise the BAG design are illustrated in **Figure 2** and **Figure 3.**

All other monitoring programmes will utilise survey designs specific to the receptors of interest. These designs are described in more detail in **Sections 4, 5, 9, 10, 11** and **12.**

2.5 Data analysis

Data analyses will be specific to each monitoring programme and will include descriptive statistics, inferential techniques, univariate and multivariate methods, power analysis and distribution plots to provide visual summaries of biological and physical data sets.

Further and specific details of the statistical techniques to be used for each monitoring programme are presented under "data analysis" in each of the relevant monitoring sections of this BEMP. All of the analyses proposed have been selected due to their ability to provide robust, meaningful and accurate outputs which will provide valuable insights into spatial and temporal changes in biological and physical variables of interest.

All statistical analyses will be undertaken by experienced statistical scientists using appropriate software packages.

2.6 Quality Assurance

All data gathered as part of the baseline monitoring programme will be governed by TTR's Quality Assurance Management System and will comply with the requirements of AS/NZS ISO 9001-2008.

Specific quality control procedures, approaches and considerations are outlined for each of the different monitoring programmes that are included within this BEMP to ensure that the results are robust prior to submission to the EPA in compliance with Marine Consent conditions.

Quality assurance procedures for data management, statistical analyses and reporting are common to all Baseline Monitoring Programmes and are described below.

2.6.1 Data Management

A purpose-designed database will be developed for each Baseline Monitoring Programme into which the resulting data will be entered. Data will be entered by a scientist and then checked by a second scientist. In addition, software error checking queries will be run to detect errors or omissions that may still be present.

Data exported for use in statistical analyses will be locked to avoid corruption or accidental over-write. Any changes to original datasheets will be saved as different versions to ensure overwrites do not occur.

Example data fields to be included in the database are:

- Sample data: unique sample identification, collection location, time, date, habitat, type and size/capacity of equipment used, depth (if subtidal), comments;
- Climate data: location, weather conditions, rainfall, sea state;
- Ambient data: tidal state, water quality variables, predominant substratum type; and
- Taxonomic data: taxonomic code, species, genus, family, order, class, phyla, taxonomic authority, and abundance/count.

2.6.2 Analyses

All statistical analyses carried out will be checked by a senior scientist for appropriateness of technique and interpretation of results.

All video footage will be error checked before undertaking any analysis or presentation in a GPS package.

2.6.3 Reports

Reports will be internally reviewed by Associate and Principal Scientists who have relevant experience. All reports are subject to a document control procedure to ensure different versions of the report are tracked through time and cannot be overwritten.

2.7 Reporting

Each baseline monitoring programme will have a unique reporting schedule as detailed in the respective monitoring programme sections and as summarised in **Table 4**.

Table 3 Reporting schedule for Baseline Monitoring Programme

Report	Of Relevance to:										Reporting timeframe
	Water Quality & Sedimentation	Model Validation	Oceanography	Primary Productivity	Zooplankton	Subtidal Benthos	Subtidal and Intertidal Reefs	Marine Mammals	Underwater Noise	Recreational Fishing	
Daily Trip Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Due to TTR within 24 hours of the completion of each monitoring day
Monthly Monitoring Report	✓			✓							Due within 20 working days of the end of each monthly survey
Quarterly Monitoring Report			✓		✓	✓					Due within 30 working days of the end of each quarterly survey
Annual Monitoring Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Due within 40 working days of the end of the monitoring year
OSPM Validation Report		✓									Due within 40 working days of the completion of the baseline phase
LSST Deployment Report		✓									Due within 20 working days after the retrieval of the LSST
Aerial Survey Report								✓			Due within 20 working days of survey completion
Final Monitoring Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Due within 60 days after baseline programme completion

All reports except daily reports will be provided to the EPA and the TRG, and will typically follow the outline below:

- A non-technical Executive Summary;
- Introduction with relevant background information and a review of previous monitoring results;
- Methodology, including field, statistical and laboratory procedures, descriptions of sites sampled (including GPS coordinates); maps indicating sampling locations;
- Data analysis and results, presented in tables and figures (including photographs), as well as a trend analysis and interpretation of analytical data collected and a discussion of the results. Raw or summarised data will be presented in appendices; and
- Conclusions and Recommendations.

The reporting requirements that are common to all monitoring programmes include a Daily Trip Report, an Annual Monitoring Report and a Final Monitoring Report. Further detail on each of these reports is provided below.

2.7.1 Daily Trip Report

A Daily Trip Report will be completed for all monitoring programmes for each day of field work. An approved template will be utilised for this purpose, with the completed reports being submitted to TTR within 24 hours of completion of each monitoring day.

Each Daily Trip Report will typically include the following components:

- A summary of activities;
- The number of samples collected etc;
- A summary of deployment/retrieval of monitoring equipment;
- A description of any sampling difficulties;
- The ships manifest;
- A weather summary;
- Details of any health and safety issues or near-misses; and
- Any quality assurance issues.

2.7.2 Annual Monitoring Report

For each monitoring programme an Annual Monitoring Report will be prepared. These reports will outline the following environmental components:

- A summary report on all monitoring undertaken in the previous 12 months;
- Details of monitoring proposed for the next 12 months;
- Details of any TRG reviews of the annual monitoring data, along with any recommendations of any actions or changes to the BEMP for the subsequent 12 months; and
- Appendices containing raw data from the preceding 12 months of monitoring.

2.7.3 Final Monitoring Report

For each monitoring programme a Final Monitoring Report will be prepared at the completion of the baseline monitoring phase. These reports will include full data analysis, data summaries and interpretation of all data collected throughout the two year baseline phase. A critical component of these reports will be the inclusion of any recommendations for monitoring design modifications to be incorporated into the EMMP.

2.8 Health and Safety

Working around the marine environment has the potential to pose a Health and Safety risk, thus, controls will be established as part of the baseline monitoring programme to reduce the likelihood of an incident as far as possible before entering the field. For any marine monitoring multiple levels of Health and Safety management will be implemented to ensure these controls are well established. Job Hazard Analyses will be implemented and reviewed prior to departure into the field.

All potential hazards that may arise will be identified and discussed prior to any field work, and wherever possible mitigation measures will be agreed on and implemented to address the identified hazards, reducing risk to As Low As Reasonably Practicable.

Prior to the departure of each field trip, a survey plan will be prepared which includes the environmental monitoring survey plan, key project personnel and responsibilities, health and safety management, hazard identification, hazard map and risk assessment, and site communication.

The survey plan will provide high-level detail on the survey being conducted as well as the detail of the health and safety management arrangements to be implemented as part of the baseline monitoring programme to ensure that the work is undertaken safely. All tasks will be risk assessed to ensure that the potential hazards are identified and safe systems of work are developed and implemented.

2.9 Operational Sediment Plume Model

TTR will develop, maintain and use an OSPM to assist with predicting background SSC levels. Water quality, sedimentation and oceanography data collected during the baseline monitoring programme will be fundamental to validating and refining the existing model to ensure accuracy of the results.

In situ instruments will be placed at a number of sensitive sites and the results from these instruments will be used to compare the model predictions of the different environmental parameters at that specific location.

The OSPM will be regularly calibrated with in-situ measurements and will be reviewed regularly by the TRG. The results of this review will be utilised to inform the nature and scope of the ongoing environmental monitoring programme.

2.10 Community Involvement

TTR wish to engage and involve the local community in as much of the baseline monitoring programme as possible. TTR will provide the public with up to date information on the environmental monitoring programmes. This information will be made available to the public through TTRs website as well as being on the agenda for the community meetings held every six months during the BEMP, which TTR will facilitate. These meetings will be notified at least four weeks prior through TTRs websites and advertisements in local newspapers and radio stations.

A lot of the environmental monitoring programme requires working offshore in the remote marine environment, which has its difficulties for community involvement as a result of the stringent health and safety requirements TTR will be operating under.

However, the onshore monitoring components are better suited to community involvement and TTR will be vigilant towards such opportunities. Community members and iwi groups will be invited where possible to participate in the collection of baseline data to promote a better understanding of sampling methodologies and how baseline data might be used to assess the potential effects of the Project.

3 WATER QUALITY AND SEDIMENTATION BASELINE MONITORING PLAN

3.1 Introduction

Operationally-derived sediments are predicted to be one of the key project-related impacts, where effects on the water column are likely to arise from the development and dispersion of suspended sediment plumes derived from the iron sand extraction.

The Water Quality and Sedimentation Baseline Monitoring Programme has been developed primarily to ensure robust baseline data is collected against which project-related impacts can be measured. The results will also be used to validate the OSPM.

This baseline monitoring programme will provide critical data to quantify the natural baseline variability in SSC in the STB. Understanding baseline SSC is fundamental to the development of appropriate Response and Compliance Limits which will be adopted during the iron sand extraction in order to manage project-related impacts. For instance, if during the Project, SSC levels exceed predetermined limits, then management actions will be implemented to moderate the environmental impacts.

Sampling methodology, and key indicator parameters that will be monitored are summarised in **Table 4** and discussed in **Section 3.5**.

3.2 Background

The STB is very exposed to southerly and westerly storms resulting in large swells, initiating active bed transport and resuspension of sediments. There are four large rivers which flow into the STB, the Patea, Whanganui, Rangitikei and the Manawatu which at times can provide significant inputs of sediments.

Biota in the water column and benthic environment of the STB are tolerant to the dynamic and exposed environment in which they live which includes river inputs and regular strong wave activity. As a result, the natural variability of SSC and underwater light penetration are high and have to be taken into consideration when assessing for environmental effects of an activity (i.e. are the monitoring results due to natural variability or Project related).

3.3 Objectives

The overall objectives of the Water Quality and Sedimentation Baseline Monitoring Programme are to:

- Provide a baseline assessment of water quality in the STB against which potential impacts from iron sand extraction can be measured;
- Provide baseline data of SSC in the STB against which potential impacts from iron sand extraction can be measured; and
- Provide data to inform other components of the BEMP, in particular the Model Validation Baseline Monitoring Programme.

3.4 Sampling Approach

The sampling design and methods for the Water Quality and Sedimentation Baseline Monitoring Programme have been informed based on the current understanding of water quality and marine ecosystems in the STB, as well as the predicted project-related impacts derived from the OSPM.

It has been identified within the IA that SSC and turbidity are a readily measured variable with sufficient accuracy that can indicate the potential effects of the iron sand extraction. Therefore knowledge of the baseline levels of SSC and turbidity are critical.

It is recognised that a range of other physical processes affect turbidity. Hence additional variables pertinent to plume dispersion have been included in the list of key variables to be monitored as part of this programme which is closely inter-related with the Model Validation Baseline Monitoring Programme (**Section 4**).

This baseline monitoring programme will also measure a number of general water quality parameters, including metals, nutrients and Chlorophyll-a (proxy for primary production), which will inform the Primary Productivity Baseline Monitoring Programme (**Section 3**). Metal concentrations that could have toxicity effects on marine organisms are indicators of potential toxicity will be compared against ANZECC guidelines.

3.5 Sampling Design

The proposed sampling design uses the gradient (BAG) approach as described in **Section 2.4** and has been established to monitor the gradient of effects of the sediment plume dispersing away from the Project Area once iron sand extraction activities commence.

To provide optimal resolution of baseline monitoring data, the sampling design comprises of:

- In-situ water quality monitoring at fixed sites using meters;
- Vertical profiling of the water column; and
- Water samples at 1 m from the seabed and 5 m below the surface.

The above sample design will be used to test for the parameters listed in **Table 4**.

Table 4 Overview of the water quality and sediment programme methodology

Parameters	Water Samples (seabed & surface)	Synoptic Survey (water profiles)	In-situ meters (seabed sensors)
Metals (Cd, Cu, Ni, Hg)	✓		
Nutrients (TP, DRP, NO_3, NO_2, NH_4, DRSi)	✓		
Chlorophyll-α		✓	✓
Conductivity	✓	✓	✓
Temperature	✓	✓	✓
pH	✓	✓	✓
Photosynthetic Available Radiation		✓	✓
Turbidity	✓		
Suspended Sediment Concentration		✓	✓
Dissolved Oxygen		✓	
Depth		✓	
Water Clarity	✓		
Sedimentation rates			✓

Note: *Green indicates the sampling method utilised*

The monitoring station locations that will be utilised to conduct the sampling defined in **Table 4** are illustrated in **Figure 3** and **Figure 4**. The in-situ monitoring locations have been placed adjacent to sensitive habitats (i.e. The North and South Traps), as well as at sites designed to assess the sediment plume gradient (1 km & 20 km down plume). These sensitive habitats have Response Limits and Compliance Limits established against which compliance will be monitored once iron sand extraction activities commence and the baseline monitoring programme will be used to validate that these limits are sufficient.

The in-situ instruments will be in place for the duration of the baseline monitoring programme (two years), prior to iron sand extraction commencing. A time series of data will be recorded which will account for temporal and natural variability within the STB and will establish a further understanding of seasonality.

During the monthly servicing operations of the in-situ meters, vertical water quality profiling and samples will be conducted alongside the fixed mooring sites for validation as well as light profile interpretation and confirmation of the relationship between SSC (mg/L) and turbidity (NTU).

During the baseline monitoring programme the synoptic surveys and water column samples will be collected monthly to take into account the temporal variation, while the in-situ instruments will be serviced every month to download the data and replace batteries where required.

3.5.1.1 Turbidity and SSC

At each of the fixed mooring locations, turbidity optical sensors will be placed on a frame, approximately 1 m above the seabed. These sensors will be in-situ data-logging instruments and data will be telemetered back on an hourly basis to a controlled and secure database. Although near real-time data is not critical during the baseline phase, it is important that the telemetry system is thoroughly established to ensure that it is failsafe once iron sand extraction commences. The performance of this system will be critical as near-real time SSC results will be automatically assessed against Response Limits and Compliance Limits during iron sand extraction and will form the basis of compliance monitoring against consent conditions.

Turbidity will be monitored using an instrument such as the WET Labs ECO NTU sensors. During each servicing operation a water sample will be collected and tested for SSC to locally calibrate the relationship between SSC (mg/L) and turbidity (*Nephelometric Turbidity Units*, **NTU**). These results will then be incorporated to the OSPM validation process.

3.5.1.2 Photosynthetically Available Radiation (PAR)

Underwater light will be monitored by instruments such as the upward-looking WET Labs ECO PAR sensors and will be installed alongside the turbidity sensor on the frame, approximately 1 m above the seabed. Light attenuation will be determined from the surface and bottom light measurements combined with the depth of the seabed sensor. ECO PAR sensors measure underwater light in the photosynthetically reactive bandwidth 400-700 nm. The sensor is equipped with quality precision optics and bio-wiper technology to allow the sensor to be deployed for extended periods of time.

3.5.1.3 Conductivity, temperature and depth (CTD)

Conductivity, temperature and depth measurements will be monitored using equipment such as an In-Situ Inc. Aqua TROLL instrument. The Aqua TROLL unit, equipped with the TROLL Shield Antifouling System is designed for long duration, fixed-site deployments. This instrument will also be mounted on the frame and deployed approximately 1 m above the seabed.

3.5.1.4 Sediment traps

Sedimentation rates will be measured using sediment traps deployed on the heavy instrument frame at each of the seabed mooring locations. The sediment traps will be retrieved with the real-time stations at monthly intervals. The sediment traps consist of PVC tubes, attached to a vertical post on the seabed mooring frame, with the bottom ends sealed and the open-end facing upward. All sediment traps will be deployed in accordance with recommended strategy described in Storlazzi *et al*. (2011).

3.5.1.5 Seabed moorings and servicing

The seabed moorings will consist of a steel anchor or large concrete mooring blocks with a vertical steel frame, attached to a surface buoy by a mooring tether. The sensors will be attached to the vertical pole while the sediment traps will be attached to a horizontal cross bar fixed to the vertical post.

The tether line between the seabed mooring and surface buoy will be as a minimum 150% of site water depth at Highest Astronomical Tide (**HAT**). The moorings will be deployed and recovered from a vessel with appropriate lifting gear and the locations of moorings will be marked using GPS during deployment operations.

Servicing trips will involve the recovery and servicing of each mooring and instrument package. Spare systems will be carried on-board in the event a full swap-out of monitoring station due to problems or where periodic major servicing works are required. Servicing will be undertaken on a monthly basis (approximate). The equipment specifications for the sensors and meters allow for deployments to extend for periods of up to two months; however, servicing intervals shall be monthly and no more than six weeks to ensure consistently high quality data is collected.

3.5.1.6 Vertical Profiling

Vertical profiling campaigns will be conducted alongside the servicing of fixed instrumentation as well as along transects at radiating distances away from the Project Area (**Figure 3**).

A multi-parameter water profiler such as a CTD will be utilised to continuously measure water quality parameters in profile. The profiler will measure those parameters detailed in **Table 4**. Results from these synoptic surveys will be downloaded and analysed within 12 hours.

3.6 Data Analyses and Processing

Data will be quality controlled and downloaded to the Project Database for archival and future retrieval for analysis as required.

The turbidity and PAR data will be analysed using time series analysis techniques including auto and cross spectral analysis, filtering and event analyses. Correlations with salinity and temperature will be undertaken to assess algal growth limitation processes.

The results from the Water Quality and Sedimentation Baseline Monitoring Programme will be evaluated over the course of each sampling year for trends and effects.

3.7 Reporting

The following reports will be generated for the Water Quality and Sedimentation Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Monthly Monitoring Report to summarise the findings of the monthly surveys and of the telemetered SSC data;
- An Annual Monitoring Report to summarise the previous 12 months of data;
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Water Quality and Sedimentation Baseline Monitoring Programme.

4 MODEL VALIDATION BASELINE MONITORING PLAN

4.1 Introduction

This section of the BEMP describes how data will be used to validate the numerical hydrodynamics and sediment transport modelling assumptions in the STB.

As part of the IA, numerical hydrodynamics and sediment transport modelling of the STB was undertaken using a range of model packages to simulate waves, currents, water levels and fine sediment transport under natural conditions and projected conditions during iron sand extraction.

The baseline monitoring programme will collect a range of data to that will allow the following models to be refined:

- the Sediment Plume Model which was used in the IA to describe natural sediment transport processes in the STB; and
- the OSPM, a hindcast model which is under development and is based on the sediment plume model. The OSPM will be used during iron sand extraction to run simulations of actual conditions and discharges of de-ored sediment to estimate the project-related effects of elevated SSC levels. Data collected during baseline monitoring will be used to refine model forcing terms, and to conduct calibration and validation.

Field work for this component will occur in conjunction with the Water Quality and Sedimentation Baseline Monitoring Programme (**Section 3**) and the Oceanography Baseline Monitoring Programme (**Section 5**) where data collected from the moored data collection units, synoptic water quality surveys and particle size analysis will be utilised for model validation purposes.

Specific requirements for the Model Validation Baseline Monitoring Programme include:

- Collection of data that demonstrates the 3-dimensional dispersion processes are adequately represented by the depth-averaged model;
- updated model forcing data; and ongoing data for future calibration and validation of the OSPM; and
- Particle size distribution data (**PSD**) of the sediment in and around the Project Area to verify background sedimentation patterns.

4.2 Objectives

One of the critical issues in determining impacts from iron sand extraction activities is the differentiation between “background” SSC and the “added” project-related contribution of sediment and associated turbidity.

This model validation programme sets out to confirm that all model inputs reflect the background conditions of the STB as accurately as possible. By ensuring that the background conditions are accurately reflected, the accuracy of the operationally derived predictions with regards to plume behaviour during iron sand extraction will also increase.

The objectives of the Model Validation Baseline Monitoring Programme are to:

- Provide high quality data for the validation of the Sediment Plume Model used in the IA. This model will be used to inform the development of the OSPM that will be run in hindcast mode during iron sand extraction to differentiate between background SSC levels and project-related SSC;
- Provide high quality temporal and spatial resolution of the currents and turbidity characteristics of the STB to understand natural variability of these parameters; and
- Obtain a time-series of in-situ SSC, PSD and settling velocity data along with current and wave measurements to allow determination of critical shear-stresses for re-suspension and settling.

The baseline monitoring programme objectives will be achieved through:

- the use of moored instruments to provide high temporal resolution of the specific variables (turbidity, water temperature and conductivity) at the mooring location;
- field campaign surveys involving deployment of current meters, water quality profilers, and water sampling to provide snapshots of the spatial variability of the turbid plume characteristics; and
- the use of moored (bottom-mounted) in-situ particle-size and settling velocity monitors in conjunction with current and wave monitors.

4.3 Methods

The baseline monitoring programme will utilise moored instruments and vessel-based surveys as described in the Water Quality and Sedimentation Baseline Monitoring Programme (**Section 3**) and Oceanography Baseline Monitoring Programme (**Section** 5) as well as the details within this section. This section describes the near, mid and far-field model validation measurements.

4.3.1 Sediment Plume Model Validation

- <u>Model source terms</u> – Data on the background fine sediment profile in the STB will be measured by the use of a Laser In-Situ Scattering and Tranmissometer (**LSST**);
- <u>Turbidity/SSC variability</u> – time-series measurements of turbidity at the water quality monitoring sites will be analysed, converted to SSC and compared to the model outputs; and
- <u>Sedimentation variability</u> – measurements of sedimentation across the STB will be compared to the model estimates by the sediment traps located at all of the fixed mooring locations and the LSST.

The Sediment Plume Model will be assumed to be validated if the data collected indicates that the model inputs are the same as or more conservative than the background measurements.

4.3.2 Operational Sediment Plume Model (OSPM) Validation

Turbidity, sedimentation, particle size and currents will be measured at a number of fixed locations as part of the Water Quality and Sedimentation Baseline Monitoring Programme and Subtidal Benthos Baseline Monitoring Programme.

These results will be compared to predictions by the OSPM. Validation will be assumed if the OSPM predictions accurately reflect the measured background results. This comparison will require matching of time scales between the resolution of the model results and the measured data.

4.3.3 Monitoring Techniques

The surveys used in the validation baseline monitoring are summarised in the following sections.

4.3.3.1 Moored Instruments

Water quality characteristics have been simulated by using nearfield and far-field modelling, which in turn is based on conservative assumptions relating to source terms and sediment behaviour. In order to validate these characteristics baseline monitoring will be carried out to confirm the actual source terms of the Sediment Plume Model.

Parameters are measured using a combination of Acoustic Doppler Current Profiler (**ADCP**) and water quality data (including, turbidity, conductivity, temperature and pH measurements).

Upward-looking ADCP units will be deployed to measure vertical profiles of water currents and optical backscatter. The ADCP units will be programmed to ensure consistency across all stations (currents x 0.5 m bins average of 0.25 Hz samples over 10 mins; logged every 10 mins). The moorings will incorporate near-bed turbidity sensors as the ADCP does not resolve backscatter in the near- bed waters. One of these instruments will also record surface waves to allow assessment of the contribution, if any of wave action on sediment movement and resuspension.

The LSST technology allows the measuring and recording of time-series of SSC and PSD. It is also possible to measure and record time-series of settling velocity using a variant of the same technology (LSST-ST). This data allows characterisation of the sediment in suspension and will provide direct input for model calibration and validation. The PSD data will confirm background model inputs and also identify times when seabed material is being re-suspended. By including measurements of currents and waves through an acoustic wave and current (**AWAC**) instrument (similar technology to the ADCP) the shear stress on the seabed can be measured and thus robust estimates obtained for the critical shear stresses for settling and resuspension – important parameters in the modelling of sediment transport.

4.3.3.2 Locations

ADCP and turbidity moorings will be located as shown in **Figure 4**.

4.3.3.3 Indicators

Water current vectors from the moored ADCPs (two horizontal and the vertical components) will be measured in a vertical profile from just above the bed to just below the surface. Acoustic backscatter is also resolved in these vertical bins. Turbidity will be measured at the single point near the bottom at each of the ADCP moorings. Water samples will be collected at deployment and recovery and analysed for SSC and particle size distribution. Additional samples at these sites will be collected during the deployments to calibrate the instruments against actual background measurements.

The data from the ADCP will also be used to obtain the surface elevation relative to the instrument and thus provide tidal height information for model calibration and validation.

4.3.4 Data Analyses and Processing

The data collected by the ADCPs and turbidity loggers will be quality controlled by de-spiking and flagging any poor quality data. The resulting ‘processed’ data will be stored and archived in a secure database for archival and future retrieval as required.

4.4 Timing and Frequency

The OSPM shall be calibrated and validated at least every six months during the baseline monitoring period.

The schedule for data collection during the Model Validation Baseline Monitoring Programme is summarised in **Table 5**.

Table 5: Schedule for Model Validation Baseline Monitoring

Monitoring Parameters	Sites	Monitoring Frequency
Turbidity Logging	5 sites	Continuous deployments for two years prior to iron sand extraction commencing. Monthly data downloads.
ADCP deployments	5 sites	Continuous deployments for two years prior to iron sand extraction commencing. Quarterly data downloads.
LSST frames	The Traps and the Project Area	4 week deployment prior to iron sand extraction commencing
Synoptic Surveys WQ Profiler Niskin water sampler (Total Suspended Solids, **TSS**)	35 sites	Monthly for two years prior to iron sand extraction commencing

4.5 Reporting

The following reports will be generated for the Model Validation Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- An OSPM Validation Report will be produced each time the OSPM is calibrated the validated (at least every six months) during the Model Validation Baseline Monitoring Programme. This report will detail the methods used and the results in relation to background turbidity for comparison with the sediment plume model. Any anomalies in will be investigated using additional model validation measurements and outputs;
- An Annual Monitoring Report to summarise the previous 12 months of data;
- An LSST Deployment Report will be compiled at the completion of the LSST deployment. This report will include interpretation of the data in terms of characterising the suspended sediment and defining the PSD and settling velocities for background sediment. The TSS/turbidity relationships during each deployment will be presented; and
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Model Validation Baseline Monitoring Programme.

5 OCEANOGRAPHY BASELINE MONITORING PLAN

5.1 Background

Physical oceanography processes such as waves and currents are largely responsible for sediment movement in the STB (Hadfield & Macdonald, 2015). A number of studies were undertaken during the IA development phase and are summarised within this background section.

The STB is classed as a high-energy wave environment, where wave measurements at the 50 m depth contour routinely recorded significant wave heights in excess of 4 m and up to a maximum of 7.1 m. Significant wave heights greater than 2 m mainly arrive from the south to south-southeast or from the southwest to west-southwest sectors (MacDonald *et al*., 2012) with wave height decreasing with proximity to the coast.

ADCPs deployed on the seabed at various locations throughout the STB have shown that tides and winds are the main contributors to water movement here. Tidal currents account for 40 - 78% of measured currents, with wind driven currents accounting for the remainder. Current speeds during peak ebb and flood flows range from 0.13 ms^{-1} and 0.25 ms^{-1} (M2 tides), with tidal speeds further influenced by spring (higher speed) and neap tides (lower speed) (MacDonald *et al*., 2012).

Within the STB, west and southeast winds have the most influence on currents, where moderate to strong winds can increase current speed as well as alter current direction.

Due to the high energy environment in the STB, the water column is generally well mixed, with small vertical differences in temperature and salinity. Although slight, a temperature gradient exists in the water column with surface waters warmer than those at depth with sea surface temperatures ranging from 13 °C in September to 19 °C in March. Offshore water temperatures are slightly cooler than those inshore with less pronounced seasonal variations. Salinity levels are typically around 35 psu; however, lower salinity levels are likely to occur in close proximity to major rivers, such as Patea, Waitotara and Whanganui.

There is the potential that iron sand extraction could have the following effects on physical oceanography processes in the STB:

- Minor effects on physical driver of waves by refracting (bending the wave direction) and shoaling (changing the wave height) as the waves pass over the modified seabed (pits and mounds created by iron sand extraction); and
- Localised effects on currents through the formation of site specific features several kilometres long as a result of interactions with the pits and mounds.

The Oceanography Baseline Monitoring Programme has been developed with these potential operational effects in mind.

5.2 Objectives

The objectives of the oceanography monitoring programme are to:

- Provide a baseline assessment of coastal processes and bathymetry in the STB against which potential impacts from iron sand extraction can be measured;

- Provide data to inform the Model Validation Baseline Monitoring Programme; and

- Provide a long-term data set of oceanographic data within the STB.

5.3 Methods

The key component of this baseline monitoring programme is the deployment of ADCP and AWAC units at selected locations both within and inshore of the Project Area. These deployments will inform the Model Validation Baseline Monitoring Programme (**Section 4**). In addition, seabed bathymetry will also be assessed under this baseline monitoring programme.

5.3.1 Deployment Locations

ADCP and AWAC meters will be deployed at locations within and surrounding the Project Area during the two years before iron sand extraction commences. The mooring locations that will be utilised for deployment of the ADCP and AWAC are shown in **Figure 4**.

5.3.2 Deployment Methodology

The ACDP and AWAC instruments will be housed in a customised fabricated frame that can be easily deployed and retrieved by a surface vessel, or if necessary by divers. A transponder will be attached to the instrument frame to assist with re-location. Ideally the instruments will be located with/near-to existing mooring structures that will have been deployed for other monitoring instrumentation as part of the baseline monitoring programme; however, not all of these locations may be suitable for the ADCP/AWAC meters.

Each instrument will have a ground line, made from positively buoyant rope material, which is stretched between the mooring weight/anchor and the instrument frame, approximately 1.5 times the water depth in length. In the event that the surface marker float becomes detached from the mooring weight/anchor line (such as in a large storm event, or as a result of intentional vandalism) the ground line could be dragged up using a grapnel allowing the retrieval of the instrument.

The ADCP/AWAC meters will be deployed continuously during the two year baseline monitoring period and will be retrieved every three-months to download the data and replace the batteries. This data will then provide an understanding of the seasonality within the oceanographic conditions of the STB prior to the Project commencing.

The data gathered as part of the baseline oceanography monitoring programme will be fed into the OSPM and will contribute to the long-term data set for the oceanographic conditions within the STB.

Following the completion of each deployment period the instruments will be retrieved and the data downloaded. The instruments and batteries will be checked, tested and replaced if necessary and will be sealed back up and programmed for the next deployment period. All data that is downloaded from the instruments will be backed up to suitably secure servers and then processed and analysed by trained and experienced scientists.

5.4 Seabed Bathymetry

The bathymetry of the seabed has a distinct influence on the water currents and waves that move past/over it, particularly for waves as the water depth decrease. Iron sand extraction is likely to leave notable pits and mounds in the seabed once iron sand extraction activities commence.

Seabed bathymetry in the Project Area and surrounds will be surveyed twice (annually) during the baseline monitoring programme. This will provide a baseline seabed bathymetry database against which comparisons can be made once iron sand extraction commences.

Bathymetry surveys will be undertaken utilising multi-beam sonar, ensuring that suitable overlap of passes occurs so that no significant seabed features are missed. The sonar units will be deployed from surface vessels using hull-mounted arrays, and will be suitably tested and calibrated. All imagery collected will be processed by trained and experienced personnel, producing geo-rectified images of the seabed so the plots can be imported into GIS software.

5.5 Reporting

The following reports will be generated for the Oceanography Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data;
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Oceanography Baseline Monitoring Programme.

6 PRIMARY PRODUCTIVITY BASELINE MONITORING PLAN

6.1 Background

The STB/Western Cook Strait is one of the most biologically productive coastal regions in New Zealand. The two main types of primary producers in this area include:

- Phytoplankton - occur in the water column; and
- Macroalgae - generally occur in relatively small areas that are relatively close to the shore and on hard substrate such as rocky reefs, cobbles and shell debris.

These organisms form the base of the food chain and use sunlight to synthesis organic compounds (via photosynthesis) and provide key energy sources to the STB ecosystem. For example, animals living in or on the seabed rely on energy from:

- Particulate and dissolved organic matter from phytoplankton in the water column, which sinks to and/or is otherwise incorporated into the sediments (detrital flux);
- detritus (particulate organic matter) from seaweed settling onto the seabed;
- organic matter coming from rivers, and/or;
- animals on/in the seabed taking food from the water column.

The primary production in the highly dynamic STB region is strongly influenced by drivers such as light and nutrient availability as well as grazing by zooplankton. Many studies consider nutrients to be the main limitation on primary production rather than light availability (Bradford *et al*., 1986; Zeldis *et al*., 2013).

Iron sand extraction will release sediments into the water column which will temporarily affect the optical properties of the water, specifically its clarity and colour (Pinkerton & Gall, 2015; Cahoon *et al*., 2015). The propagation and dispersal of the sediment plume derived from extraction activities will result in absorption and scattering of light in the water column, reducing available light for primary producers with subsequent flow on effects to fish and marine mammals. Elevated turbidity/SSC could also reduce available light reaching the seabed. Increased sedimentation rates (as the plume settles) could also smother primary producers and reduce productivity.

However, the STB ecosystem is subject to regular storm-related disturbance, and biological assemblages have become accustomed to such disturbance and sedimentation; therefore, it is likely that primary producer communities will be tolerant to intermittent elevations in SSC.

The Primary Productivity Monitoring Programme has been designed with these predicted effects in mind and has also incorporated the recommendations from the joint witness statements that were produced during the 2014 EPA hearing. Where, experts agreed that wide natural temporal and spatial variations in the abundance of microphytobenthos would severely limit the statistical power to detect any changes between baseline and operational monitoring.

6.2 Objective

The objective of the Primary Productivity Baseline Monitoring Programme is to provide a baseline assessment of primary productivity in the STB against which potential impacts from iron sand extraction can be measured during the EMMP.

The Primary Productivity Baseline Monitoring Programme does not address macroalgae which is covered in **Section 9**.

The Primary Productivity Baseline Monitoring Programme will focus on measuring the parameters outlined in **Table 6**.

Table 6: Primary productivity baseline monitoring parameters

Sample type	Parameters measured
Phytoplankton*	Chlorophyll-a, phytoplankton community composition (taxonomic identification and enumeration)
Micro-zooplankton*	Micro-zooplankton (zooplankton <200 µM), community composition (taxonomic identification and enumeration)
Microphytobenthos***	Chlorophyll-a of surficial benthic sediments
Light availability**	PAR loggers
Turbidity*	NTU loggers
Nutrients*	TP, TP, DRP, DRSi, NO3, NO2, NH4

** Samples for these monitoring criteria are listed here under primary productivity monitoring but would be collected as part of the Water Quality and Sedimentation Baseline Monitoring Programme.*
*** PAR measurements would be collected during the synoptic surveys outlined in the Water Quality and Sedimentation Baseline Monitoring Programme (via CTD) but longer term PAR sensor deployments would be undertaken as part of the Primary Productivity Baseline Monitoring Programme.*
*** Samples for microphytobenthos (benthic microalgae) are listed here under primary productivity monitoring but would be collected as part of the benthic sediment monitoring (**Section 10**).

6.3 Methodology

The Primary Productivity Baseline Monitoring Programme is summarised in **Table 7**. It is important to note that many of these parameters will be sampled during the Water Quality and Sedimentation and Subtidal Benthos Baseline Monitoring Programmes (see **Section 3** and **Section 8**). In the large part the sampling sites and sampling schedule for this baseline monitoring programme will follow that of the Water Quality and Sedimentation Baseline Monitoring Programme to ensure a full correlation of data.

To estimate the standing stock of phytoplankton in the water column measurements of chlorophyll-a (fluorescence), light (PAR) and turbidity (NTU) will be recorded at various sites across the STB. Water samples will be analysed for chlorophyll-a content, nutrients and SSC (via laboratory analyses), phytoplankton and micro-zooplankton community composition (via taxonomic identification and enumeration), with simultaneous optical recordings of chlorophyll-a, light and turbidity along depth profiles. Modelling methodology will be used to extrapolate the productivity estimates from these sampling sites to a background productivity estimate for the entire STB.

6.4 Sampling Design, Techniques and Scheduling

A BAG sampling design will be utilised in the Primary Productivity Baseline Monitoring Programme, the same as that used in the Water Quality and Sedimentation Baseline Monitoring Programme. The proposed sampling stations are indicated in **Figure 3**.

Field sampling techniques for the collection of water samples are detailed in **Section 3** while those for benthic sampling are detailed in **Section 8**.

The timing and frequency of sampling events is outlined in **Table 7** for the Primary Productivity Baseline Monitoring Programme. These surveys will be undertaken in conjunction with the water quality and sedimentation baseline monitoring programme.

Table 7: Primary Productivity Baseline Monitoring Programme

Scope	Sites	Frequency of Sampling
Fixed meters for Chl-a, PAR, turbidity	Fixed moorings at 5 locations, with sensors near the surface (~5m) and near seabed (~1m above seabed). Monthly servicing/download at time of water quality synoptic surveys.	Continuous monitoring for 2 years prior to beginning of extraction activities. Monthly servicing/download at time of water quality synoptic surveys.
Water column phytoplankton, micro-zooplankton, nutrients and turbidity.	Water quality monitoring stations as detailed in **Section 3**.	Monthly sampling for 2 years prior to beginning of activities.
Synoptic profiling surveys (Turbidity, Chl-a PAR, salinity, temperature, depth).	As part of water quality sampling at stations along transects extending away from extraction areas, as detailed in **Figure 3**.	Monthly surveys for 2 years prior to beginning of activities.

6.5 Analysis

Laboratory analysis of water samples will follow the protocol detailed in **Section 3**.

Primary productivity results will be statistically analysed using the methods outlined in the Water Quality and Sedimentation Baseline Monitoring Programme (see **Section 3**).

6.6 Reporting

The following reports will be generated for the Primary Productivity Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Monthly Monitoring Report to summarise the findings of the monthly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data;
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Primary Productivity Baseline Monitoring Programme.

6.7 Community Involvement

Due to the strict health and safety regulations surrounding working aboard vessels in the open ocean it is difficult to safely involve local community members in the sample collection or physical monitoring. A synthesis of findings from the primary production monitoring programme will be presented to the community periodically in accordance with TTR's ongoing commitment to stakeholder engagement and community meetings.

7 ZOOPLANKTON BASELINE MONITORING PLAN

7.1 Background

Zooplankton are microscopic animals which typically inhabit surface waters and play a critical role in marine food webs, and are the link between primary producers and many other marine fauna (James, 2016). Zooplankton range in size from single celled protozoa to large species of krill, and also include larval crabs, molluscs, and fish. Zooplankton can be divided into three size groups: micro-zooplankton (<200 µm), meso-zooplankton (0.2 – 20 mm) and macro-zooplankton (>20 mm). Zooplankton distribution is influenced by many factors including oceanic upwelling of nutrient-rich water, tidal mixing, riverine discharges, coastal processes and the abundance and distribution of phytoplankton and predators.

The STB region is considered to be very productive, with zooplankton biomass estimates being among the highest recorded for coastal New Zealand (MacDiarmid *et al*., 2013). The STB is influenced by the D'Urville Current and upwelling from the Kahurangi Shoals which introduces cold nutrient rich waters to the region. The nutrients from these sources drive primary production as water moves around the top western side of the South Island and into the STB where, other nutrient sources (including Cook Strait) contribute to a further increase in primary production. As the highly productive upwelling plumes from Kahurangi Shoals develop, a concurrent increase in zooplankton biomass occurs (James & Wilkinson, 1988). These upwelling events are also thought to be important for the squid aggregations which occur in the lower Taranaki Bight (James, 2016), and the blue whale foraging grounds in this region (Torres *et al*., 2015). Zooplankton distribution predominantly depends on the prevailing currents, advective processes, and in-situ primary production; hence zooplankton communities can be highly transient.

Some meso-zooplankton sampling was undertaken in the STB in the 1970s and 1980s (Battaerd, 1983; Bradford, 1977, 1978, 1980; Bradford *et al*., 1993). However, this work was conducted at least 20 years ago, and was mostly well offshore. This work also lacked estimates of zooplankton biomass for the whole water column, which are important components of ecosystem models (MacDiarmid *et al*., 2013). To address this information gap, TTR commissioned NIWA to study zooplankton communities in the region predicted to be impacted by a sediment plume from the iron sand extraction. Zooplankton was sampled from the sea surface to just above the sea floor at 19 stations along two transects which ran approximately east-west and north-south through the centre of the proposed extraction area (MacDiarmid *et al*., 2015). Sampling took place in February 2015 and, while this study is a snap shot in time, James (2016) notes the key findings of this study as follows:

- There was no obvious pattern in zooplankton biomass inshore-offshore but highest biomass was found over the Patea Shoals and east towards Whanganui;
- Copepods dominated most stations sampled except salps and juvenile euphausiids which dominated the stations with highest biomass. Most of the copepods were omnivores and dominated by Oithona and Paracalanus; and
- The community was typical of nearshore waters and, as would be expected, was dominated by neritic or coastal species.

Zooplankton can be affected by high levels of suspended sediments through the clogging of respiratory surfaces and/or feeding apparatus as well as impair prey detection (Arendt *et al*. 2011). Such potential impacts have been considered in the development of this Zooplankton Baseline Monitoring Programme.

7.2 Monitoring Objectives

The objectives of the Zooplankton Baseline Monitoring Programme are to:

- Provide a baseline assessment of zooplankton (biomass, abundance and diversity) in the STB against which potential impacts from iron sand extraction can be measured; and

- Provide a baseline assessment of water colour and clarity in the STB against which potential impacts from iron sand extraction can be measured

7.3 Sampling Design

The sampling design utilises the BAG sampling approach to monitor along transects radiating away from the Project Area.

Baseline monitoring will be undertaken quarterly at locations as shown in **Figure 3** and will align with sampling for other water column parameters as discussed in the Water Quality and Sedimentation Baseline Monitoring Programme (see **Section 3**). This design is flexible to allow for changes to the monitoring programme over time based on results and recommendations from the TRG.

7.4 Field Sampling Techniques

The following subsections detail the approach that will be utilised during field sampling of zooplankton, water colour, and water clarity.

7.4.1 Zooplankton

Zooplankton will be sampled from the sea surface to just above the sea floor using a 57 cm conical net with 200 µm mesh known as "The Heron" net (or similar). The PVC cod-end of the net will have a removable lower section with window meshes to enhance water filtration through the net. One zooplankton sample will be collected at 32 stations along transects surrounding the Project Area. At each station the water depth will be noted and the appropriate length of hauling rope (~2-3 m short of the seafloor depth) will be flaked onto the deck. This is to ensure the net does not make contact with the seafloor at the full extent of its vertical drop.

Prior to each deployment once the vessel is stationary, the net choking rope will be fully eased to ensure the mouth of the net is not restricted. The net will be cast by hand from the vessel and allowed to free-fall to the desired depth with no restriction on the hauling rope. Once the required depth is reached, the hauling rope will become taut closing off the choking rope to secure and prevent any further zooplankton entering the net sampling. At this point the net will be hauled to the surface.

On the vessel deck the net will be held vertically and then rinsed with filtered seawater (30 µm) directed towards the cod-end to ensure any zooplankton trapped on the upper net are forced to the cod-end. Contents of the cod-end will then be tipped into a bucket and any large jellyfish and/or salps removed from the sample which will be transferred into a sample container via a 200 µm filter funnel to remove excess water. Approximately 100 ml of concentrated formaldehyde will be added to each sample jar along with a label, and this will then be topped up with filtered seawater to ensure a preservative of a 4% formalin solution.

7.4.2 Water colour and clarity

At each sampling station the surface water colour will be determined by matching it to standard Munsell colour cards (Davies-Colley, 1997). This will always be done on the shaded side of the vessel to exclude glare.

At each station the water clarity in the vertical direction will be determined by deploying a Secchi disc on a measured tape. The depth at which the disc disappears from view will be recorded.

7.5 Laboratory Analysis

Each preserved zooplankton sample will be split in two by volume using a standard plankton splitter. One half of the original sample will undergo fractionated biomass analysis by pouring the sample through a tower of stacked pre-weighed filters consisting of three mesh sizes: 1,000 µm, 500 µm and 200 µm. Each pre-weighed filter will measure 70 mm in diameter and range from 4-5 g in weight. Fractionated wet weights will be determined by blotting the samples and weighing with the filters to four decimal places on a precision balance. Dry weights will be derived after drying samples on filters in an appropriate laboratory oven for 24 hours at 60ºC and reweighing to a constant weight.

The second half of each zooplankton sample will undergo identification and enumeration by an experienced zooplankton taxonomist. The sample will then be drained through a 100 µm sieve to remove the formalin in seawater, which will be retained to re-preserve the sample after use. The sample will then be washed in tap water to remove any remaining traces of formalin, and then re-suspended in tap water. This re-suspended sample will be split, using a plankton splitter in order to get a manageable sized sample for counting. The split will be recorded and the unused sample placed back into the original container with the retained formalin. The sub-sample for analysis will be placed into a sorting tray, and individuals will be identified and counted.

7.6 Statistical Analysis

7.6.1 Distribution plots

Distribution plots of zooplankton communities will be produced using Geographic Information System (**GIS**) ArcMap to provide visual summaries of zooplankton biomass (wet and dry weight); these will be shown as bar graphs overlaid on GIS maps of the STB, and broad taxonomic numerical composition of zooplankton samples (shown as pie graphs overlain on GIS maps). Munsell-scale surface water colour and water clarity will be plotted with average zooplankton biomass and taxonomic composition for each site. In addition water quality parameters which can affect zooplankton distribution and abundance, such as chlorophyll-a concentration, PAR and suspended sediment concentrations will be plotted along with the zooplankton data.

7.6.2 Univariate and Mulitvariate Statistics

Wet and dry weights of zooplankton samples will be compared among sample locations with regards to their range, absolute highest and lowest values and averages (±SE). Zooplankton community structures will be analysed using standard univariate statistical indices – Margalef's species richness (d), Shannon Wiener diversity index (H'), Simpson's dominance index (D) and Pielou's evenness index (J'). The relative representation of different functional guilds will be examined and taxa contributing most to the biomass at various sites will be identified as well as any taxa related distributional patterns.

Non-Multidimensional Scaling (**nMDS**) plots, cluster analysis and analysis of similarity tests (**ANOSIM**) will be used to identify differences/similarities in the assemblage of zooplankton between all sampling locations. Differences identified from the ANOSIM procedure will be further investigated using permutational multivariate analysis of variance (**PERMANOVA**). Models will be run to examine the effects of location on zooplankton community composition.

To determine which taxa are contributing most to, or are most responsible for, any significant differences detected using the ANOSIM, the SIMPER procedure will be performed. SIMPER analysis determines the contribution that each species/taxa makes to the average similarity of a group of samples.

Relationships between zooplankton assemblages and the environmental data will be examined using distance based linear models (**DISTLM**). These will investigate how much variation in community structure is explained by each (environmental) variable and will be used to identify key drivers in community structure.

7.7 Timing and Frequency

Quarterly baseline zooplankton surveys will be undertaken during the Zooplankton Baseline Monitoring Programme. Note that the zooplankton sampling to date in the STB has only been done over the summer months; quarterly sampling is proposed here as this will provide an understanding of seasonal influences on zooplankton communities. As such the timing and frequency of these surveys will allow for valuable seasonal and temporal (inter-annual and intra-annual) comparisons which will provide greater insight into zooplankton communities in the STB.

Sampling frequency will be aligned with the Water Quality and Sedimentation Baseline Monitoring Programme to maximise efficiency. The proposed zooplankton monitoring schedule is provided in **Table 8**.

Table 8: Schedule for zooplankton sampling

Location	Site	Frequency
Transects surrounding the Project Area	32 sample locations along the transects	Quarterly surveys over two years prior to extraction activities.

7.8 Reporting

The following reports will be generated for the Zooplankton Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the monthly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data;
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Zooplankton Baseline Monitoring Programme.

7.9 Community Involvement

Due to the HSE requirements for offshore field staff it is difficult to easily involve members of the local iwi/hapu/community in the zooplankton sampling activities. TTR will facilitate local meetings and community presentations to present baseline monitoring results as part of the community meetings. The presentations will provide an educational component of what zooplankton communities exist within the STB and will be conveyed in simple and effectively manner, such as including videos of how and where the monitoring is taking place.

8 SUBTIDAL BENTHOS BASELINE MONITORING PLAN

8.1 Background

Subtidal benthos represents a large component of marine biodiversity and ecosystem productivity. It consists of two components: infauna - aquatic animals that live within the sediments of the seabed, and epifauna (also called epibenthos) which generally live on the surface of the sediment.

Biota living within, or on, the sediment are commonly classified according to their size into; macrofauna (animals retained on a 0.5 or 1 mm mesh size) and meiofauna (animals 63 – 500 µm). The vast majority (95%) of the benthic biomass of soft-sediments of the STB is comprised of macroinvertebrates and most live in the upper sediments (i.e. to a depth of ~10 cm) (Anderson *et al*., 2013; Beaumont *et al*., 2013).

It is predicted that iron sand extraction will affect the soft-bottom assemblages within the STB either directly via removal during sediment extraction and smothering from disturbed or deposited sediments, or indirectly through changes in sediment characteristics following iron sand extraction. The STB is subject to regular storm-related disturbance, and benthic assemblages here have adapted to disturbance and sedimentation events. As a result it is considered that benthic and epifaunal communities will have a certain degree of tolerance of intermittent elevations in SSC and deposition rates (Beaumont *et al*., 2013; Anderson *et al*., 2013).

The Subtidal Benthos Baseline Monitoring Programme has been designed with these potential impacts in mind.

8.2 Objectives

The objectives of the Subtidal Benthos Baseline Monitoring Programme are to:

- Provide a baseline assessment of infaunal and epifaunal communities (abundance and diversity) in the STB against which potential impacts from iron sand extraction can be measured; and
- Provide a baseline assessment of sediment characteristics (sediment grain size, redox potential (**ORP**) and pH) in the STB against which potential impacts from iron sand extraction can be measured.

8.3 Benthic Environmental Indicators

Environmental indicators are useful tools in assessing ecosystem functional and structural integrity. Useful indicators of the health of the benthic environment are listed below and will also be used during the Subtidal Benthos Baseline Monitoring Programme.

8.3.1 Taxa diversity and abundance

These parameters provide an important baseline for ecosystem health. Having a robust set of baseline data will enable comparisons between baseline monitoring data and operational monitoring data to provide an important measure of project-related impacts once iron sand extraction activities commence.

The use of diversity and abundance as indicators would require the sorting and enumeration of benthic fauna from samples to the taxonomic level of ‘Family’. The use of the ‘Family’ level of taxonomic resolution is considered sufficient to identify differences in community structure through multivariate analyses in shallow water benthic assemblages and identification to this higher level (rather than to ‘genus’ level) reduces the time required to achieve a result from each monitoring event.

8.3.2 Faunal indicators

Marine sediments in the STB are characterised by only moderate biodiversity, and are dominated by polychaete worms. Baseline monitoring will quantify the proportion of the different feeding guilds (i.e. filter feeders, deposit feeders, scavengers etc.) present in and around the Project Area. Analysis of faunal guilds will be based on ‘Family’ level of identification, and hence may be a less rigorous indicator than if species are identified to a higher level, but it will still be sufficient to indicate the nature of broad changes in community structure once iron sand extraction commences.

8.3.3 Benthic Microalgae

Benthic microalgae are regarded as important primary producers in shallow water marine ecosystems, where the taxonomy and ecology of benthic microalgae are distinct from those of the phytoplankton (Cahoon & Safi, 2002). Replicate sediment samples will be collected at each of the benthic monitoring stations (**Figure 2**) and will be analysed for Chlorophyll-a, which is a proxy for micro-phytobenthos.

8.3.4 Sediment characteristics

The physical characteristics of sediment play an important factor in determining the structure of benthic assemblages (Brown & McLachlan, 1990). Understanding the sediment characteristics prior to iron sand extraction is therefore important as sediment PSD is predicted to change as a result of iron sand extraction activities. The use of this indicator will be achieved by collecting sediment samples in parallel with benthic samples and analysis of the particle size distributions.

8.3.5 REDOX potential and pH

These physical characteristics will also be measured as they give an indication of the oxic state of the marine sediments which can influence the distribution of infaunal communities which require oxygen to survive.

8.3.6 Total organic carbon (TOC)

Flux of carbon to the sediment has been shown to influence the infauna/epifauna communities in similar marine environments to those found in the STB. Increased organic matter provides greater food sources for deposit feeding and scavenging taxa on and in the sediments; however, if levels of organic matter are too high they can impact on the oxygen levels within the sediment, as they utilise oxygen during the decay process. Baseline TOC will be measured as part of the Subtidal Benthos Baseline Monitoring Programme.

8.3.7 Total free sulphide (TFS)

This indicator provides a further measure of the reductive/oxidative state of the seabed sediments, and is used widely in environmental monitoring around marine industrial facilities such as fish-farms, where it has shown predictable relationships with seabed health and infauna community assemblage (Keeley *et al*., 2011). For this reason background levels of TFS will provide important baseline data.

8.3.8 Metals

Chemical contaminants are largely contained within the finest sediment fractions, with metals in particular adsorbing onto the surface of these smallest particles. Contaminants in sediments collected within the STB were examined by Vopel *et al*. (2013) who found that the majority of chemicals were at very low concentrations. Exceptions to this were the metals cadmium, nickel and copper, which exceeded or approached the ANZECC guideline levels. Physical disturbance of the sediments during iron sand extraction could release these metals to the water column and their increased concentrations (if bioavailable) could be detrimental to the health of benthic organisms and influence the community assemblage. A more thorough understanding of the background levels of metals in STB sediment will be useful against which potential project-related impacts can be gauged.

8.4 Methodology Overview

The Subtidal Benthos Baseline Monitoring Programme will be undertaken for a period of two years prior to commencement of iron sand extraction. Sampling will be undertaken quarterly to take into account any seasonality that may exist within the STB. The aim of the baseline phase is to confirm that the sampling sites chosen are suitable for monitoring, to collect baseline data on the soft-bottom benthos within the Project Area and surrounds and to gain an understanding of the seasonality that exists among subtidal benthos in the STB.

8.5 Sampling Locations

The benthic monitoring will be undertaken within the Project Area, as well as at a series of sites that follow a distance gradient away from the Project Area. The Sediment Plume Model outputs (Hadfield & MacDonald, 2015) were used to select the subtidal benthos sampling locations (**Figure 2**). A BAG sampling approach has been used to locate sample stations along gradients radiating away from the Project Area (both along and across the predicted sediment plume axes). This approach spreads the sample locations along a distance gradient from the Project Area following the predicted path of the sediment plume, where the degree of influence of the extraction plume is expected to change with distance. Sample locations have also been located in the opposite direction to the predicted plumes paths, i.e. in the offshore and alongshore directions.

During baseline monitoring a total of three sample stations will be located within the Project Area (**Figure 2)**. These sample stations have been located in both the rippled sand and worm field areas known to exist here.

8.6 Sampling Design

The BAG sampling design sets a robust foundation against which operational monitoring results can be assessed and this baseline monitoring programme will gather a robust set of data taking into account seasonality that results can be compared with. The sampling design, which will occur each quarter, is summarised in **Table 9**.

Table 9: Subtidal benthos sampling design

Location	Stations	Transects	Replicates	Total Samples (per survey)
Benthic gradient sites (outside the Project Area)	32 stations	1 video transect per station	3 replicate benthic grab samples per station	96 Infauna 96 Phys-chem 32 Video Transects
Operational sites (within the Project Area)	3 stations	1 video transect per station	3 replicate benthic grab samples per station	9 Infauna 9 Phys-chem 3 Video Transects

8.7 Field Sampling approach

Field sampling will be undertaken as detailed below.

8.7.1 Sediment Physico-chemical and Infauna Sampling

Sediment samples for infauna and physico-chemical analyses will be collected using a modified double Van-Veen grab (the 'grab') sampler (or similar) which will be deployed by a winch from a surface vessel. The use of a double grab sampler means that undisturbed sediment physico-chemical samples can be collected from directly alongside the infauna/macrofauna samples in independent buckets, without reducing the volume of either set of samples required. The double Van-Veen has a maximum sample depth of 0.16 m and in harder sand sediments additional weight can be mounted to the grabs frame to ensure sufficient penetration depth to collect the required depth/volume. Each independent bucket within the double-grab has a volume of 10 L of sediment. The upper surfaces of the grab sampler are fitted with 0.5 mm mesh which ensures organisms within the sample are not washed out during ascent from the seabed, but allows water to pass through during descent to reduce the pressure wave ahead of the instrument while it is lowered to the seabed. At each sample station the grab sampler will be deployed three times to collect three separate replicate samples. The water depth and the GPS position of each replicate sample will be recorded to maintain consistency with future surveys.

A replicate grab sample is considered acceptable for analysis if the sample has been landed on-board the surface vessel without undue disturbance, contains the required amount of sediment (and similar volume to all other replicates) and has not been contaminated by anthropogenic sources during descent/ascent. Once confirmed as a success, sediment from the grab sample will be sub-sampled to enable the required analyses to be undertaken.

Infauna samples are collected from the grab using a 13 cm internal diameter core, which is pushed into the sediment to a depth of 50 mm, and the sediment within that core is gently washed over a 0.5 mm sieve to remove some of the finer sediments. The samples will initially be sieved on board the vessel over a 0.5 mm mesh sieve, and the sediment and infauna retained on the sieve, as well as any organisms stuck to/in the sieve mesh will then be washed into a suitable container and preserved with a 70% ethanol solution for transport to the taxonomic laboratory. All infauna samples will be clearly labelled internally and externally with project details, date, location, site and replicate number. Initial survey work by Anderson *et al*. (2013) within the proposed area of operation sampled infauna at three different depths within the sediment and found the greatest majority of organisms were present within the upper 50 mm of the sediments. Continued sampling of infauna/macrofauna in the upper 50 mm will allow some comparisons to be drawn with these earlier studies.

Sediment physico-chemical samples will be collected from three 64 mm internal diameter cores which are simultaneously pushed into the sediment on one side of the second grab bucket. The upper 50 mm of sediment within each core is then distributed into separate sterile sample bags, and chilled for later grain size, total organic-carbon and metals suite analyses. The undisturbed side of the second bucket is then opened and pH and REDOX-ORP probes can be inserted to collect measurements on these parameters. A 5 ml vertical core sample through the upper 50 mm of sediment in this part of the grab is also collected for the analysis of total-free sulphides (TFS, hydrogen sulphide). The sample is capped to prevent oxidisation changing the TFS levels, and then chilled. NOTE: TFS samples must be analysed at the laboratory within 24 hours of sample collection.

Sediment samples collected for analysis of grain size, organic carbon and heavy metals will be stored in sterile sample containers/bags with external labels showing project name, sampling date, site and replicate number as well as the specific analyses required. Sealed sample bags will be immediately placed in a chilled environment (cooler bin or chiller) following collection, and stored below 4°C until returning to the onshore dispatch facility, where they will be kept in a chilled environment.

The benthic microalgae or microphytobenthos will be determined at each monitoring station by collecting triplicate core samples. A 50 mm diameter core sample will be collected from each grab sample and the top 5 mm of surficial sediment will be collected and analysed for Chlorophyll-*a* concentrations. The amount of benthic microalgal production is considered to be highly dependent on what the light conditions were in the preceding few days. Therefore, to interpret the sample results an understanding of the likely seabed light levels were, which will be undertaken through a combination of satellite data and the light meters that will be in-situ at the fixed mooring stations (**Figure 4**).

Samples will subsequently be dispatched packed with suitable cooling to an IANZ/NATA accredited laboratory, accompanied by a Chain of Custody document.

8.7.2 Epifauna Sampling

A remote drop camera and video will be used to identify epibenthic assemblages, as well as recording seabed morphology at each sample station. The drop camera, which records high-definition still images at each sampling site, yields high quality photographs suitable for photo-quadrat analysis, including quantitative analyses, from low light and low visibility conditions. The video camera collects high-definition video footage of the epifauna, macroalgae, mobile taxa (fish) and visible infauna.

During sampling the camera system will be lowered to the seabed at the start of each transect situated approximately 50 cm above the substratum as the vessel drifts with the current (at approximately 0.5 – 1 km/hr) until the end of each transect. Positioning the camera 50 cm above the seabed will provide a photo quadrat size of ~ 40 x 65 cm, but achieving this is reliant on near-seabed visibility being sufficient to allow clear images at this distance. Fifteen replicate photo quadrats will be collected per transect, with total transect length being approximately 100 m.

GPS positions of each sample site, and GPS tracks for each transect will be recorded to facilitate their relocation in future surveys.

8.7.3 Field Equipment

Field equipment would comprise of the following (or equivalent):

8.7.3.1 Benthic Grabs

Benthic assemblages and sediment size will be sampled using a stainless steel grab sampler such as ponar, Van-Veen, Modified Double Van-Veen or HAPS. Given the sandy nature of the sediments at the proposed sampling areas, the grab sampler will need to be weighted as necessary to enable sufficient penetration depth to ensure that the required depth and volume of sediments are collected. These types of samplers are suited to the sediment and water depths expected in the Project Area.

8.7.3.2 Remote Drop Camera and video surveys

A remote drop camera will be used to identify epibenthic assemblages and seabed morphology at each location. The drop camera, which takes a high-definition video and high resolution still images, will consist of either separate units for still and video imagery, or an integrated camera which can collect both simultaneously. In order to collect representative photo-quadrat images, the still camera will point downwards and will automatically adjust focus and exposure to suit conditions on the seafloor.

Video footage is collected from a camera with suitable high intensity video lighting so that morphological features of the seabed can be easily distinguished. This video camera may be best configured slightly forward facing to allow better appreciation of the topography of the seabed being filmed. The camera system will feed a live picture back to the surface vessel via an umbilical to allow scientists on-board to assess and make notes on seabed features, and capture extra still images or adjust lighting as necessary. A forward facing video camera system will also be fitted with scaling lasers to allow some estimation of the size of organisms or features to be made. Due to the exposed nature of the proposed site the camera system and frame will contain adequate weight to give it suitable stability in all working conditions likely to be experienced.

8.8 Laboratory Analyses

Laboratory analysis will comprise of the following (or equivalent) sub-sections.

8.8.1 Infauna Analysis

Biological samples will be sorted, identified and counted by experienced taxonomists. Animals will be identified to a minimum of 'Family' level and separated into major groups; polychaetes, molluscs, crustaceans and echinoderms (for example). For groups where further identification would require a large expenditure of time (e.g. oligochaetes) or taxonomic status is insufficient to achieve a finer level of identification (e.g. anemones), identification would be to a lower resolution such as Class or Sub Order.

8.8.2 Sediment Physico-chemistry

Sediment samples for grain size, total organic content, metals and total free sulphides would be dispatched directly from the shore base on the day of collection for analysis by a NATA/IANZ accredited laboratory, accompanied with a Chain of Custody document.

8.8.3 Sediment Grain Size

The grain size distribution of sediment samples collected is quantified using either Laser Particle sizing, or more traditional stacked sieved methods (such as AS 1289.3.6.11-1995). Laser particle sizing (such as using a Beckman Coulter LS13 320 Dual Wavelength Laser Particle Size Analyser) is a more efficient, more accurate method that allows better resolution and repeatability than the stacked sieve method. However, the laser particle analysis is not suitable for samples with significant proportions of coarse grained sediments (>1.6 mm) as the initial sieving step associated with this analysis removes these larger particles. Either technique will be used as determined suitable by sediment characteristics.

8.8.4 Total Organic Carbon

Organic content of sediment samples is assessed by analysing for total organic carbon content. Samples are air dried in the laboratory and sieved to remove particles greater than 2 mm. Samples are then subjected to acid pre-treatment to remove any carbonates present followed by Catalytic Combustion (at 900°C, in presence of O2), separation, and measurement by Thermal Conductivity Detector [Elementar Analyser].

8.8.5 Metals

Initial studies by Vopel *et al.* (2013) investigated a large suite of metals from STB sediments. From this suite Cd, Cr and Ni were identified as exceeding or approaching ANZECC guideline values for marine sediments. A full suite of metals will be assessed from sediment samples during the Subtidal Benthos Baseline Monitoring Programme according to the tiered approach outlined below:

Tier 1: In the laboratory a small subsample of each of the three replicate metals samples from a station is combined into a composite sample. The sample is air dried and sieved to remove particles larger than 2 mm before being subjected to a total recoverable metals digestion method (US EPA method 200.2) utilising a warmed nitric/hydrochloric acid solution and analysis of the resulting elutriate via ICP-MS. If the results of this test return values above ISQG-Low guideline values for any metal this would prompt Tier 2 sampling.

Tier 2: All three individual replicate samples are analysed for the metal/s that were above guideline levels in Tier-1 testing, using the same methodology as Tier-1 (nitric/hydrochloric acid digestion (US EPA 200.2)). Results of this testing will reveal if the elevated metals level was caused by single patch of metals enriched sediments (no further testing required), or if metals were more widely elevated across all replicates (Tier 3 testing prompted).

Tier 3: All three replicate samples are sieved to split off the <63 µm fraction ('fines') from the remainder of the sediments. Both fractions are then tested for the 'bioavailable' metals content (for the metal/s in question) utilising a weaker hydrochloric acid extraction technique. This will reveal both which fraction of the sediment the elevated metals content resides within ('fines' vs 'coarse') and also whether the elevated metal/s (from total recoverable testing) have 'bioavailable' concentrations that still breach guideline levels.

8.8.6 Total Free Sulphides

Sulphide ion concentration will be measured using a suitable sulphide probe (such as an Orion Silver/Sulphide combination electrode) and a calibrated meter. Each 5 ml sediment sample is standardised with a sodium sulphide stock, in a ratio of 1:1 of sample/standard:sulphide anti-oxidant buffer, following the methodology of Wildish *et al*... (1999). The solution will be mixed with the probe to ensure the probe is in contact with the entire sediment sample (Wildish *et al*., 1999).

8.8.7 Redox Potential and Sediment pH

A REDOX/pH meter will be used on board the vessel to obtain measurements of REDOX potential and pH in the sediment within each of the three replicate grab samples collected at each sampling station. Readings will be recorded onto suitable field sheets and later entered into the project database. Data obtained will give an indication of the extent of reducing conditions (e.g. anoxic sediment) which will then be related to the levels of total free-sulphide as well as the composition and abundance of infaunal assemblages.

8.8.8 Analysis of photoquadrat images

Video and photographs collected along each transect will be downloaded to a hard drive for manipulation and analysis. Percentage cover of benthic organisms, macroalgae etc as well as seabed morphology in photo-quadrats will be determined by digitally overlaying a virtual photo-quadrat (scaled to approximately 40 cm x 65 cm) on each captured still image. Each photo-quadrat would be divided into five equal blocks in which ten points would be randomly selected to give a total of 50 points for each photo-quadrat. Software such as Coral Point Count with Excel extensions (CPCe) program (Kohler & Gill, 2006), or similar, would be used to measure the percentage cover of key categories of sediment type, epifauna (such as corals, sponges, ascidians, hydroids, bryozoans, tubeworms and anemones) and macroalgae.

Video footage will be viewed by suitably experienced scientists who will record the presence (and semi-quantitative abundances) of any other organisms observed in, on or just above the seabed, which will further assist in visually characterising the seabed habitats identified in the still images.

8.9 Statistical Analysis

8.9.1 Power Analysis

Baseline data will be used to assess the power of the sample designs proposed to detect ecologically or socially meaningful impacts that may be attributable to future iron sand extraction. The ability of these designs to detect changes will be examined by a suite of methods, potentially including comparisons of confidence limits and determination of power using simulated data (i.e. an effect size likely to reflect the magnitude of an impact) or standard power formulae. Given the complexity of the designs and the fact that impacts are likely to be interpreted through a series of statistically significant interactions, the use of simulated data built around an effect size and assumed variance is the approach favoured at this time.

8.9.2 Distribution plots

Distribution plots of substrate and biological data will be produced using GIS ArcMap to provide visual summaries of substrate and biological features across the sampling sites. Macroinvertebrate data will be plotted to show the distribution of the total number of individuals and species/taxonomic groups in relation to each sample location.

8.9.3 Sediment data analysis

Sediment physico-chemical parameters (pH, hydrogen sulphide, salinity, grain size, total organic carbon and metals) will each be analysed using univariate analysis to examine differences among sample locations (to examine spatial impacts). Where necessary, data will be transformed to fulfil the assumptions of the analysis and post-hoc tests will be performed to examine the directions of significant relationships.

Sediment metal concentrations will also be compared against national sediment quality criteria (i.e. ANZECC, 2000). These commonly used guidelines are based on statistical models of toxicity data for a wide range of contaminants, and aim to predict levels of contaminants in aquatic sediments above which adverse ecological effects may occur. The criteria are defined as Interim Sediment Quality Guideline–Low (ISQG-Low) and –High (ISQG-High) levels, which represent two distinct probability thresholds for possible and probable biological effects respectively. Where values are less than their respective ANZECC ISQG-Low values, there is low risk and no action is required. Exceedances of ANZECC ISQG-High values indicate that the concentration of the contaminant is at a level where significant biological effects are expected to occur. Exceedance of the ISQG-High values suggests that adverse environmental effects are probably already occurring.

8.9.4 Infauna and epifauna data analysis

Univariate analysis will include the calculation of diversity indices (number of taxa, total abundance, Shannon-Wiener diversity, and Pielou evenness) as well as analysing the relative representation of major infaunal groups, including functional groups. Non-Multidimensional Scaling (nMDS) plots, cluster analysis and analysis of similarity tests (ANOSIM) will be used to identify differences/similarities in the assemblage of benthic organisms between all sampling sites. Differences identified from the ANOSIM procedure will be further investigated using permutational multivariate analysis of variance (PERMANOVA). Models will be run to examine the effects of site on macroinvertebrate community composition.

To determine which taxa are contributing most to, or are most responsible for, any significant differences detected using the ANOSIM, the SIMPER procedure will be performed. SIMPER analysis determines the contribution that each species/taxa makes to the average similarity of a group of samples.

Relationships between infauna assemblages and the environmental data will be examined using distance based linear models (DISTLM). These will investigate how much variation in community structure is explained by each predictor (environmental) variable and will be used to identify key drivers in community structure.

8.10 Timing and Frequency

The baseline field surveys will be undertaken quarterly for the two years prior to the commencement of iron sand extraction, to gain suitable data on the baseline levels of all parameters and an indication of the background variation that exists spatially and temporally through the STB. Surveys will aim to be approximately aligned with the mid points of each season, and ongoing rounds of monitoring would aim to take place at approximately the same time of year to allow for consistent temporal comparisons. A review of the monitoring results and methodology will occur at the end of the Subtidal Benthos Baseline Monitoring Programme.

The benthic baseline monitoring programme will be reviewed at the end of the first year by the TRG, to allow suitable revisions to take place that reflect any updated knowledge, understanding and technology or simply based on the monitoring results prior to any iron sand extraction activities commencing.

8.11 Reporting

The following reports will be generated for the Subtidal Benthos Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Subtidal Benthos Baseline Monitoring Programme.

8.12 Quality Assurance

8.12.1 Field Work

For all replicate samples collected, a unique sample code, a record of the GPS position, time, date, depth, sediment type and weather conditions will be recorded on waterproof field sheets. All data will be transcribed into the master project database linked to each unique sample code. GPS positions will be downloaded into excel format then imported into the master database. A photographic record will also be kept for each core sample collected. Core samples will be transferred into suitable sterile sample bags labelled externally with the unique sample code. Hard copies of the original datasheets will be scanned and stored electronically within the master database.

Field data integrity will be checked using a two-person field checklist and chain-of-custody documentation. Internal quality assurance of field sampling operations will include the collection and analysis of duplicate sediment samples collected at several randomly selected stations during each survey. External laboratory quality assurance will include the analysis of blind replicate environmental samples.

8.12.2 Laboratory

All samples will be logged upon receipt from the field on an internal chain of custody and lab management sheet. In the laboratory, a sample sign-in/sign out system is used to track sample status and time required to process each sample.

8.13 Community Involvement

Due to the HSE requirements for offshore field staff it is difficult to easily involve members of the local iwi/hapu/community in the physical benthic sampling activities. TTR will facilitate local meetings and community presentations of baseline monitoring results. The presentations will provide an educational component of what marine life and benthic environments exist within the STB and will be conveyed in simple and effectively manner, such as including videos of how and where the monitoring is taking place.

9 SUBTIDAL AND INTERTIDAL REEF BASELINE MONITORING PLAN

9.1 Background

An assessment of benthic habitats in the STB was conducted during the development of the IA (see Anderson *et al*., 2013). This assessment recorded (broadly) two types of soft sediment habitats, and two types of rocky outcrop habitats (hard rock and mudstone outcrops). The soft sediment habitats and mudstone outcrops were characteristically low in species abundance and diversity, while in contrast, the hard rock outcrops were reported to support abundant and diverse macrobenthic assemblages.

Offshore subtidal reef systems that are recognised as ecologically and scientifically significant in the STB (as described in TRC, 2004) include Four Mile Reef and the North and South Traps (**Figure 5**).

There is only one intertidal reef system of significance inshore of the Project Area that is classified by the TRC as an Area of Significant Conservation Value which is the Waiinu Reef. The Patea Reef, although not listed as having particular significance, does have cultural significance. This large reef is located immediately inshore of the Project Area and hence has been included as part of this baseline monitoring programme. The locations of these important subtidal and intertidal reefs are illustrated in **Figure 5** and **Figure 6** and also include significantly important kaimoana gathering areas identified by local iwi.

Visual surveys of the reef habitats at the North and South Traps were undertaken by TTR in February 2014 by diver and drop camera surveys. These surveys indicated that the North and South Traps were characterised by classic urchin barren communities, with rocky outcrops and ridges dominated by sea urchins (*Evechinus chloroticus*) and low growing red and brown macroalgae; a few isolated *Ecklonia* sporophytes were present and the conspicuous fish species noted included Leatherjackets (*Parika scaber*), Blue Cod (*Parapercis colias*), Red Moki (*Cheilodactylus spectabilis*) and Blue Maomao (*Scorpis violacea*). Unconsolidated seabed sediments at the Traps were generally less than 10 mm thick and were underlain by a hard rock basement.

A bathymetric and video survey of the Traps was also conducted by ASR Ltd. for the TRC to produce habitat maps of the area (**Figure 7**). Similar features were observed, with the addition of patchily dense stands of *Ecklonia radiata.*

No rare or vulnerable ecosystems or threatened species habitat was identified as being present at the North and South Traps. The nature of the seabed and fish communities present suggests that they will be relatively tolerant to SSC elevations from iron sand extraction. The Sediment Plume Model suggests that significant amounts of project-related sediments will not accumulate at the Traps or at any of the other offshore reef systems. These findings have contributed to the design of the Subtidal and Intertidal Reef Baseline Monitoring Programme.

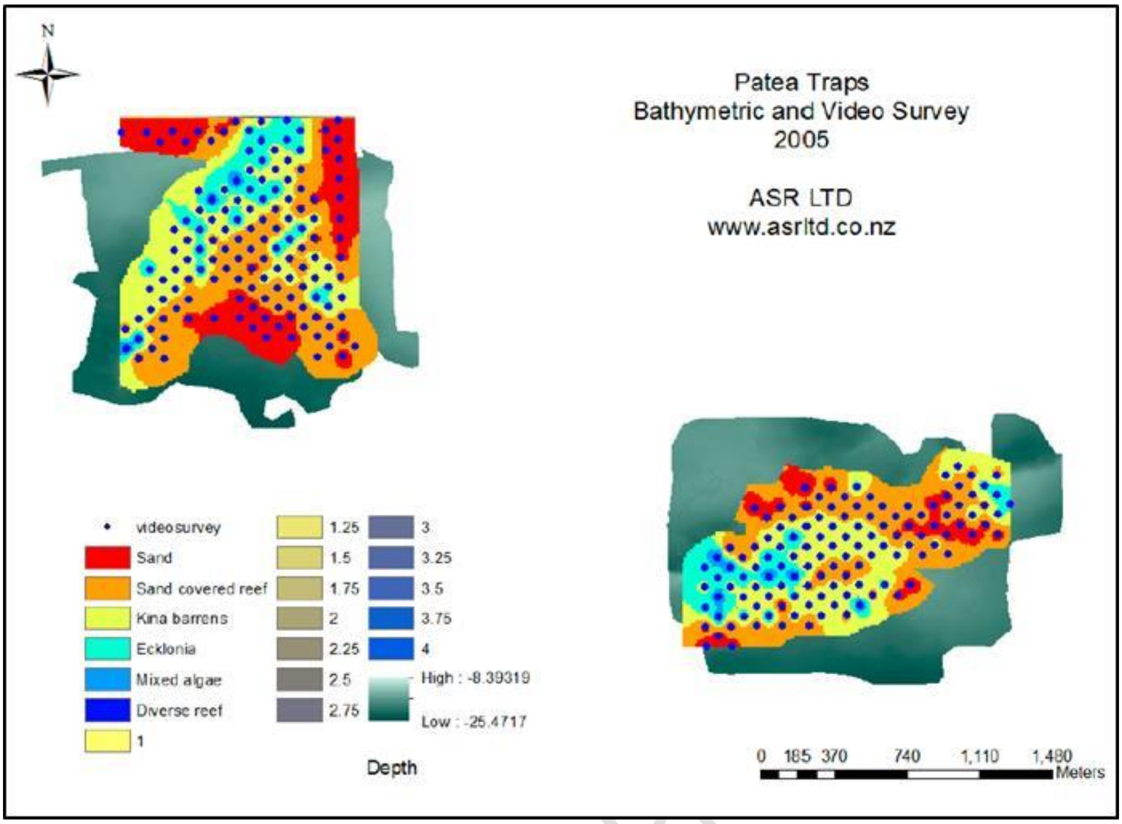

Figure 7 Habitat map of North and South Traps (from ASR, 2005)

9.2 Objectives

The specific objective of the Subtidal and Intertidal Reef Baseline Monitoring Programme is to provide a baseline assessment of subtidal and intertidal reef communities in the STB against which potential impacts from iron sand extraction can be measured.

9.3 Biological Indicators

Biological indicators are useful tools for assessing ecosystem functional and structural integrity. Useful indicators for subtidal and intertidal reef assemblages include:

- Number of taxa and abundance: These parameters provide an indication of ecosystem health. Where a significant decline in the number of taxa (diversity) and/or abundance of individuals compared to the baseline may indicate a potential impact;
- Percentage cover and density of macroalgae: *Ecklonia radiata* is considered to be a key species indicator for potential adverse effects, as it has a recognised role in determining ecosystem attributes. The abundance/density of macroalgae (*Macrocystis sp*. and *Ecklonia sp.*) will be assessed as part of this baseline monitoring project. The density of holdfasts provides a reliable parameter; and
- Habitat type: The major habitat type or percentage cover of each habitat type (e.g. exposed bedrock, cobbles, biogenic rubble, sand, fine sediment/mud etc.) identified in photo-quadrats may change if the subtidal and intertidal reef areas are exposed to changes in sediment deposition. An assessment of the habitat types prior to iron sand extraction will provide a useful comparison for operational monitoring data.

9.4 Methodology

A two year baseline monitoring programme will be implemented, where the aim will be to confirm that the intertidal and subtidal reef sampling sites chosen are suitable for monitoring and to collect baseline data on reef communities. Sampling will be undertaken to assess background spatial and temporal variability across the indices of interest.

Subtidal monitoring will be undertaken at the following locations as illustrated in **Figure 5**:

- North and South Traps;
- Four mile reef;
- Tuteremoana; and
- Grahams Bank.

Intertidal monitoring will be undertaken at the following locations as illustrated in **Figure 6**:

- Waiinu Reef;
- Patea Reef;
- Waihi Reef;
- Puketapu Reef; and
- Opunake Reef.

9.5 Sampling Design

Sampling design for the Subtidal and Intertidal Reefs Baseline Monitoring Programme is outlined in **Table 10**.

Table 10: Subtidal and Intertidal Reef Sampling Design

Area	Locations	Sites	Replicates	Transects	Total Samples (per survey)
Subtidal Reef Sites	North Trap	20	3	3 x video transect per site 3 x diver transects	66
	South Trap	20	3	3 x video transect per site 3 x diver transects	66
	Four Mile Reef	20	3	3 x video transect per site	63
	Grahams Bank	20	3	3 x video transect per site	63
	Tuteremoana	20	3	3 x video transect per site	63
Intertidal Reef sites	Patea Reef	1	25	1 x 50 m transect	25
	Waiinu Reef	1	25	1 x 50 m transect	25
	Waihi Reef	1	25	1 x 50 m transect	25
	Puketapu Reef	1	25	1 x 50 m transect	25
	Opunake Reef	1	25	1 x 50 m transect	25

9.6 Field Sampling Techniques

9.6.1 Intertidal Surveys

9.6.1.1 Sediment inundation patterns on intertidal reefs

Sand inundation along the Taranaki coastline is a regular occurrence along both sandy beaches and intertidal reefs, and is known to be highly variable due to natural processes. To assess the level of sand/fine sediment coverage of intertidal reef areas inshore of the Project Area, high resolution aerial photographs will be captured one per year over the summer period (utilising drone technology or a fixed wing plane) to provide images of the reefs during a spring low tide. These images will be georeferenced to enable calculations of sediment percentage cover to be determined.

Intertidal reef inspections will be undertaken quarterly by appropriately trained and experienced scientists who will walk the reefs and locate areas of sediment cover identified in the aerial image and confirm the approximate sediment grainsize (gravel, coarse sand, fine sand, mud/fine sediment). Photographs and GPS coordinates will be taken at each location so that any patches of sand inundation can be monitored through time.

Intertidal inspections over the summer period will be timed to coincide with the aerial photographs to ground truth the images. This ground truthing will be undertaken as soon as practicable (ideally within 1-2 days) of the images being collected during the same spring low tide period.

A further measure of sand coverage on the intertidal reefs will be collected during quadrat surveys, as detailed in the next section.

9.6.1.2 Intertidal ecology

The ecological assemblages at the intertidal reefs will be assessed quarterly by identifying and counting all organisms and marine algae within 25 randomly placed quadrats along a predetermined 50 m transect at the low tide mark. The 50 m transect will be laid parallel to the shore, approximately 0.6 metres above chart datum, and within this transect five 5 m x 3 m blocks will be established. Within each block, 5 random 0.25 m^2 quadrats will be laid on the reef. For each quadrat the percentage cover of algae and encrusting species will be estimated using a grid, while for all other species will be counted. Under boulder biota will be counted where rocks and cobbles are easily overturned.

One transect will be conducted within each of the selected intertidal reefs (**Figure 6**) to enable an estimate of species abundance and diversity. The recording of the sediment/habitat type within each quadrat will provide a semi-quantitative measure of the levels of sand inundation/depletion across the each reef location.

Identification of the taxa within each quadrat will be performed using a standardised key and reference images. This will allow faster and more consistent identification of the taxa that are present. Any new taxa found, or where identification is not certain, will be collected within a suitable sample container and chilled, before being returned to an experienced taxonomist for formal identification.

The methodology for the intertidal quadrat surveys is the same as that used by the TRC, where they currently undertake intertidal reef surveys around the Taranaki coastline. Using a consistent methodology will enable a comparison of data to areas further afield from the Project Area, as well as providing comparisons with TRC data that may already exist around the selected survey locations.

With regards to survey timing, the aim will be to complete each quarterly intertidal survey during the middle portion of each season (dependent on the spring low tide periods), with approximate timing remaining consistent from year to year to allow for consistent temporal comparisons.

9.6.2 Subtidal

9.6.2.1 Sediment inundation/depletion on subtidal reefs

Changes to the coverage of subtidal reefs by sediment will be partially assessed by photo-quadrats during the subtidal ecology surveys (see **Section 9.6.2.2**). But to assess subtidal sediment inundation on a wider scale, sonar surveys will be undertaken.

A fixed survey area will be established around each reef area (defined by GPS coordinates at each corner). Utilising either side-scan sonar (**SSS**) or multi-beam echo sounding (**MBES**) the entire area will be surveyed to produce a map identifying the areas of sand inundation and exposed rock. The maps will be produced using suitable GIS software that will enable sedimentation patterns to be tracked through time (during both baseline and operational monitoring programmes).

9.6.2.2 Subtidal ecology

The ecological assemblages at subtidal reefs will be assessed quarterly via drop-camera photo-quadrats. Twenty stations at each of the subtidal reef sites will be established with three replicate photo-quadrat images collected at each site using a high-resolution digital still camera with suitable high intensity lighting, mounted to a 0.25 m^2 quadrat. The image will be GPS tagged so that the location of the image, and the seabed habitats observed within it, can also be mapped.

The drop camera consists of a high-resolution still camera with auto focussing and exposure adjustment, and high intensity strobes all suited for underwater photography. The camera system is mounted to a frame which can attach to a series of different sized quadrats, with an adjustable distance between the camera system and the quadrat to ensure the entire quadrat is captured in each image. The unit will be deployed from a surface vessel with adequate weight attached to sink at a suitable rate and remain positioned on the seabed in the expected swell/surge conditions found in the STB reef areas. An umbilical cable connecting the camera system to the surface vessel allows real-time viewing of the seabed to ensure images are only captured at the correct moment when mobile sediments or taxa are not obscuring the seabed.

The camera system will be lowered gently to the seabed and once the quadrat is resting on the seabed, and any disturbed sediment has settled or drifted away a clear image will be captured. Each image will be analysed by a suitably trained and experienced scientist who will identify and count all taxa present in the image and record details of macroalgae coverage/density as well as habitat type (mud, sand, gravel, cobble reef, bedrock reef etc.), and any signs of sediment inundation. The surveys will aim to resample the same stations during each survey to allow time series data to be compiled.

9.6.2.3 Video Sampling

A high-definition remote video system with LED lighting and scaling equipment will be lowered to just above the seabed at the reef sites, and held approximately 0.5 m above the seafloor while the surface vessel drifts, or slowly motors along a transect at least 100 m long. The camera will be positioned approximately 0.50 m above the seabed to provide adequate clarity, even in turbid conditions. The video camera is tethered to a surface vessel via an umbilical cable which feeds live footage to the surface where it is recorded.

Video footage will be analysed by suitable trained and experienced scientists to identify and record presence of epifauna species, algal/macroalgal coverage, seabed topography and coverage of sediments on the reef. Habitat and taxa types observed during the tows will be recorded, as well as the locations of features of interest (reefs, conspicuous taxa of interest such as scallops, mussels, crayfish, hydroid colonies etc.) along with the positions of boundaries between different habitat types.

Video sled tows have the advantage of not having the same depth limits as diver video transects, and they can also extend for a longer distance, allowing collection of seabed epibenthic imagery in areas beyond safe diving depths. All video footage will be viewed in real time and recorded so that it can be reviewed later for further confirmation of important observations, and kept securely archived.

GPS tracks of each transect will be recorded to facilitate transect location for comparison with future surveys.

9.6.2.4 Kelp Monitoring

To assess the health of macroalgae communities at the sensitive subtidal reef systems of the North and South Traps a series of permanent transects will be established (in consultation with TRC). At each site, two stainless steel pins will be anchored into the bedrock substrate of the reef 50 m apart. Each pin will be fitted with a high visibility tag marked with a unique identity code specific to each transect (and different for each end of each transect). Small floats will be attached to each pin to allow them to be relocated easily.

During each monitoring round a 50 m transect tape will be stretched between the two pins by SCUBA divers. Density (abundance) and algae taxa richness will be determined by placing four 1 m^2 quadrats at 5 m intervals along the transect line. Within each quadrat the number and identity (species) of each large algal species will be recorded, by counting the number of holdfasts. Where possible the large algae species will be separated into life history stages to track demographic changes over time (i.e. recruits, small plants, large plants, mature plants).

Macroalgae diversity and coverage measurements will be taken by collecting photo-quadrat images every meter along each transect. The photo-quadrat system will utilise a 0.25 m^2 quadrat connected to a high-resolution still camera with high-intensity strobe units to provide suitable lighting for underwater photography. Photo-quadrat images will be analysed onshore on large high resolution screens where algal taxa will be identified to the lowest practicable taxonomic level (preferentially to at least genus level). Evidence of sediment cover will also be recorded.

Representative samples of any new or unknown algal species observed by the divers while collecting photo-quadrats or density quadrat information will be returned to the laboratory and formally identified with the assistance of a trained and experienced taxonomist.

The macroalgae surveys will be undertaken biannually throughout the Subtidal and Intertidal Reef Baseline Monitoring Programme.

9.7 Timing and Frequency

The proposed sampling schedule is summarised in **Table 11.**

Table 11: Sampling frequency for Intertidal and Subtidal Reef Baseline Monitoring

Location	Stations	Frequency of sampling
Subtidal Reef locations – Traps, Four mile reef, Grahams Ban, Tuteremoana. ➢ Drop-camera Quadrats ➢ Epifauna video tows ➢ Diver transects (Traps)	20 stations per reef system for drop camera 3 video transects per reef	Quarterly surveys to be completed for two years prior to extraction activities commencing
Intertidal Reef Locations - Patea, Waiinu, Waiihi, Opunake, Puketapu ➢ Quadrat transect surveys	One transect per reef system	Quarterly surveys to be completed for two years prior to extraction activities commencing
Intertidal Reef locations - Patea, Waiinu, Waiihi, Opunake, Puketapu ➢ Sediment inundation surveys	Single set of aerial images per reef area 4 sand inundation inspections per reef per year	Quarterly surveys to be completed for two years prior to extraction activities commencing. Aerial images to be taken, and ground-truthed, over summer.
Subtidal Reef baseline sediment levels - Traps, Four mile reef, Grahams Ban, Tuteremoana. ➢ Bathymetry survey	Entire coverage around each reef system	Annually

9.8 Reporting

The following reports will be generated for the Subtidal and Intertidal Reef Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Subtidal and Intertidal Reef Baseline Monitoring Programme.

9.9 Data Analysis

9.9.1 Analysis of Photo-quadrats

Videos and photographs will be downloaded to a hard drive for manipulation and analysis. Percentage cover of benthic organisms and seabed morphology in photo-quadrats will be determined by digitally overlaying a virtual photo-quadrat (scaled to approximately 40 cm x 65 cm) on each captured video frame. Each photo-quadrat will be divided into five equal blocks in which ten points will be randomly selected to give a total of 50 points for each photo-quadrat. Software such as Coral Point Count with Excel extensions (CPCe) programme (Kohler & Gill, 2006), will be used to measure the percentage cover of key categories of sediment type and epifauna (such as corals, sponges, ascidians, hydroids, bryozoans, tubeworms and anemones).

9.9.2 Power analysis

Baseline data will be used to assess the power of the sample designs proposed to detect ecologically or socially meaningful impacts that may be attributable to the Project. The ability of these designs to detect changes will be examined by a suite of methods, potentially including comparisons of confidence limits and determination of power using simulated data (i.e. an effect size likely to reflect the magnitude of an impact) or standard power formulae. Given the complexity of the designs and the fact that impacts are likely to be interpreted through a series of statistically significant interactions, the use of simulated data built around an effect size and assumed variance is the approach favoured at this time.

9.9.3 Reef organisms data analysis

Univariate analysis of the intertidal data will include the calculation of diversity indices (number of taxa, total abundance, Shannon-Wiener diversity, and Pielou evenness) as well as analysing the relative representation of major faunal groups, including functional groups. The subtidal data will be analysed with regards to the relative representation of major reef fauna groups, such as corals, sponges, ascidians, hydroids, bryozoans, tubeworms and anemones.

Non-Multidimensional Scaling (nMDS) plots, cluster analysis and analysis of similarity tests (ANOSIM) will be used to identify differences/similarities in the representation of major reef (intertidal and subtidal) fauna groups between sampling sites. Differences identified from the ANOSIM procedure will be further investigated using permutational multivariate analysis of variance (PERMANOVA). Models will be run to examine the effects of site on intertidal and subtidal reef community composition.

To determine which major reef fauna groups of taxa are contributing most to, or are most responsible for, any significant differences detected using ANOSIM, the SIMPER procedure will be performed. SIMPER analysis determines the contribution that each taxa/taxa group makes to the average similarity of a group of samples.

Relationships between reef fauna and the environmental data (e.g. sediment type, algal coverage) will be examined using distance based linear models (DISTLM). This will investigate how much variation in community structure is explained by each predictor (environmental) variable and will be used to identify key drivers in community structure.

9.10 Quality Assurance

All intertidal quadrat transects will be assigned a unique sample code, as well as GPS position, time, date, and weather conditions which will be recorded on waterproof field sheets. All data will be transcribed into the master project database linked to each unique sample code. GPS positions will be downloaded into excel format then imported into a master database. Hard copies of the original datasheets will be scanned and stored electronically within the master database.

Aerial imagery and ground-truthing images will be coded with unique identifiers and entered into appropriate GIS software. Copies of all imagery and the ground-truthing data will be scanned and electronic copies stored in safe locations and backed up regularly.

Subtidal photo-quadrat images and benthic videos will be given unique codes and a record of the GPS position, time, date, and weather conditions will be recorded. Following analysis, all data will be transcribed into the master project database and linked to each unique code for that particular survey.

Field data integrity will be checked using a two-person field checklist and where appropriate, chain-of-custody documentation will be kept.

9.11 Community Involvement

Community participation will be invited for the intertidal reef assessments which includes the transect quadrat surveys and sand inundation inspections along the intertidal reefs. Suitable training and supervision will be provided by trained and experienced scientists for quality assurance reasons to maintain data quality.

Local community involvement will provide an opportunity to show how the baseline monitoring is conducted and how the results will contribute to the overall assessment of project-related impacts once iron sand extraction commences.

10 MARINE MAMMAL BASELINE MONITORING PLAN

10.1 Background

The following sources of data were used to estimate the use of the Project Area and surrounding waters by marine mammals during the IA development:

- an assessment of marine mammal sighting data;
- a review of relevant literature;
- habitat modelling;
- marine mammal aerial observations; and
- information supplied by marine mammal experts.

From these assessments it was concluded that the sighting probability or density of marine mammals in the vicinity of the Project Area is relatively low; however, the marine mammal taxa outlined in **Table 12** could potentially use the Project Area and surrounding waters (Joint Witness Statement, 2014). For most species listed there is a paucity of information with regard to abundance, residency and habitat use in the STB, but some species are thought to only have a seasonal presence, e.g. humpback whales during their winter northern migration, and for some species the STB represents the very periphery of their distribution (e.g. Maui's dolphins).

The potential impacts of iron sand extraction on marine mammals as identified in the Joint Witness Statement (2014) include habitat displacement, ship strike, entanglement, underwater noise and reduced habitat quality.

The Marine Mammal Baseline Monitoring Programme has been designed with these potential impacts in mind.

Table 12 Marine mammal taxa potentially present in the Project Area

Taxa	NZ Threat Classification	IUCN Threat Classification
Humpback whale *Megaptera novaeangliae*	Migrant	Endangered
Antarctic blue whale *Balaenoptera musculus intermedia*	Migrant	Endangered
Pygmy blue whale *Balaenoptera musculus brevicauda*	Migrant	Endangered
Fin whale *Balaenoptera physalus*	Migrant	Endangered
Dwarf minke whale *Balaenoptera acutorostrata*	Not threatened	Data deficient
Antarctic minke whale *Balaenoptera bonarensis*	Not threatened	Data deficient
Sei whale *Balaenoptera borealis*	Migrant	Endangered
Southern right whale *Eubalaena australis*	Nationally endangered	Least concern
Sperm whale *Physeter Macrocephalus*	Not threatened	Vulnerable
Long-finned pilot whale *Globicephala melas*	Not threatened	Data deficient
Short finned pilot whale *Globicephala macrorhynchus*	Migrant	Data deficient
Killer whale *Orcinus orca*	Nationally critical	Data deficient
False killer whale *Pseudorca crassidens*	Not threatened	Data deficient
Bottlenose dolphin *Tursiops truncatus*	Nationally endangered	Least concern
Common dolphin *Delphinus delphis*	Not threatened	Least concern
Dusky dolphin *Lagenorhynchus obscurus*	Not threatened	Data deficient
Maui's dolphin *Cephalorhynchus hectori maui*	Nationally critical	Critically endangered
Hector's dolphin *Cephalorhynchus hectori hectori*	Nationally endangered	Endangered
New Zealand fur seal *Arctocephalus forsteri*	Not threatened	Least concern

10.2 Monitoring Objective

The monitoring objective of the Marine Mammal Baseline Monitoring Programme is:

- To conduct surveys to describe the variability of marine mammal relative abundance and distribution in the STB before the commencement of any iron sand extraction activities.

10.3 Monitoring Methodology

Three types of marine mammal monitoring will be undertaken by TTR during the baseline monitoring programme, these are:

- Incidental sightings;
- Aerial surveys; and
- Acoustic surveys.

Each monitoring component is discussed below.

10.3.1 Incidental sightings

Incidental marine mammal sightings are those made opportunistically by any TTR employee or contractor in the course of all baseline monitoring activities in the STB. Incidental sightings of any whales or dolphins[2] from anywhere in the STB are of relevance and should be recorded.

Incidental sightings data will assist with ground-truthing the risk of ship strikes and entanglements and is also potentially helpful in defining the extreme limits of a population's distribution (e.g. Maui's dolphins).

All personnel who make incidental sightings of marine mammals will be required to complete a 'Marine Mammal Sighting Form'. Training will be provided on the completion of these forms during inductions and species identification guides will be readily available to increase the accuracy of the information collected.

The completed forms will be collated periodically into a centralised electronic database from which reports will be compiled. These reports will include basic descriptive analyses and summary statistics as appropriate.

All marine mammal sightings will be provided to the DOC for inclusion into their marine mammal sighting database.

10.3.2 Aerial surveys

Aerial surveys will be designed in order to describe the variability of relative abundance and distribution of marine mammals in the STB during the two year period prior to iron sand extraction activities commencing. The distribution data collected during the Marine Mammal Baseline Monitoring Programme will provide a valuable baseline comparison that survey results during iron sand activities can be compared with.

The aerial surveys will be designed by qualified and experienced marine mammal scientists, and will be of sufficient duration, frequency and seasonality to ensure the objective of this baseline monitoring programme can be met. Aerial surveys will adopt scientifically accepted suitable marine mammal survey methodologies. The frequency of surveys will take into account seasonal variability and will ensure there is sufficient statistical power for the detection of trends through time (Buckland *et al*., 1993).

It is not the intention of aerial surveys to obtain absolute abundance estimates of marine mammal species. Instead, relative abundances between surveys are sought to detect any apparent trends in density.

A line-transect methodology will be employed over an area that encompasses the Project Area and surrounding waters. In defining the survey area, consideration will be given to 1) relevance to the objective, 2) biological relevance, and 3) survey practicalities (Dawson *et al*., 2008).

Data analysis will be undertaken using specialised software packages (e.g. Distance: see Thomas *et al*., 2010 and www.distancesampling.org) and estimates of potential biases in monitoring data will be undertaken. Reporting will occur following the annual synthesis of results. Trend detection analysis will not occur during baseline monitoring, but will be critical during operational monitoring.

[2] No need to record fur seal sightings

10.3.3 Acoustic surveys

Acoustic surveys are useful techniques for gathering information about cetacean distribution and can also contribute towards abundance estimates. In this respect, the use of acoustic surveys will be beneficial in gathering baseline data on marine mammal distribution and density within the STB.

Acoustic surveys will be designed by qualified and experienced scientists, and will be of sufficient duration, frequency and seasonality to ensure the objective can be met. The acoustic surveys will adopt scientifically accepted suitable marine mammal survey methodologies.

Multiple autonomous sea noise loggers and/or echolocation click detectors will be deployed to assess habitat use by specific marine mammals in the STB during the Marine Mammal Baseline Monitoring Programme. These devices will be retrieved periodically to replace batteries and download data. This technique will provide an ongoing assessment of habitat use which will complement the schedule of aerial surveys.

With regards to the acoustic survey design, the primary species of interest in the STB are blue whales (with vocalisations ranging in frequency from 0.01 to 0.4 kHz) and Hector’s/Maui’s dolphins (with vocalisations around 129 kHz). The monitoring devices and programming will be selected so that each device can theoretically measure the vocalisations of either one of these two species, given they are at the opposite ends the frequency spectrum. Likewise, given the habitat of these two species is very different, where Hector’s/Maui’s dolphins are more often present in coastal waters and blue whales reside in deeper offshore waters, these differences will be considered in the development of the acoustic survey design.

Specific software will be used for the processing and analysis of acoustic data once downloaded from the monitoring device units. Data will be interpreted by an acoustician, where the results will be used to generate reports that will provide an iterative appreciation of marine mammal presence through time in the STB around the Project Area.

10.4 Data management

The following actions will be implemented with regards to the management of monitoring data:

- A standardised datasheet will be used to record all incidental marine mammal sightings; and
- Incidental marine mammal sighting data will be collated into a centralised electronic database from which annual summary reports will be compiled.

10.5 Reporting

The following reports will be generated for the Marine Mammal Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- An Annual Monitoring Report to summarise the previous 12 months of marine mammal data (incidental, aerial and acoustic);
- An Aerial Survey Report will be prepared following the completion of each aerial survey; and
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Marine Mammal Baseline Monitoring Programme.

10.6 Community participation

A synthesis of findings from the Marine Mammal Baseline Monitoring Programme will be presented to the community periodically in accordance with TTR's ongoing commitment to stakeholder engagement. In addition to the reporting of findings TTR will also encourage community involvement through the reporting of marine mammals sightings in the STB through the Department of Conservations web portal[3].

[3] www.doc.govt.nz/marinemammalsightings

11 UNDERWATER NOISE BASELINE MONITORING PLAN

11.1 Introduction

Underwater noise in the STB is predominately influenced by existing shipping traffic, marine biological sources and natural events (e.g. wind and rainfalls etc.).

The iron sand extraction project will generate underwater sound, which has the potential to subject marine fauna in the close vicinity to adverse noise effects. The IA places particular emphasis on the potential noise interactions with marine mammals. In order to quantify the operational noise associated with iron sand extraction it is critical to first measure the background underwater noise of the STB.

This Underwater Noise Baseline Monitoring Programme has been developed to characterise the underwater acoustic environment prior to iron sand extraction commencing.

11.2 Objectives

The key objectives of the noise monitoring programme are to:

- Establish underwater noise characteristics in the vicinity of the Project Area, prior to the commencement of iron sand extraction; and
- Provide data to inform the Marine Mammal Baseline Monitoring Programme.

11.3 Monitoring Methodology

Baseline monitoring will be undertaken by long-term deployments of underwater automatic noise logging systems which are comprised of an electronic circuit board, a heavy duty housing unit with a built-in hydrophone unit, which can be deployed within the water column or on the seabed by a stable mooring arrangement. The electronic circuit board includes an integrated battery bay, control panel, display screen and memory slots. **Table 13** gives an example of specifications for a Wildlife SM3M Submersible Logging System which is one of the options that could be used for the Underwater Noise Baseline Monitoring Programme.

Three sea noise loggers will be deployed at three different representative locations (X (i.e. off-shore location), Y (i.e. location next to Project Area), Z (i.e. near-shore location) as shown in **Figure 8**. The loggers will be deployed during the two year baseline monitoring programme and will be recovered and serviced every six months to download the data. The recovery of the loggers will not result in a significant disruption to the time series of data collection. Having the loggers in place for two years during the baseline monitoring phase will provide an indication of background and anthropogenic noise levels within the STB. The deployment will also provide an understanding of the marine mammals that frequent the area which will be identified by echolocations recorded on the loggers.

Table 13 Specifications for a Wildlife SM3M Submersible Logging System

Key Features	Specification Details
Working depth	Up to 150 m
Operating temperature	0 to 40 °C
Dimensions	16.5 cm in diameter/79.4 cm in length
Weight	Without batteries - 9.5 kg in air; Fully populated with batteries - 13.5 kg in air and 1.5 kg buoyancy in salt water
Power	Maximum 32 alkaline D cell batteries or lithium manganese batteries (4.5 – 17V DC)
Sampling rate	4 – 96 kHz
Storage	Up to 512GB with SDXC
Recording schedules	Programmable
Data format	WAC (compressed) or WAV
Dynamic range	78 – 165 dB re 1µPa with 0 gain input
Gain setting	0 – 59.5 dB in 0.5 dB steps
Hydrophone	Hydrophones of different specifications (Low Noise, Standard, Ultrasonic, High-SPL) can be selected depending on the monitoring purpose
Noise floor with standard hydrophone	-134 dBfs/sqrt(Hz) @ 48 kHz sample rate, 1 K input impedance, 1dB gain
Calibration	The electronics of the board and hydrophone are calibrated and are not expected to shift the value in years, unless some damage occurs.

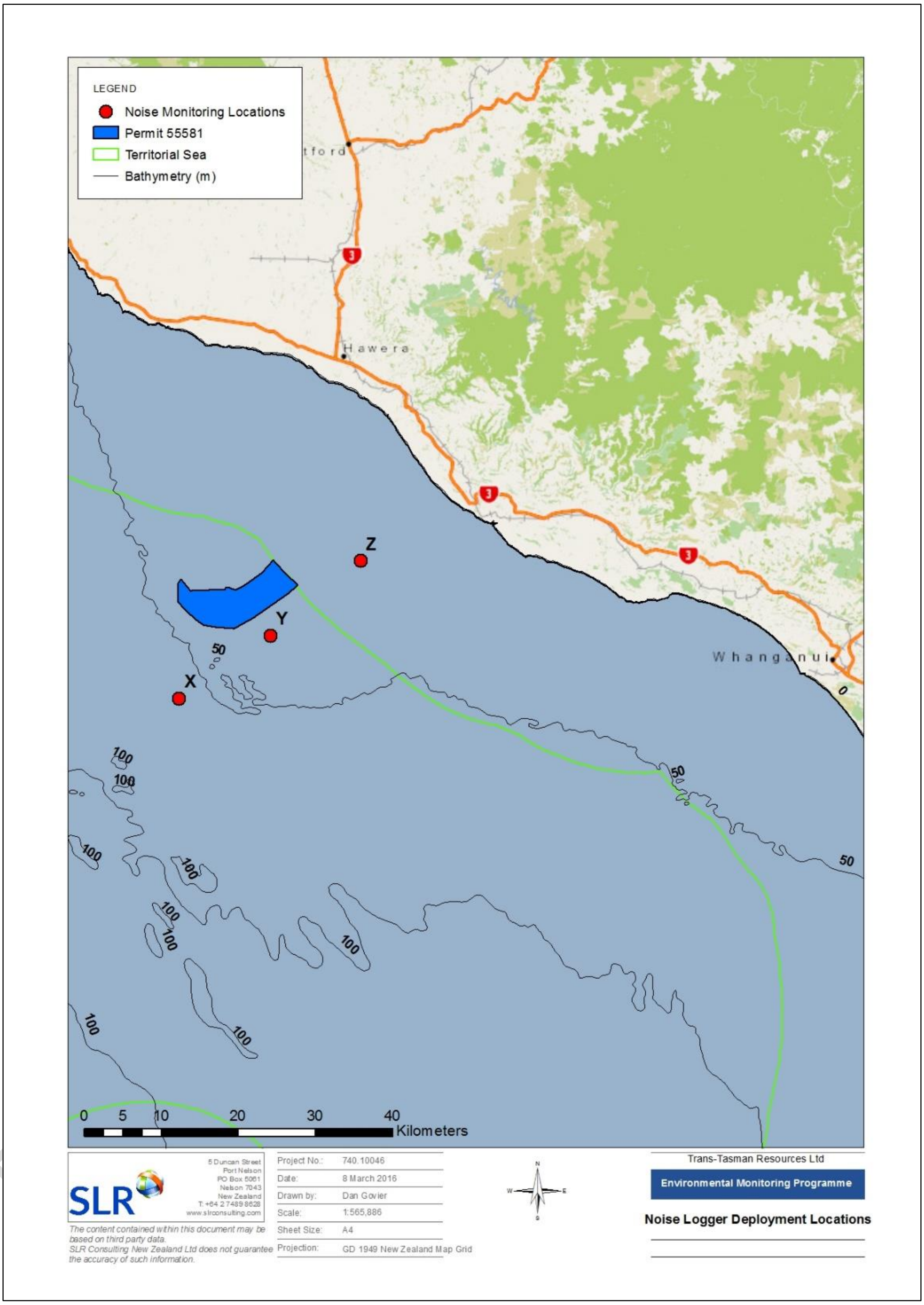

Figure 8 Sea noise logger deployment locations

11.4 Data Analysis

Signal processing and analysis will be undertaken on the noise logger data. This analysis and interpretation will take into consideration the site specific activities occurring during the monitoring period for each monitoring location as well as meteorological conditions and date.

The predominant characteristics of the underwater noise environment in the vicinity of the Project Area will be identified, including but not limited to:

- Temporal and spatial variations in overall underwater noise levels;
- Spectral variations in underwater noise levels;
- Major noise contributors of various origins; and
- Correlations with other natural environment parameters such as weather, sea states and tides.

11.5 Reporting

The following reports will be generated for the Underwater Noise Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Underwater Noise Baseline Monitoring Programme.

12 RECREATIONAL FISHING BASELINE MONITORING PLAN

12.1 Background

Recreational fishing is a popular activity in the STB and includes line fishing from boats, diving, and the shore (such as surfcasting and long-lining). Very little recreational fishing occurs more than 20 km offshore along the STB, with areas most commonly fished typically occurring within 10 km of the shore (RG&A, 2013).

The main public access and activity points for recreational fishers along the STB coast include: Ohawe Beach, Waihi Beach, the mouths of the Tangahoe and Manawapou Rivers, as well as from Patea, Waipipi, Waiinu, Kai Iwi, and Whanganui. Boat launching occurs at Ohawe, Patea, Waipipi, Waiinu, Kai Iwi and Whanganui; however, the use of these launching areas is significantly limited by weather and tidal conditions, with dangerous bar crossings or beach launchings necessary at these launching locations.

Shore-based fishing includes surfcasting and shellfish gathering. Surfcasting mainly occurs at Ohawe and Waihi Beaches, the mouths of the Tangahoe and Manawapou Rivers, Waipipi, Waverly, Wainui, Kai Iwi and Whanganui, while shellfish gathering typically occurs at Whenakura, Waitotara, Waiinu, Kai Iwi, Whanganui, south of Patea, and from Ohawe to the Manawapou River. Boating occurs throughout the STB but predominantly north of Patea. Diving is mainly for rock lobster at Ohawe, Graham's Bank, the North and South Traps (particularly from late October through to April), and on rocky seams off Waitotara and Waverly (RG&A, 2013).

Recreationally caught fish species identified as having a high probability of occurrence within the STB include barracouta, blue cod, carpet shark, eagle ray, frostfish, jack mackerel, john dory, kahawai, leatherjacket, red cod, red gurnard, rig, snapper, spiny dogfish, tarakihi, trevally, and blue warehou (MacDiarmid *et al*., 2013). Additional fish species have been identified within Ngati Ruanui's Deed of Settlement as taonga (treasured). These include: hapuku/groper, grey mullet, butterfish, blue moki, common smelt, black flounder, NZ sole, yellow-belly flounder, sand flounder, eels and elephant fish. Large game fish such as kingfish, tuna and marlin can be caught within STB during summer months as warm currents push down the coast. Rock lobsters are also recreationally important in the STB and have been identified as taonga by Ngati Ruanui.

A number of recreational fishing, diving and boating clubs have been established throughout the STB. Recreational fishing groups include New Plymouth Sportfishing and Underwater Club, Whanganui Manawatu Sea Fishing Club, Patea Fishing Club, Opunake Surfcasting/Angling Opunake, Kaonga Fishing Club, and Patea Surfcasters Club. Diving and boating groups active within the STB include Patea and District Boating, Cape Egmont Boat Club, Ohawe Boating and Angling, and Opunake Boat and Underwater Club.

12.2 Objectives

The primary objective of the Recreational Fishing Baseline Monitoring Programme is to provide a baseline assessment of recreational fishing (target species and fishing effort) in the STB against which potential impacts from iron sand extraction can be measured.

12.3 Methods

Two years of baseline monitoring will occur before the commencement of iron sand extraction. This baseline data will be used as the standard from which any changes will be gauged.

There are four broad information needs that will guide data collection:

1. Demographics and catch data of recreational fishers in the area. This information will be obtained by boat ramp surveys; and
2. The distribution of recreational fishing vessels in relation to the Project Area. This information will be acquired using a combination of boat ramp surveys, and recreational club surveys.

The Recreational Fishing Baseline Monitoring Programme will utilise a general temporal and spatial sampling design and subsequent data analysis will be applicable to boat ramp and recreational club surveys.

12.3.1 Boat Ramp Surveys

Information on recreational fishing effort and catch will be collected using boat ramp surveys. Surveys will be conducted with the assistance of recreational fishing, diving and boating clubs and at the following boat ramps and are shown in **Figure 9**.

Boat ramps surveys will occur on a mixture of weekdays and weekends, with ramp visits lasting for a standard period of time for each survey day. Boat ramp surveys are to occur at least quarterly to capture seasonal variation.

Due to the highly tidal nature of many of the boat ramps in the STB, ramp visits will need to be coordinated around the optimal tide; for example the Patea boat ramp and associated bar are difficult to navigate at low tide, while the Ohawe ramp is difficult at high tide.

For safety reasons, boat ramps will not be visited at night, and two staff will be utilised for remote locations. This will also help to maximise the survey opportunities during peak fishing periods.

Surveyors will ideally approach all incoming boats, but only those that have been actively fishing will be interviewed. One person per boat who is over the age of 15 will be asked to participate in the survey. Each survey will consist of a number of pre-determined questions based on fisher demographics, fishing effort and catch.

The specific survey questions will be confirmed prior to baseline monitoring commencing. A summary of expected survey outputs is provided below:

- Estimates of relative ramp utilisation: number of boats using each ramp per survey day;
- Estimates of relative recreational fishing effort: hours spent actively fishing;
- Estimates of relative harvest rates and catch composition (number and species);
- Comparisons of size frequency distributions of key species landed by recreational fishers;
- Estimates of relative release rates for all species caught; and
- Identification of primary recreational fishing locations in relation to the Project Area.

The expected types of data to be collected are summarised in **Table 14**.

Figure 9 Boat ramp survey locations

Table 14: Quantitative data yield per ramp visit

Variables	Description/Comment
Ramp utilisation	Number of trailers present per ramp visit
Number of interviews	Number of boats for which interviews were able to be obtained
Boat characteristics	Boat length, motor size
Fisher demographics	Number of fishers, fisher ages, genders
Fishing locations	Places fished, time spent at each location
Fishing method	Line/diver/pot/net etc.
CPUE	Number of fish caught per angler hour (catch per unit of effort)
Fish abundance retained	Total number of fish/species caught and returned to the ramp
Fish abundance discarded	Estimate of total number of caught fish returned to the water
Fish size	Lengths of retained fish (length to caudal fork & total length)

12.3.2 Boat Ramp Camera Observations

Camera systems provide a cost effective and reliable means of monitoring trends in boat ramp traffic over time (Hartill, 2015); so to ensure accuracy and efficiency cameras may be set up at popular boat ramps once the necessary permissions are obtained. The cameras could be established in an appropriate position that allows a full view of the use of the launching ramp. Cameras would capture a time stamped image of the ramp at set time intervals (specifics to be confirmed but the intervals must be appropriate to accurately capture ramp usage). The images could then be viewed as a time-lapsed video to determine the number of boats using the ramp over a given period of time. The feasibility of this monitoring technique will be assessed during the BEMP with recommendations on whether this monitoring should be included as part of the EMMP.

12.3.3 Recreational Club Surveys

When monitoring recreational fishing, it is important to take into account community values and people's perceptions of their surroundings (Källqvist, 2009). Surveys targeting recreational fishing, boating and diving clubs will be utilised to gain an understanding of fishers' attitudes towards recreational fishing in the STB with regard to the quality of the fishing and their views on how future iron sand extraction might affect this.

Recreational plant surveys will occur annually and data from them will augment data collected during boat ramp surveys. Attitudes and information of surfcasters will also be incorporated through recreational club surveys.

Specific survey questions for recreational clubs will be confirmed before baseline monitoring commences; however, questions will be based on a Likert-Scale (a scale used to assign a numerical value to a person's attitude or perspective on a topic) or similar, when possible to allow for statistical analysis. Attitudes to be investigated include: quality of the fishing, predicted interference between fishing and iron sand extraction, and preferred times of fishing.

12.4 Quality Assurance

All field data will be recorded on waterproof field sheets with a unique sample code, which will be logged into the master database.

Survey staff will have a good understanding of the Project and associated requirements, and will be appropriately trained in survey/questionnaire methodology and health and safety requirements.

12.5 Data Management

All data will be entered into a purpose-designed database that conforms to TTR's electronic database information requirements. Examples of tables within the database and the data recorded will include:

- Sample information: unique sample identification, collection location, time, date, survey duration, comments;
- Demographic Data: information about the recreational fishers, vessel type, frequency of fishing etc.;
- Climate data: weather conditions, sea state, time of high and low tides;
- Taxonomic data: species, fish size; and
- Data Codes.

All data entered into the database will be checked by a second scientist. Error checking queries will be run to detect errors or omissions.

Data exported for use in statistical analyses will be locked to avoid corruption or accidental over-write. Excel spread sheets will be imported into a Project master database. Any changes to original datasheets will be saved as different versions to ensure overwrites do not occur.

12.6 Statistical Analyses

Data will be analysed statistically using a range of descriptive and inferential techniques.

Descriptive statistics will include means, standard errors, co-efficient of variation and, where appropriate, calculation of confidence limits associated with means.

Inferential statistics will be used to test hypotheses regarding changes in variables associated with recreational fishing among locations.

Standard tests will include multivariate analyses to compare groups of species and univariate analyses to compare catch indices, and utilisation by fishers.

Data collected during the Recreational Fishing Baseline Monitoring Programme will be used to assess the power of the survey design with regards to detecting meaningful impacts that may be attributable to the Project during the subsequent operational monitoring once iron sand extraction is underway. The ability of these designs to detect changes will be examined by a suite of methods, potentially including comparisons of confidence limits and determination of power using simulated data (i.e. an effect size likely to reflect the magnitude of an impact) or standard power formulae. Given the complexity of the sampling design and the fact that impacts are likely to be interpreted through a series of statistically significant interactions, the use of simulated data built around an effect size and assumed variance is the approach favoured at this time. The exact methodology will be resolved once the baseline monitoring data is available and will be incorporated into the EMMP.

12.7 Reporting

The following reports will be generated for the Recreational Fishing Baseline Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the baseline phase to summarise the findings of the Recreational Fishing Baseline Monitoring Programme

12.8 Community Involvement

Community involvement is an important component of the Recreational Fishing Baseline Monitoring Programme. While boat ramp and recreational club surveys cannot occur without participation from the fishing community, another important community involvement component is the potential use of members of the community, to conduct ramp visits and collect survey data.

Those conducting the surveys will be appropriately trained with regards to survey techniques and any health and safety requirements.

An added benefit to the use of community members to conduct boat ramp surveys is education of the wider community and possible increased participation in boat ramp surveys. Although those conducting surveys will have no enforcement power, fishers may be hesitant to participate in surveys for fear of the consequences (such as fines or confiscation of property associated with Fisheries Officers). The use of community members in conducting surveys is likely to engender trust and encourage community participation. The baseline monitoring programme is critical in setting the scene for ongoing monitoring within the EMMP that is scheduled to occur once iron sand extraction commences.

13 REFERENCES

Anderson TJ, MacDiarmid A, Stewart R, 2013. Benthic habitats, macrobenthos and surficial sediments of the nearshore South Taranaki Bight. NIWA Client Report NEL2013-012.

Arendt, K.E.; Dutz, J.; Jonasdottir, S.H., ; Jung-Madsen, S.; Mortensen, J.; Møller E.F.; Nielsen, T.G. (2011) Effects of suspended sediments on copepods feeding in a glacial influenced sub-Arctic fjord. *Journal of Plankton Research* 33: 1526–1537.

Battaerd, W.R. 1983. Zooplankton of the South Taranaki Bight. Report (Maui Development Environmental Study) No. 83-1. ix, 142 ill. 130 cm. p.

Bradford, J. M. 1977. Distribution of the pelagic copepod *Temora turbinata* in New Zealand coastal waters and possible trans-Tasman population continuity. *New Zealand Journal of Marine and Freshwater Research II*: 131-144.

Bradford, J. M. 1978. *Paracalanus indicus* Wolfenden and *Corycaeus aucklandicus* Kramer, two neritic pelagic copepods from New Zealand. *Journal of the Royal Society of New Zealand* 8: 133-141.

Bradford, J. M. 1980. New Zealand region, zooplankton biomass (0-200 m). New Zealand Oceanographic Institute chart, miscellaneous series 41.

Bradford-Grieve, J.M.; Murdoch, R.C.; Chapman, B.E. 1993. Composition of macrozooplankton assemblages associated with the formation and decay of pulses within an upwelling plume in greater Cook Strait, New Zealand. New Zealand Journal of Marine and Freshwater Research 27: 1-22.

Buckland ST., Anderson DR., Burnham KP., Laake JL. 1993. Distance sampling: estimating abundance of biological populations. London: Chapman and Hall. 446 pp.

Cahoon, L.B., Pinkerton, M.H., Hawes, I. 2015. Effects on primary production of proposed iron-sand mining in the South Taranaki Bight region. Unpublished report for TTR, September 2015.

Davies-Colley, R. J., et al. 1997. Matching natural water colours to Munsell standards. Journal of the American Water Resources Association 33(6): 1351-1361.

Dawson S., Wade P., Slooten E., Barlow J. 2008. Design and field methods for sighting surveys of cetaceans in coastal and riverine habitats. Mammal Review 38:19-49.

Hadfield, M, & Macdonald, H, 2015, "*Sediment Plume Modelling"*, NIWA Client Report: WLG2015-22, prepared for Trans-Tasman Resources Ltd, 117p.

Hadfield, M., H. Macdonald. 2015. South Taranaki Bight Iron Sand Extraction Sediment Plume Modelling (2015 revision). NIWA report WLG2015-22 (project TTR15301) for Trans-Tasman Resources Ltd, September 2015.

Hammond PS., Macleod K., Berggren P., Borchers DL., Burt L., Canadas A., Desportes G., Donovan GP., Gilles A., Gillespie D., Gordon J., Hiby L., Kuklik I., Leaper R., Lehnert K., Leopold M., Lovell P., Oien N., Paxton CGM., Ridoux V., Rogan E., Samarra F., Scheidat M., Sequeira M., Siebert U., Skov H., Swift R., Tasker M., Teilmann J., Van Canneyt O., Vazquez JA. 2013. Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation* 164:107-122.

Hartill, B, 2015, "*Evaluation of Web Camera Based Monitoring of Levels of Recreational Fishing Effort in FMA1*", New Zealand Fisheries Assessment Report 2015/22, 16p.

James M, 2016, Trans-Tasman Resources Ltd Consent Application: Ecological Assessments, Aquatic Environmental Sciences Client Report prepared for Trans-Tasman Resources Ltd.

James MR; Wilkinson VH, 1988, Biomass, carbon ingestion, and ammonia excretion by zooplankton associated with an upwelling plume in western Cook Strait, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 1988, Vol. 22: 249-257.

Joint Witness Statement. 2014. Joint Statement of Experts in the field of effects on marine mammals including noise, Report to the EPA in relation to the TTR Marine Consent Hearing. 26 March 2014.

Källqvist, EMLA, 2009, "*Who is Catching What? – A Survey of Recreational Fishing Effort and Success on Taiapure and Mataitai Management Areas*", a thesis presented in partial fulfilment for the degree of Master of Science in Environmental Science at the University of Canterbury, Christchurch, New Zealand.

MacDiarmid, A, Anderson, O, & Sturman, J, 2013, "*South Taranaki Bight Fish and Fisheries"*, NIWA Client Report No: WLG2012-13, prepared for Trans-Tasman Resources Ltd, 70p.

MacDiarmid, A., Gall, M., Robinson, K., Steward, R., Fenwick, M. 2015. Zooplankton communities and surface water quality in the South Taranaki Bight February 2015. NIWA client report No: WLG2015-25 prepared for Trans-Tasman Resources Ltd.

MacDiarmid, A.; Anderson, O.; Sturman, J. 2013. South Taranaki Bight fish and fisheries. NIWA Client Report: WLG2012-13 prepared for Trans-Tasman Resources Ltd.

MacDonald, I, Budd, R, Bremner, D, & Edhouse, S, 2012, "*South Taranaki Bight Iron Sand Mining: Oceanographic Measurements Data Report"*, NIWA Client Report: HAM2012-147, prepared for Trans-Tasman Resources Ltd, 106p.

Ngāti Ruanui, 2001, '*Deed of Settlement of Historical Claims'*, accessed from http://nz01.terabyte.co.nz/ots/DocumentLibrary/RuanuiDeed12May2001.pdf

Pinkerton, M., Gall, M. 2015. Optical effects of proposed iron-sand mining in the South Taranaki Bight region. NIWA report number WLG2015-26 prepared for Trans-Tasman Resources Ltd.

RG&A, 2013, "*Trans-Tasman Resources Ltd Sea Bed Mining, South Taranaki – Recreation and Tourism Assessment of Effects",* prepared for Trans-Tasman Resources Ltd. 43p.

Taranaki Regional Council, 2004. Inventory of coastal areas of local or regional significance in the Taranaki Region.

Thomas LT., Buckland ST., Rexstad EA., Laake JL., Strindberg S., Hedley SL., Bishop JRB., Marques TA., Burnham KP. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14.

Torres, LG., Gill, PC., Graham, B., Steel, D., Hamner, RM., Baker, S., Constantine, R., Escobar-Flores, P., Sutton, P., Bury, S., Bott, N., Pinkerton, M. 2015. Population, habitat and prey characteristics of blue whales foraging in the South Taranaki Bight, New Zealand. SC/66a/SH6, International Whaling Commission.

Wilber, D. H.; Clarke, D. G. (2001). Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. *North American Journal of Fisheries Management* 21:855-875.

Appendix 5.7: Draft Environmental Monitoring and Management Plan

SOUTH TARANAKI BIGHT OFFSHORE IRON SAND EXTRACTION AND PROCESSING PROJECT

ENVIRONMENTAL MONITORING AND MANAGEMENT PLAN

DRAFT – WITHOUT PREDJUDICE – FOR CONSULTATION PURPOSES ONLY

August 2016

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GLOSSARY OF TERMS

ADCP	Acoustic Doppler Current Profiler
ANOSIM	Analysis of Similarity
AWAC	Acoustic Wave and Current
BEMP	Baseline Environmental Monitoring Plan
BWT	Ballast Water Treatment
BWM Convention	Ballast Water Management Convention
BAG	Before After Gradient
CPCe	Coral Point Count with Excel Extensions
CRMS	Craft Risk Management Standard
CTD	Conductivity, Temperature and Depth
DISTLM	Distance-based Linear Models
DOC	Department of Conservation
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EMMP	Environmental Management and Monitoring Plan
EPA	Environmental Protection Authority
FSO	Floating Storage and Offloading Vessel
G8	Guidelines for Approval of Ballast Water Management Systems
GIS	Geographic Information System
HAT	Highest Astronomical Tide
HSE	Health, Safety and Environment
IA	Impact Assessment
IMO	International Maritime Organisation
IMV	Integrated Mining Vessel
Iron Sand Extraction	Sediment excavation and the subsequent deposition of tailings
IUCN	International Union for the Conservation of Nature
KRG	Kaitiakitanga Reference Group
LSST	Laser In-Situ Scattering and Tranmissometer
MBES	Multi-beam Echo Sounding
MPI	Ministry for Primary Industries
nMDS	Non-Multidimensional Scaling
NTU	Nephelometric Turbidity Units
NZTCS	New Zealand Threat Classification System
ORP	Redox Potential
OSPM	Operational Sediment Plume Model
PAR	Photosynthetically Available Radiation
PERMANOVA	Permutational Multivariate Analysis of Variance
Project Area	The 66 km2 from which iron sand extraction is proposed
PSD	Particle Size Distribution
QA/QC	Quality Assurance/Quality Control
SIMPER analysis	A statistical method to determine similarity between samples
SSC	Suspended Sediment Concentration
SSS	Side-Scan Sonar
STB	South Taranaki Bight

TFS	Total Free Sulphide
The Project	The TTR Iron Sand Extraction Project
TOC	Total Organic Carbon
TRC	Taranaki Regional Council
TRG	Technical Review Group
TSS	Total Suspended Solids
TTR	Trans-Tasman Resources Limited

1 INTRODUCTION

1.1 Background

Trans-Tasman Resources Limited (**TTR**) is a privately owned New Zealand company, established in September 2007 to explore, assess and uncover the potential of offshore iron ore deposits off the west coast of the North Island of New Zealand.

TTR is seeking marine consents under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (the **EEZ Act**) to undertake iron ore extraction and processing activities in a total Project Area of no more than 66 square kilometres (the **Project Area**), located between 22 and 36 kilometres (12 and 19 nautical miles) offshore in the South Taranaki Bight (**STB**) (**Figure 1**).

The TTR Iron Sand Extraction Project (the **Project**) involves the extraction of up to 18 million cubic metres per year (up to 50 million tonnes per year) of seabed material containing iron sand, for processing on-site utilising an Integrated Mining Vessel (**IMV**). Around 10% of the extracted material will be processed into iron ore concentrate and stored by a Floating Storage and Offloading Vessel (**FSO**) before being exported by a bulk carrier. All residual sediment (approximately 45 million tonnes per year) will be returned to the seabed as de-ored sediment via a controlled discharge at depth below the IMV. This extraction, and the subsequent deposition of residual sediment, is herein referred to as **'iron sand extraction'**.

During iron sand extraction there will be the potential for an increase in suspended sediment concentrations (**SSC**). Response Limits and Compliance Limits have been determined for SSC's based on the latest discharge plume modelling undertaken in 2015 to help manage any potential adverse effects to the receiving environment.

The overall management of the Project will be designed to prevent the SSC from the iron sand extraction plume in combination with naturally occurring suspended sediment, from reaching the 95th percentile of levels of natural SSC variability currently experienced at a number of key sites identified within the STB. However, TTR has no control over natural events (i.e. large storms/floods) that can result in SSC concentrations being greater than the 95th percentile. If SSC concentrations reach the Response Limit (80th percentile), an assessment will be undertaken to determine whether the results are due to the Project or natural variability. Further details of the environmental management framework for the Project are provided in **Section 2.3**, while compliance with SSC concentrations is discussed in Section **2.7**

Prior to the commencement of any iron sand extraction activities a two year baseline environmental monitoring programme has been conducted in accordance with the Baseline Environmental Monitoring Plan (**BEMP**). The BEMP has identified the natural background levels of SSC in the STB, taking into account spatial and temporal variation. These results have been incorporated within this Environmental Management and Monitoring Plan (**EMMP**) to determine the final parameters assessed and to finalise the Response Limits and Compliance Limits (**Table 2)** that will be monitored during the term of the marine consents.

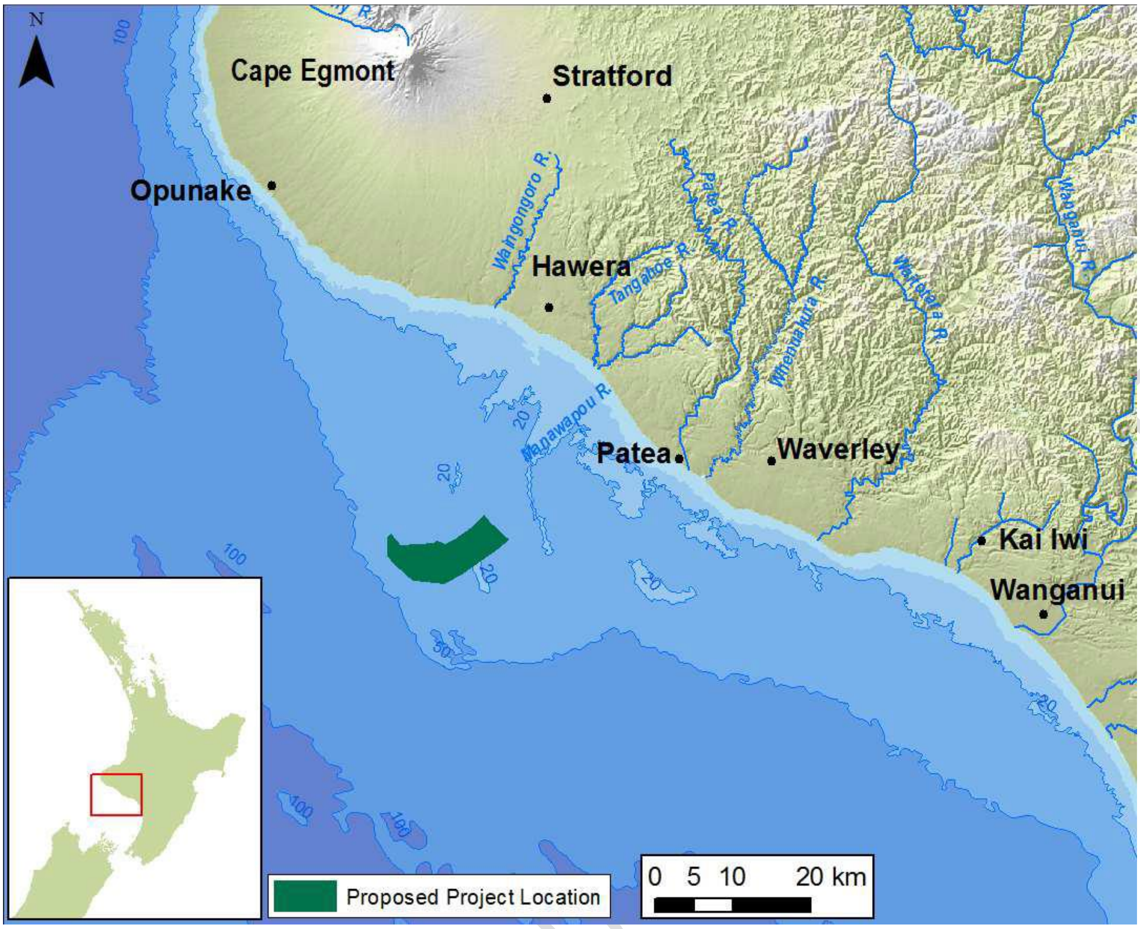

Figure 1 Iron sand recovery area in the South Taranaki Bight.

1.2 Purpose of this Document

TTR have developed this EMMP to ensure that the mitigation measures identified within the marine consents for the Project will be implemented throughout the life-cycle of the Project.

The two years of baseline monitoring undertaken within the STB surrounding the Operational Area in accordance with the BEMP has undergone a review to confirm that the Response Limit and Compliance Limits defined in **Table 2** are appropriate to be monitored as part of the Environmental Monitoring Programme. This enables the EMMP to ensure that the activities authorised by the marine consent comply with the marine consent conditions.

The purpose of the EMMP includes:

- The development of objectives for the monitoring and management associated with the marine consents;
- Ensuring compliance with all regulatory requirements and guidelines;
- Implementation of an Environmental Monitoring Programme, including sampling design, methodology, frequency, duration and monitoring locations;
- Description of the Technical Review Group (**TRG**);
- Validation of the Operational Sediment Plume Model (**OSPM**) and providing feedback for continual improvement;
- Verifying environmental performance;

- Identification of the operational responses to be undertaken if 'Response Limits or Compliance Limits' are reached;
- Details of data analysis and processing for all parameters being monitored; and
- Reporting methods and frequency for all parameters being monitored.

This EMMP has been prepared by TTR to comply with the proposed marine consent conditions and has been further refined after the completion of the BEMP, prior to Project commencement. The environmental monitoring defined within this EMMP will commence within one month of the iron sand extraction activities commencing.

At any time throughout the term of the marine consents, TTR may review and amend the EMMP based on the monitoring information collected, or following direction from the TRG; providing that any amendments have been approved by the EPA (acting in a technical certification capacity).

It is noted that the monitoring programmes incorporated within this EMMP will not necessarily allow a cause and effect relationship to be determined for all monitoring results due to the very large degree of natural variability that exists for many of the environmental parameters being measured. The EMMP, will however facilitate a large amount of monitoring data to be gathered over both temporal and spatial scales during the term of the consent which will provide a robust set of environmental data within the STB. This environmental data can be incorporated into a general State of the Environment assessment for the STB that will be of value to the Taranaki/Whanganui region and the scientific community.

1.3 Scope of this Document

This EMMP sets out TTR's approach to avoid, manage or mitigate adverse environmental impacts of the Project using monitoring and an Environmental Management Strategy to provide early detection of changes in the STB ecosystem, and modify the Project as appropriate, such that negative Project-related impacts can be prevented or mitigated.
This EMMP:

- Outlines TTR's Environmental Management Strategy;
- Identifies key areas for attention in respect of ongoing monitoring;
- Details the Response Limits and Compliance Limits as well as the Operational Response measures that will be in place; and
- Presents details for each element of the monitoring programme.

The individual monitoring programmes outlined within this document have been developed to monitor and record Project-related changes of the marine environment so that if necessary, early detection will enable appropriate management responses to be implemented.

This EMMP sets out a robust environmental monitoring programme to ensure regulatory compliance and to provide confirmation that the effects from the iron sand extraction activities are consistent with those predicted in TTR's marine consent application material.

This EMMP provides TTRs Environmental Management Strategy (**Section 2**), the Primary Environmental Drivers in the STB (**Section 3**) and the Environmental Monitoring Programme (**Section 4**) that will be implemented.

The EMMP then addresses each of the individual monitoring programmes in the following sections as set out in **Table** 1.

Table 1 TTRs Environmental Monitoring Programme

Monitoring programme	EMMP Section
Water quality and subtidal sedimentation	**Section 5**
Model validation	**Section 6**
Oceanography	**Section 7**
Primary productivity	**Section 8**
Zooplankton	**Section 9**
Subtidal benthos	**Section 10**
Subtidal and intertidal reefs	**Section 11**
Kaimoana	**Section 12**
Marine Mammals	**Section 13**
Underwater noise	**Section 14**
Recreational fishing	**Section 15**
Biosecurity	**Section 16**
Management plans and reporting	**Section 17**

2 ENVIRONMENTAL MANAGEMENT STRATEGY

2.1 Introduction

The management of environmental risks associated with the Project is integral to any business decision making process. Environmental risks and hazards will be identified during the planning stages and operation of all activities and their associated risks will be assessed and managed via a structured environmental management system. These mechanisms will ensure that TTR's environmental standards will be maintained, the commitments specified in the Impact Assessment (**IA**) will be achieved and any unforeseen aspects of the Project are detected and addressed.

The Environmental Management Strategy (and EMMP) is essential for the successful implementation of the Project; ensuring compliance with consent conditions, highlighting key environmental objectives, mitigation measures and monitoring programmes to be adhered to, as well as the regulatory and reporting requirements. If any anomalies or unexpected results are found as part of the environmental monitoring programme, then the Environmental Monitoring Strategy will provide a framework for addressing any issues.

TTR's Environmental Management Strategy will be utilised for the following components:

1) Provide early warning of any potential adverse effects to the marine ecosystem during project inception and operation. These results will be statistically assessed to determine whether any anomalies are attributable to the Project or whether they are due to natural environmental conditions, and

2) To establish Operational Response measures that TTR will implement to prevent or mitigate any negative trends which can be deemed attributable to the Project and are found to exceed applicable thresholds that have been determined.

The EMMP is considered as a 'live' document and will be updated throughout the life of the Project based on baseline reviews, monitoring results or if a significant change to the Project arises. These updates could include changes to monitoring locations and timing of monitoring to reflect any operational changes or changes in methodology due to advances in technology or scientific understanding. Formal reviews of this EMMP will occur annually to ensure all relevant recommendations from monitoring findings are incorporated into the next year of monitoring and will be provided to the TRG.

2.2 Objectives and Scope of TTR's Environmental Management Strategy

The objective of the TTR Environmental Management Strategy is to undertake a science-based, systematic approach to monitoring and managing the impacts of the Project on the STB ecosystem.

The Environmental Management Strategy set out in this section of the EMMP establishes protocols to:

- Plan, monitor, and evaluate the parameters identified for the shared environmental concerns and issues;
- Establish appropriate thresholds for an Operational Response; and
- Establish potential Operational Response measures to address any issues if they develop.

2.3 Environmental Management Framework

2.4 Overview

Effective environmental management systems incorporate the following four components as illustrated in
Figure 2:

- Planning;
- Monitoring;
- Evaluation; and
- Operational Response.

The following paragraphs describe TTR’s approach to the Environmental Management Strategies that are embodied in the EMMP.

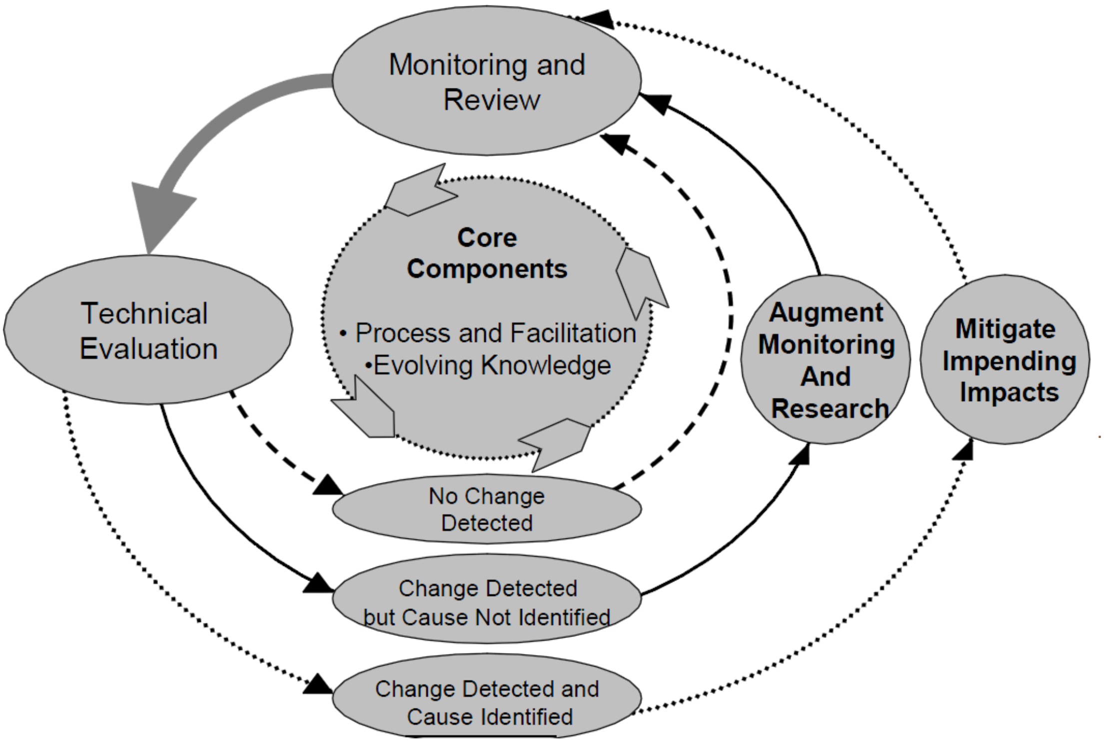

Figure 2: Conceptual Environmental Management Framework (Source: Vancouver Port Authority 2006)

2.5 Planning

The initial planning component involved feedback from the following regulatory and scientific agencies:

- Environmental Protection Authority (**EPA**);
- Taranaki Regional Council (**TRC**);
- Department of Conservation (**DOC**);
- Maritime New Zealand (**MNZ**); and
- New Zealand Petroleum & Minerals (**NZP&M**).

The planning component involved a structured and considered review of:

- Environmental information collected for the IA;
- Information from regulatory agencies and other parties generated through their independent research efforts;
- Information from the 2014 hearing of TTR's marine consent application; and
- Results and recommendations from the two year baseline monitoring programme conducted in accordance with the BEMP.

The planning process identified key components and parameters for monitoring that will provide the necessary controls for the operation and also improve the level of understanding of the STB ecosystem as well as confirming the Response Limits and Compliance Limits.

The Environmental Monitoring Programme will be reviewed prior to initiation of monitoring by the TRG and the EPA. Over the term of the marine consents, the Environmental Monitoring Programme will be subject to modification based on monitoring results and review from the TRG (see **Section 2.7.2**).

2.6 Monitoring

TTR will ensure that activities authorised by the marine consents are managed in such a way as to prevent any exceedances of the Response Limits or Compliance Limits as defined in **Table 2** for SSC.

The two year baseline monitoring programme was conducted in accordance with the BEMP, prior to commencement of the Project. This provided a baseline set of data to gain an understanding of temporal and spatial variability of results as well as defining the parameters to be monitored and the appropriate Response Limits and Compliance Limits.

Prior to the commencement of the iron sand extraction activities and following the BEMP, TTR will review the numerical values of the Response Limits and Compliance Limits to confirm that the numerical values are appropriate following the validation of the OSPM. These limits will be reviewed by incorporating the baseline environmental monitoring data with the same methodology previously used to determine them. In the event that the process results in a change to any limit in **Table 2**, the EPA shall certify the change by way of issuing a Memorandum of Certification (**MoC**) to TTR. Any change to the limits will not require a change of consent conditions but will be identified through the MoC issued by the EPA and will be included as an updated schedule to the Marine Consents.

The Environmental Monitoring Programme in accordance with this EMMP will continue for the life of the Project once extraction activities commence and will incorporate any recommendations made within the review of the BEMP results.

Following the completion of the iron sand extraction activities, a post-extraction monitoring plan is to be developed to monitor the biological environment within the consented area to demonstrate that the biological environment within the extraction area is recovering following the completion of the iron sand extraction activities. This post-extraction monitoring will extend for a period of four years once extraction activities cease or such lesser time as approved by the EPA. A post-extraction monitoring plan will be submitted to the EPA at least three months prior to the completion of the iron sand extraction activities for approval.

As set out in **Sections 5-16**, the Environmental Monitoring Programme will be amended as required based on the previous monitoring results, TRG recommendations and any Operational Response measures undertaken.

2.7 Operational Response

TTR will monitor SSC at a number of key sensitive areas to identify whether any SSC generated by the Project reaches the Response Limits or Compliance Limits which have been determined for the Project. The Response Limits and Compliance Limits are specific to the monitoring locations within the STB and have been refined following the completion of the BEMP. If monitoring shows that the Response Limits or Compliance Limits have been reached, it will prompt an Operational Response to be implemented. Two mechanisms for compliance with consent conditions have been determined, a 'Response Limit' and a 'Compliance Limit'.

SSC will be monitored continuously via optical turbidity sensors at the fixed mooring locations identified in **Figure 8** for which the Response Limit and Compliance Limits have been determined (**Table 2**). The turbidity sensors will be components of the in-situ data-logging instruments on the fixed moorings, allowing SSC to be measured ~ 1 m above the seabed and below surface. Monitoring data will be telemetered back on an hourly basis to a controlled and secure database where it will be automatically assessed for compliance against the defined limits.

Notification systems will be implemented to ensure that if any SSC's reach or exceed the Response Limits, TTRs Project Manager will be notified immediately by text message and email. The TTR Project Manager will then be responsible for implementing the appropriate Operational Response to ensure that the relevant Compliance Limit will not be breached in accordance with **Section 2.7.1.1**. The use of telemetered data will ensure that TTR can monitor for compliance against the SSC Response and Compliance Limits continuously during iron sand extraction activities and that Operational Responses can be implemented rapidly to significantly reduce the likelihood of any non-compliance events.

The Response Limits and Compliance Limits have been derived from the natural/background SSC's currently experienced within the STB at the identified key sensitive locations through the discharge plume modelling and validated as part of the BEMP. These limits have been implemented to prevent the SSC from the iron sand extraction plume in combination with naturally occurring suspended sediment, from reaching the 95th percentile of levels of natural SSC experienced at those particular locations.

Should SSC reach the Response Limit (80th percentile of natural SSC in STB), TTR will initiate an investigation into the cause of the breach and recommendations on proposed Operational Responses to address the breach and/or increased monitoring. Iron sand extraction activities will be allowed to continue whilst this investigation process is underway. Whereas, reaching the Compliance Limit (95th percentile of natural SSC in STB) requires iron sand extraction activities to cease immediately until an investigation has been conducted into the cause of the breach and Operational Responses to be implemented.

Essentially, the EMMP and any consequent management actions that are implemented have been designed to prevent the SSC from the iron sand extraction plume in combination with naturally occurring suspended sediment, from reaching the Compliance Limit (95th percentile) of the natural SSC currently experienced at key sites within the STB.

Operational Responses for underwater noise and marine mammals have also been developed with stakeholders and regulators. These measures are largely derived from well-established thresholds for marine mammal hearing impacts and a standardised approach for managing these effects.

If a Response Limit or Compliance Limit is reached for SSC, the event and the associated Operational Response will be reported to the EPA; a Response Limit breach will be notified immediately but no later than 48 hours, whereas a Compliance Limit breach will be notified immediately and iron sand extraction activities will be ceased immediately. **Figure 3** illustrates the approach TTR will implement if any exceedance to the Response or Compliance Limits occurs as determined through the environmental monitoring programme. Specific details of the operational responses are provided in **Section 2.8**.

TTR will also ensure that activities authorised by the Marine Consents will be managed to prevent any exceedances of Interim Sediment Quality-High (ISQG-High) values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC, 2000), or any subsequent versions thereof.

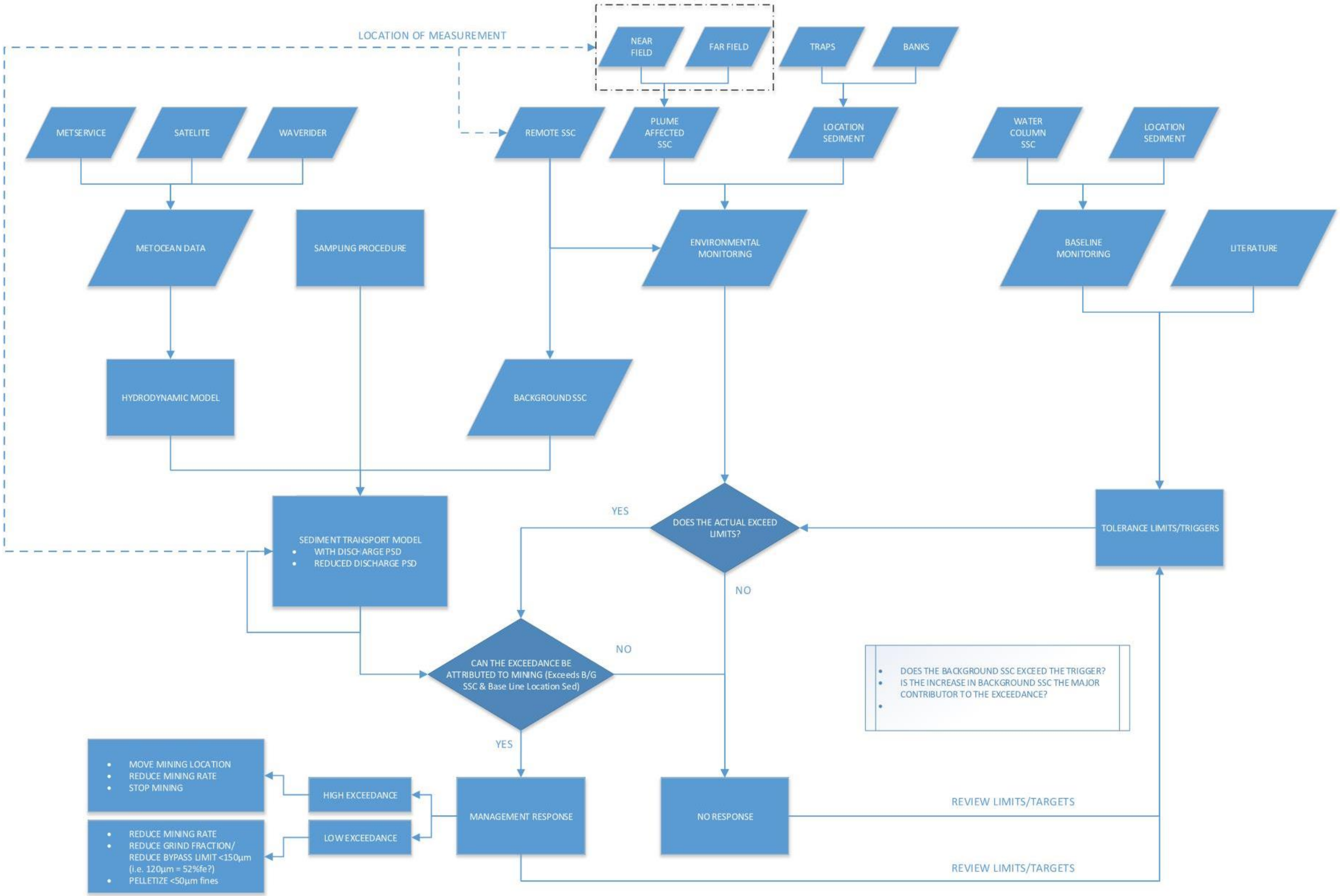

Figure 3 TTR's environmental management approach for SSC in relation to Response Limits and Compliance Limits

2.7.1 Activation of Response and Compliance Limits

If the Response Limit or Compliance Limit is reached, and it is established that the Project (as opposed to natural variability in background conditions) was the cause then an Operational Response will be implemented as identified in the following subsections.

2.7.1.1 Exceedance of Response Limit

If environmental monitoring identifies that an activity authorised by the marine consents has resulted in a 'Response Limit' being exceeded, but has not yet reached the 'Compliance Limit', TTR will undertake an Operational Response to ensure that the relevant Compliance Limit (**Table 2**) will not be breached.

The following actions will be undertaken if a Response Limit is breached:

- TTR will analyse the monitoring data in further detail to confirm if the breach is a result of an activity authorised by the consented activities within 48 hours of becoming aware of the breach;
- If the breach is a result of a consented activity, TTR will immediately, but not later than 48 hours, undertake an additional round of environmental monitoring at the location/s where the Response Limit was breached and notify the EPA of the exceedance;
- If additional monitoring results are still at or above the Response Limit but not greater than the Compliance Limit, then TTR shall undertake further investigations within 48 hours of becoming aware of the further results, and initiate investigations as to the cause and identify an Operational Response (**Section 2.7.1.3**) that will ensure that the Response Limit is no longer breached;
- No later than five working days following the completion of the investigation, TTR will provide the investigation results to the TRG for review and to provide recommendation on proposed Operational Responses to address the breach. The TRG shall provide any response within 10 working days of receiving the investigation results unless otherwise agreed by the EPA;
- No later than five working days after the 10 working day period above has expired, TTR shall provide to the EPA for approval in a technical certification capacity, a report summarising the investigations undertaken, identify the proposed Operational Response/s to be undertaken, and state why such responses are considered appropriate. This will include a summary of any commentary or recommendations from the TRG and, where necessary an exploration as two why a TRG recommendation has not been accepted;
- Following the implementation of the approved Operational Response/s, TTR will undertake a further round of environmental monitoring at the location of the initial breach; and
- If the further monitoring demonstrates that the results are still above the Response Limit, further investigations of the cause shall be undertaken to identify further Operational Responses to address the on-going breach of the Response Limit. All further investigations will be compiled into a report and submitted to the EPA for approval in a technical certification capacity before any further recommendations are implemented.

2.7.1.2 Exceedance of Compliance Limit

If the environmental monitoring identifies that an activity authorised by the marine consents has resulted in a 'Compliance Limit' being exceeded, TTR will immediately cease all iron sand extraction activities and notify the EPA of the breach.

If a breach occurs, TTR will:

- Immediately but not later than 48 hours, initiate an investigation into the cause of the breach and identify the Operational Response/s to be implemented (**Section 2.7.1.3**);
- No later than five working days following the completion of the investigation, TTR will provide the investigation results and recommendation to the TRG for review and to provide recommendations on proposed operational responses to address the breach. The TRG shall provide any response within 10 working days of receiving the information unless otherwise agreed by the EPA;
- No later than five working days after the 10 working day period referred to above has expired, TTR shall provide a report to the EPA in a technical certification capacity summarising the investigations undertaken and identify the proposed Operational Response/s to be undertaken. The report shall state why such responses are considered appropriate and include a summary of any commentary or recommendations from the TRG, and where necessary, an explanation as to why a TRG recommendation has not been accepted;
- Immediately, but no later than 48 hours following the EPAs approval, TTR will implement the Operational Response/s and once implemented, undertake a further round of environmental monitoring at the location of the breach; and
- Not recommence iron sand extraction activities until TTR can demonstrate to the EPA that the operating regime ensures that the Compliance Limit is no longer being breached. However, if within five working days the EPA has not approved recommencement, or advised TTR that it is not approved, the recommencement will be deemed to have been approved.

2.7.1.3 Potential Operational Responses Following an Exceedance

Management options that TTR would consider in the event that the Response Limits or Compliance Limits are reached include:

- Review of iron sand excavation plan and scheduling;
- Review run of iron sand excavation Particle Size Distribution (**PSD**);
- Review tailings discharge PSD;
- Review operational efficiency of process equipment;
- Undertake additional monitoring;
- Reduce grinding and/or repair/replace processing equipment;
- Adjust extraction depth;
- Limiting the meteorological and oceanographic conditions under which extraction takes place (i.e. wind speed and sea state);
- Relocate the IMV;
- Lower extraction rate; and in extreme cases
- Cease extraction activities pending full review.

Following the completion of any Operational Response/s undertaken in accordance with the Marine Consent conditions, TTR will provide a report to the EPA as soon as practicable, but no later than 10 working days, that details the circumstances which resulted in either the Response Limit or Compliance Limit being breached. The report will also detail the investigations and any subsequent Operational Response implemented and will include any commentary from the TRG.

2.7.2 Monitoring Equipment

For the purpose of all the monitoring in accordance with this EMMP, TTR will undertake the requisite monitoring at all times except:

- During a mechanical or technical breakdown or malfunction of monitoring equipment; or
- Where monitoring equipment has been damaged or is being replaced; or
- Due to unforeseen circumstances.

If any of the above situations occur, TTR will immediately notify the EPA of any such occurrence but no later than 24 hours following, identifying:

- What monitoring was affected and for how long; and
- When the monitoring will recommence.

2.7.3 Technical Review Group Evaluation

The TRG was established prior to the commencement of the BEMP and consists of one suitably qualified and experienced representative chosen by TTR, TRC, Sanford Limited, the Kaitiakitanga Reference Group (**KRG**), Te Tai Hauauru Regional Fishing Forum, and DOC. Each representative has specialist expertise in one or more of the key environmental, ecosystem, matauranga Maori and engineering components being monitored.

The role of the TRG is to provide technical oversight and advice to TTR which includes, but is not limited to the following:

- Review and provide advice on the appropriateness of the environmental monitoring parameters prior to the commencement of the BEMP;
- Compare monitoring data against the background data to assist in determining if any activities authorised by the Marine Consents have resulted in adverse effects that were not anticipated at time of granting;
- Consider and make recommendations on the following:
    - The appropriateness of the Response Limit and Compliance Limit values and the ISQG-Low and ISQG-High values;
    - The implementation of Operational Responses provided for under the Marine Consents;
    - Potential Operational Responses that may be implemented based on the investigations into the causes of any breach of the Response Limits or Compliance Limits or any ISQG-Low or ISQG-High values;
    - The need for any new Response Limit and/or Compliance Limit for any parameter or for any new ISQG-Low and ISQG-High values being monitored; and
    - Any revised Response Limit and/or Compliance Limit value determined.

- Community knowledge and matauranga Maori issues when reviewing the monitoring data;
- An annual data review of each years monitoring results, which will be tabulated, reviewed and compared against the previous monitoring data collected and the Response Limit and Compliance Limits; and
- Make recommendations to TTR that a review of the consent conditions for the purpose of avoiding, remedying or mitigating adverse environmental effects from exercising of the Marine Consents is appropriate to be dealt with at a later stage.

The TRG met annually during the BEMP; however, for the first five years following commencement of the iron sand extraction activities the TRG will meet quarterly and then annually thereafter to review and discuss the previously submitted monitoring and annual reports. Following each meeting, minutes will be provided to the EPA and on TTRs website within 10 working days of each meeting being held.

2.8 Environmental Management Measures

The predicted effects of the Project are largely based on an existing knowledge of 'ecological thresholds' which define the level at which an adverse effect is expected for a specific biological receptor. Ecological thresholds to SSC for the proposed project have been selected based on best available scientific evidence that correlates adverse effects with environmental disturbance from other extraction projects and/or similar activities internationally. Further refinement of these thresholds has been undertaken following the results of the two year baseline monitoring programme conducted in accordance with the BEMP.

In conjunction with these ecological thresholds and in order to minimise adverse effects from the Project, a number of Operational Responses have also been proposed. These measures aim to identify instances when operational effects warrant caution whereby an Operational Response will be implemented to minimise effects.

2.8.1 Suspended Sediment Concentrations (SSC)

SSC has been identified as the primary driver of potential environmental effects associated with the Project. Ecological thresholds, together with the sediment plume model and the baseline monitoring programme results, were used to determine the Response and Compliance Limits for SSC.

The SSC data in the STB which was used in sediment plume modelling was informed by measurements of background sediment concentrations and other oceanographic parameters addressed by NIWA, as set out in the Oceanographic Measurements Report (Report 7), the Nearshore Measurements Report (Report 8), and the Remote Sensing Report (Report 9). This data was further validated by incorporating the monitoring results of the baseline monitoring programme.

Site-specific tolerance limits to SSC for the sensitive sites have been identified as part of the IA process (i.e. North and South Traps, Rolling Grounds, Graham Bank and the nearshore reef systems). Two limits have been determined, the 80th percentile (Response Limit) and the 95th percentile (Compliance Limit) of the natural SSC variability experienced at these sites prior to iron sand extraction (**Table 2**). The 80th percentile Response Limit will act as an early indicator that SSC is approaching the 95th percentile. An Operational Response to lower the SSC (see **Section 2.7**) will be immediate and mandatory if the 95th percentile Compliance Limit is reached. In the event that the 80th percentile Response Limit is reached, an Operational Response will only be required if a direct causative link can be made to the Project. Review of the particle size distribution of tailings is likely to be a key management tool in reducing SSC.

The Environmental Monitoring Programme in **Section 5** has been developed to monitor SSC in relation to the Response Limits and Compliance Limits so that effects of the extraction can be managed to acceptable concentrations. The SSCs will be monitored continuously and telemetered back to shore on an hourly basis (See **Section 2.7**) to ensure compliance can be assessed. Monitoring will also assess SSC against predicted concentrations in order to validate the outputs of the sediment plume modelling. This validation was also undertaken for the background levels of SSC during the two year baseline environmental monitoring programme. Turbidity may be used as a proxy for SSC during the environmental monitoring programme once the relationship between SSC and turbidity has been validated from the water samples and optically measured results. These validations will be ongoing through the life of the monitoring programme.

Since the sediment transportation model calculates excess (above background) SSC caused by the extraction and disposal, the median of the background concentrations was subtracted from the 99th percentile of the background concentrations. This was used to derive the response and Compliance Limits for SSC presented in **Table 2** as used for all the subsequent analyses. The locations for these defined Response Limits and Compliance Limits are presented in **Figure 4**.

Table 2: Suspended Sediment Concentration Response and Compliance Limits

STB Sites	Background percentiles (SSC mg/L)			
	Surface		Bottom	
	80th percentile - Response Limit	95th percentile - Compliance Limit	80th percentile - Response Limit	95th percentile - Compliance Limit
Rolling Grounds	0.3	1.1	3.5	15.3
Graham Bank	1.7	4.5	32.8	84.0
Source A to Whanganui 1 km	1.1	2.7	16.9	44.2
Source A to Whanganui 20 km	2.3	5.9	29.0	76.6
South Traps	6.3	11.1	37.7	97.4
North Traps	7.2	12.4	46.5	115.0
Tuteremoana	8.5	13.6	23.7	62.5

Figure 4 SSC Response Limit and Compliance Limit Locations

2.8.2 Biological and Ecological Monitoring

Changes in macroinvertebrate and zooplankton community composition will be examined using a suite of univariate and multivariate community analysis tools designed to detect statistically significant ($p<0.05$) changes in community composition. Changes in communities can often occur as a result of natural spatial and temporal variation; therefore, if significant changes are identified, further analyses will be done to investigate the environmental and/or anthropogenic variables driving these changes, and in particular, determine whether these changes are occurring as a result of the iron sand extraction activities.

Biological statistical analyses will include: 1) Non-Multidimensional Scaling (**nMDS**) plots and analysis of similarity (**ANOSIM**) tests to identify differences/similarities in the assemblage of benthic organisms between a-priori specified groups of sampling sites (Extraction, Deposition and Non-extraction); 2) Distance based linear models (**DISTLM**) to test how much variation in community structure is explained by each predictor (environmental) variable; 3) SIMPER analysis to determine the contribution that each species/taxa makes to the average similarity of a group of samples, and; 4) PERMANOVA models to examine the effects of site and sampling period on macroinvertebrate community composition.

2.8.3 Physico-chemical Evaluation

Physical and chemical variables to be monitored as part of the environmental monitoring programme will include sediment grain size, organic content, REDOX (**ORP**), pH, total free-sulphide and metals (principally Cd, Cu, Ni and Hg). Spatial and temporal changes in each of these variables will be examined using appropriate statistical techniques, for example general linear models, to detect statistically significant ($p <0.05$) differences through time (i.e. differences between pre and during extraction measurements) and among sites (to examine spatial impacts along the gradients). Baseline monitoring at the selected sample stations will provide an indication of natural background concentrations taking into account spatial and temporal variation from which changes can be assessed.

Sediment metal concentrations will also be compared against national sediment quality criteria (i.e. ANZECC, 2000), where suitable criteria are available. These commonly used guidelines are based on statistical models of toxicity data for a wide range of contaminants, and aim to predict levels of contaminants in aquatic sediments above which adverse ecological effects may occur. The ANZECC 2000 criteria are defined as Interim Sediment Quality Guideline–Low (ISQG-Low) and –High (ISQG-High) levels, which represent two distinct probability thresholds for possible and probable biological effects respectively.

2.8.4 Underwater Noise

A number of management actions will be adopted to minimise any potential adverse effects associated with underwater noise and/or to assist with quantifying the impacts of underwater noise. These actions are outlined below.

There are two management measures that specifically relate to compliance monitoring of underwater noise, these are:

- The combined noise from the IMV and crawler operating under representative full production conditions shall, at 10 m below the sea surface and 500 m from the IMV, not exceed 130 dB re 1µPa RMS linear in any of the following frequency ranges: low frequency 10-100 Hz, mid-frequency 100-10,000 Hz, and high frequency >10,000 Hz; or
- The overall combined noise level across all frequencies shall not exceed a sound pressure level of 135 dB re 1µPa RMS linear at 10 m below the sea surface and 500 m from the IMV.

TTR have adopted an underwater noise monitoring programme to test for compliance with these management measures and is detailed in **Section 14**.

2.8.5 Start-up Procedures

The use of 'pre-start observations' and 'soft starts' during any operational start-up will aim to minimise the potential negative effects of underwater noise in the STB.

Soft starts involve a gradual increase in power over a minimum of 20 minutes whenever iron sand extraction activities commence or recommence after a break (e.g. when the IMV is relocated between extraction blocks, or following the cessation of activities for inclement weather or an Operational Response etc.). Soft starts are implemented to give animals in the immediate vicinity a chance to leave the area before full production operational noise is reached. Soft starts are preceded by a 30 minute period of pre-start observations with operational start-up being delayed if whales or dolphins are present.

2.8.6 Marine Mammals

A number of management actions will be adopted to minimise potential impacts on marine mammals during the iron sand extraction activities. The management actions that relate to marine mammals are summarised below.

There are two management measures related to compliance monitoring of marine mammals; one of these are solely related to the monitoring of underwater noise and is covered in **Section 14**. The other management measure, whilst also related to underwater noise, has broader implications for marine mammals and is outlined below:

- If a whale or dolphin approaches to within 500 m (the mitigation zone) of the IMV in the 30 minutes prior to a soft start, then the soft start should be delayed until the animals have been observed leaving the mitigation zone or have not been detected within the mitigation zone for 30 minutes.

In addition to the monitoring programme for marine mammals, a Marine Mammal Management Plan has been prepared which describes additional requirements with regards to marine mammals including:

- Strategies to support compliance with Operational Responses, consent conditions and relevant legislation (in particular the Marine Mammals Protection Act 1978 and Marine Mammals Protection Regulations 1992);
- Procedures and protocols to minimise the risk of whale and dolphin entanglement; and
- A training framework relating to marine mammal operational responses.

2.8.7 Seabirds

There is a recognised potential that vessel lights may attract nocturnal seabirds and that this attraction may result in bird strike (the collision between seabirds and vessel structures). Management measures for threatened seabird species will be developed in consultation with DOC and are incorporated in the Seabird Effects (Lighting) Mitigation and Management Plan. This plan was prepared in accordance with the following objectives:

- To mitigate and where possible avoid adverse effects on seabirds from vessel lighting;
- To establish thresholds of adverse effects for threatened seabirds;
- To identify Operational Responses that will be implemented when thresholds are reached; and

- To monitor bird strike and manage extraction activities to reduce bird strike incidence.

In addition to these objectives the Seabird Effects (Lighting) Mitigation and Management Plan also covers the reporting of incidental seabird sightings and the training of personnel in relation to seabird requirements.

3 PRIMARY ENVIRONMENTAL DRIVERS

3.1 Introduction

This section summarises the main areas of ecological sensitivity and primary drivers of environmental effects associated with the Project.

3.2 Affected Ecosystem Components

The main direct physical impact on aquatic communities will be the physical removal of sessile and sedentary species, as well as relatively immobile taxa within the Project Area. It is likely that all larger, hard-bodied organisms will be screened out, but larger soft-bodied organisms will be destroyed as they go through the extraction pump and will be removed from the area of the extraction pit. Smaller organisms such as bacteria and protozoa and maybe some polychaete worms will possibly survive the iron sand extraction process and be redeposited on the seafloor.

Recolonisation and recovery is predicted to occur on a continual basis with the total amount of habitat affected at any one time being quite low.

In close proximity to the iron sand extraction activities, suspended sediments will have an effect on the local biota through impacts on fish and through decreased light within the water column and the seabed. But due to the highly dynamic nature of the environment and the continually moving nature of the extraction activities as the area is progressively mined, the long term effects of shading on fish and primary production are considered to be relatively intermittent and of low impact.

TTR’s evaluation identified four moderate-high and 40 low risk effects that may arise from the iron sand extraction activities, with the moderate to high risk effects comprising of:

a. effects on benthic organisms within the direct extraction and deposition areas;

b. potential effects on benthic organisms further afield from the immediate extraction and deposition areas;

c. potential effects on biogenic offshore habitats due the potential choking effect; and

d. potential effects of unplanned events including biosecurity incursions and oil spills.

The North and South Traps have been identified as an area of potential sensitivity in relation to the Project. The Traps are subtidal rocky reef formations characterised by *Ecklonia radiata* habitat assemblages, located some 25 km to the east of the Project Area.

In addition, noise from the Project has the potential to adversely affect fish and marine mammals in the broader STB.

The above factors, in addition to others, structure the three interacting communities that could be affected by the Project and which provide the principal focus of this EMMP:

- Subtidal communities inhabiting soft and hard substrata that include invertebrates living on or within bottom sediments and on reef formations within 20 km of the proposed operational area;
- Planktonic and primary producers (i.e. phytoplankton, zooplankton, etc.); and
- Fish and marine mammals in the STB.

The placement of the sample stations within the environmental monitoring programme has been designed to include the different habitats that were identified as part of the early investigation work surrounding the iron sand extraction area. Both physical samples and video footage will be collected at each sample station across each of the different habitats to provide an understanding of the physical, chemical and visual state of the habitat (i.e. sand waves, ripple sand, biogenic habitat (bryozoan rubble & bivalve rubble). These sample methodologies will help determine whether there is any sediment deposition and if so, whether it has had any significant effect to the benthic communities.

3.3 Primary Source of Impacts and Associated Receptors

Outside the area of iron sand extraction, the primary potential source of Project-related environmental impacts is the mobilisation of sediments into the water column and their subsequent dispersion and deposition. Specific impact pathways include the following:

- Sedimentation effects via the accumulation/deposition of sediments which may lead to smothering of benthic communities;
- Increased SSC within the water column could reduce light penetration and photic depth and therefore the availability of light for photosynthesis. This has the potential to impact on water column phytoplankton, macroalgae and productivity, with subsequent flow on effects to fish and marine mammals; and
- Elevated SSC could directly impact on fish behaviour and distribution.

Water quality will play a key role in the assessment phase of the monitoring programme as it can provide an early indicator for the benthic, reef and primary productivity monitoring programmes. Measurements of SSC, turbidity and deposition are indicators for the deposition of fine sediments from the Project and will be monitored throughout the lifecycle of the Project.

Figure 5 provides a schematic representation of the interaction between each of the monitoring programmes, and highlights those affected by turbidity and sedimentation.

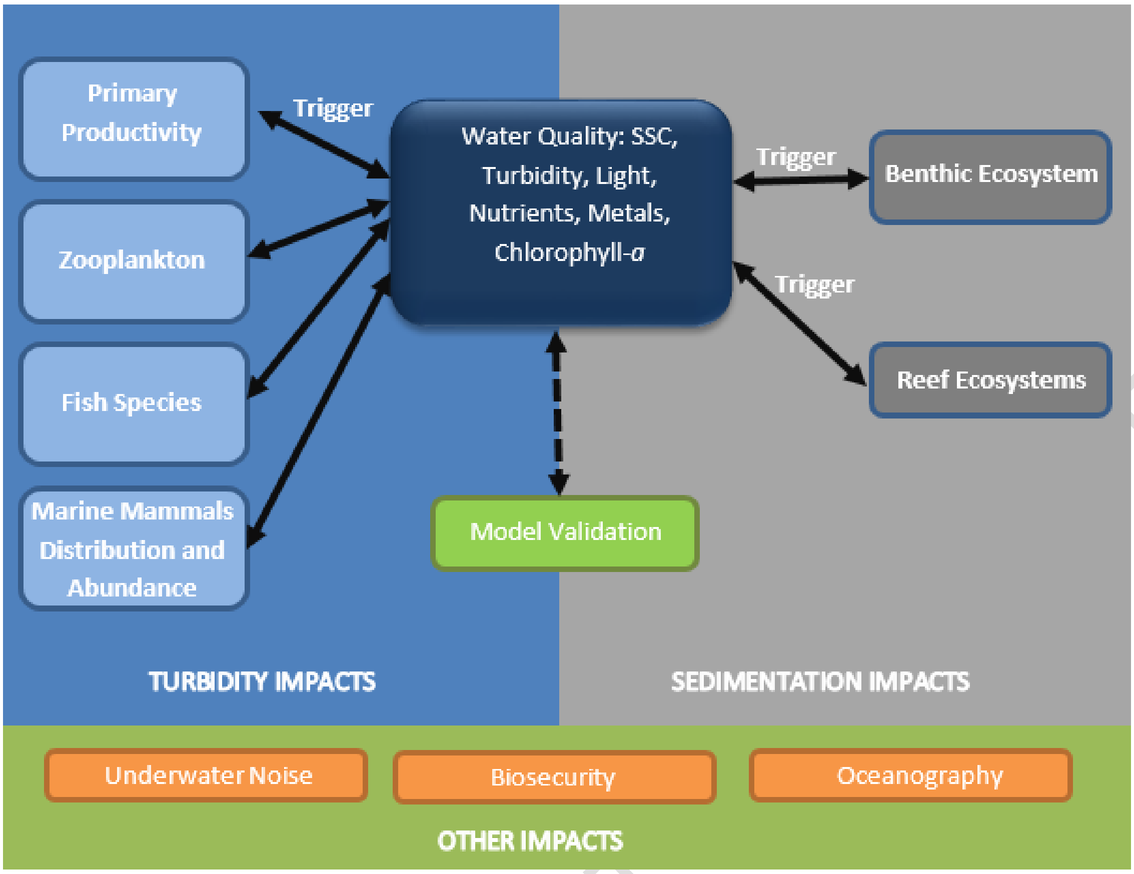

Figure 5 Turbidity and Sedimentation Interactions with the STB Marine Environment

The primary focus of the environmental monitoring programme is the assessment of the physical parameters (SSC, turbidity and noise), with biological indicators generally being used in a descriptive role. The environmental monitoring programme is part of the broader Environmental Monitoring Strategy adopted by TTR and the rationale for this is provided in **Section 4**.

4 ENVIRONMENTAL MONITORING PROGRAMME OVERVIEW

The critical elements of an environmental monitoring programme is that it needs to be practical, sufficiently robust to detect changes if they were to occur, and take into account the tolerances of important biota and natural variability in time and space.

TTR's environmental monitoring programme has been designed to capture the spatial and temporal aspects of the Project at geographic and ecological scales appropriate for predicting and observing potential effects from the Project. Findings and recommendations from the BEMP have been incorporated into this EMMP and environmental monitoring programme following the two year baseline monitoring programme.

Within the environmental monitoring programme, fixed sites have been included to provide continuous measurements of sedimentation, light levels and oceanographic conditions to monitor for compliance as well as assist in the validation of the sediment plume model. The continuous monitoring at these fixed point locations (**Figure 8**) will also be supplemented with regular synoptic surveys at pre-determined monitoring locations to monitor for compliance, changes over time to the marine environment and communities as well as recovery of the seabed in the re-deposited sediments.

The development of this EMMP has been based on recognition of the key habitats and ecosystem components identified within the STB and their interactions with the primary impact sources (i.e. turbidity and sedimentation) resulting from iron sand extraction as well as the findings and recommendations from the BEMP.

The purpose of the BEMP was to gather a robust set of baseline data over a two year period that incorporates natural variability and seasonality at a spatial scale appropriate for the assessment of all potential deposition areas for a number of different environmental parameters. This baseline data was also used to assist in the validation of the sediment plume model, which will be continually validated with the results recorded as part of this EMMP.

The key sensitive sites that were determined as part of the initial investigations in support of the IA have been included in both the BEMP and EMMP. From the modelling data, which has been validated during the BEMP, SSC Response Limits and Compliance Limits have been defined for these key sensitive sites and will be monitored for compliance for the duration of the Marine Consents. These Response Limits and Compliance Limits are summarised in **Table 2** and will be monitored continuously, with data being telemetered back to shore on an hourly basis (See **Section 2.7**) to assess for compliance; with the environmental monitoring methodologies detailed in **Sections 5-17**.

The monitoring locations have been based on interpretation of the sediment plume model predictions prepared during refinement of the Project design over 2014-2015. Primarily, this included gaining an appreciation of the extent, gradients and intensity of plumes linked to the Project in terms of turbidity and sediment deposition within the STB. The methodologies for each monitoring programme may be refined following the completion of the BEMP and consultation with the TRG.

The benthic monitoring programme and placement of sample stations has been designed to detect ecologically significant community changes that can be attributable to the iron sand extraction activities.

Once the iron sand extraction activities commence, additional monitoring sites will be included within the extraction area each year to assess the rate of ecological recolonisation. Further details of the recolonisation monitoring are provided in **Section 10**.

Table 3 provides an overview of the monitoring programmes that will be implemented as part of this EMMP and summarises the key indicators and parameters that will be assessed. Detailed monitoring methodologies for each of the programmes are provided in **Sections 5-17**.

4.1 Monitoring Locations

Monitoring locations were identified as part of the development of the BEMP and were selected based on the monitoring locations being specific to each of the different environmental parameters being monitored. Allocation of monitoring stations required a selection of representative/selective sites within each benthic community type (i.e. worm fields, inshore reefs, offshore biogenic habitats). Given there are a number of different parameters to be monitored (i.e. benthic communities, water column, sensitive sites, and marine mammals etc.) a number of different monitoring locations will be used. The monitoring locations are shown in **Figure 6**, **Figure 7**, **Figure 8**, **Figure 9**, **Figure 10** and **Figure 13**.

The ongoing environmental monitoring programme will use the same monitoring sites as those used during the baseline monitoring programme.

The monitoring locations have been designated to achieve the objectives of the monitoring activities and provide long term data on the environmental conditions and communities at that specific location. Under the EMMP, baseline data will be used to facilitate comparisons to assess if any adverse effects identified are attributable to the Project, as well gain an understanding of the recovery to the benthic communities within the completed extraction blocks.

Table 3: Overview of Monitoring Programmes and Methodologies

Monitoring Programme	Objectives	Methods
Water Quality and Sedimentation	Provide an early warning indicator of potential for impact on sensitive receptors due to deteriorating water quality. Provide contextual water quality and sedimentation data in the investigations of recorded impacts on benthic and reef ecosystems. The continued collection of water quality data in conjunction with the BEMP that accounts for spatial and temporal variability of turbidity, typical for the STB. Monitoring of sedimentation rate.	Deployed Mooring Turbidity PAR Temperature Conductivity Depth Gross Sedimentation (settlement tubes)
Model Validation	Provide high quality data for the validation of the sediment plume model results. Provide calibration and validation data for the enhancement of the Hydrodynamics and Sediment Transport models that will be run in Hindcast mode to simulate actual conditions during the Project – the OSPM. Provide high quality temporal and spatial resolution of the currents and turbidity characteristics during the Project to support validation of numerical models under a range of conditions. Obtain time-series of in-situ suspended sediment concentrations, particle size distributions and settling velocity along with current and wave measurements to allow determination of critical shear-stresses for re-suspension and settling as well as differentiation between background and extracted material suspended sediment concentrations.	Turbidity / moored sensors and profiles Sedimentation Currents / moored and vessel based transects Waves / moored instruments Particle size and settling velocity / moored instruments and profiles
Oceanography	Detect changes or trends in oceanographic processes that could not be identified via coastal processes; Detection of any significant negative coastal processes attributable to the Project; Early detection of any significant coastal processes to allow the Project to be adapted or the implementation of management measures; Validation of the sediment plume transport model and informing the real-time sediment plume model during the iron sand extraction phase of the project; and Provision of a long-term data set of oceanographic data within the STB.	Deployment of ADCP for measuring waves Deployment of AWAC for measuring currents

Monitoring Programme	Objectives	Methods
Primary Productivity	Investigate the potential effects of iron sand extraction and deposition on primary productivity by plankton. Determine how primary productivity indicators respond to gradient of effect with distance from operational Project areas.	Phytoplankton community composition, Chlorophyll-a levels in the water column, micro-zooplankton community composition, chlorophyll-a in surficial sediments, Light availability - PAR logger Turbidity - NTU logger
Zooplankton	Assess the potential effects of iron sand extraction on the biomass, abundance and diversity of zooplankton communities. Assess the potential effects of iron sand extraction on water colour, clarity, and compare data to zooplankton abundance, diversity and biomass results.	Zooplankton diversity, abundance and distribution Surface water colour and clarity
Subtidal Benthos	Investigate the potential effects of iron sand extraction on the abundance and diversity of soft-bottom infauna and epifaunal communities within and surrounding the extraction area; Determine whether there are significant changes in sediment characteristics (sediment grain size, redox potential (ORP) and pH) following iron sand extraction; and assess how any changes affect abundance and diversity of soft bottom communities; and Follow the subsequent recovery of any infauna and epifauna communities that may be impacted and relate this to depth of sedimentation, nature of sediment and ORP. Determine the recolonisation of the de-ored sediment after it has been deposited back on the seabed.	Ecological benthic sampling programme Abundance and diversity of infauna and epifauna Sediment physico-chemical characteristics Microphytobenthos
Subtidal and Intertidal Reefs	Investigate the potential effects of iron sand extraction on the abundance and diversity of selected subtidal and intertidal reef communities in the STB. Investigate the levels of sand inundation/depletion around selected intertidal reef systems along the STB coastline.	Intertidal and subtidal ecological surveys using both quantitative and qualitative methods. Drop camera photoquads. Diver surveys
Marine mammals	To ground-truth the predicted impacts of iron sand extraction on marine mammals; and To conduct surveys to describe the variability of marine mammal relative abundance and distribution in the STB during and after iron sand extraction.	Incidental sightings Systematic observations Aerial surveys Acoustic surveys

Monitoring Programme	Objectives	Methods
Underwater Noise	Establish underwater noise characteristics at selected locations within STB relative to the noise contour established by way of marine consent condition.	Fixed-point underwater noise surveys Underwater noise: vessel surveys
Recreational Fish	Monitor and report on impacts to key recreationally targeted fish species to determine if changes to recreational fishing and fish catch occur from the Project.	Catch per unit effort, total abundance, size, Vessel counts
Biofouling and Biosecurity	Early detection of new marine pests introduced into the STB. To allow implementation of marine pests emergency response where any Introduced Marine Pests are detected.	Invasive species presence or absence

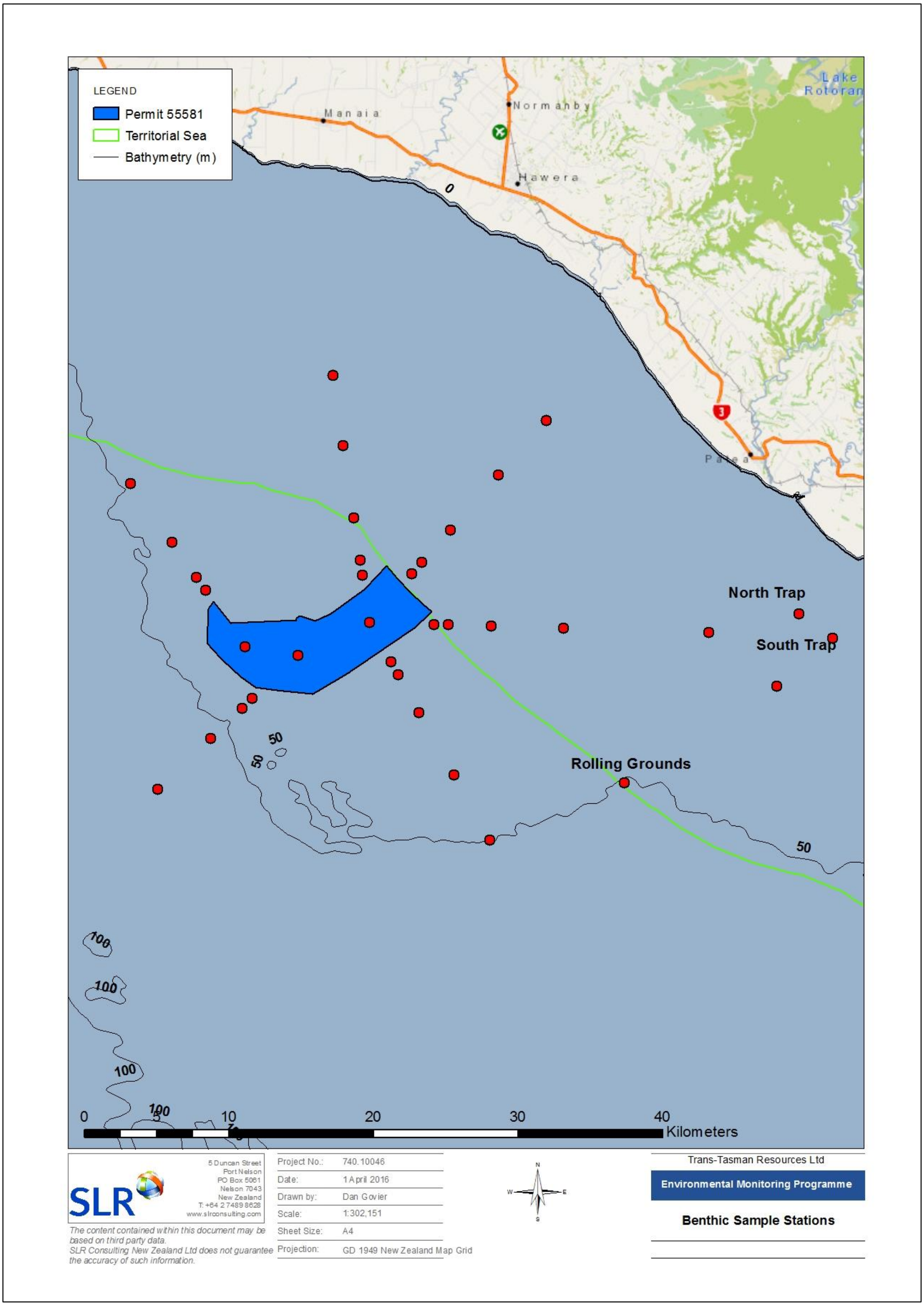

Figure 6: Location of benthic monitoring stations in STB in relation to the extraction area

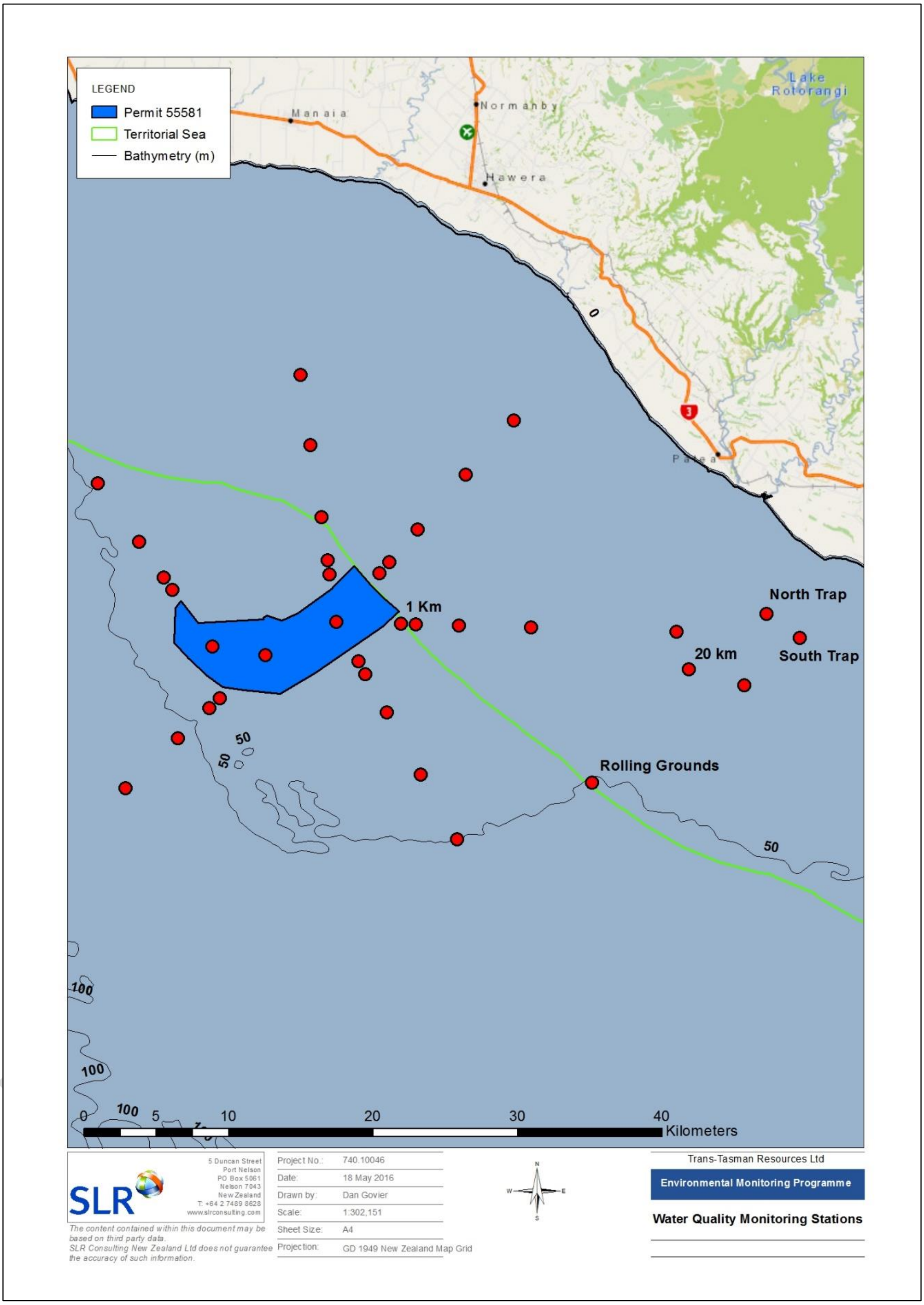

Figure 7 Location of water quality monitoring stations in the STB in relation to the extraction area

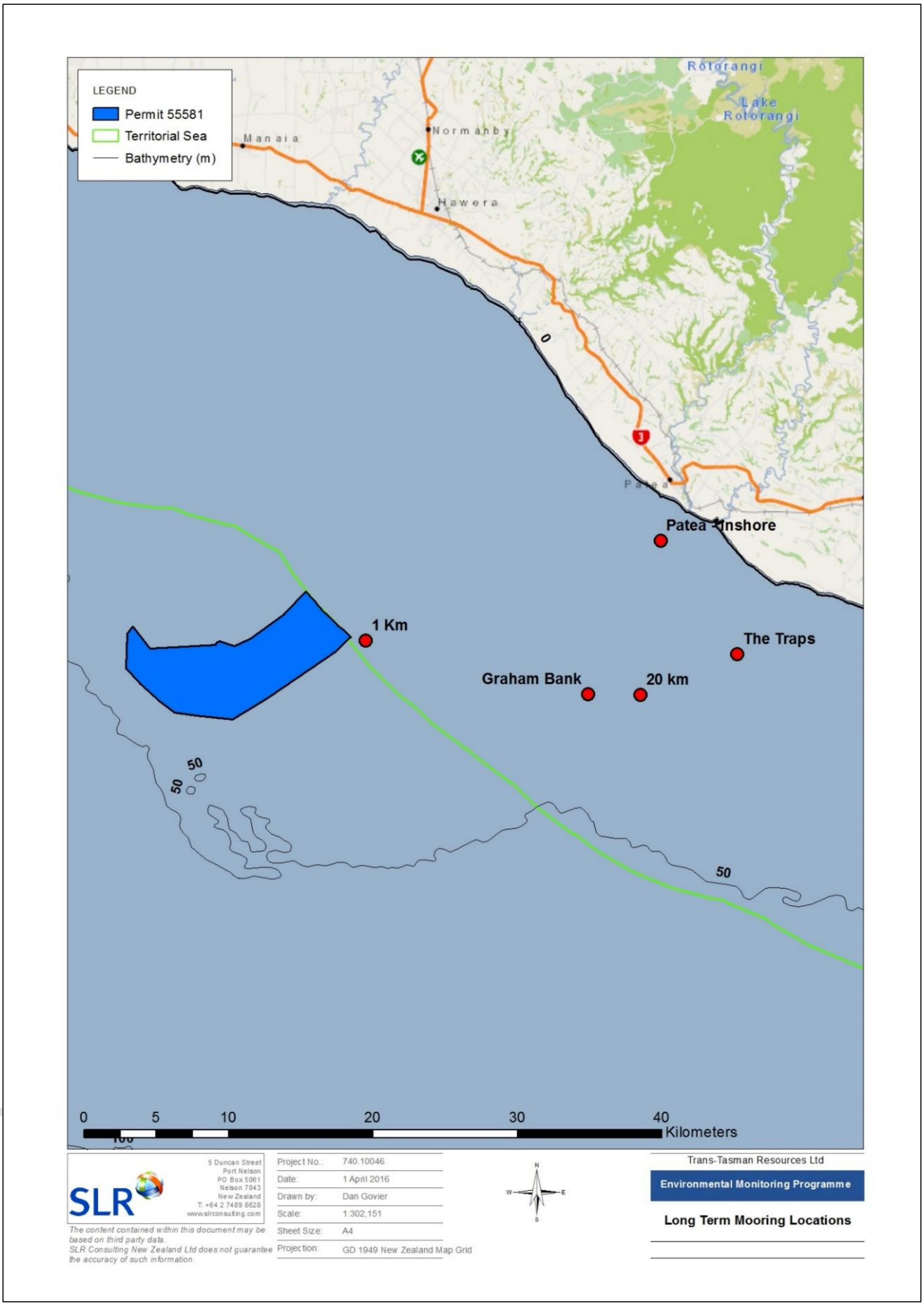

Figure 8 Location of fixed mooring locations in the STB in relation to the extraction area

4.2 Timing and Frequency

In order to monitor potential effects of iron sand extraction throughout the STB, the sampling schedule for each of the monitoring programmes (**Sections 5-16**) has incorporated the spatial and temporal scales over which impacts could be observed.

A two year baseline monitoring programme has been undertaken in accordance with the BEMP to provide further information on the marine environment in the STB prior to iron sand extraction activities commencing. The baseline monitoring programme also validated the sediment plume model and confirmed that the Response Limits and Compliance Limits are appropriate for implementation during the EMMP.

The baseline monitoring programme was largely undertaken on a quarterly basis to provide an understanding of natural variability and seasonality on ecological communities and water column characteristics within the STB. This baseline data will be used to determine whether any environmental changes to the marine environment or anomalies in sample results are attributable to the Project.

The environmental monitoring programme will continue for the duration of the Project and for a period of four years after completion of iron sand extraction activities (or a lesser time as approved by the EPA) in accordance with the post-extraction monitoring plan. Post-extraction monitoring will be undertaken to gain an understanding of the recovery of the seabed and marine communities following all extraction activities ceasing.

The frequency of monitoring in **Sections 5-16** reflects the assumption that a continuous monitoring programme will be implemented throughout the term of the TTR Project. As noted in the IA there will be operational and weather downtime; however, downtime periods will be accounted for during the interpretation of monitoring results.

4.3 Sampling Design

A 'Before After Gradient' (**BAG**) sample design will be utilised for most components of the Environmental Monitoring Programme. This design means that sample locations are placed at intervals distributed at variable distances from the extraction area. A BAG design is useful where a disturbance attenuates from a point source (i.e. extraction area), compared to other designs where impacts have distinct boundaries and control/impact sites can be identified. The use of this sampling design is also supported by the fact that no control sites could be selected that are close enough to the disturbance to have comparable natural variability to the disturbed environment and still be far enough away that they are not affected by the disturbance (Ellis & Schneider, 1996). Ellis & Schneider (1996) found that a BAG design was more powerful than a control impact sample design in detecting changes due to anthropogenic disturbances. The BAG sampling design avoided the problem of arbitrarily selecting control sites and the results from a gradient layout design enabled chemical, physical and biological changes to be assessed as a function of distance from the disturbance area.

A primary concentration gradient of the sediment plume has been indicated by the modelling, resulting in sample stations being placed along this primary axis of deposition out to at least 20 km from the extraction area. Sample locations have also been placed along other secondary axes radiating away from the extraction location and sediment plume to enable a full assessment of disturbance to the receiving marine environment.

The sample stations for the Project are indicated **Figure 6**, **Figure 7**, **Figure 8**, **Figure 9**, **Figure 10** and **Figure 13**, while the specific sampling methods for each of the different monitoring components are detailed in **Sections 5 - 16**.

Water quality monitoring will be undertaken at a number of transects radiating away from the extraction location, where synoptic surveys will be undertaken along these transects. The water quality monitoring locations are provided in **Figure 7**, while details of the monitoring approach are provided in **Section 5**.

Marine mammal and underwater noise monitoring programmes will utilise survey designs and monitoring stations specific to those receptors of interest. These designs are described in more detail in **Sections 12** and **14.**

4.4 Data analysis

Data analysis will be specific to each monitoring programme and will include descriptive statistics, inferential techniques, univariate and multivariate methods, power analysis and distribution plots to provide visual summaries of biological and physical data sets. Monitoring data will be tested for differences along the gradient monitoring sites and before, during and after extraction for changes in relation to the gradient of effects monitoring as appropriate.

Further and specific details of the statistical techniques to be used for each monitoring programme are presented under “data analysis” in each of the relevant monitoring sections of this EMMP. All of the analyses proposed have been selected due to their ability to provide robust, meaningful and accurate outputs which will provide valuable insights into spatial and temporal changes in biological and physical variables of interest. They will also enable any impacts related to iron sand extraction to be identified and their scale/magnitude assessed.

All statistical analyses will be undertaken by experienced statistical scientists using appropriate software packages.

4.5 Quality Assurance

All data gathered as part of the baseline monitoring programme was governed by TTR’s Quality Assurance Management System and complied with the requirements of AS/NZS ISO 9001-2008.

Quality control procedures, approaches and considerations will be in place for each of the different monitoring programmes to ensure that the results are robust prior to submission to the EPA in compliance with Marine Consent conditions.

Quality assurance procedures for data management, statistical analyses and reporting are common to all environmental monitoring programmes and are described below.

4.5.1 Data Management

A purpose-designed database will be developed for each environmental monitoring programme into which the resulting data will be entered. Data will be entered by a scientist and then checked by a second scientist. In addition, software error checking queries will be run to detect errors or omissions that may still be present.

Data exported for use in statistical analyses will be locked to avoid corruption or accidental over-write. Any changes to original datasheets will be saved as different versions to ensure overwrites do not occur.

4.5.2 Analyses

All statistical analyses carried out will be checked by a senior scientist for appropriateness of technique and interpretation of results.

All video footage will be error checked before undertaking any analysis or presentation.

4.5.3 Reports

Reports will be internally reviewed by Associate and Principal Scientists. All reports are subject to a document control procedure to ensure different versions of the report are tracked through time and cannot be overwritten.

4.6 Reporting

Each environmental monitoring programme will have a unique reporting schedule as detailed in the respective monitoring programme sections and as summarised in Table 4.

All reports except daily reports will be provided to the EPA and the TRG. Routine monitoring reports will typically follow the outline below:

- A non-technical Executive Summary;
- Introduction with relevant background information and a review of previous monitoring results;
- Methodology, including field, statistical and laboratory procedures, descriptions of sites sampled (including GPS coordinates); maps indicating sampling locations;
- Data analysis and results presented in tables and figures (including photographs), as well as a trend analysis and interpretation of analytical data collected and a discussion of the results. Raw or summarised data will be presented in appendices; and
- Conclusions and Recommendations.

Table 4 Reporting schedule for Environmental Monitoring Programme

Report	Of Relevance to:												Reporting timeframe
	Water Quality & Sedimentation	Model Validation	Oceanography	Primary Productivity	Zooplankton	Subtidal Benthos	Subtidal and Intertidal Reefs	Marine Mammals	Underwater Noise	Recreational Fishing	Kaimoana	Biosecurity	
Daily Trip Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Due to TTR within 24 hours of the completion of each monitoring day
Monthly Monitoring Report	✓	✓											Due within 20 working days of the end of each monthly survey
Quarterly Monitoring Report			✓	✓	✓	✓	✓						Due within 30 working days of the end of each quarterly survey
Annual Monitoring Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Due within 40 working days of the end of the monitoring year
OSPM Validation Report		✓											Due within 40 working days of the completion of the baseline phase
LSST Deployment Report		✓											Due within 20 working days after the retrieval of the LSST
Aerial Survey Report								✓					Due within 20 working days of survey completion
Final Monitoring Report	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Due within 60 days after baseline programme completion
Response Limit Breach	✓												Due to EPA immediately (within 48 hours) of the discovery of a breach
Compliance Limit Breach	✓								✓				Due to EPA immediately following the discovery of a breach
Quarterly Operational Report (marine mammal start-up)								✓					Due within 40 working days of the end of each quarter
Underwater Noise Monitoring Report									✓				Due within 20 working days of monitoring being undertaken
Biosecurity In-water Inspection Report												✓	Due within 20 working days of inspection completion
Biosecurity Post-cleaning Report												✓	Due within 20 working days of completion of cleaning

The reporting requirements that are common to all monitoring programmes include a Daily Trip Report, an Annual Monitoring Report and a Final Monitoring Report. Further detail on each of these reports is provided below.

4.6.1 Daily Trip Report

A Daily Trip Report will be completed for all monitoring programmes for each day of field work. An approved template will be utilised for this purpose, with the completed reports being submitted to TTR within 24 hours of completion of each monitoring day.

Each Daily Trip Report will typically include the following components:

- A summary of activities;
- The number of samples collected etc.;
- A summary of deployment/retrieval of monitoring equipment;
- A description of any sampling difficulties;
- The ships manifest;

- A weather summary;
- Details of any health and safety issues or near-misses; and
- Any quality assurance issues.

4.6.2 Annual Monitoring Report

For each monitoring programme an Annual Monitoring Report will be prepared. These reports will outline the following environmental components:

- A summary report on all monitoring undertaken in the previous 12 months;
- Details of monitoring proposed for the next 12 months;
- Details of any TRG reviews of the annual monitoring data, along with any recommendations of any actions or changes to the EMMP for the subsequent 12 months; and
- Appendices containing raw data from the preceding 12 months of monitoring.

4.6.3 Final Monitoring Report

For each monitoring programme a Final Monitoring Report will be prepared at the completion of the environmental monitoring programme. These reports will include full data analysis, data summaries and interpretation of all data collected during the programme.

4.7 Health and Safety

Working around the marine environment has the potential to pose Health and Safety risks, thus, controls will be established as part of the environmental monitoring programmes to reduce the likelihood of an incident as far as possible before entering the field. As part of the environmental monitoring programme multiple levels of Health and Safety management will be implemented to ensure these controls are well established. Job Hazard Analyses will be implemented and reviewed prior to departure into the field.

All potential hazards that may arise will be identified and discussed prior to any field work, and wherever possible mitigation measures will be agreed on and implemented to address the identified hazards, reducing risk to As Low As Reasonably Practicable.

Prior to each environmental monitoring programme, a survey plan will be prepared and will include the environmental monitoring survey plan, key project personnel and responsibilities, health and safety management, hazard identification, hazard map and risk assessment, and site communication.

The survey plan will provide high-level detail on the survey being conducted as well as the detail of the health and safety management arrangements to be implemented as part of the environmental monitoring programme to ensure that the work is undertaken safely. All tasks involved in each environmental monitoring programme will be risk assessed to ensure that the potential hazards are identified and safe systems of work are developed and implemented.

4.8 Operational Sediment Plume Model

TTR will maintain an OSPM to manage the iron sand extraction activities to comply with the Marine Consent conditions and provide an effective mechanism to assist in:

- The development of the environmental response methodologies that are applied with respect to SSC;

- Predicting background and extraction derived SSC to inform the management of the iron sand extraction activities;
- Distinguishing operationally derived contributions to SSC from background processes; and
- Forecasting as accurately as possible, sediment plume dynamics including but not limited to:
    - Intensity; and
    - Geographic spread.

The monitoring programmes within this EMMP will be utilised to feed back into the sediment plume model to be continually validating the accuracy of the results. The outputs from the OSPM will be used as part of the compliance monitoring synoptic surveys for water quality. Further details of the water quality synoptic surveys that will be undertaken to monitor for compliance with consent conditions is provided in **Section 5.5.7**

In situ instruments will be placed at a number of sensitive sites (**Figure 8**) and the results will be used to compare with the model predictions during iron sand extraction activities. This will enable a long term data set to be collected for a number of different water quality and oceanography parameters that can be used to confirm the environmental effects predicted as part of the IA and sediment plume modelling.

The OSPM will be calibrated and validated with real world measurements derived from the ongoing physical monitoring data at least every six months for the first three years of iron sand extraction activities and then every 24 months thereafter. The results of these reviews will be utilised to inform the nature and scope of the ongoing environmental monitoring programme.

4.9 Community Involvement

TTR wish to engage and involve the local community in as much of the Environmental Monitoring Programme as possible. TTR will provide the public with up to date information on the iron sand extraction activities and environmental monitoring programmes. This information will be made available to the public through TTRs website for the duration of the marine consent.

TTR will provide and facilitate community meetings every six months (during the months of February and July for each year) for the first five years of the iron sand extraction activities and annually at all other times. These meetings will be notified at least four weeks prior through TTRs website and advertisements in local newspapers and radio stations.

A lot of the environmental monitoring programme requires working offshore in the remote marine environment, which has its difficulties for community involvement as a result of the stringent health and safety requirements TTR will be operating under.

However, the onshore components of the environmental monitoring programme will look to involve community or iwi members to gain a better understanding of sampling methodology and why these methods are being utilised as a way to assess the potential effects of the Project.

Where community involvement cannot be undertaken (i.e. offshore monitoring), presentations of findings from the monitoring programmes will be provided during the community meetings with the opportunity for everyone to gain an insight into the methodologies and what results are being recorded. This will enable the community an opportunity to ask questions around methodologies, what results have been found and how these results compare to what was predicted.

5 WATER QUALITY AND SEDIMENTATION MONITORING PLAN

5.1 Introduction

Operationally-derived sediments have the greatest potential to influence the water column of the STB as a result of the development and dispersion of suspended sediment plumes derived from the iron sand extraction activities.

The Water Quality and Sedimentation monitoring programme has been developed to provide an early warning system for any adverse effects identified within the STB marine environment. Monitoring results will be incorporated into the OSPM and will be utilised to determine that the environmental effects of the extraction activities are no more than predicted. This data will be monitored continuously and telemetered back to shore on an hourly basis (See **Section 2.7**) to ensure compliance can be assessed against the predetermined Response Limits and Compliance Limits (**Table 2**) at the selected key sensitive locations surrounding the extraction area (**Figure 7**).

The data from the water quality and sedimentation monitoring programme will also be incorporated into other monitoring programmes within this EMMP, particularly:

- Sediment plume modelling validation (**Section 6**);
- Benthic monitoring programme (**Section 10**);
- Primary productivity monitoring programme (**Section 8**); and
- Zooplankton monitoring programme (**Section 9**).

The validation and continual development of the OSPM requires additional oceanographic and water quality information to be collected (i.e. current profiles, sediment particle sizing measurements), and these parameters will be provided as part of the Oceanography Monitoring Programme (**Section 7**).

Sampling methodology, and key indicator parameters that will be monitored as part of the Water Quality and Sedimentation Monitoring Programme, are summarised in **Table 5**. Further details of the methodologies for each specific parameter are provided in **Section 5.5**.

5.2 Background

The STB is exposed to southerly and westerly storms, producing large swells which initiate active bed transport and resuspension of sediments. There are four large rivers which flow into the STB, the Patea, Whanganui, Rangitikei and the Manawatu which at times can provide significant inputs of sediments.

Biota in the water column and benthic environment of the STB are tolerant to the dynamic and exposed environment in which they live which includes river inputs and regular strong wave activity. As a result, the natural variability of SSC and underwater light penetration are high and have to be taken into consideration when comparing monitoring data to the Response Limits and Compliance Limits in determining whether any elevations are due to natural variability or a result of the Project.

5.3 Objectives

The overall objectives of the water quality and sedimentation monitoring programme are to:

- Provide an early warning indicator for potential impact on sensitive receptors due to deteriorating water quality;
- Provide contextual water quality and sedimentation data in the investigations of recorded impacts on benthic communities and of significant areas i.e. North and South Traps;
- Collect water quality data that accounts for spatial and temporal variability of turbidity and SSC, typical for the STB;
- Monitor for compliance against Response Limits and Compliance Limits;
- Provide a long term data set of water quality and sedimentation parameters in the STB;
- Monitor sedimentation rates in relation to Project-derived sediments; and
- Provide environmental data to continually validate the OSPM.

5.4 Sampling Approach

Sample design and methodology has been based on the current understanding of water quality and marine ecosystems in the STB, as well as the potential Project impacts derived from the hydrodynamic and sediment transport modelling.

SSC and turbidity are a readily measured variable with sufficient accuracy that can indicate the potential effects of the iron sand extraction. However, there are a range of other physical processes that affect turbidity and hence additional variables pertinent to the hydrodynamic dispersion effects and ecosystem have been included in the list of key variables to be monitored for the iron sand extraction.

Any potential for toxicity to marine organisms within the STB will be tested by a number of parameters being collected. These parameters will act as indicators to potential toxicity and will be compared against ANZECC guidelines. The parameters will include metals, nutrients and Chlorophyll-a – which is also a proxy for primary production, and the data will be incorporated into the primary production monitoring programme.

5.5 Sampling Design

5.5.1 Overview

The proposed sampling design uses the gradient approach to monitor the gradient of effects of the sediment plume dispersing away from the Project Area. This sampling design allows changes of the potential impact location to be evaluated against sites differing in proximity to the operational area.

To provide optimal resolution of the effects of the Project, the sampling design comprises of:

- In-situ water quality monitoring at fixed sites using meters;
- Vertical profiling of the water column; and
- Water samples at 1 m from the seabed and 5 m below the surface.

The above sample design will be used to test for the parameters in **Table 5**.

Table 5 Overview of the water quality and sediment programme methodology

Parameters	**Water Samples (1m off seabed & 5m below surface**	**Synoptic Survey (water profiles)**	**In-situ meters (seabed sensors)**
Metals (Cd, Cu, Ni, Hg)	■		
Nutrients (TP, DRP, NO_3, NO_2, NH_4, DRSi)	■		
Chlorophyll-α		■	■
Conductivity	■	■	■
Temperature	■	■	■
pH	■	■	■
Photosynthetic Available Radiation		■	■
Turbidity	■		
Suspended Sediment Concentration		■	■
Dissolved Oxygen		■	
Depth		■	
Water Clarity	■		
Sedimentation rates			■

Note: Green indicates the sampling method utilised

The location of the monitoring stations utilised to conduct the sampling defined in **Table 5** is provided in **Figure 7** and **Figure 8**. The in-situ monitoring locations have been placed adjacent to sensitive receptors habitats (i.e. The Traps), as well as at sites designed to resolve the sediment plume gradient (1km & 20 km down plume) within which the Response and Compliance Limits have been determined (**Section 2.8.1**), as a means to measure compliance with consent conditions.

The in-situ instruments will be in place for the duration of the iron sand extraction activities and will be serviced monthly to download the data and replace batteries where required. During servicing operations of the in-situ meters, vertical water quality profiling and samples will be conducted alongside the fixed mooring sites for validation as well as light profile interpretation and confirmation of the relationship between SSC (mg/L) and turbidity (*Nephelometric Turbidity Units*, **NTU**).

In the BEMP the synoptic surveys and water column samples were collected monthly to understand the temporal variation. This frequency will increase to fortnightly as a way of TTR managing compliance with the Response Limits and Compliance Limits. Water column data will be monitored continuously at the fixed mooring locations (**Figure 8**) and telemetered back to shore on an hourly basis (See **Section 2.7**). This, in combination with the collection of physical water samples for the validation relationship between Turbidity and SSC, will ensure compliance can be assessed. These results will also be incorporated into the OSPM.

5.5.2 Turbidity and Suspended Sediment Concentration

At each of the fixed mooring locations, turbidity sensors will be placed on a frame, approximately 1 m above the seabed during iron sand extraction activities. These sensors will be in-situ self-logging instruments and will be downloaded during routine servicing every month. Turbidity will be monitored using an instrument such as the WET Labs ECO NTU sensors. During each servicing operation a water sample will be collected and tested for SSC to locally calibrate the relationship between SSC (mg/L) and turbidity (NTU). These results will be incorporated into the OSPM.

5.5.3 Photosynthetically Available Radiation (PAR)

Underwater light will be monitored by instruments such as the upward-looking WET Labs ECO PAR sensors and will be installed alongside the turbidity sensor on the frame, approximately 1 m above the seabed. Light attenuation will be determined from the surface and bottom light measurements combined with the depth of the seabed sensor. ECO PAR sensors measure underwater light in the photosynthetically reactive bandwidth 400-700 nm. The sensor is equipped with quality precision optics and bio-wiper technology to allow the sensor to be deployed for extended periods of time.

5.5.4 Conductivity, temperature and depth (CTD)

Conductivity, temperature and depth measurements will be monitored using equipment such as an In-Situ Inc. Aqua TROLL instrument. The Aqua TROLL unit, equipped with the TROLL Shield Antifouling System is designed for long duration, fixed-site deployments. This instrument will also be mounted on the frame and deployed approx. 1 m above the seabed.

5.5.5 Sediment traps

Sedimentation rates will be measured using sediment traps deployed on the heavy instrument frame at each of the seabed mooring locations. The sediment traps will be retrieved with the real-time stations at one month intervals. The sediment traps consist of PVC tubes, attached to a vertical post on the seabed mooring frame, with the bottom ends sealed and the open-end facing upward. All sediment traps will be deployed in accordance with recommended strategy described in Storlazzi *et al*., (2011).

5.5.6 Seabed moorings and servicing

The seabed moorings will consist of a steel anchor or large concrete blocks with a vertical steel frame, attached to a surface buoy by a mooring tether. The sensors will be attached to the vertical pole while the sediment traps will be attached to a horizontal cross bar fixed to the vertical post.

The tether line between the seabed mooring and surface buoy will be as a minimum 150% of site water depth at Highest Astronomical Tide (**HAT**). The moorings will be deployed and recovered from a vessel with appropriate lifting gear and the locations of moorings will be marked using GPS during deployment activities.

Servicing trips will involve the recovery and servicing of each mooring and instrument package. Spare systems will be carried on-board in the event of a problem or where periodic major servicing works are required. Servicing will be undertaken on a monthly basis (approximate). The equipment specifications for the sensors and meters allow for deployments to extend for periods of up to two months; however, servicing intervals shall be monthly and no more than six weeks to ensure consistently high quality data is collected.

5.5.7 Vertical Profiling

Vertical profiling campaigns will be conducted alongside the servicing of fixed instrumentation as well as along transects at radiating distances away from the extraction location (**Figure 7**). This vertical profiling will be used to monitor for compliance with the 80th percentile (Response Limit) and 95th percentile (Compliance Limit) of natural variation (**Section 2.3**).

A multi-parameter water profiler such as a CTD instrument will be utilised to continuously measure water quality parameters in profile. The profiler will measure those parameters detailed in **Table 5**. Results from these synoptic surveys will be downloaded and analysed within 12 hours so TTR can ascertain whether compliance has been achieved with the environmental thresholds. If there is any exceedance the Environmental Management framework will be initiated and the EPA will be notified and kept updated through the management process that is followed (**Section 2.7**).

5.6 Data Analyses and Processing

Collected data will be quality controlled and loaded to the Project Database for archival and future retrieval for analysis as required. The SSC/turbidity data will be analysed following receipt of each data set to determine whether any exceedances of the Response Limits and Compliance Limits have occurred.

The turbidity and PAR data will be analysed using time series analysis techniques including auto and cross spectral analysis, filtering and event analyses. Correlations with salinity and temperature will be undertaken to assess algal growth limitation processes.

The SSC collected as part of the BEMP will be used to calibrate and validate the Operational Sediment Plume Model and provide data to verify the 'Response Limit' and 'Compliance Limit' values set in **Table 2**. As per the conditions, calibration and validation of the OSPM and Response and Compliance Limits will occur for the first three years of iron sand extraction activities, and then every 24 months thereafter.

Validation will occur by statistically comparing the modelled and actual measured values to provide a measure of the OSPM accuracy. The aim of the validation process is to assess whether the actual measurements differ from the predicted values and if so by what margin, and over how much of the period that was being reviewed (i.e. the percentage of time the values differ and the range, median, mean, etc. of this difference). A range of statistical techniques (within suitable statistical programmes) can be employed to assess any differences, including, but not limited to, scatterplots of predicted vs actual concentrations (and examining the adjusted R^2 value), residual plots (observed – predicted values) and calculating the root mean squared error (or standard error of the regression).

If the actual measured SSC values do not fall within 10% of the modelled values listed in **Table 2** for 95% of time within each review period, the OSPM will be revised using the actual data to update the Response and Compliance Limit values in accordance with Schedule 3 within the Marine Consent conditions.

The results from the water quality and sedimentation monitoring programme will be evaluated over the course of each sampling year for trends and effects. If monitoring results are found to indicate a trend toward adverse ecosystem effects in the STB or that the Response Limits and Compliance Limits have been reached (**Table 2**), TTR commits to implementing appropriate operational and engineered mitigation measures directed at achieving compliance with the Response Limits and Compliance Limits for SSC as discussed in **Section 2.3** and **Section 2.7**.

However, the first response to an exceedance of a Response Limit or Compliance Limit will be to undertake a full assessment of all monitoring results as well as the OSPM, current extraction activities and weather conditions to determine whether the exceedance is a result of natural environmental conditions or the Project. If no clear answer the first option would be to undertake additional sampling to determine the cause of the exceedances.

5.7 Reporting

The following reports will be generated for the Water Quality and Sedimentation Monitoring Programme:

- Notification of a Response or Compliance Limit breach;
- A Daily Trip Report at the completion of each monitoring day;
- A Monthly Monitoring Report;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Water Quality and Sedimentation Monitoring.

6 MODEL VALIDATION MONITORING PLAN

6.1 Introduction

This section of the EMMP describes the data collection components of the Environmental Monitoring Programme that will be utilised to continually calibrate and validate the OSPM.

The monitoring data collected as part of the BEMP was used to validate the numerical hydrodynamics and sediment transport modelling of the STB that was used in the IA to simulate waves, currents, water levels and fine sediment transport under natural conditions and projected conditions during the Project. Likewise data from the BEMP was used to validate the OSPM.

The EMMP will collect a range of data that will also be incorporated into the OSPM which will run simulations of actual conditions and discharges throughout the Project operation. The monitoring data will be used for model forcing terms, calibration and validation.

Field work for the Model Validation will be undertaken in conjunction with the Water Quality and Sedimentation monitoring programme (**Section 5**). The validation component will utilise data collected from the moored turbidity loggers and synoptic water quality surveys of the Water Quality Monitoring programme and particle size analysis.

Specific requirements for the Model Validation monitoring programme include:

- Collection of data that demonstrates the 3-dimensional dispersion processes are adequately represented by the depth-averaged model;
- Updated model forcing data; and ongoing data for future calibration and validation of the OSPM; and
- Particle size distribution data of the sediment in and around the Project Area to verify actual versus predicted dispersion and sedimentation patterns, with the intention to confirm that the model assumptions have resulted in more conservative predictions than the field measurements.

6.2 Model Assumptions

The sediment plume model used the ROMS hydrodynamic model methodology to simulate dispersion, resuspension and settling of fine sediments generated by the iron sand extraction (Hadfield & MacDonald, 2015). The modelling comprised of a set of nested domains; an outer domain and two inner domains. The outer domain covered Greater Cook Strait and provided oceanographic data for the inner domains. The two inner domains were defined and used in different sediment simulations, with a larger domain extending from Cape Egmont to north of Kapiti Island, and a smaller domain covers an area over the Patea Shoals (Hadfield & MacDonald, 2015).

A number of assumptions were adopted for the purpose of the OSPM and include:

- That the seabed composition is uniform over the model domains;
- That a volume extraction rate of 1.195 m^3/s will be reached at full operation and an up-time of 80%, giving an annual extraction volume of 30.15 x 10^6 m^3;
- That the discharge point for the tailings will be 4 – 6 m above the seabed; and

- That the discharge rate data for fine sediments closely represents the composition of the trapped fine sediment in the mined patch, with the remainder of the patch assumed to be composed of the three coarsest classes in the original seabed.

6.3 Objectives

Model validation requires confirmation that the model predictions are the same as, or more conservative than, field measurements collected during the iron sand extraction activities. Measurements of the source terms, far-field turbidity and sedimentation at ongoing monitoring sites, during iron sand extraction will be compared with the OSPM outputs. In addition; turbidity, SSC, currents, and particle size distributions will be collected from near, medium and far field locations using a combination of sensors, water samples and grab samples.

One of the critical issues in determining Project impacts is the differentiation between “ambient” or “background” SSC and the “added” Project contribution of sediment and associated turbidity. TTR turbidity effects in the STB can arise either directly due to suspension by iron sand extraction activities, or from re-suspension of deposited material either in close proximity to the operation or at in the medium and far fields as a consequence of natural wave processes.

The objectives of the model validation monitoring programme are to:

- Provide calibration and validation data for the enhancement of the sediment plume models that will be run in hindcast mode to simulate conditions during the Project;
- Provide high quality temporal and spatial resolution of the currents, turbidity and sediment characteristics during iron sand extraction to support the continual validation of the OSPM under a range of conditions; and
- Obtain a time-series of data for SSC, particle size distributions and settling velocity along with current and wave measurements to allow the determination of critical shear-stresses for resuspension and settling as well as differentiation between background and extracted-material SSC’s.

The monitoring programme objectives will be achieved through:

- the use of moored instruments to provide high temporal resolution of the specific variables (turbidity, water temperature and conductivity) at the mooring location;
- field campaign surveys involving deployment of current meters, water quality profilers, and water sampling to provide snapshots of the spatial variability of the turbid plume characteristics; and
- the use of moored (bottom-mounted) in-situ particle-size and settling velocity monitors in conjunction with current and wave monitors.

6.4 Methods

The monitoring programme will utilise moored instruments and vessel-based campaign surveys as described in the water quality monitoring programme (**Section 5**) as well as the details within this monitoring programme. This document describes the near, mid and far-field model validation measurements programme.

6.4.1 Operational Sediment Plume Model (OSPM) Validation

Turbidity, sedimentation, particle size and currents will be measured at a number of fixed locations as part of the water quality and sedimentation monitoring programme and subtidal benthos monitoring programme. The three main components required for the validation process are summarised below:

- Model source terms – Data on the load of fine sediment created by iron sand extraction will be measured by the use of a Laser In-Situ Scattering and Tranmissometer (**LSST**);
- Turbidity/SSC variability – time-series measurements of turbidity at the water quality monitoring sites will be analysed to determine the operational contribution to the measured signals, converted SSC and compared to the model outputs; and
- Sedimentation variability – measurements of sedimentation across the STB will be compared to the model estimates by the sediment traps located at all of the fixed mooring locations and the LSST.

These results will be compared to what has been predicted by the OSPM and if these results are found to be more conservative than the measured results, it will be determined that the OSPM has been validated. Further details of the assessment methodology between measured and modelled SSC values can be found within **Section 5.6**. This comparison will require matching of time scales between the resolution of the model results and the measured data.

6.4.2 Validation Monitoring

The surveys used in the validation of the OSPM are summarised in the following sub-sections.

6.4.2.1 Characterisation monitoring

TTR's projected operational water quality effects have been simulated by using nearfield and farfield modelling, which was based on various conservative assumptions relating to source terms and sediment behaviour. In order to validate the boundaries and intensity of the sediment plume, characterisation monitoring will be carried out for representative conditions at the commencement of the works. This will confirm the actual source terms which will be compared to assumptions made in the sediment plume modelling.

Characterisation monitoring is an intensive monitoring campaign where on-board data (production parameters) and near-field/mid-field data (plume parameters) are gathered simultaneously. Plume parameters are measured using a combination of Acoustic Doppler Current Profiler (**ADCP**) and water quality data (including, turbidity, conductivity, temperature and pH measurements).

Data from characterisation surveys in combination with data relating to run-of-mine characteristics (material type, extraction methodology and production rate for example) and cyclone and tailings discharge will allow an estimation of the loss rate and release of fine material to the environment from the Project.

Source term characterisation will involve composite daily sampling of run-of-mine, cyclone overflow and tailings discharge for PSD analysis. Sampling will continue for a 6-month period from commencement of iron sand extraction activities until the TRG is satisfied that source term has been characterised to a level to allow comparison with the OSPM assumptions.

The estimated loss rate from extraction and tailings deposition, as derived from monitoring data, review of geotechnical and extraction production data and supported by modelled estimates of the production and associated loss rates as necessary can then be used as inputs to the OSPM.

By combining production information with the results of characterisation campaigns it will be possible to verify whether source terms are more or less than the assumed predictions when compared against observed conditions.

6.4.2.2 Moored Instruments

Upward-looking ADCP units will be deployed to measure vertical profiles of water currents and optical backscatter. The ADCP units will be programmed to ensure consistency across all stations (currents x 0.5 m bins average of 0.25 Hz samples over 10 mins; logged every 10 mins). The moorings will incorporate near-bed turbidity sensors as the ADCP does not resolve backscatter in the near- bed waters. One of these instruments will be deployed in the vicinity of the disposal location and will also record surface waves to allow assessment of the contribution, if any of wave action on sediment movement and resuspension.

The LISST technology allows the measuring and recording of time-series of suspended sediment concentration and particle size distribution. It is also possible to measure and record time-series of settling velocity using a variant of the same technology (LISST-ST). This data allows characterisation of the sediment in suspension and will provide direct input for model calibration and validation. The particle size distributions allow differentiation of background material from extracted material and also identify times when bed material is being re-suspended. By including measurements of currents and waves through an acoustic wave and current (**AWAC**) instrument (similar technology to the ADCP) the shear stress on the bed can be measured and thus robust estimates obtained for the critical shear stresses for settling and resuspension – important parameters in the modelling of sediment transport.

6.4.2.3 Locations

ADCP and turbidity moorings will be located as shown in **Figure 8**.

6.4.2.4 Indicators

Water current vectors from the moored ADCPs (two horizontal and the vertical components) will be measured in a vertical profile from just above the bed to just below the surface. Acoustic backscatter is also resolved in these vertical bins. Turbidity will be measured at the single point near the bottom at each of the ADCP moorings. Water samples will be collected at deployment and recovery and analysed for SSC and particle size distribution. Additional samples at these sites will be collected during the deployments as part of the campaign measurements when the opportunity arises to enable the relationship between the meters and actual samples.

The data from the ADCP will also be used to obtain the surface elevation relative to the instrument and thus provide tidal height information for model calibration and validation.

6.4.3 Data Analyses and Processing

The data collected by the ADCPs and turbidity loggers will be quality controlled and a brief summary report on the conditions during the deployment period and data return statistics will be compiled. The processed (de-spiking and any poor quality data flagged) data will be stored and archived in a secure database for archival and future retrieval as required.

6.5 Timing and Frequency

Moored instruments will be deployed continuously and serviced monthly, while synoptic surveys once iron sand extraction activities commence will be undertaken fortnightly as per the water quality and sedimentation monitoring programme (**Section 5**). The anticipated schedule is set out in **Table 6**.

Table 6: Schedule for Model Validation Monitoring

Monitoring Frequency			
Moorings	**Sites**	**During Extraction**	**Post-Extraction**
ADCP and Turbidity Logging	5 sites	Servicing every 4- weeks. Recommendations will be provided in the annual review as to whether the frequency of sampling should be decreased.	One year
LISST frames	The Traps and vicinity of the disposal site	Two deployments coinciding with start Extraction commencing and six months later	None
Synoptic Surveys WQ Profiler Niskin water sampler for TSS collection	35 sites	Monthly	One year

6.6 Reporting

The following reports will be generated for the Model Validation Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Monthly Monitoring Report;
- An OSPM Validation Report will be produced each time the OSPM is calibrated and validated (at least every six months during the first three years of iron sand extraction activities and every 24 months thereafter) during the Model Validation Monitoring Programme. This report will detail the methods used and the results in relation to background turbidity for comparison with the sediment plume model. Any anomalies will be investigated using additional model validation measurements and outputs;
- An Annual Monitoring Report to summarise the previous 12 months of data;
- A LSST Deployment Report will be compiled at the completion of the LSST deployment. This report will include interpretation of the data in terms of characterising the suspended sediment and defining the PSD and settling velocities for background sediment. The TSS/turbidity relationships during each deployment will be presented; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Model Validation Monitoring Programme.

7 OCEANOGRAPHY MONITORING PLAN

7.1 Background

Physical oceanography processes such as waves and currents are largely responsible for sediment movement in the STB (Hadfield & Macdonald, 2015). A number of studies were undertaken as part of the baseline monitoring programme for TTRs IA and a summary from these reports have been utilised within this background section.

The STB is classed as a high-energy wave environment, where wave measurements at the 50 m depth contour has routinely recorded significant wave heights in excess of 4 m and up to a maximum of 7.1 m. Significant wave heights greater than 2 m mainly arrive from the south to south-southeast or from the southwest to west-southwest sectors (MacDonald *et al*., 2012) with wave height decreasing with proximity to the coast.

ADCPs deployed on the seabed at various locations throughout the STB have shown that tides and winds are the main contributors to water movement in the STB. Tidal currents account for 40 - 78% of measured currents, with wind driven currents accounting for the remainder. Current speeds during peak ebb and flood flows range from 0.13 ms^{-1} and 0.25 ms^{-1} (M2 tides), with tidal speeds further influenced by spring (higher speed) and neap tides (lower speed) (MacDonald *et al*., 2012).

Within the STB, west and southeast winds have the most influence on currents, where moderate to strong winds can increase current speed as well as alter current direction.

Due to the high energy environment in the STB, the water column is generally well mixed, with small vertical differences in temperature and salinity. Although slight, a temperature gradient exists in the water column with surface waters warmer than those at depth with temperatures ranging from 13 °C in September to 19 °C in March. Offshore water temperatures are slightly cooler than those inshore with less pronounced seasonal variations. Salinity levels are typically around 35 psu; however, lower salinity levels are likely to occur in close proximity to major rivers, such as Patea, Waitotara and Whanganui.

There is the potential that iron sand extraction could have the following effects on physical oceanography processes in the STB:

- Minor effects on physical driver of waves by refracting (bending the wave direction) and shoaling (changing the wave height) as the waves pass over the modified seabed (pits and mounds created by iron sand extraction); and
- Localised effects on currents through the formation of site specific features several kilometres long as a result of interactions with the pits and mounds.

7.2 Objectives

The objectives of the oceanography monitoring programme are to:

- Detect changes or trends in oceanographic processes that could not be identified via coastal processes;
- Detection of any coastal process changes attributable to the Project;
- Validation and data input to the operational sediment plume transport model; and
- Provision of a long-term data set of oceanographic data within the STB.

7.3 Methods

The key component of the oceanography monitoring programme is the deployment of ADCP and AWAC units at selected locations both within and inshore of the Project Area.

7.3.1 Deployment Locations

ADCP and AWAC meters will be deployed at locations surrounding the Project Area along the dominant wave direction from the Project Area. The mooring locations that will be utilised for deployment of the ADCP and AWAC are shown in **Figure 8**.

7.3.2 Deployment Methodology

The ADCP and AWAC instruments will be housed in a customised fabricated frame that can be easily deployed and retrieved by a surface vessel, or if necessary by divers. A transponder will be attached to the instrument frame to assist with re-location. Ideally the instruments will be located with/near-to existing mooring structures that will have been deployed for other monitoring instrumentation as part of the environmental monitoring programme; however, not all of these locations may be suitable for the ADCP/AWAC meters.

Each instrument will have a ground line, made from positively buoyant rope material, which is stretched between the mooring weight/anchor and the instrument frame, approximately 1.5 times the water depth in length. In the event that the surface marker float becomes detached from the mooring weight/anchor line (such as in a large storm event, or as a result of intentional vandalism) the ground line could be dragged up using a grapnel allowing the retrieval of the instrument.

Once iron sand extraction commences, the seasonal data recorded from the ADCP/AWAC meters during the BEMP will be compared to the equivalent data to assess for any significant changes that may have occurred as a result of iron sand extraction and cannot be attributable to the environmental conditions at that time (i.e. El Niño vs La Nina).

The ADCP/AWAC meters will be deployed for a period of two years with retrieval and downloading of the instruments undertaken every three months. The instruments and batteries will be checked, tested and replaced if necessary and will be sealed back up and programmed for the next deployment period. All data that is downloaded from the instruments will be backed up to suitably secure servers and then processed and analysed by trained and experienced scientists. Following this initial two year period and dependent on the results, three month deployments will be undertaken twice per year at selected sites.

7.4 Seabed Bathymetry

The bathymetry of the seabed has a distinct influence on the water currents and waves that move past/over it, particularly for waves as the water depths decrease. Iron sand extraction is likely to leave notable pits and mounds in the seabed as the seabed is cut and tailings are replaced. Features such as the predicted mounds and pits may influence waves and currents within/around the Project Area and therefore it is important to identify their presence following iron sand extraction and where possible attempt to align or rule out their presence with changes in waves and currents measured by instruments (if changed are found to have occurred).

Bathymetric surveys will be conducted quarterly to ensure the pits at the end of each of the mining lanes is no deeper than 10 m (maximum depth) and 5 m (average) below the pre-mined seabed level. The average depth and coordinates of any unfilled pits remaining after the completion of a mining lane will be recorded and reported in the Quarterly Operational Report (**Section 17.2**).

Bathymetric surveys will also be undertaken to ensure that the re-deposition mounds at the start of each mining lane are no higher than 9 m above the pre-mined seabed level. The height and coordinates of any such mounds created during the deposition of seabed material shall be recorded and reported in the Quarterly Operational Report (**Section 17.2**).

Following cessation of iron sand extraction activities at the operational sites, bathymetric surveys will continue annually for a period of four years, in order to assess the recovery of the seabed back to its natural state.

Bathymetry surveys will be undertaken utilising multi-beam sonar, ensuring that suitable overlap of passes occurs so that no significant seabed features are missed. The sonar units will be deployed from surface vessels using hull-mounted arrays, and will be suitably tested and calibrated. All imagery collected will be processed by trained and experienced personnel, producing geo-rectified images of the seabed so the plots can be imported into GIS software. Any seabed mounds that are observed will be recorded and reported in the Quarterly Operational Report.

7.5 Reporting

The following reports will be generated for the Oceanography Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Oceanography Monitoring Programme.

8 PRIMARY PRODUCTIVITY MONITORING PLAN

8.1 Background

The STB/Western Cook Strait is one of the most biologically productive coastal regions in New Zealand. The two main types of primary producers in this area include:

- Phytoplankton - occur in the water column; and
- Macroalgae - generally occur in relatively small areas that are relatively close to the shore and on hard substrate such as rocky reefs, cobbles and shell debris.

These organisms form the base of the food chain and use sunlight to synthesise organic compounds (via photosynthesis) and provide key energy sources to the STB ecosystem. For example, animals living in or on the seabed rely on energy from:

- Particulate and dissolved organic matter from phytoplankton primary production in the water column, which sinks to and/or is otherwise incorporated into the sediments (detrital flux);
- detritus (particulate organic matter) from seaweed settling onto the seabed;
- organic matter coming from rivers, and/or;
- animals on/in the seabed taking food from the water column.

The primary production in the highly dynamic STB region is strongly influenced by drivers such as light and nutrient availability as well as grazing by zooplankton. Many studies consider nutrients to be the main limitation on primary production rather than light availability (Bradford *et al*., 1986; Zeldis *et al*., 2013).

The Project will release sediments into the water column which will affect the optical properties of the water, specifically its clarity and colour. The propagation and dispersal of the sediment plume derived from iron sand extraction activities will result in absorption and scattering of light in the water column, reducing available light for primary producers. Elevated turbidity/SSC could also reduce available light reaching the seabed. Increased sedimentation rates (as the plume settles) could also smother primary producers and reduce productivity.

The predicted effects of the Project on the optical properties of the water column in the STB were modelled and investigated by NIWA (Pinkerton & Gall, 2015; Cahoon *et al*., 2015). The effects were predicted based on applying an optical model to the results of a sediment transport model (Hadfield & Macdonald, 2015). The report concludes that the optical effects of iron sand extraction activities were likely to cease very quickly following the cessation of activities, i.e.in the order of weeks or months.

Expert conferencing during the 2014 EPA hearing produced a number of recommendations from the joint witness statements which have been built into the primary productivity monitoring programme. Where, experts agreed that due to the wide natural variation in space and time in the abundance of microphytobenthos it would not be possible for sampling to have sufficient statistical power to detect a change due to iron sand extraction.

8.2 Potential Project Impacts and Receptors

Outside the area of direct iron sand extraction, the primary potential source of Project-related environmental impacts is the mobilisation of sediments (and its constituents such as nutrients) into the water column and their subsequent dispersion and deposition. Specific impact pathways include the following:

- Increased SSC within the water column could reduce light penetration and photic depth and therefore the availability of light for photosynthesis. This has the potential to impact on water column phytoplankton, and macroalgae productivity, with subsequent flow on effects to zooplankton, fish and marine mammals; and
- Sedimentation effects via the accumulation/deposition of sediments which may lead to smothering of some sedentary marine organisms and microphytobenthos.

8.3 Objectives

The objectives of the "Primary Productivity" monitoring programme are to:

- Ground-truth the predicted impacts of the iron sand extraction on primary productivity by plankton and macroalgae;
- Determine how primary productivity indicators respond to the gradient of effect with distance from the Project Area.

The objectives of the primary productivity monitoring programme do not address macroalgae which is covered in **Section 11**. Primary productivity monitoring will be undertaken according to the criteria set out in **Table 7**.

Table 7: Primary productivity monitoring criteria

Sample type	Criteria measured
Phytoplankton*	Chlorophyll-a, phytoplankton community composition (taxonomic identification and enumeration)
Micro-zooplankton	Micro-zooplankton (zooplankton <200 µM), community composition (taxonomic identification and enumeration)
Microphytobenthos***	Chlorophyll-a of surficial benthic sediments
Light availability**	PAR loggers
Turbidity*	NTU loggers
Nutrients*	TP, TP, DRP, DRSi, NO3, NO2, NH4

* Samples for these monitoring criteria are listed here under primary productivity monitoring but would be collected as part of the water quality monitoring, which would be sampled at the same time.
** PAR measurements would be collected during the synoptic water quality surveys (via CTD) but longer term PAR sensor deployments would fall under primary productivity monitoring and are detailed in **Section 5**.
*** Samples for microphytobenthos (benthic microalgae) are listed here under primary productivity monitoring but would be collected as part of the benthic sediment monitoring (**Section 10**).

8.4 Operational Response Measures

The STB ecosystem is subject to regular storm-related disturbance, and biological assemblages have become adapted to disturbance and sedimentation, and it is likely that primary producer communities will be tolerant to intermittent elevations in SSC and deposition.

Based on a lack of sensitivity data and the high natural variability within primary producer communities, it is not possible to define specific management limits for SSC or sediment deposition.

The secondary driver of effects on phytoplankton will be reduced light transmissivity. So the most appropriate approach for primary productivity monitoring will be to measure changes in the underwater light regime.

8.5 Methodology

The primary productivity monitoring programme is summarised in **Table 8**. It is important to note that many of these parameters will be sampled during the water quality or benthic sediment monitoring programmes (**Section 5** and **Section 10**). Hence, water quality data is a fundamental requirement of this primary productivity monitoring programme, and the methodology associated with the collection of water quality data is described in **Section 5**. In the large part, the sampling sites and sampling schedule for this primary productivity monitoring programme will follow that of the water quality monitoring programme to ensure a full correlation of data.

To estimate the standing stock of phytoplankton in the water column measurements of chlorophyll-a (fluorescence), light (PAR) and turbidity (NTU) will be recorded at various sites across the STB. Water samples will be analysed for chlorophyll-a content, nutrients and SSC (via laboratory analyses), phytoplankton and micro-zooplankton community composition (via taxonomic identification and enumeration), with simultaneous optical recordings of chlorophyll-a, light and turbidity along depth profiles. Modelling methodology will be used to extrapolate the productivity estimates from these sampling sites to a productivity estimate for the entire STB (before, during and after iron sand extraction).

The combination of these indicators will provide information on primary productivity over long-, medium- and short-term scales, both for sample locations and over the STB.

8.6 Sampling Design

A BAG sampling design will be utilised in the primary productivity monitoring, the same as that used for the water quality monitoring. The proposed sampling stations are indicated in **Figure 7**.

The monitoring programme will be conducted in three phases:

- Phase 1: Baseline sampling (2 years prior to iron sand extraction and completed as part of the BEMP);
- Phase 2: During iron sand extraction activities (the most intensive phase); and
- Phase 3: Post-extraction (for four years after completion of iron sand extraction).

The monitoring design will be kept somewhat flexible to allow for changes over time based on recommendations from the TRG following the finalisation of each annual monitoring report.

8.7 Field Sampling Techniques

Field sampling techniques for the collection of water samples are detailed in **Section 5** while those for benthic sampling are detailed in **Section 10**.

8.8 Laboratory Analysis

Laboratory analysis of water samples will follow the programmes detailed in **Section 5**.

8.9 Statistical Analysis

Results of the water column primary productivity would be analysed using the methods outlined in the water quality monitoring programme (**Section 5**).

Data collected during iron sand extraction activities are taking place will be compared to baseline primary productivity data to determine if any changes are apparent.

8.10 Timing and Frequency

Quarterly phytoplankton surveys will be undertaken in coordination with the water quality monitoring programme. Following cessation of iron sand extraction, annual surveys will take place for a period of up to four years; however, this frequency may alter or cease based on recommendations within the monitoring reports, TRG review and EPA approval.

During the iron sand extraction activities water column primary productivity will continue to be surveyed quarterly, with annual reviews of the results which will include reviewing the frequency of monitoring.

8.11 Reporting

The following reports will be generated for the Primary Productivity Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Primary Productivity Monitoring Programme.

8.12 Community Involvement

Due to the strict health and safety regulations surrounding working aboard vessels in the open ocean it is difficult to safely involve local community members in the sample collection or physical monitoring. A synthesis of findings from the primary production monitoring programme will be presented to the community periodically in accordance with TTR’s ongoing commitment to stakeholder engagement.

Table 8: Primary productivity monitoring programme

Scope	Sites	During extraction activities	Post-extraction
Fixed meters for Chl-a, PAR, turbidity	Fixed moorings at 5 locations, with sensors near the surface (~5m) and near seabed (~1m above seabed). Monthly servicing/download at time of water quality synoptic surveys.	Continuous monitoring during extraction activities. Frequency reviewed annually. Monthly servicing/download at time of water quality synoptic surveys.	Continuous monitoring for period of four years following cessation of extraction activities. Frequency reviewed annually. Monthly servicing/download at time of water quality synoptic surveys.
Water column phytoplankton, micro-zooplankton, nutrients and turbidity.	Water quality monitoring stations as detailed in **Section 5**.	Quarterly sampling during extraction activities, with frequency reviewed annually.	Quarterly sampling for period of four years following cessation of extraction activities. Frequency reviewed annually.
Synoptic profiling surveys (Turbidity, Chl-a PAR, salinity, temperature, depth).	As part of water quality sampling at stations along transects extending away from extraction areas, as detailed in **Figure 7.**	Monthly synoptic surveys during extraction activities with frequency reviewed annually.	Monthly sampling for period of four years following cessation of extraction activities. Frequency reviewed annually.

9 ZOOPLANKTON MONITORING PLAN

9.1 Background

Zooplankton are microscopic animals which typically inhabit surface waters and play a critical role in marine food webs, and are the link between primary producers and many other marine fauna (James, 2016). Zooplankton distribution is influenced by many factors including oceanic upwelling of nutrient-rich water, tidal mixing, riverine discharges, coastal processes and the abundance and distribution of phytoplankton and predators.

The STB region is considered to be very productive, with zooplankton biomass estimates being among the highest recorded for coastal New Zealand (MacDiarmid *et al*., 2013). The STB is influenced by the D'Urville Current and upwelling from the Kahurangi Shoals which introduces cold nutrient rich waters to the region. The nutrients from these sources drive primary production as water moves around the top western side of the South Island and into the STB where, other nutrient sources (including Cook Strait) contribute to a further increase in primary production. As the highly productive upwelling plumes from Kahurangi Shoals develop, a concurrent increase in zooplankton biomass occurs (James & Wilkinson, 1988). These upwelling events are also thought to be important for the squid aggregations which occur in the lower Taranaki Bight (James, 2016), and the blue whale foraging grounds in this region (Torres et al., 2015). Zooplankton distribution predominantly depends on the prevailing currents, advective processes, and in-situ primary production; hence zooplankton communities can be highly transient.

Some meso-zooplankton sampling was undertaken in the STB in the 1970s and 1980s (Battaerd, 1983; Bradford, 1977, 1978, 1980; Bradford *et al*., 1993). However, this work was conducted at least 20 years ago, and was mostly well offshore, it also lacked estimates of zooplankton biomass for the whole water column, which are important components of ecosystem models (MacDiarmid *et al*., 2013). To address this information gap, TTR commissioned NIWA to study zooplankton communities in the region that may be impacted by a sediment plume from the iron sand extraction. Zooplankton was sampled from the sea surface to just above the sea floor at 19 stations along two transects which ran approximately east-west and north-south through the centre of the proposed extraction area (MacDiarmid *et al*., 2015). Sampling took place in February 2015 and, while this study is a snap shot in time, James (2016) notes the key findings of this study as follows:

- There was no obvious pattern in zooplankton biomass inshore-offshore but highest biomass was found over the Patea Shoals and east towards Whanganui;
- Copepods dominated most stations sampled except salps and juvenile euphausiids which dominated the stations with highest biomass. Most of the copepods were omnivores and dominated by Oithona and Paracalanus; and
- The community was typical of nearshore waters and, as would be expected, was dominated by neritic or coastal species.

Zooplankton can be affected by high concentrations of suspended sediments. Arendt *et al*. (2011) found that concentrations of fine sediment above 20 mg/l can clog zooplankton respiratory surfaces and/or feeding apparatus as well as impair prey detection. Considerably higher levels would be required to have a significant impact with Wilber & Clarke (2001) finding fish eggs and larvae were only impacted if SSC was over 500 mg/L. Plume modelling of the iron sand extraction predicts that SSC in near surface waters will increase by up to 3 mg/L. This increase in SSC is significantly lower than the ecological thresholds for impact described above; hence, any impacts to zooplankton are predicted to be minor and will be followed by rapid recovery (James, 2016).

9.2 Monitoring Objectives

The overall objectives of the zooplankton monitoring programme are to:

- Ground truth the predicted effects of iron sand extraction on the biomass, abundance and diversity of zooplankton communities; and
- Correlate data on water colour, clarity, and optically active component concentrations (as collected under the Primary Productivity Monitoring Programme) to zooplankton abundance, diversity and biomass results.

9.3 Sampling Design

The sampling design combines the BAG sampling approach that seeks to monitor the gradient effect of the sediment plumes along transects radiating away from the extraction area.

The zooplankton monitoring programme will be conducted in three Phases:

- Phase 1: Baseline sampling (two years pre-operational – conducted under the BEMP);
- Phase 2: During iron sand extraction; and
- Phase 3: Post-extraction (up to 4 years following completion of iron sand extraction).

Monitoring will be undertaken quarterly at locations as shown in **Figure 7** and will align with sampling for other water column parameters (e.g. water quality). This design is flexible to allow for changes to the monitoring programme over time based on results and findings/recommendations in the annual report as well as following submission to the TRG.

9.4 Field Sampling Techniques

The following sections detail the approach that will be utilised during field sampling of zooplankton, water colour, and water clarity.

9.4.1 Zooplankton

Zooplankton will be sampled from the sea surface to just above the sea floor using a 57 cm conical net with 200 µm mesh such as “The Heron” net (or similar). The PVC cod-end of the net will have a removable lower section with window meshes to enhance water filtration through the net. One zooplankton sample will be collected at 32 stations along transects surrounding the extraction area and will be at the same stations as the water quality monitoring programmes (**Figure 7**). At each station the water depth will be noted and the appropriate length of hauling rope (~2-3 m short of the seafloor depth) will be flaked onto the deck. This is to ensure the net does not make contact with the seafloor at the full extent of its vertical drop.

Prior to each deployment once the vessel is stationary, the net choking rope will be fully eased to ensure the mouth of the net is not restricted. The net will be cast by hand from the vessel and allowed to free-fall to the desired depth with no restriction on the hauling rope. Once the required depth is reached, the hauling rope will become taut closing off the choking rope to secure and prevent any further zooplankton entering the net sampling. At this point the net will be hauled to the surface.

On the vessel deck the net will be held vertically and then rinsed with filtered seawater (30 µm) directed towards the cod-end to ensure any zooplankton trapped on the upper net are forced to the cod-end. Contents of the cod-end will then be tipped into a bucket and any large jellyfish and/or salps removed from the sample which will be transferred into a sample container via a 200 µm filter funnel to remove excess water. Approximately 100 ml of concentrated formaldehyde will be added to each sample jar along with a label, and this will then be topped up with filtered seawater to ensure a preservative of a 4% formalin solution.

9.4.2 Water colour and clarity

At each sampling station the surface water colour will be determined by matching it to standard Munsell colour cards (Davies-Colley, 1997). This will always be done on the shaded side of the vessel to exclude glare.

At each station the water clarity in the vertical direction will be determined by deploying a Secchi disc on a measured tape. The depth at which the disc disappears from view will be recorded.

9.5 Laboratory Analysis

Each preserved zooplankton sample will be split in two by volume using a standard plankton splitter. One half of the original sample will undergo fractionated biomass analysis by pouring the sample through a tower of stacked pre-weighed filters consisting of three mesh sizes: 1,000 µm, 500 µm and 200 µm. Each pre-weighed filter will measure 70 mm in diameter and range from 4-5 g in weight. Fractionated wet weights will be determined by blotting the samples and weighing with the filters to four decimal places on a precision balance. Dry weights will be derived after drying samples on filters in an appropriate laboratory oven for 24 hours at 60ºC and reweighing to a constant weight.

The second half of each zooplankton sample will undergo identification and enumeration by an experienced zooplankton taxonomist. The sample will then be drained through a 100 µm sieve to remove the formalin in seawater, which will be retained to re-preserve the sample after use. The sample will then be washed in tap water to remove any remaining traces of formalin, and then re-suspended in tap water. This re-suspended sample will be split, using a plankton splitter in order to get a manageable sized sample for counting. The split will be recorded and the unused sample placed back into the original container with the retained formalin. The sub-sample for analysis will be placed into a sorting tray, and individuals will be identified and counted.

9.6 Statistical Analysis

9.6.1 Distribution plots

Distribution plots of zooplankton communities will be produced using Geographic Information System (**GIS**) ArcMap to provide visual summaries of zooplankton biomass (wet and dry weight); these will be shown as bar graphs overlaid on GIS maps of the STB, and broad taxonomic numerical composition of zooplankton samples (shown as pie graphs overlain on GIS maps). Munsell-scale surface water colour and water clarity will be plotted with average zooplankton biomass and taxonomic composition for each site. In addition water quality parameters which can affect zooplankton distribution and abundance, such as chlorophyll-a concentration, PAR and suspended sediment concentrations will be plotted along with the zooplankton data.

9.6.2 Univariate and Mulitvariate Statistics

Wet and dry weights of zooplankton samples will be compared among sample locations with regards to their range, absolute highest and lowest values and averages (±SE). Zooplankton community structures will be analysed using standard univariate statistical indices – Margalef's species richness (d), Shannon Wiener diversity index (H'), Simpson's dominance index (D) and Pielou's evenness index (J'). The relative representation of different functional guilds will be examined and taxa contributing most to the biomass at various sites will be identified as well as any taxa related distributional patterns.

Non-Multidimensional Scaling (nMDS) plots, cluster analysis and analysis of similarity tests (ANOSIM) will be used to identify differences/similarities in the assemblage of zooplankton between all sampling locations, as well as a-priori specified groups of sampling sites (Extraction, Deposition and Non-extraction). Differences identified from the ANOSIM procedure will be further investigated using permutational multivariate analysis of variance (PERMANOVA). Models will be run to examine the effects of location and sampling period on zooplankton community composition.

To determine which taxa are contributing most to, or are most responsible for, any significant differences detected using the ANOSIM, the SIMPER procedure will be performed. SIMPER analysis determines the contribution that each species/taxa makes to the average similarity of a group of samples.

Relationships between zooplankton assemblages and the environmental data will be examined using distance based linear models (DISTLM). These will investigate how much variation in community structure is explained by each (environmental) variable and will be used to identify key drivers in community structure, particularly with respect to the influence of SSC and sedimentation on zooplankton community structure.

9.7 Timing and Frequency

Quarterly surveys will be undertaken during the term of the consent and for a period of up to four years following cessation of iron sand extraction. Prior to the BEMP, zooplankton sampling in the STB had only been conducted over the summer months; so the BEMP has now provided further information on seasonal influences on zooplankton communities in the STB. As such, the timing and frequency of these surveys will allow for valuable seasonal and temporal (inter-annual and intra-annual) comparisons to provide greater insight into the effects (if any) of the Project on zooplankton communities in the STB.

Information on the frequency, location and volume of material that has been extracted from and deposited to the operational area will be used to assist with determination of the specific timing of sampling, as well as with the interpretation of results. Sampling frequency will be aligned with other water column sampling programmes (e.g. water quality) to maximise efficiency.

The proposed zooplankton monitoring schedule for the project is provided in **Table 9**.

Table 9: Monitoring frequency for zooplankton sampling.

Location	Site	During extraction activities	Post-extraction
Transects surrounding the extraction area	32 sample locations along the transects	4x seasonal surveys to be completed each year during iron sand extraction activities. Timing to broadly match baseline.	4x seasonal surveys to be done during the first year following the cessation of extraction activities for a period of up to four years.

9.8 Reporting

The following reports will be generated for the Zooplankton Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the monthly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Zooplankton Programme.

9.9 Community Involvement

Due to the HSE requirements for offshore field staff it is difficult to involve members of the local iwi/hapu/community in the zooplankton sampling activities. TTR will facilitate local meetings and community presentations to present baseline and ongoing monitoring results as part of the community meetings. The presentations will provide an education component of what zooplankton communities exist within the STB and will be conveyed in simple and effectively manner, such as including videos of how and where the monitoring is taking place.

10 SUBTIDAL BENTHOS MONITORING PLAN

10.1 Background

Subtidal benthos represents a large component of marine biodiversity and ecosystem productivity. It consists of two components: infauna - aquatic animals that live within the sediments of the seabed, and epifauna (also called epibenthos) which generally live on the surface of the sediment.

Biota living within, or on, the sediment are commonly classified according to their size into; macrofauna (animals retained on a 0.5 or 1 mm mesh size) and meiofauna (animals 63 – 500 µm). The vast majority (95%) of the benthic biomass of soft-sediments of the STB is comprised of macroinvertebrates and most live in the upper sediments (i.e. to a depth of ~10 cm) (Anderson *et al*., 2013; Beaumont *et al*., 2013).

Iron sand extraction will affect the soft-bottom assemblages within the STB either directly via removal during sediment extraction and smothering from disturbed or deposited sediments, or indirectly through changes in sediment characteristics following iron sand extraction. The subtidal benthos monitoring programme has been designed to assess these impacts on infauna and epifauna and to examine how they recover over time.

10.2 Potential Project Impacts and Receptors

Benthic assemblages within the STB could be affected by the Project via three main mechanisms:

- Direct removal from within the iron sand extraction footprint;
- Direct smothering via deposition of de-ored sediments; and
- Indirect changes to the physical characteristics of the sediment (e.g. through resuspension and accretion of finer sediment particles released during iron sand extraction).

The physical extraction of sediments will remove all of the associated infaunal and epifaunal invertebrates occurring in the extraction area. Impacts on benthic invertebrates within the extraction area will be significant, but localised and relatively temporary, persisting until re-colonisation commences. Deposition of de-ored tailing material within the mined areas will occur reasonably quickly following extraction so the mined seabed will not have recolonised before the tailings material is deposited. The screening and physical removal techniques used to extract the iron sands mean that few organisms will likely survive to be re-deposited to the seabed with the de-ored tailings. In addition, dispersion and deposition of the sediment plume resulting from the extraction activity has the potential to impact on benthic primary productivity and clogging of the respiratory and feeding appendages of epifaunal and infaunal organisms.

Recolonisation by benthos of excavated areas (into which tailings have been deposited) is likely to commence relatively quickly, within a few months of the cessation of deposition. Recovery of benthic assemblages to comparable pre-extraction conditions may, however, take longer. The rate of recovery of infaunal assemblages will depend on local hydrodynamic conditions, the degree of changes in sediment composition caused by iron sand extraction and the successful recruitment of larvae and immigration of mobile species to the affected area. Recovery is likely to result in assemblages that are very similar in structure to those originally present, due to grain size similarities between the existing sediment and deposited tailings. The proposed extraction area is a very exposed, highly dynamic environment, where natural disturbance events are frequent (e.g. storm events with large winds and high amounts of riverine input), and as such, the existing benthic communities are dominated by short-lived, opportunistic and early successional stage taxa which tend to recover relatively quickly following disturbance (Beaumont *et al*., 2013; Anderson *et al*., 2013).

10.3 Objectives

The objectives of the subtidal benthos monitoring programme are to:

- Ground truth the predicted effects of iron sand extraction on the abundance and diversity of soft-bottom infauna and epifaunal communities within and surrounding the Project Area;
- Determine whether there are significant changes in sediment characteristics (sediment grain size, redox potential and pH) following iron sand extraction; and assess how any changes affect abundance and diversity of soft bottom communities;
- Follow the subsequent recovery of any infauna and epifauna communities that may be impacted and relate this to depth of sedimentation, nature of sediment and redox potential; and
- Determine the recolonisation of the de-ored sediment after it has been deposited back on the seabed.

10.4 Environmental Assessment

The STB benthos is subject to regular storm-related disturbance, and biological assemblages in the STB have adapted to disturbance and sedimentation events. As a result it is considered that benthic and epifaunal communities will have a certain degree of tolerance of intermittent elevations in SSC and deposition rates (Beaumont *et al*., 2013; Anderson *et al*., 2013).

Based on the variability of the SSC levels within the STB due to environmental variability statistical analyses will be undertaken on the monitoring results to detect any significant changes in subtidal benthos populations or communities between the baseline data and over time once iron sand extraction commences.

10.5 Benthic Environmental Indicators

Biological indicators are useful tools in assessing ecosystem functional and structural integrity. Useful indicators of the health of the benthic environment are listed below and will also be used during the subtidal benthos monitoring programme.

10.5.1 Taxa diversity and abundance

These parameters will provide an indication of ecosystem health. A significant decline in the number of different taxa present (diversity) and/or the abundance of individuals compared to the baseline may indicate an impact. Similarly, an increased abundance of pollution tolerant, opportunistic species (such as capitellid polychaete worms) as opposed to slow growing sensitive species is also an indication of disturbed conditions (e.g. Clarke, 1997). The use of diversity and abundance as indicators would require the sorting and enumeration of benthic fauna from samples to the taxonomic level of ‘Family’. The use of the ‘Family’ level of taxonomic resolution is considered sufficient to identify differences in community structure through multivariate analyses in shallow water benthic assemblages and identification to this higher level (rather than to ‘genus’ level) reduces the time required to achieve a result from each monitoring event.

10.5.2 Faunal indicators

Marine sediments in the STB are characterised by only moderate biodiversity, and are dominated by polychaete worms. Consideration will be given to the proportion of the different feeding guilds present in assemblages before versus after iron sand extraction (i.e. filter feeders, deposit feeders, scavengers etc.). Analysis of faunal guilds will be based on ‘Family’ level of identification, and hence may be a less rigorous indicator than if species are identified to a higher level, but it will still be sufficient to indicate the nature of broad changes in community structure.

10.5.3 Benthic Microalgae

Benthic microalgae are regarded as important primary producers in shallow water marine ecosystems, where the taxonomy and ecology of benthic microalgae are distinct from those of the phytoplankton (Cahoon & Safi, 2002). Replicate sediment samples will be collected at each of the benthic monitoring stations (**Figure 6**) and will be analysed for Chlorophyll-a, which is a proxy for micro-phytobenthos.

10.5.4 Sediment characteristics

The physical characteristics of sediment are an important factor in determining the structure of benthic assemblages (Brown & McLachlan, 1990). Grain size of substrates has been identified as an important factor that is useful for the assessment of impacts on filter feeders as there is a close relationship between particle size and the potential to clog the filtration structures and impair feeding. Sediment particle size distribution will indicate whether differences in assemblage structure before and after habitat disturbance are related to changes in the physical characteristics of sediments. The use of this indicator will be achieved by collecting sediment samples in parallel with benthic samples and analysis of the particle size distributions.

10.5.5 REDOX potential and pH

These physical characteristics will also be measured as they give an indication of the oxic state of the marine sediments which can influence the distribution of infaunal communities which require oxygen to survive.

10.5.6 Total organic carbon (TOC)

Flux of carbon to the sediment has been shown to influence the infauna/epifauna communities in similar marine environments to those found in the STB. Increased organic matter provides greater food sources for deposit feeding and scavenging taxa on and in the sediments; however, if concentrations of organic matter are too high they can impact on the oxygen levels within the sediment, as they utilise oxygen during the decay process.

10.5.7 Total free sulphide (TFS)

This indicator provides a further measure of the reductive/oxidative state of the seabed sediments, and is used widely in environmental monitoring around marine industrial facilities such as fish-farms, where it has shown predictable relationships with seabed health and infauna community assemblage (Keeley *et al*., 2011).

10.5.8 Metals

Chemical contaminants are largely contained within the finest sediment fractions, with metals in particular adsorbing onto the surface of these smallest particles. Contaminants in sediments collected within the STB were examined by Vopel *et al*. (2013) who found that the majority of chemicals were at very low concentrations. Exceptions to this were the metals cadmium, nickel and copper, where levels in the elutriates created during the sampling process reached above the ANZECC guidelines. This sampling acted to simulate some of the processes used during the physical extraction of the iron-sands. Physical disturbance of the sediments during iron sand extraction could release these metals to the water column and their increased concentrations (if bioavailable) could be detrimental to the health of benthic organisms and influence the community assemblage.

10.6 Methodology Overview

The following sections provide information about the subtidal benthos monitoring programme around the Project Area.

10.6.1 Phase 1: Baseline Monitoring

A two year baseline monitoring programme was undertaken in accordance with the BEMP prior to commencement of iron sand extraction activities. The baseline monitoring programme was utilised to confirm that the sampling sites chosen were suitable for monitoring, collection of baseline data on the soft-bottom benthos within the Project Area and surrounds and to gain an understanding of the seasonality that exists among subtidal benthos in the STB.

10.6.2 Phase 2: Iron Sand Extraction

The aim of Phase 2 is to ground truth the predicted effects of iron sand extraction activities within the STB. The monitoring will be undertaken within the operational area, as well as along the distance gradients that were established during the baseline phase. Surveys within this phase will be undertaken at similar times of the year (to each other and to the baseline) to allow consistent temporal comparison.

Information on the frequency, location and volume of material that has been extracted and deposited prior to each survey would be taken into consideration in the timing of sampling and interpretation of results. The specific objectives of this phase are to:

- Assess changes in the abundance and diversity of infauna and epifauna assemblages relative to those measured during the baseline sampling;
- Assess changes in the physico-chemical characteristics of the sediments relative to baseline measurements (i.e. grain size, REDOX (ORP), pH, total free-sulphide, metals (principally Cd, Cu and Ni) and total organic carbon);
- Investigate the relationship between the physico-chemical characteristics of the sediment (grain size distribution, REDOX and pH) and the composition of infaunal and epibenthic assemblages, and whether changes in infauna/epifauna distribution and abundance (if found to have occurred) are linked with changes to physico-chemical parameters;

- Investigate whether changes in infauna/epifauna distribution and abundance and sediment characteristics have changed only in certain areas (possible extraction effects) or over much larger scales (possibly showing larger wide-scale natural variation); and
- Assess recolonisation of the de-ored sediment in the Project Area.

10.6.3 Phase 3: Post-Extraction

The aim of the post-extraction monitoring plan is to determine the nature and extent of recovery of STB infauna and epifauna distribution and abundances within the consent area. The post-extraction monitoring will be undertaken for a period of four years, or such lesser time as approved by the EPA. The specific objectives of this phase are to:

- Assess recovery of infauna and epifauna abundance and diversity by comparing infauna and epifauna assemblages with those measured in previous phases;
- Investigate changes in sediment physico-chemical characteristics after cessation of extraction activities and compare with measurements in previous phases;
- Investigate the relationship between the recovery of physico-chemical characteristics of the sediment and the recovery of infaunal and epibenthic assemblages;
- Determine recolonisation rates within the de-ored sediment within the Project Area.

10.7 Sampling Locations

The location of the subtidal benthos sample locations (**Figure 6**) were derived from the sediment plume model outputs (Hadfield & MacDonald, 2015). A BAG sampling approach will be used and the sample stations are based along gradients radiating away from the extraction area, both along and across the dominant sediment plume direction. This approach spreads the sample locations along a distance gradient from the Project Area following the predicted path of the sediment plume, where the degree of influence of the extraction plume is expected to change with distance. Sample locations have also been located in the opposite direction to the predicted plumes paths, i.e. in the offshore and alongshore directions.

During the baseline monitoring programme under the BEMP, three sample stations were sampled within the iron sand extraction area, these sampling locations are detailed in **Figure 6**. These sample stations have been located in both the rippled sand and worm field areas known to exist within the Project Area.

Following the start of iron sand extraction activities, an additional two stations (with three replicates per station) will be added annually for the first five years of extraction activities. These additional stations will be located in areas where iron sand extraction has very recently been completed and will be monitored for the life of the project. This will ensure that the physico-chemical and infaunal characteristics of recently de-ored sediments (tailings) are assessed, thereby providing information on rates of recovery of the sediment and recolonisation by infauna and epifauna.

It is inevitable that some, if not all, of the original Project Area sampling stations will be subject to iron sand extraction throughout the life of the programme. This will only add to the strength of the sampling design as the full scale of effects (from no effects (baseline) to full operational disturbance and recolonisation) will be able to be assessed at these specific locations.

10.8 Sampling Design

The ‘gradient-of-effects’ sampling design allows changes at the potential impact location to be evaluated against natural variation along each of the monitoring gradient transects.

The subtidal benthos monitoring programme will be conducted in three phases (**Section 10.6**); however, minor changes to the survey design may arise following TRG reviews.

Subtidal benthos monitoring will be undertaken at the sample locations shown in **Figure 6**, with the sampling design summarised in (**Table 10**) for the life of the project.

Table 10: Subtidal benthos sampling design

Sites	Locations	Stations	Transects	Replicates	Total Samples (per survey)
Benthic gradient sites	Benthic	32 stations	1 video transect per station	3 replicate benthic grab samples per station	96 Infauna 96 Phys-chem 32 Video Transects
Operational sites	Operational	3 stations	1 video transect per station	3 replicate benthic grab samples per station	9Infauna 9 Phys-chem 3 Video Transects
Operational 'de-ored' sites	De-ored	2 new stations added annually for the first 5 years following commencement of irons and extraction, situated in the areas most recently disturbed area.	1 video transect per station	3 replicate benthic grab samples per station	Year-1 6 Infauna 6 Phys-chem 2 Video Transects Year-2 12 Infauna 12 Phys-chem 4 Video Transects Year-3 18 Infauna 18 Phys-chem 6 Video Transects Year-4 24 Infauna 24 Phys-chem 8 Video Transects Year-5 30 Infauna 30 Phys-chem 10 Video Transects

10.9 Field Sampling approach

Field sampling will be undertaken as detailed below; however, the exact sampling devices, or instrumentation utilised may vary from that stated here as technology will evolve throughout the duration of the EMMP and recommendations following the completion of the BEMP.

10.9.1 Sediment Physico-chemical and Infauna Sampling

Sediment samples for infauna and physico-chemical analyses will be collected using a modified double Van-Veen grab (the 'grab') sampler (or similar) which will be deployed by a winch from a surface vessel. The use of a double grab sampler means that undisturbed sediment physico-chemical samples can be collected from directly alongside the infauna/macrofauna samples in independent buckets, without reducing the volume of either set of samples required. The double Van-Veen has a maximum sample depth of 0.16 m and in harder sand sediments additional weight can be mounted to the grabs frame to ensure sufficient penetration depth to collect the required depth/volume. Each independent bucket within the double-grab has a volume of 10 L of sediment. The upper surfaces of the grab sampler are fitted with 0.5 mm mesh which ensures organisms within the sample are not washed out during ascent from the seabed, but allows water to pass through during descent to reduce the pressure wave ahead of the instrument while it is lowered to the seabed. At each sample station the grab sampler will be deployed three times to collect three separate replicate samples. The water depth and the GPS position of each replicate sample will be recorded to maintain consistency with future surveys.

A replicate grab sample is considered acceptable for analysis if the sample has been landed on-board the surface vessel without undue disturbance, contains the required amount of sediment (and similar volume to all other replicates) and has not been contaminated by anthropogenic sources during descent/ascent. Once confirmed as a success, sediment from the grab sample will be sub-sampled to enable the required analyses to be undertaken.

Infauna samples are collected from the grab using a 13 cm internal diameter core, which is pushed into the sediment to a depth of 50 mm. The samples will initially be sieved on board the vessel over a 0.5 mm mesh sieve to remove some of the finer sediments, and the sediment and infauna retained on the sieve, as well as any organisms stuck to/in the sieve mesh will then be washed into a suitable container and preserved with a 70% ethanol solution for transport to the taxonomic laboratory. All infauna samples will be clearly labelled internally and externally with project details, date, location, site and replicate number. Initial survey work by Anderson *et al*. (2013) within the proposed area of operation sampled infauna at three different depths within the sediment and found the greatest majority of organisms were present within the upper 50 mm of the sediments. Continued sampling of infauna/macrofauna in the upper 50 mm will allow some comparisons to be drawn with these earlier studies.

Sediment physico-chemical samples will be collected from three 64 mm internal diameter cores which are simultaneously pushed into the sediment on one side of the second grab bucket. The upper 50 mm of sediment within each core is then distributed into separate sterile sample bags, and chilled for later grain size, total organic-carbon and metals suite analyses. The undisturbed side of the second bucket is then opened and pH and REDOX-ORP probes can be inserted to collect measurements on these parameters. A 5 ml vertical core sample through the upper 50 mm of sediment in this part of the grab is also collected for the analysis of total-free sulphides (TFS, hydrogen sulphide). The sample is capped to prevent oxidisation changing the TFS levels, and then chilled. NOTE: TFS samples must be analysed at the laboratory within 24 hours of sample collection. Sediment samples collected for analysis of grain size, organic carbon and heavy metals will be stored in sterile sample containers/bags with external labels showing project name, sampling date, site and replicate number as well as the specific analyses required. Sealed sample bags will be immediately placed in a chilled environment (cooler bin or chiller) following collection, and stored below 4°C until returning to the onshore dispatch facility, where they will be kept in a chilled environment.

The benthic microalgae or microphytobenthos will be determined at each monitoring station by collecting triplicate core samples. A 50 mm diameter core sample will be collected from each grab sample and the top 5 mm of surficial sediment will be collected and analysed for Chlorophyll-*a* concentrations. The amount of benthic microalgal production is considered to be highly dependent on what the light conditions were in the preceding few days. Therefore, to interpret the sample results an understanding of the likely seabed light levels were, which will be undertaken through a combination of satellite data and the light meters that will be in-situ at the fixed mooring stations (**Figure 8**).

Samples will subsequently be dispatched packed with suitable cooling to an IANZ accredited laboratory, accompanied by a Chain of Custody document.

The deposition of the coarse tailings from the IMV will be continuously recorded and monitored which will include particle size distribution, rate and volume. These results will be incorporated into the Quarterly Operational Report (**Section 17.2**).

10.9.2 Epifauna Sampling

A remote drop camera and video will be used to identify epibenthic assemblages, as well as recording seabed morphology at each sample station. The drop camera, which records high-definition still images at each sampling site, yields high quality photographs suitable for photo-quadrat analysis, including quantitative analyses, from low light and low visibility conditions. The video camera collects high-definition video footage of the epifauna, macroalgae, mobile taxa (fish) and visible infauna, as well as allowing visual assessment of any notable physical disturbance of the sea-floor which may be linked to iron sand extraction.

During sampling the camera system will be lowered to the seabed at the start of each transect situated approximately 50 cm above the substratum as the vessel drifts with the current (at approximately 0.5 – 1 km/hr) until the end of each transect. Positioning the camera 50 cm above the seabed will provide a photo quadrat size of ~ 40 x 65 cm, but achieving this is reliant on near-seabed visibility being sufficient to allow clear images at this distance. Fifteen replicate photo quadrats will be collected per transect, with total transect length being approximately 100 m.

GPS positions of each sample site, and GPS tracks for each transect will be recorded to facilitate their relocation in future surveys.

10.9.3 Field Equipment

Field equipment will comprise of the following subsections.

10.9.3.1 Benthic Grabs

Benthic assemblages and sediment size will be sampled using a stainless steel grab sampler such as ponar, Van-Veen, Modified Double Van-Veen or HAPS. Given the sandy nature of the sediments at the proposed sampling areas, the grab sampler will need to be weighted as necessary to enable sufficient penetration depth to ensure that the required depth and volume of sediments are collected. These types of samplers are suited to the sediment and water depths expected in the Project Area.

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10.9.3.2 Remote Drop Camera and video surveys

A remote drop camera will be used to identify epibenthic assemblages and seabed morphology at each location. The drop camera, which takes a high-definition video and high resolution still images at each sampling site, will consist of either separate units for still and video imagery, or an integrated camera which can collect both simultaneously. In order to collect representative photo-quadrat images, the still camera will point downwards and will automatically adjust focus and exposure to suit conditions on the seafloor.

Video footage is collected from a camera with suitable high intensity video lighting so that morphological features of the seabed can be easily distinguished. This video camera may be best configured slightly forward facing to allow better appreciation of the topography of the seabed being filmed. The camera system will feed a live picture back to the surface vessel via an umbilical to allow scientists on-board to assess and make notes on seabed features, and capture extra still images or adjust lighting as necessary. A forward facing video camera system will also be fitted with scaling lasers to allow some estimation of the size of organisms or features to be made. Due to the exposed nature of the proposed site the camera system and frame will contain adequate weight to give it suitable stability in all working conditions likely to be experienced.

10.10 Laboratory Analyses

Laboratory analysis will comprise of the following (or equivalent) sub-sections.

10.10.1 Infauna Analysis

Biological samples will be sorted, identified and counted by experienced taxonomists. Animals will be identified to a minimum of ‘Family’ level and separated into major groups; polychaetes, molluscs, crustaceans and echinoderms (for example). For groups where further identification would require a large expenditure of time (e.g. oligochaetes) or taxonomic status is insufficient to achieve a finer level of identification (e.g. anemones), identification would be to a lower resolution such as Class or Sub Order.

10.10.2 Sediment Physico-chemistry

Sediment samples for grain size, total organic content, metals and total free sulphides would be dispatched directly from the shore base on the day of collection for analysis by a NATA/IANZ accredited laboratory, accompanied with a Chain of Custody document.

10.10.3 Sediment Grain Size

The grain size distribution of sediment samples collected is quantified using either Laser Particle sizing, or more traditional stacked sieved methods (such as AS 1289.3.6.11-1995). Laser particle sizing (such as using a Beckman Coulter LS13 320 Dual Wavelength Laser Particle Size Analyser) is a more efficient, more accurate method that allows better resolution and repeatability than the stacked sieve method. However, the laser particle analysis is not suitable for samples with significant proportions of coarse grained sediments (>1.6 mm) as the initial sieving step associated with this analysis removes these larger particles. Either technique will be used as determined suitable by sediment characteristics.

10.10.4 Total Organic Carbon

Organic content of sediment samples is assessed by analysing for total organic carbon content. Samples are air dried in the laboratory and sieved to remove particles greater than 2 mm. Samples are then subjected to acid pre-treatment to remove any carbonates present followed by Catalytic Combustion (at 900°C, in presence of O2), separation, and measurement by Thermal Conductivity Detector [Elementar Analyser].

10.10.5 Metals

Initial studies by Vopel *et al.* (2013) investigated a large suite of metals from STB sediments. From this suite Cd, Cr and Ni were identified as reaching levels near or above ANZECC guideline values for marine sediments. A tiered approach to metals analysis is proposed which is based on the investigation of these three metals. The proposed tiered approach is as follows:

Tier 1: In the laboratory a small subsample of each of the three replicate metals samples from a station is combined into a composite sample. The sample is air dried and sieved to remove particles larger than 2 mm before being subjected to a total recoverable metals digestion method (US EPA method 200.2) utilising a warmed nitric/hydrochloric acid solution and analysis of the resulting elutriate via ICP-MS. If the results of this test return values above ISQG-Low guideline values for any of the three metals this would trigger Tier 2 sampling.

Tier 2: All three individual replicate samples are analysed for the metal or metals that were above guideline levels in Tier-1 testing, using the same methodology as Tier-1 (nitric/hydrochloric acid digestion (US EPA 200.2)). Results of this testing will reveal if the elevated metals level was caused by a single patch of metals enriched sediments (no further testing required), or if metals were more widely elevated across all replicates (Tier 3 testing triggered).

Tier 3: All three replicate samples are sieved to split off the <63 µm fraction ('fines') from the remainder of the sediments. Both fractions are then tested for the 'bioavailable' metals content (for the metal/metals in question) utilising a weaker hydrochloric acid extraction technique. This will reveal which fraction of the sediment the elevated metals content resides within ('fines' vs 'coarse') and also whether the elevated metal(s) (from total recoverable testing) have 'bioavailable' concentrations that still breach guideline levels.

10.10.6 Total Free Sulphides

Sulphide ion concentration will be measured using a suitable sulphide probe (such as an Orion Silver/Sulphide combination electrode) and a calibrated meter. Each 5 ml sediment sample is standardised with a sodium sulphide stock, in a ratio of 1:1 of sample/standard:sulphide anti-oxidant buffer, following the methodology of Wildish *et al*.. (1999). The solution will be mixed with the probe to ensure the probe is in contact with the entire sediment sample (Wildish *et al*., 1999).

10.10.7 Redox Potential and Sediment pH

A REDOX/pH meter will be used on board the vessel to obtain measurements of REDOX potential and pH in the sediment within each of the three replicate grab samples collected at each sampling station. Readings will be recorded onto suitable field sheets and later entered into the project database. Data obtained will give an indication of the extent of reducing conditions (e.g. anoxic sediment) which will then be related to the levels of total free-sulphide as well as the composition and abundance of infaunal assemblages.

10.10.8 Analysis of photoquadrat images

Video and photographs collected along each transect will be downloaded to a hard drive for manipulation and analysis. Percentage cover of benthic organisms, macroalgae etc as well as seabed morphology in photo-quadrats will be determined by digitally overlaying a virtual photo-quadrat (scaled to approximately 40 cm x 65 cm) on each captured still image. Each photo-quadrat would be divided into five equal blocks in which ten points would be randomly selected to give a total of 50 points for each photo-quadrat. Software such as Coral Point Count with Excel extensions (CPCe) program (Kohler & Gill, 2006), or similar, would be used to measure the percentage cover of key categories of sediment type, epifauna (such as corals, sponges, ascidians, hydroids, bryozoans, tubeworms and anemones) and macroalgae. The photo-quadrats would also be used to quantify any evidence of smothering by sediment; this will then be compared to data collected in later phases of the monitoring programme.

Video footage will be viewed by suitably experienced scientists who will record the presence (and semi-quantitative abundances) of any other organisms observed in, on or just above the seabed, which will further assist in visually characterising the seabed habitats identified in the still images. Review of video footage will also note and capture screen shots of notable signs of physical disturbance and anthropogenic activity that might be present on the seabed.

10.11Statistical Analysis

10.11.1 Power Analysis

Baseline data will be used to assess the power of the sample designs proposed to detect ecologically or socially meaningful impacts that may be attributable to iron sand extraction. The ability of these designs to detect changes will be examined by a suite of methods, potentially including comparisons of confidence limits and determination of power using simulated data (i.e. an effect size likely to reflect the magnitude of an impact) or standard power formulae. Given the complexity of the designs and the fact that impacts are likely to be interpreted through a series of statistically significant interactions, the use of simulated data built around an effect size and assumed variance is the approach favoured at this time.

10.11.2 Distribution plots

Distribution plots of substrate and biological data will be produced using GIS ArcMap to provide visual summaries of substrate and biological features across the sampling sites. Macroinvertebrate data will be plotted to show the distribution of the total number of individuals and species/taxonomic groups in relation to each sample location.

10.11.3 Sediment data analysis

Sediment physico-chemical parameters (pH, hydrogen sulphide, salinity, grain size, total organic carbon and metals) will each be analysed using univariate analysis to examine changes through time (i.e. differences between pre- and during measurements) and among sample locations (to examine spatial impacts). Where necessary, data will be transformed to fulfil the assumptions of the analysis and post-hoc tests will be performed to examine the directions of significant relationships.

Sediment metal concentrations will also be compared against national sediment quality criteria (i.e. ANZECC, 2000). These commonly used guidelines are based on statistical models of toxicity data for a wide range of contaminants, and aim to predict levels of contaminants in aquatic sediments above which adverse ecological effects may occur. The criteria are defined as Interim Sediment Quality Guideline–Low (ISQG-Low) and –High (ISQG-High) levels, which represent two distinct probability thresholds for possible and probable biological effects respectively. Where values are less than their respective ANZECC ISQG-Low values, there is low risk and no action is required. Triggering ANZECC ISQG-High values indicates that the concentration of the contaminant is at a level where significant biological effects are expected to occur. Exceedance of the ISQG-High values suggests that adverse environmental effects are probably already occurring and are a prompt for management to address and remediate the issue.

10.11.4 Infauna and epifauna data analysis

Univariate analysis will include the calculation of diversity indices (number of taxa, total abundance, Shannon-Wiener diversity, and Pielou evenness) as well as analysing the relative representation of major infaunal groups, including functional groups. Non-Multidimensional Scaling (nMDS) plots, cluster analysis and analysis of similarity tests (ANOSIM) will be used to identify differences/similarities in the assemblage of benthic organisms between all sampling sites, as well as *a-priori* specified groups of sampling sites (Extraction, Deposition and Non-extraction). Differences identified from the ANOSIM procedure will be further investigated using permutational multivariate analysis of variance (PERMANOVA). Models will be run to examine the effects of site and sampling period on macroinvertebrate community composition.

To determine which taxa are contributing most to, or are most responsible for, any significant differences detected using the ANOSIM, the SIMPER procedure will be performed. SIMPER analysis determines the contribution that each species/taxa makes to the average similarity of a group of samples.

Relationships between infauna assemblages and the environmental data will be examined using distance based linear models (DISTLM). These will investigate how much variation in community structure is explained by each predictor (environmental) variable and will be used to identify key drivers in community structure, particularly with respect to the influence of SSC and sedimentation on community structure.

10.12 Timing and Frequency

The two year baseline monitoring programme (was undertaken as part of the BEMP, where the sampling was completed quarterly prior to the commencement of iron sand extraction, to gain suitable data on the baseline levels of all parameters and an indication of the natural/background variation that exists spatially and temporally.

Quarterly monitoring surveys for the benthos monitoring programmes will be undertaken once iron sand extraction begins, which will continue throughout the life of the project, and for a period of four years following the cessation of iron sand extraction.

The benthic monitoring programme will be reviewed annually by the TRG, to allow suitable revisions to take place that reflect updated knowledge, understanding and technology. These reviews will include a review of the frequency of monitoring, which may indicate that sampling could be reduced to biannually, and occur in the two seasons showing the greatest differences in results e.g. summer vs. winter or autumn vs. spring (based on the BEMP results). The subtidal benthic monitoring schedule is provided in **Table 11**.

Table 11: Monitoring frequency for Subtidal Benthos Monitoring Program

Location	Site	During	Post-extraction
Benthic Gradient ➢ Infauna ➢ Epifauna ➢ Phys-chem ➢ Microphytobenthos	32 sites	Quarterly throughout the life of the extraction activities. However, the frequency may change following TRG review and the results/recommendations made within the annual report.	Quarterly for 4 years following cessation of extraction activities
Operational areas ➢ Infauna ➢ Epifauna ➢ Phys-chem	3 sites	Quarterly throughout the life of the extraction activities. However, the frequency may change following the TRG review each year and the results/ recommendations made within the annual report.	Quarterly for 4 years following cessation of extraction activities
Operational 'de-ored' areas ➢ Infauna ➢ Epifauna ➢ Phys-chem	2 stations added annually for first five years, at blocks most recently de-ored.	Stations surveyed quarterly, with two further stations added annually.	Quarterly for 4 years following cessation of extraction activities

10.13 Reporting

The following reports will be generated for the Subtidal Benthos Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Subtidal Benthos Monitoring Programme.

10.14 Quality Assurance

10.14.1 Field Work

For all replicate samples collected, a unique sample code, a record of the GPS position, time, date, depth, sediment type and weather conditions will be recorded on waterproof field sheets. All data will be transcribed into the master project database linked to each unique sample code. GPS positions will be downloaded into excel format then imported into the master database. A photographic record will also be kept for each core sample collected. Core samples will be transferred into suitable sterile sample bags labelled externally with the unique sample code. Hard copies of the original datasheets will be scanned and stored electronically within the master database.

Field data integrity will be checked using a two-person field checklist and chain-of-custody documentation. Internal quality assurance of field sampling activities will include the collection and analysis of duplicate sediment samples collected at several randomly selected stations during each survey. External laboratory quality assurance will include the analysis of blind replicate environmental samples.

10.14.2 Laboratory

All samples will be logged upon receipt from the field on an internal chain of custody and lab management sheet. In the laboratory, a sample sign-in/sign out system is used to track sample status and time required to process each sample.

10.15 Community Involvement

Due to the HSE requirements for offshore field staff it is difficult to involve members of the local iwi/hapu/community in the physical benthic sampling activities. TTR will facilitate local meetings and community presentations of baseline and the ongoing monitoring results. The presentations will provide an education component of what marine life and benthic environments exist within the STB and will be conveyed in simple and effectively manner, such as including videos of how and where the monitoring is taking place.

11 SUBTIDAL AND INTERTIDAL REEF MONITORING PLAN

11.1 Background

TTR's assessment of benthic habitats in the South Taranaki Bight (see Anderson *et al*., 2013) recorded (broadly) two types of soft sediment habitats, and two types of rocky outcrop habitats (hard rock and mudstone outcrops). The soft sediment habitats and mudstone outcrops were characteristically low in species abundance and diversity, while in contrast, the hard rock outcrops were reported to support abundant and diverse macrobenthic assemblages.

Offshore subtidal reef systems that are recognised as ecologically and scientifically significant in the South Taranaki region (as described in TRC, 2004) include Four Mile Reef and the North and South Traps (**Figure 9**).

There is only one intertidal reef system of significance inshore of the Project Area that is classified by the TRC as an Area of significant conservation value which is the Waiinu Reef. The Patea Reef, although not listed as having particular significance does have cultural significance. This large reef is located immediately inshore of the Project Area and is part of this monitoring programme. The locations of these important subtidal and intertidal reefs are illustrated in **Figure 9** and **Figure 10** and also include significantly important kaimoana gathering areas identified by local iwi.

Figure 9: Subtidal Reef Monitoring Locations in the STB

Figure 10 Intertidal Reef Monitoring Locations in the STB

The current knowledge of these reef communities was further developed by TTR through visual surveys of the seabed habitats at the North and South Traps in February 2014 by diver and drop camera surveys. Data obtained from these surveys is summarised below.

The North and South Traps sites were characterised by classic urchin barren communities, with rocky outcrops and ridges dominated by sea urchins (*Evechinus chloroticus*) and low growing red and brown macroalgae; a few isolated *Ecklonia* sporophytes were present and the conspicuous fish species noted included Leatherjackets (*Parika scaber*), Blue Cod (*Parapercis colias*), Red Moki (*Cheilodactylus spectabilis*) and Blue Maomao (*Scorpis violacea*). Unconsolidated seabed sediments at the Traps were generally less than 10 mm thick and were underlain by a hard rock basement.

A bathymetric and video survey of the Traps was also conducted by ASR Ltd. for the TRC to produce habitat maps of the area (**Figure 11**). Similar features were observed as found by TTR in the 2014 survey, with the addition of patchily dense stands of *Ecklonia radiata.*

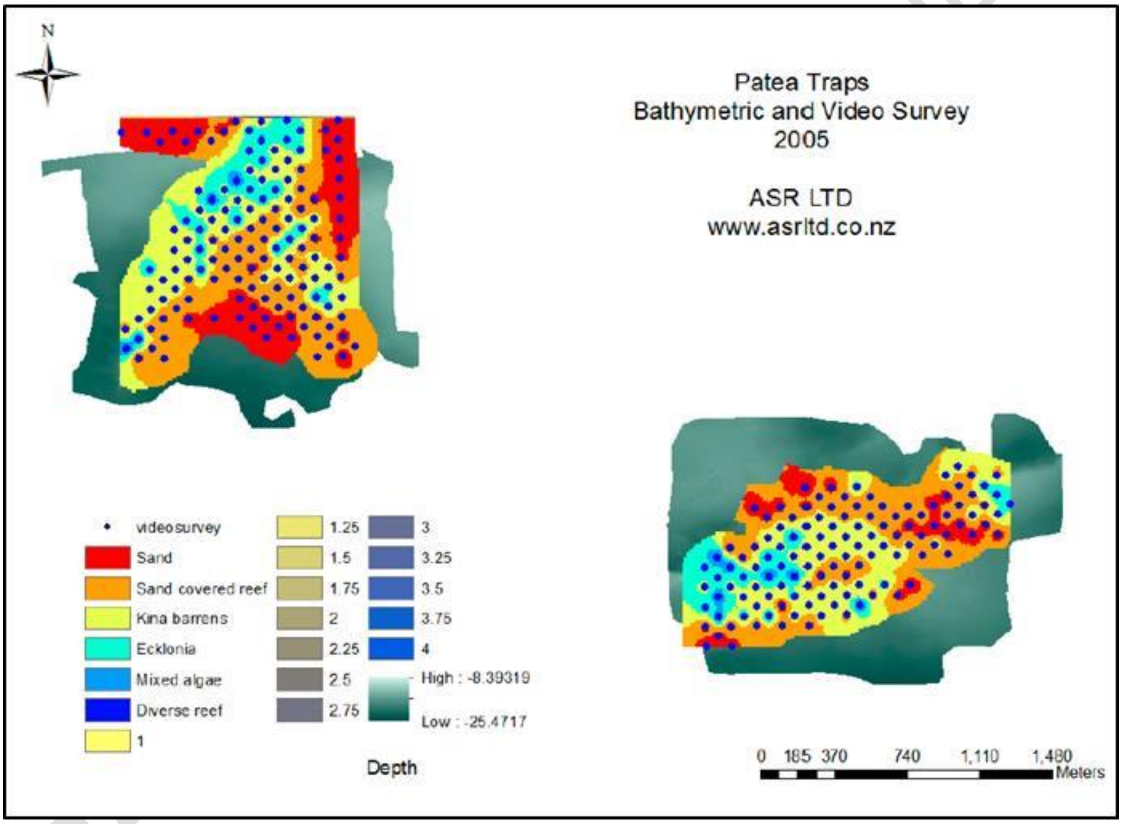

Figure 11: Habitat map of North and South Traps from ASR (2005)

No rare or vulnerable ecosystems or habitats of threatened species were identified as being present at the North and South Traps. The nature of the seabed and fish communities present suggests that they will be relatively tolerant to sediment elevations. In addition to this, the results of NIWA sediment plume modelling suggest that significant amounts of sediments derived from the iron sand extraction will not accumulate at the Traps or at any of the other offshore reef systems.

11.2 Objectives

The specific objectives of the subtidal and intertidal reef monitoring programme are listed below.

- Ground truth the predicted effects of iron sand extraction on the abundance and diversity of selected subtidal reef communities in the STB;
- Ground truth the predicted effects of iron sand extraction on the abundance and diversity of selected intertidal reef communities along coastal STB; and
- Investigate the levels of sand inundation/depletion around selected intertidal reef systems along the STB coastline and assess whether changes in sand levels could be attributed to iron sand extraction or as a result of natural variation.

11.3 Biological Indicators

Biological indicators are useful tools for assessing ecosystem functional and structural integrity. Useful indicators for effects on subtidal and intertidal reef assemblages include:

- Number of taxa and abundance: These parameters provide an indication of ecosystem health. A significant decline in the number of taxa (diversity) and/or abundance of individuals compared to the baseline may indicate a potential impact;
- Percentage cover and density of macroalgae: *Ecklonia radiata* is considered to be a key species indicator for potential adverse effects, as it has a recognised role in determining ecosystem attributes. The abundance/density of *Macrocyctis* sp. and *Ecklonia* sp. macroalgae has been used in previous studies to assess impacts of anthropogenic activities on subtidal reef systems. A significant decline in the number of stems or holdfasts of the particular macroalgae compared to the baseline numbers may indicate an impact has occurred; however, other environmental data will have to be assessed to determine whether the impact was a result of an activity or a natural event; and
- Habitat type: The Major habitat type or percentage cover of each habitat type (e.g. exposed bedrock, cobbles, biogenic rubble, sand, fine sediment/mud etc.) identified in photo-quadrats may change if the subtidal and intertidal reef areas are exposed to increased (or decreased) levels of sediment deposition as a result of iron sand extraction.

11.4 Methodology

11.4.1 Phase 1: Baseline Monitoring

The two year baseline monitoring programme confirmed that the intertidal and subtidal reef sampling sites are suitable for monitoring.

11.4.2 Phase 2: During Iron Sand Extraction

The aim of Phase 2 is to ground truth the predicted effects of iron sand extraction activities on the sub-tidal and intertidal reef systems within the STB and to monitor for compliance against the Response Limits and Compliance Limits.

The subtidal monitoring programmes will be undertaken at:

- North and South Traps;
- Four mile reef;
- Tuteremoana; and
- Grahams Bank.

While intertidal monitoring will be undertaken at the following locations.

- Waiinu Reef;
- Patea Reef;
- Waihi Reef;
- Puketapu Reef; and
- Opunake Reef.

Surveys will be undertaken at similar times of the year to the baseline assessments to allow consistent temporal comparisons to be made.

The specific objectives of this phase are to:

- Assess changes in abundance and diversity of subtidal reef assemblages relative to that measured in the BEMP, including the coverage/density of macroalgae;
- Assess changes in the abundance and diversity of intertidal reef assemblages relative to that measured in the BEMP; and
- Assess changes in the frequency of habitat types on subtidal and intertidal reef systems (e.g. exposed bedrock, cobbles, biogenic rubble, sand etc.) relative to that measured in the BEMP to look for signs of increased fine sediment deposition.

11.4.3 Phase 3: Post-extraction

The aim of the post-extraction monitoring is to determine the nature and extent of recovery of subtidal and intertidal reef assemblages and habitat in the event of a documented effect (during iron sand extraction) within the consent area. The specific objective of this phase is to assess recovery by comparing the abundance and diversity of reef assemblages with that measured in previous phases and to assess the levels of fine sediment/sand inundation/depletion compared to previous phases. The post-extraction monitoring may occur for a period of up to four years after iron sand extraction activities cease unless the EPA approve a lesser time.

11.5 Sampling Design

Subtidal and intertidal monitoring will be undertaken at the reef locations shown in **Figure 9** and **Figure 10**, with the sample design outlined in **Table 12**.

Table 12: Subtidal and Intertidal Reef Sampling Design

Area	Locations	Sites	Replicates	Transects	Total Samples (per survey)
Subtidal Reef Sites	North Trap	20	3	3 x video transect per site 3 x diver transects	66
	South Trap	20	3	3 x video transect per site 3 x diver transects	66
	Four Mile Reef	20	3	3 x video transect per site	63
	Grahams Bank	20	3	3 x video transect per site	63
	Tuteremoana	20	3	3 x video transect per site	63
Intertidal Reef sites	Patea Reef	1	25	1 x 50m transect	25
	Waiinu Reef	1	25	1 x 50m transect	25
	Waihi Reef	1	25	1 x 50m transect	25
	Puketapu Reef	1	25	1 x 50m transect	25
	Opunake Reef	1	25	1 x 50m transect	25

11.6 Field Sampling Techniques

11.6.1 Intertidal Surveys

11.6.1.1 Sediment inundation/depletion on intertidal reefs

Sand inundation along the Taranaki coastline is a regular occurrence along both sandy beaches and intertidal reefs, and is known to be highly variable due to natural processes. To assess the level of sand/fine sediment coverage of intertidal reef areas inshore of the Project Area, high resolution aerial photographs will be captured one per year over the summer period (utilising drone, or fixed wing plane technology) to provide images of the reefs over a spring low tide. These images will be georeferenced to enable calculations of percentage cover and any changes to the sedimentation rates and patterns to be determined through time.

Intertidal reef inspections will be undertaken quarterly by appropriately trained and experienced scientists who will walk the reefs and locate areas of sediment cover identified in the aerial image and confirm the approximate sediment grainsize (gravel, coarse sand, fine sand, mud/fine sediment). Photographs and GPS coordinates will be taken at each location so that any patches of sand can be identified and monitored through time.

Intertidal inspections over the summer period will be timed to coincide with the aerial photographs to ground truth the images. This ground truthing will be undertaken as soon as practicable (ideally within 1-2 days) of the images being collected during the same spring low tide period.

A further measure of sand coverage on the intertidal reefs will be collected during quadrat surveys, as detailed in the next section.

11.6.1.2 Intertidal ecology

The ecological assemblages at the intertidal reefs will be assessed by identifying and counting all organisms and marine plants/algae within 25 randomly placed quadrats along a predetermined 50 m transect at the low tide mark. The 50 m transect will be laid parallel to the shore, approximately 0.6 metres above chart datum, and within this transect five 5 m x 3 m blocks will be established. Within each block, 5 random 0.25 m^2 quadrats will be laid on the reef. For each quadrat the percentage cover of algae and encrusting animal species will be estimated using a grid, while all other species will be counted. Under boulder biota will be counted where rocks and cobbles are easily overturned.

One transect will be conducted within each of the selected intertidal reefs (**Figure 10**) to enable an estimate of species abundance and diversity. The recording of the sediment/habitat type within each quadrat will provide a semi-quantitative measure of the levels of sand inundation/depletion across the each reef location.

Identification of the taxa within each quadrat will be performed using a standardised key and representative images. This will allow faster and more consistent identification of the taxa that are present. Any new taxa found, or where identification is not certain, will be collected within a suitable sample container and chilled, before being returned to an experienced taxonomist for formal identification.

The methodology for the intertidal quadrat surveys is the same as what is used by the TRC, who currently undertake intertidal reef surveys around the Taranaki coastline. Using a consistent methodology will enable a comparison of data to areas further north beyond any influence of TTRs Project, as well as providing comparisons with TRC data that may already exist around the selected survey locations.

Kaimoana species identified during the quadrat surveys will be counted; however, it is noted that this is not the best methodology for establishing records of kaimoana species, particularly at 0.6 m above chart datum on the reef. It has been identified that there are a number of important kaimoana species along the STB and they are of high cultural importance so kaimoana monitoring is also included as part of the intertidal monitoring programme.

Further details of the Kaimoana Monitoring Programme is provided in **Section 12**.

11.7 Subtidal

11.7.1 Sediment inundation/depletion on subtidal reefs

Changes to the coverage of subtidal reefs by sand/fine silt will be somewhat assessed by the recording of the predominant habitat types in each photo-quadrat during the subtidal ecology surveys. But to assess coverage on a wider/larger scale, sonar surveys will be undertaken annually. An area around each subtidal reef will be established with defined GPS coordinates at each corner, and this same area will then be assessed during each subsequent subtidal survey. Utilising side-scan sonar (**SSS**) or multi-beam echo sounding (**MBES**) the entire area will be covered to produce a map identifying the sand and exposed rock areas. The maps will be produced using suitable GIS software that will enable the area of sand/fine sediment and exposed rock to be established within the predetermined 'box' and any changes to habitat can then be compared between surveys and over time.

11.7.2 Subtidal ecology

The ecological assemblages at subtidal reefs will be assessed via drop-camera photo-quadrats. Twenty stations at each of the subtidal reef sites will be established with three replicate photo-quadrat images collected at each site using a high-resolution digital still camera with suitable high intensity lighting, mounted to a 0.25 m^2 quadrat. The image is GPS tagged so that the location of the image, and the seabed habitats observed within it, can be later mapped.

The drop camera consists of a high-resolution still camera with auto focussing and exposure adjustment, and high intensity strobes all suited for underwater photography. The camera system is mounted to a frame which can attach to a series of different sized quadrats, with an adjustable distance between the camera system and the quadrat to ensure the entire quadrat is captured in each image. The unit will be deployed from the surface vessel with adequate weight attached to sink at a suitable rate and remain positioned on the seabed in the expected swell/surge conditions found in the STB reef areas. An umbilical cable connecting the camera system to the surface vessel allows real-time viewing of the seabed to ensure images are only captured at the correct moment when mobile sediments or taxa are not obscuring the seabed.

The camera system will be lowered gently to the seabed and once the quadrat is resting on the seabed, and any disturbed sediment has settled or drifted away a clear image will be captured. Each image will be analysed by a suitably trained and experienced scientist who will identify and count all taxa present in the image and record details of macroalgae coverage/density as well as habitat type (mud, sand, gravel, cobble reef, bedrock reef etc.), and any signs of fine sediment or sand inundation. The surveys will aim to resample the same stations during each survey to allow some degree of direct comparisons between surveys.

11.7.3 Video Sampling

A high-definition remote video system with LED lighting and scaling equipment will be lowered to just above the seabed at the reef sites, and held approximately 0.5 m above the seafloor while the surface vessel drifts, or slowly motors along a transect at least 100 m long. The camera will be positioned approximately 0.50 m above the seabed as it is considered this will provide adequate clarity, even in turbid conditions.

The video camera is tethered to a surface vessel via an umbilical cable which feeds live footage to the surface where it is recorded.

Video footage will be analysed by suitable trained and experienced scientists to identify and record presence of epifauna species, algal/macroalgal coverage, seabed topography and coverage of sand/fine sediments on the reef. Habitat and taxa types observed during the tows will be recorded, as well as the locations of features of interest (reefs, conspicuous taxa of interest such as scallops, mussels, crayfish, hydroid colonies etc.) along with the positions of boundaries between different habitat types.

Video sled tows have the advantage of not having the same depth limits as diver video transects, and they can also extend for a longer distance, allowing collection of seabed epibenthic imagery in areas beyond safe diving depths. All video footage will be viewed in real time and recorded so that it can be reviewed later for further confirmation of important observations, and kept securely archived.

GPS tracks of each transect will be recorded to facilitate transect location for comparison with future surveys.

11.7.4 Kelp Monitoring

To assess the health of macroalgae communities at the sensitive subtidal reef systems of the North and South Traps a series of permanent transects will be established (in consultation with TRC). At each site, two stainless steel pins will be anchored into the bedrock substrate of the reef 50 m apart. Each pin will be fitted with a high visibility tag marked with a unique identity code specific to each transect (and different for each end of each transect). Small floats will be attached to each pin to allow them to be relocated easily during each subsequent round of monitoring.

During each monitoring round a 50 m transect tape will be stretched between the two permanent pins by divers operating using SCUBA equipment. Density (abundance) and algae taxa richness will be determined by placing four 1 m^2 quadrats at 5 m intervals along the transect line. Within each quadrat the number and identity (species) of each large algal species will be recorded, by counting the number of holdfasts. Where possible the large algae species will be separated into life history stages to track demographic changes over time (i.e. recruits, small plants, large plants, mature plants).

Macroalgae diversity and coverage measurements will be taken by collecting photo-quadrat images every metre along each transect. The photo-quadrat system will utilise a 0.25 m^2 quadrat connected to a high-resolution still camera with high-intensity strobe units to provide suitable lighting for underwater photography. Photo-quadrat images will be analysed onshore on large high resolution screens where algal taxa will be identified to the lowest practicable level (preferentially to at least genus level). Evidence of sediment cover will be established from analysis of the photo-quadrat images.

Representative samples of any new or unknown algal species observed by the divers while collecting photo-quadrats or density quadrat information will be returned to the laboratory and formally identified with the assistance of a trained and experienced taxonomist.

The macroalgae surveys will be undertaken biannually commencing at the start of the BEMP and once iron sand extraction commences.

11.8 Timing and Frequency

Subtidal and intertidal reef surveys will be undertaken on a quarterly basis; however, this frequency may change to biannual based on the annual summary reports and TRG recommendations.

Following cessation of the iron sand extraction activities, subtidal and intertidal monitoring programmes will continue for four years.

Kaimoana and macroalgae surveys will be undertaken biannually and any changes to the frequency of these surveys will be based TRG recommendations.

Intertidal sand inspections will be undertaken quarterly and will be timed to coincide with the intertidal surveys. The annual set of aerial photographs will be undertaken over the summer spring low tide period.

Quarterly surveys will be aimed at being completed during the middle portion of each season dependent on the spring low tide periods, with approximate timing remaining consistent from year to year to allow for consistent temporal comparisons.

Information on the frequency, location and volume of material that has been extracted will be used to assist consideration of timing of sampling. The sampling schedule is provided in **Table 13.**

Table 13: Sampling frequency for Intertidal and Subtidal Reef Monitoring

Location	Stations	During extraction	Post-extraction
Subtidal Reef – Traps, Four mile reef, Grahams Bank, Tuteremoana Drop-camera Quadrats Epifauna video tows Diver transects (Traps)	20 locations per reef system for drop camera Three video transects per reef	Quarterly surveys to be completed following beginning of iron sand extraction activities. Frequency to be reviewed annually.	Annual surveys to be completed for four years after completion of extraction activities.
Intertidal Reef – Patea, Waiinu, Waihi, Opunake Quadrat transect surveys	One transect per reef system	Quarterly surveys to be completed following beginning of iron sand extraction activities. Frequency to be reviewed annually.	Annual surveys to be completed for four years after completion of extraction activities
Intertidal Reef – Patea, Waiinu, Waiihi, Opunake, Puketapu Kaimoana surveys	60 minute – rapid visual search	Biannual surveys to be completed following beginning of iron sand extraction activities. Frequency to be reviewed annually.	Annual surveys to be completed for four years after completion of extraction activities
Intertidal Reef – Patea, Waiinu, Waiihi, Opunake, Puketapu Sand/fine sediment inundation surveys	Single set of aerial images per reef area Four sand inspection over each reef per year	Quarterly surveys to be completed following beginning of iron sand extraction activities. Aerial images to be ground-truthed annually. Frequency to be reviewed annually.	Annual surveys to be completed for four years after completion of extraction activities.
Subtidal Reef Locations - Traps, Four mile reef, Grahams Bank, Tuteremoana Bathymetry survey – MBES or SSS	Entire coverage around each reef system	Annually with frequency to be reviewed annually.	Annually for four years after completion of extraction activities.

11.9 Reporting

The following reports will be generated for the Subtidal and Intertidal Reef Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Quarterly Monitoring Report to summarise the findings of the quarterly surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Subtidal and Intertidal Reef Monitoring Programme.

11.10 Data Analysis

11.10.1 Analysis of Photo-quadrats

Video and photographs will be downloaded to a hard drive for manipulation and analysis. Percentage cover of benthic organisms and seabed morphology in photo-quadrats will be determined by digitally overlaying a virtual photo-quadrat (scaled to approximately 40 cm x 65 cm) on each captured video frame. Each photo-quadrat will be divided into five equal blocks in which ten points will be randomly selected to give a total of 50 points for each photo-quadrat. Software such as Coral Point Count with Excel extensions (CPCe) programme (Kohler & Gill, 2006), will be used to measure the percentage cover of key categories of sediment type and epifauna (such as corals, sponges, ascidians, hydroids, bryozoans, tubeworms and anemones). The photo-quadrats will also be used to quantify any evidence of smothering by sediment.

11.10.2 Power analysis

The BEMP data was used to assess the power of the sample designs to detect ecologically or socially meaningful impacts that may be attributable to the Project. The ability of these designs to detect changes will be examined by a suite of methods, potentially including comparisons of confidence limits and determination of power using simulated data (i.e. an effect size likely to reflect the magnitude of an impact) or standard power formulae. Given the complexity of the designs and the fact that impacts are likely to be interpreted through a series of statistically significant interactions, the use of simulated data built around an effect size and assumed variance is the approach favoured at this time.

11.10.3 Reef organisms data analysis

Univariate analysis of the intertidal data will include the calculation of diversity indices (number of taxa, total abundance, Shannon-Wiener diversity, and Pielou evenness) as well as analysing the relative representation of major faunal groups, including functional groups. The subtidal data will be analysed with regards to the relative representation of major reef fauna groups, such as corals, sponges, ascidians, hydroids, bryozoans, tubeworms and anemones.

Non-Multidimensional Scaling (nMDS) plots, cluster analysis and analysis of similarity tests (ANOSIM) will be used to identify differences/similarities in the representation of major reef (intertidal and subtidal) fauna groups between sampling sites. Differences identified from the ANOSIM procedure will be further investigated using permutational multivariate analysis of variance (PERMANOVA). Models will be run to examine the effects of site and sampling period on intertidal and subtidal reef community composition.

To determine which major reef fauna groups of taxa are contributing most to, or are most responsible for, any significant differences detected using ANOSIM, the SIMPER procedure will be performed. SIMPER analysis determines the contribution that each taxa/taxa group makes to the average similarity of a group of samples.

Relationships between reef fauna and the environmental data (e.g. sediment type, algal coverage) will be examined using distance based linear models (DISTLM). This will investigate how much variation in community structure is explained by each predictor (environmental) variable and will be used to identify key drivers in community structure, particularly with respect to the influence of sedimentation on community structure.

11.11Quality Assurance

All intertidal quadrat transects will be assigned a unique sample code, as well as GPS position, time, date, and weather conditions which will be recorded on waterproof field sheets. All data will be transcribed into the master project database linked to each unique sample code. GPS positions will be downloaded into excel format then imported into a master database. Hard copies of the original datasheets will be scanned and stored electronically within the master database.

Aerial imagery and ground-truthing images will be coded with unique identifiers and entered into appropriate GIS software. Copies of all imagery and the ground-truthing data will be scanned and electronic copies stored in safe locations and backed up regularly.

Subtidal photo-quadrat images and benthic videos will be given unique codes and a record of the GPS position, time, date, and weather conditions will be recorded. Following analysis, all data will be transcribed into the master project database and linked to each unique code for that particular survey.

Field data integrity will be checked using a two-person field checklist and where appropriate, chain-of-custody documentation will be kept.

11.12 Community Involvement

Community participation will be invited for the intertidal reef assessments which includes the transect quadrat surveys, kaimoana surveys and sand inspections along the reefs. Suitable training and supervision will be provided by trained and experienced scientists for QA/QC reasons to ensure survey results are comparable. Local community involvement will provide an opportunity to show how the ecological monitoring is conducted and how the results contribute to the overall assessment to determine whether iron sand extraction is having any influence on the surrounding marine environment.

12 KAIMOANA MONITORING PLAN

12.1 Background

The rohe of Ngāti Ruanui lies directly inshore of the Project Area spanning the coastal area from Whenuakura River in the south to Waingongoro River in the north. Ngāti Ruanui is tangata whenua for the Project Area.

The Deed of Settlement between Ngāti Ruanui and the Crown (Ngāti Ruanui, 2001) makes a statutory acknowledgement to the Coastal Area (**Figure 8**); acknowledging that the kaimoana (seafood) resources here have, and continue to, provide the people of Ngāti Ruanui with a constant supply of food resources. The reefs have particular significance, providing koura (rock lobsters), paua, kina, pupu (cat's eye), papaka (paddle crab), pipi, tuatua etc. Hapuka (groper), moki, kanae (mullet), mako (shark) and patiki (flounder) swim freely between the many reefs along the Ngāti Ruanui coastline and many of these are also considered of customary importance.

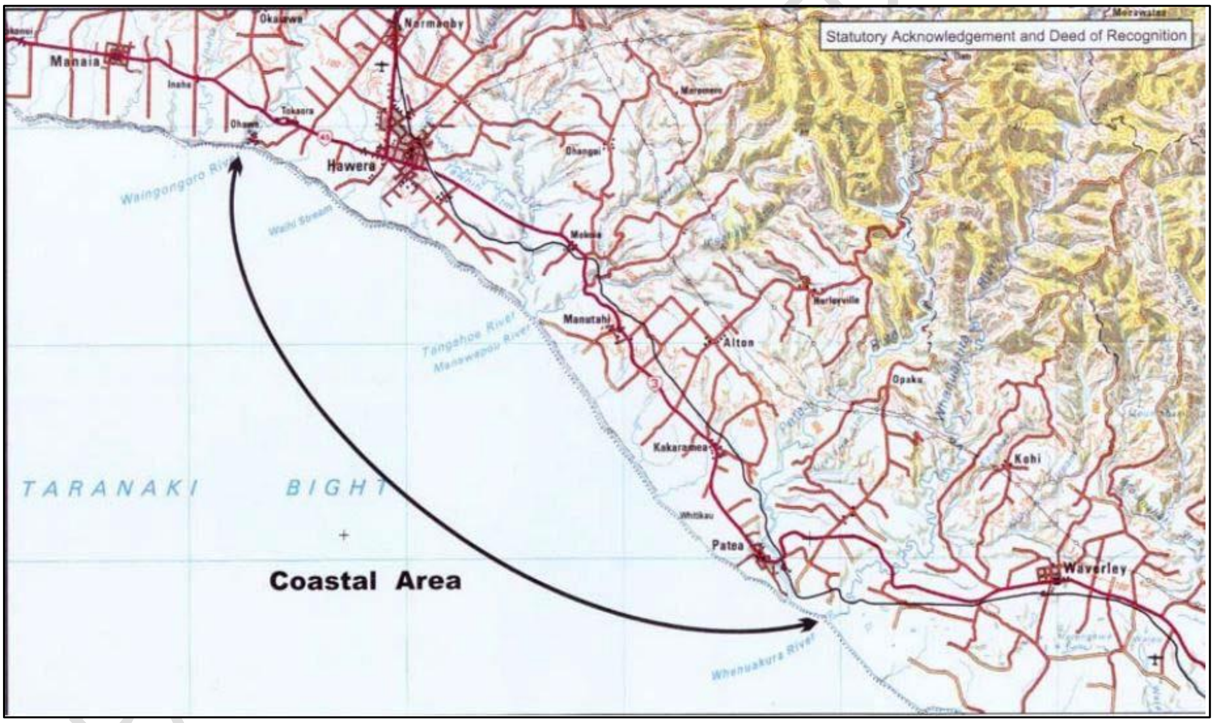

Figure 12 Statutory Acknowledgement Area of Ngāti Ruanui

Ngāti Ruanui has identified a list of taonga (treasured) species that it considers to have significant cultural value. These taonga species are listed below:

<u>Fish species:</u>
Hapuku (groper), kahawai, kanae (grey mullet), marari (butterfish), blue moki, paraki (common smelt), para (frostfish), patiki (black flounder, NZ sole, lemon sole, yellow-belly flounder, sand flounder), putukituki (rock cod), pioke (school shark), reperepe (elephant fish, tuna (long-finned and short-finned eels), and koiro (conger eel).

Invertebrates:
Kaeo (sea tulip), koeke (shrimp), wheke (octopus), koura (rock lobster), kaunga (hermit crab), papaka (mud crab and paddle crab), kotore (sea anemone), rore (sea cucumber), patangatana (starfish), kina (sea urchin), kutae (green lipped and blue mussels), paua (black footed paua), hihiwa (yellow footed paua), pipi, pupu, purimu (surf clam), rori (sea snail), tuangi (cockle), tuatua, waharoa (horse mussel), waikaka (mud snail), karaura (rock oyster), and kuakua (scallop).

This Kaimoana Baseline Monitoring Programme will be closely linked to the data collected during the Subtidal and Intertidal Reef Baseline Monitoring Programme, which will also provide data of interest with regards to kaimoana species.

At the outset of the Project, TTR provided an invite to tangata whenua, including but not limited to Ngati Ruanui to establish and maintain a Kaitiakitanga Reference Group (**KRG**). The purpose of the KRG is to:

- Recognise the kaitiakitanga of tangata whenua, including but not limited to Ngati Ruanui and their relationship with the STB;
- Review and advise TTR on the suitability of the Kaimoana Monitoring Programme;
- Provide for the ongoing involvement of tangata whenua in monitoring the effects of the activities covered under the Marine Consents, including a process for any future changes to the membership of the KRG;
- Provide for kaitiaki responsibilities and values to be reflected in monitoring of the iron sand extraction area and the surrounding marine environment, including:
    - To advise TTR on monitoring for change to risk or threat to the cultural values of the STB;
    - To evaluate the data obtained from physical monitoring as it relates to cultural values of the STB and the effects on those values from the iron sand extraction, as well as the provision to advise TTR on possible monitoring or operational responses should any effects be identified;
    - To advise TTR on the appropriateness of any operational response as they relate to cultural values, proposed by others;
    - To provide a means of liaison between tangata whenua, including but not limited to Ngati Ruanui, and TTR through providing a forum for discussion about the implementation of these consents; and
- Be responsible for receiving requests for, and facilitating the provision of any cultural ceremonies by tangata whenua, including but not limited to Ngati Ruanui and other tangata whenua groups who have a relationship with the STB.

The KRG shall convene within three months of the commencement of the marine consent, and meetings shall be held at least once per year. TTR will facilitate and administer each of the formal KRG meetings, where minutes will be taken and provided to KRG members and the EPA within 20 working days of each meeting being held.

12.2 Monitoring Objective

One of the roles of the KRG is in the involvement of the Kaimoana Monitoring Plan (**KMP**). The KMP shall be prepared following consultation with the KRG at least one month prior to the commencement of any iron sand extraction activities.

The KMP will provide for the monitoring of species important to customary needs, including from customary fishing grounds around the iron sand extraction area, of tangata whenua who have a relationship to the site and shall identify as a minimum:

- The roles and responsibilities of parties who are to conduct the kaimoana monitoring;
- The methodology to be employed in the kaimoana monitoring, including to minimise the risks to health and safety and the environment;
- The kaimoana indicators to be monitored and any thresholds for desired actions that may arise from monitoring as a result of effects from the activities authorised by the Marine Consents;
- Any components of the EMMP that provides information on the kaimoana, values and indicators; and
- A reporting mechanism for results of the kaimoana monitoring to TTR, who will provide them to the EPA.

The KMP can be amended at any time during the term of the Marine Consents, and if so any proposed changes to the KMP shall be prepared by TTR following consultation with the KRG. TTR will ensure that the EPA has a copy of the most recent KMP at all times.

12.3 Biological Indicators

Biological indicators are useful tools for assessing ecosystem functional and structural integrity. The primary indicator for kaimoana species is relative abundance or density. Understanding baseline abundance/density of kaimoana species at customary fishing grounds will provide a background reference point against which abundance/density measures that are taken during iron sand extraction activities can be compared. Any change in this parameter will be a proxy for impact which may warrant further investigations.

The size (total length) of the biota will also provide a useful biological indicator for selected kaimoana species.

12.4 Methodology

Kaimoana monitoring will occur at the intertidal reef locations identified in **Figure 10** and will be undertaken to assess length-frequency, abundance and density estimates of selected kaimoana species. For the purpose of this monitoring programme, all intertidal reef sites listed are considered to be of cultural significance for kaimoana collection.

The primary kaimoana species of interest are listed in **Table 14**. Note that this species list is subject to change following review by the KRG.

Table 14 Proposed intertidal kaimoana species of interest

Kaimoana species of interest
Black footed paua (*Haliotis iris)*
Yellow footed paua (*Haliotis australis)*
Kina (*Evechinus chloroticus)*
Blue mussels (*mytilus edulis)*
Green lipped mussels (*Perna canaliculus)*
Pupu (*Turbo smaragdus & T. zediloma)*
Sea snail (*Scutus breviculus)*

The methodology proposed is non-extractive to minimise the risks to health and safety and the environment. TTR will use its best endeavours to engage tangata whenua representatives, including but not limited to Ngati Ruanui and Te Tai Hauauru Regional Fishing Forum representatives, to undertake the monitoring identified in the KMP.

12.5 Field Sampling Techniques

Biannual kaimoana surveys will be undertaken at intertidal kaimoana gathering areas surrounding the Project Area that are of significance to local hapū members. The location of these sites (**Figure 10**) has been determined through discussions with iwi.

In addition to the qualitative surveys undertaken as described in **Section 11.6.1**, the rapid visual search technique will be used as this provides the most efficient way of locating the maximum number of kaimoana species in a given time. This method provides data for the number of kaimoana species per unit time searched, which can be compared over time for each kaimoana bed.

Timed searches in appropriate habitat are used to identify, measure and count selected kaimoana species as well as collect information on aggregations and size frequency data. Each selected location will be searched for a period of 60 minutes, where all kaimoana species identified will be recorded and measured. Emphasis will however be placed on the species listed in **Table 14**. Under-rock habitat will be searched during the surveys as juvenile paua in the Taranaki region reside underneath rocks.

12.6 Timing and Frequency

Monitoring will be undertaken biannually during the iron sand extraction activities.

12.7 Reporting

The following reports will be generated for the Kaimoana Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day (including a list of participant names and hapu affiliations);
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Kaimoana Monitoring Programme.

12.8 Community Involvement

Community participation will be critical for kaimoana surveys. Suitable training and supervision will be provided by trained and experienced scientists for QA/QC reasons to maintain data quality and consistency.

13 MARINE MAMMALS MONITORING PLAN

The following sources of data were used to estimate the use of the Project Area and surrounding waters by marine mammals during the IA development:

- An assessment of marine mammal sighting data;
- A review of relevant literature;
- Habitat modelling;
- Marine mammal aerial observations; and
- Information supplied by marine mammal experts.

From these assessments it was concluded that the sighting probability or density of marine mammals in the vicinity of the Project Area is relatively low; however, the marine mammal taxa outlined in **Table 15** could potentially use the Project Area and surrounding waters (Joint Witness Statement, 2014). For most species listed there is a paucity of information with regard to abundance, residency and habitat use in the STB, but some species are thought to only have a seasonal presence, e.g. humpback whales during their winter northern migration, and for some species the STB represents the very periphery of their distribution (e.g. Maui's dolphins).

Table 15 Marine mammal taxa potentially present in the Project Area

Taxa	NZ Threat Classification	IUCN Threat Classification
Humpback whale *Megaptera novaeangliae*	Migrant	Endangered
Antarctic blue whale *Balaenoptera musculus intermedia*	Migrant	Endangered
Pygmy blue whale *Balaenoptera musculus brevicauda*	Migrant	Endangered
Fin whale *Balaenoptera physalus*	Migrant	Endangered
Dwarf minke whale *Balaenoptera acutorostrata*	Not threatened	Data deficient
Antarctic minke whale *Balaenoptera bonarensis*	Not threatened	Data deficient
Sei whale *Balaenoptera borealis*	Migrant	Endangered
Southern right whale *Eubalaena australis*	Nationally endangered	Least concern
Sperm whale *Physeter Macrocephalus*	Not threatened	Vulnerable
Long-finned pilot whale *Globicephala melas*	Not threatened	Data deficient
Short finned pilot whale *Globicephala macrorhynchus*	Migrant	Data deficient
Killer whale *Orcinus orca*	Nationally critical	Data deficient
False killer whale *Pseudorca crassidens*	Not threatened	Data deficient
Bottlenose dolphin *Tursiops truncatus*	Nationally endangered	Least concern
Common dolphin *Delphinus delphis*	Not threatened	Least concern
Dusky dolphin *Lagenorhynchus obscurus*	Not threatened	Data deficient
Maui's dolphin *Cephalorhynchus hectori maui*	Nationally critical	Critically endangered

Taxa	NZ Threat Classification	IUCN Threat Classification
Hector's dolphin *Cephalorhynchus hectori hectori*	Nationally endangered	Endangered
New Zealand fur seal *Arctocephalus forsteri*	Not threatened	Least concern

13.1 Potential Impacts

The potential impacts of iron sand extraction on marine mammals are summarised below from the information contained in the Joint Witness Statement (2014).

13.1.1 Habitat displacement

Iron sand extraction could cause marine mammals to be displaced from the Project Area. Without fully understanding the significance of the STB to marine mammal species it is difficult to assess how significant the associated loss of habitat and resources will be. However, the small proportion of STB habitat that will be disturbed by iron sand extraction and the low density of cetaceans in the vicinity indicate that habitat displacement is unlikely to be of significance to most marine mammals.

13.1.2 Ship strike

The risk of collision between TTR vessels and marine mammals is considered to be relatively low on account of the slow vessel operational speeds in the Project Area and the low number of operational vessels.

13.1.3 Entanglement

The risk of entanglement in TTR equipment is considered to be low provided that if any float lines are deployed they are of sufficiently heavy gauge and that they are maintained under tension to eliminate slack at the surface.

13.1.4 Underwater noise

In order to simplify the EMMP, the topic of underwater noise is covered in **Section 14**.

13.1.5 Reduced habitat quality

It has also been acknowledged that all potential ecosystem impacts could have flow-on effects to marine mammals, for instance increased SSC could lead to impacts on foraging success of visual predators, and any heavy metals that are re-suspended during iron sand extraction could become bioavailable through the food chain to marine mammals.

In addition to the impacts listed here, it is probable that the iron sand extraction will contribute to the potential for cumulative impacts on marine mammals in the STB, e.g. oil and gas activities, fishing activities, land-based pollutants etc.

13.2 Management Measures

There are two 'management measures' related to compliance monitoring of marine mammals; one of these is solely related to the monitoring of underwater noise and is covered in **Section 14**. The other, whilst also related to underwater noise, has broader implications for marine mammals and is outlined below:

If a whale or dolphin approaches within 500 m of the IMV in the 30 minutes prior to a soft start, then the soft start should be delayed until the animals have been observed leaving the mitigation zone or have not been detected within the mitigation zone for 30 minutes.

Delayed soft-starts are critical to ensure that machinery is not started whilst whales and dolphins are in the immediate vicinity. Strategies that will be implemented as part of TTRs Operational Response measures for the iron sand extraction activities are outlined below:

- TTR will ensure that sufficient personnel on-board the IMV as suitably trained observers in accordance with the training requirements outlined in the Marine Mammal Management Plan;
- At any one time, TTR will ensure that at least two suitably trained observers are on-board the IMV in order to fulfil the intermittent suitably trained observers role (around their standard duties);
- A suitably trained observer will be appointed for each start-up procedure and will be excused from their standard duties whilst the start-up procedure is underway;
- Prior to any start-up procedure the suitably trained observer is to request from the master and/or bridge crew of any mining related support vessel that is in the vicinity of the IMV whether they have observed any recent marine mammal activity within 500 m of the IMV. The master and or bridge crew are also to be requested to report to the suitably qualified observer any marine mammal activity they may observe during the start-up procedure. There is no expectation that a dedicated marine mammal watch will be maintained on any support vessel during the start-up procedure;
- During the start-up procedure, the suitably trained observer will be provided with an optimum vantage point on the IMV to ensure they can undertake their pre-start observation duties in an effective manner;
- Prior to each soft-start, the suitably trained observer will conduct at least 30 minutes of pre-start observations solely for the purpose of detecting whales and dolphins;
- Pre-start observations will focus on the 500 m radius (mitigation zone) around the IMV;
- The suitably trained observer will communicate the requirement for soft-start procedures to be delayed if they detect whales or dolphins within the 500 m mitigation zone;
- Soft starts will only commence in daylight hours, during good sighting conditions (visibility to at least 500 m), and when at least 30 minutes of observations by a suitably trained observer indicates that it is safe to commence.
- The suitably trained observer will complete a 'Start-up Summary Datasheet' for each pre-start observation period. This datasheet will identify all required delays to soft-starts; and
- The suitably trained observer will complete an 'Observation Datasheet' for each whale or dolphin sighting made whilst on-watch.

13.3 Monitoring Objectives

Monitoring objectives focus on ground-truthing the potential impacts, and their predicted significance, as outlined in **Section 13.4**. The specific monitoring objectives are:

- To ground-truth the predicted impacts of the iron sand extraction on marine mammals; and
- To conduct surveys to describe the variability of marine mammal relative abundance and distribution in the STB before, during and after the iron sand extraction.

A summary of the marine mammal monitoring methodologies are provided below; however, this section should be read in conjunction with the Marine Mammal Management Plan which provides further details of the monitoring and management measures in place to ensure compliance with the Marine Consent conditions.

13.4 Monitoring Methodology

Four types of marine mammal monitoring will be undertaken by TTR:

- Incidental sightings;
- Systematic observations;
- Aerial surveys; and
- Acoustic surveys.

Each monitoring component is discussed below, and the relevance to the specific monitoring objectives is summarised in **Table 16**. At all times during the exercise of the Marine Consents there will be at least one designated and trained marine mammal observer on-board each of the operational vessels, but not including bulk carriers. And while the vessel is in motion, the observer will be in a position where a clear field of vision is provided over the forward section of the vessel and beyond the bow.

In conjunction with the marine mammal observers, a video camera will be placed in a prominent position on all operational vessels where there is a clear field of vision over the forward section of the vessel, beyond the bow and to the sides of the bow which will be continuously recording while the vessel is in motion. The purpose of the video camera is to record the passage of vessels and any contact with marine mammals whilst in motion. Video footage will be fed back to the TTR website for viewing.

All TTR employees and contractors working on the vessels will be required to record any sightings of whales or dolphins including the date, time and where possible a GPS coordinate. If any Maui's or Hector's dolphins are sighted, DOC will be notified immediately.

Under the Marine Mammals Protection Act 1978, any marine mammal strikes, entanglements, injuries or deaths must be reported to DOC and the EPA as soon as practicable following any such event. If a strike, entanglement, injury or death involves a Maui's or Hector's dolphin, TTR will immediately notify DOC and the EPA; and, where possible, the carcass will be recovered and returned to shore for collection by DOC.

TTR will maintain a records log of all marine mammal sightings (except seals) and will be made available to the EPA and/or DOC upon request and will also be provided in the Annual Report.

Table 16: Relevance of each monitoring component to the specified objectives

	Objective 1	**Objective 2**
	Ground-truthing the potential impacts, and their predicted significance	Conduct surveys to describe the variability of relative abundance and distribution.
Incidental sightings	Of direct relevance to ground-truthing the risk of ship strikes and entanglements	Of potential relevance to distribution analyses
Systematic observations	Of direct relevance to ground-truthing the risk of ship strikes, entanglements and habitat displacement	Of potential relevance to distribution analyses. Sighting rates will also provide an objective measure of marine mammal presence
Aerial surveys	Of direct relevance to assessing habitat displacement	Of direct relevance to relative abundance and distribution
Acoustic surveys	Of direct relevance to assessing habitat displacement	Of direct relevance to relative abundance and distribution

13.4.1 Incidental sightings

Incidental marine mammal sightings are those made opportunistically by any TTR employee or contractor in the course of their normal daily duties. Incidental sightings of any whales or dolphins[1] from anywhere in the STB are of relevance and should be recorded. Hence, these sightings include those made by all vessel crews and helicopter crews during periods of transit, and those made by IMV crew members that are not specifically on-watch for marine mammals. Incidental sightings do not include those made by suitably trained observers during start-up procedures; these are considered to be systematic observations and are discussed in **Section 13.4.2**.

Incidental sightings data will assist with ground-truthing the risk of ship strikes and entanglements and also potentially helpful in defining the extreme limits of a population's distribution (e.g. Maui's dolphins).

All personnel who make incidental sightings of marine mammals will be required to complete a 'Marine Mammal Sighting Form'. Training will be provided on the completion of these forms during staff inductions and species identification guides will be readily available to all personnel in order to increase the accuracy of the information collected. The completed forms will be collated periodically into a centralised electronic database from which annual summary reports will be compiled. These reports will include basic descriptive analysis and summary statistics as appropriate.

In addition to making incidental sightings during the iron sand extraction period itself, staff and contractors will also be required to complete Marine Mammal Sighting Forms during any TTR related work in the two year lead up to iron sand extraction activities commencing. During this two year baseline phase numerous vessel-based trips will be made to the Project Area and surrounds for the collection of environmental data etc. Incidental marine mammal data collected during this time will be collated for the purpose of baseline data. Likewise, incidental data should also be collected during the post-extraction monitoring.

All marine mammal sightings will be provided to the DOC for inclusion into their marine mammal sighting database.

[1] No need to record fur seal sightings

13.4.2 Systematic observations

Systematic marine mammal observations are those made by the suitably trained observers who are on-watch for marine mammals during start-up procedures. The sole responsibility of the suitably trained observers during this time is to conduct pre-start observations for whales and dolphins within a 500 m mitigation zone around the IMV and, in accordance with the management measures, to call for soft-start commencement to be delayed if any detection is made within the mitigation zone. A summary of pre-start observations, soft starts and any required delays will be provided to the EPA along with the Quarterly Operational Report.

Systematic data from the suitably trained observers will be collected onto standardised datasheets for each start-up procedure. These observation records will provide the only quantitative marine mammal data collected from the IMV; whereby the ‘presence/absence’ record generated will allow a marine mammal sighting rate to be calculated. Systematic observations could also contribute to some aspects of distribution analyses. Suitably trained observer data will be collated into a centralised electronic database from which annual summary reports will be compiled. These reports will include basic descriptive analysis and summary statistics as appropriate and will clearly outline the compliance actions taken with regards to soft starts.

In addition, these observation records will also be important to characterise any direct interactions between marine mammals and TTR equipment, hence will assist with ground-truthing the predicted risk of entanglement and ship strike.

Systematic observations by suitably trained observers will be strictly limited to the operational period associated with iron sand extraction.

If a TTR related project vessel is required to enter Admiralty Bay to seek shelter, as reasonably practicable, TTR will provide the opportunity for a nominated Ngati Koata iwi observer to monitor the presence of marine mammals while the vessel is in Admiralty Bay.

13.4.3 Aerial surveys

Aerial surveys will be designed in order to describe the variability of relative abundance and distribution of marine mammals in the STB before, during and after the iron sand extraction activities. The distribution data collected during aerial surveys will be closely analysed to detect any marine mammal displacement that is a possible consequence of the commencement of extraction activities. In this respect, aerial surveys are well placed to address both monitoring objectives.

The aerial surveys will be designed by qualified and experienced marine mammal scientists, and will be of sufficient duration, frequency and seasonality to ensure the objectives can be met. All surveys will adopt scientifically accepted suitable marine mammal survey methodologies.

It is not the intention of aerial surveys to obtain absolute abundance estimates of marine mammal species in the Project Area. Instead, relative abundances between sampling periods are sought to detect any apparent trends in density.

A line-transect methodology will be employed over an area that encompasses the Project Area and surrounding waters. In defining the survey area, consideration will be given to 1) relevance to the objective, 2) biological relevance, and 3) survey practicalities (Dawson *et al*., 2008).

The frequency of surveys will take into account seasonal variability and will ensure there is sufficient statistical power for the detection of trends. For detecting trends in the survey results, the survey efforts will be undertaken over multiple years in order for sufficient power to be achieved (Buckland *et al*., 1993). Aerial surveys will be conducted during the two year baseline monitoring period, during the iron sand extraction phase and for two years post-extraction in order to fully assess potential displacement effects from trend data.

Data analysis will be undertaken using specialised software packages (e.g. Distance: see Thomas *et al*., 2010 and www.distancesampling.org) and estimates of potential biases in monitoring data will be undertaken. Reporting will occur following the synthesis of results following each survey period. As the time series of data is compiled, trend detection analysis will be undertaken.

13.4.4 Acoustic surveys

Acoustic surveys are useful techniques for gathering information about cetacean distribution and can also contribute towards abundance estimates. In this respect, the use of acoustic surveys will be beneficial in understanding how marine mammal distribution and density change through time, hence has relevance to both of the marine mammal monitoring objectives.

Acoustic surveys will be designed by qualified and experienced scientists, and will be of sufficient duration, frequency and seasonality to ensure these objectives are met. The acoustic surveys will adopt scientifically accepted suitable marine mammal survey methodologies.

Multiple autonomous sea noise loggers and/or echolocation click detectors will be deployed to assess habitat use by specific marine mammals in the STB. These devices will be retrieved periodically to replace batteries and download data. This technique will provide an ongoing assessment of habitat use which will complement the schedule of aerial surveys.

With regards to the acoustic survey design, the primary species of interest in the STB are blue whales (with vocalisations ranging in frequency from 0.01 to 0.4 kHz) and Hector's/Maui's dolphins (with vocalisations around 129 kHz). The monitoring devices and programming will be selected so that they can measure the vocalisations of these two species, given they are at the opposite ends the frequency spectrum. Likewise, given the habitat of these two species is very different, where Hector's/Maui's dolphins are more often present in coastal waters and blue whales reside in deeper offshore waters, these differences will be considered in the development of the acoustic survey design.

Specific software will be used for the processing and analysis of acoustic data once downloaded from the monitoring device units. Data will be interpreted by an acoustician, where the results will be used to generate reports that will provide an iterative appreciation of marine mammal presence through time in the STB around the Project area.

Acoustic surveys were conducted during the two year BEMP, and will also be undertaken during the iron sand extraction activities and for a period of two years after post-extraction in order to provide a long-term data set from which trends could be detected.

13.5 Data management

The following actions will be implemented with regards to the management of marine mammal monitoring data:

- A standardised datasheet will be used to record all incidental marine mammal sightings; and
- Incidental marine mammal sighting data will be collated into a centralised electronic database from which annual summary reports will be compiled.

13.6 Reporting

The following reports will be generated for the Marine Mammal Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- An Annual Monitoring Report to summarise the previous 12 months of marine mammal data (incidental, aerial and acoustic);
- An Aerial Survey Report will be prepared following the completion of each aerial survey;
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Marine Mammal Monitoring Programme; and
- In addition, a record of pre-start observations shall be included in the Quarterly Operational Report and the Annual Report in accordance with consent conditions.

13.7 Interpretation of findings

The use of marine mammal management measures in conjunction with soft starts and other management initiatives (refer to the Marine Mammal Management Plan will serve to minimise the potential impacts on marine mammals from iron sand extraction.

In addition, the results of each marine mammal monitoring component will be evaluated over the course of the monitoring programme for trends and effects. However, given the low density of marine mammals in the STB, it is unlikely that statistically significant cause and effect relationships will be detected. For this reason it is important that the instigation of additional mitigations, in relation to marine mammal concerns, is not strictly limited to statistically significant relationships.

13.8 Community participation

A synthesis of findings from the marine mammal monitoring programme will be presented to the community periodically in accordance with TTR's ongoing commitment to stakeholder engagement. In addition to the reporting of findings TTR will also encourage community involvement through the reporting of marine mammals sightings in the STB through DOCs web portal www.doc.govt.nz/marinemammalsightings.

14 UNDERWATER NOISE MONITORING PLAN

14.1 Introduction

Underwater noise in the STB is predominately influenced by existing shipping traffic, marine biological sources and natural events (e.g. wind and rainfalls etc.).

The iron sand extraction project will generate underwater sound, which has the potential to subject marine fauna in the close vicinity to adverse noise effects. The IA places particular emphasis on the potential noise interactions with marine mammals and is discussed further in that document.

A noise monitoring programme has been developed to 1) characterise the underwater acoustic environment prior to, during and post-extraction based on long-term noise logger monitoring, and 2) to quantify noise emissions from major noise-generating plants and activities (e.g. IMV and crawler) during the iron sand extraction activities using vessel based surveys.

14.2 Objectives

The key objectives of the noise monitoring programme are to:

- Establish underwater noise characteristics in the vicinity of the Project Area, which will be determined prior to, during and post iron sand extraction activities. The data will be used to assess noise levels in relation to any observed changes in abundance and distribution of marine mammals through time identified in the marine mammal monitoring programme (**Section 12**);
- Quantify noise emissions from major noise-generating plants and activities (e.g. IMV, crawler etc.) during iron sand extraction activities;
- Validate the noise model predictions that were undertaken during the IA for the project; and
- Investigate if further mitigation measures are required for the iron sand extraction based on the monitoring results.

14.3 Management Measures

The following management measure has been developed by TTR in conjunction with DOC.

- At all times during the operation of marine vessels and/or equipment, TTR will comply with the following requirements:
    - The combined noise from the IMV and crawler operating under representative full production conditions shall be measured at a nominal depth of 10 m below the sea surface and at 300 m, 500 m and 1,000 m from the port or starboard side of the IMV;
    - The overall combined noise levels at 500 m shall not exceed 130 dB re 1µPa RMS linear in any of the following frequency ranges: low frequency 10-100 Hz, mid-frequency 100-10,000 Hz, and high frequency >10,000 Hz; and
    - The overall combined noise level at a nominal depth of 10 m below the sea surface and 500 m from the IMV, across all frequencies shall not exceed a sound pressure level of 135 dB re 1µPa RMS linear;

- Measurements will be undertaken in calm sea conditions (e.g. Beaufort sea state less than 3 (beginning white capping)), with no precipitation and no external noise sources (e.g. passing ships).

In the event of an exceedance, Operational Responses will be implemented to reduce noise levels and will include the following:

- Iron Sand Extraction activities will be altered in an attempt to reduce noise levels;
- Monitoring will be repeated within one month of the resulting operational change to demonstrate compliance with the management measures has been re-established; and
- If results of the second round of compliance monitoring indicate ongoing exceedances, a further review and discussion with the regulators will be undertaken to consider additional mitigations.

14.4 Monitoring Methodology

14.4.1 Sea Noise Loggers

The aims of the long-term underwater noise logger monitoring are to:

- Characterise the underwater noise environment in the vicinity of iron sand extraction activities prior to, during and post TTR's noise generating activities (i.e. excavation, tailings deposition, and associated vessel movements etc.);
- Quantify the noise field variations as a result of the iron sand extraction activities; and
- Inform the assessment of noise levels in relation to any observed changes in abundance and distribution of marine mammals through time.

The long-term monitoring will be undertaken by underwater automatic logging systems which are comprised of an electronic circuit board, a heavy duty housing unit with a built-in hydrophone unit, which can be deployed within the water column or on the seabed by a stable mooring arrangement. The electronic circuit board includes an integrated battery bay, control panel, display screen and memory slots. **Table 17** gives an example of specifications for a Wildlife SM3M Submersible Logging System which is one of the options that will be used or similar for the underwater noise monitoring programme.

Three sea noise loggers will be deployed at three different representative locations (X (i.e. off-shore location), Y (i.e. location next to Project Area), Z (i.e. near-shore location) as shown in **Figure 13**. The loggers will be retrieved and serviced every six months to download the data. The recovery of the loggers will not result in a significant disruption to the time series of data collection. Having the loggers in place during the BEMP provided an indication of background and anthropogenic noise levels within the STB. The deployment will also provide an understanding of the marine mammals that frequent the area which will be identified by echolocations recorded on the loggers.

Table 17 Specifications for a Wildlife SM3M Submersible Logging System

Key Features	Specification Details
Working depth	Up to 150 m
Operating temperature	0 to 40 °C
Dimensions	16.5 cm in diameter/79.4 cm in length
Weight	Without batteries - 9.5 kg in air; Fully populated with batteries - 13.5 kg in air and 1.5 kg buoyancy in salt water
Power	Maximum 32 alkaline D cell batteries or lithium manganese batteries (4.5 – 17V DC)
Sampling rate	4 – 96 kHz
Storage	Up to 512GB with SDXC
Recording schedules	Programmable
Data format	WAC (compressed) or WAV
Dynamic range	78 – 165 dB re 1µPa with 0 gain input
Gain setting	0 – 59.5 dB in 0.5 dB steps
Hydrophone	Hydrophones of different specifications (Low Noise, Standard, Ultrasonic, High-SPL) can be selected depending on the monitoring purpose
Noise floor with standard hydrophone	-134 dBfs/sqrt(Hz) @ 48 kHz sample rate, 1 K input impedance, 1dB gain
Calibration	The electronics of the board and hydrophone are calibrated and are not expected to shift the value in years, unless some damage occurs.

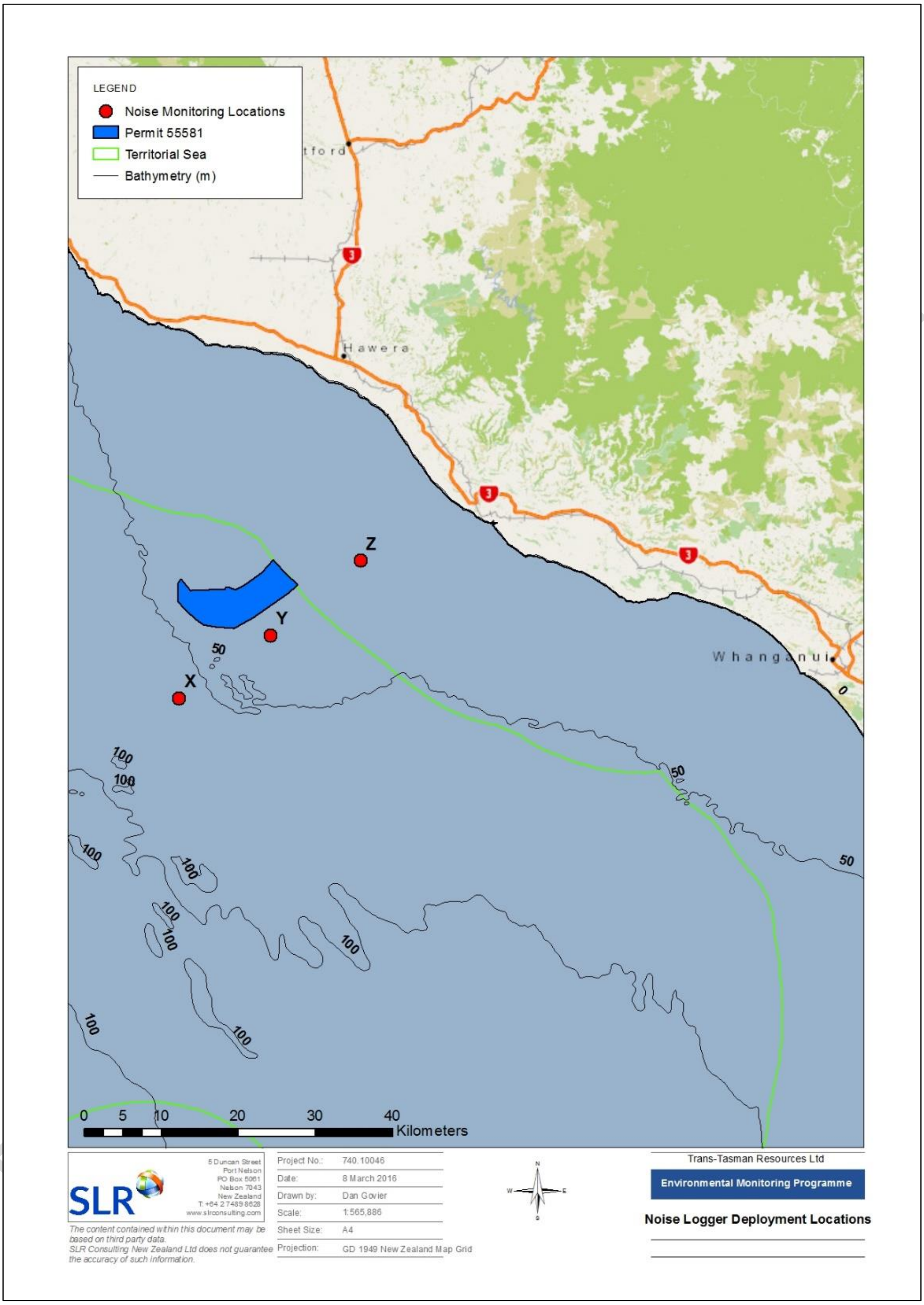

Figure 13: Sea noise logger deployment locations

14.4.2 Vessel Based Surveys

The aims of the vessel based surveys are to:

- Quantify noise emissions (i.e. determine noise source levels and spectra) from major noise-generating activities (e.g. IMV, crawler etc.) under different operational conditions;
- Measure received noise levels at various locations with different distances from noise sources, to calculate transmission loss along the propagation path, and to verify noise model predictions that have been carried out during the IA; and
- Investigate if measured noise levels exceed the management measures in accordance with consent conditions.

The vessel based survey will be performed using a hydrophone measurement system deployed from a vessel to measure underwater noise of specific activities. The system will include a hydrophone unit with appropriate sensitivity parameters, a conditioning amplifier for optimising signal dynamic range, a signal recorder for data acquisition with sufficient sampling rate, and a signal analyser installed on a laptop for real-time signal monitoring and analysis. **Table 18** provides an example of an indicative measurement system component.

Table 18 Typical vessel-based measurement system components

Equipment	Type	Specifications
Hydrophone	Reson TC4033 (with 40 m cable)	Receiving Sensitivity: -203 dB ±2 dB re 1V/μPa Linear Frequency range: 1 Hz to 80 kHz Directivity, Horizontal: Omnidirectional ±2 dB at 100 kHz
Conditioning amplifier	B&K NEXUS Type 2693	Output Dynamic Range: 1 mV/Pa – 1 V/Pa Frequency bandwidth: 1 Hz – 20 kHz
Recorder	Rion DAT recorder DA-20	Bandwidth: DC – 20 kHz
Analyser	LMS Scadas and Test.Xpress	51.2 kHz sample rate 24 bit

The vessel based surveys will be undertaken according to the following schedule and methodologies:

- Measurements will be undertaken in calm sea conditions (e.g. Beaufort sea state less than 3), with no precipitation and no external noise sources (e.g. passing ships);
- The monitoring equipment will be calibrated before and after measurements;
- The combined noise will be monitored:
    - Within one month of commencement of iron sand extraction activities and if less than 80% of full production, a further measurement will be made within one month of extraction activities reaching 90% of full production;
    - An additional two times in the first 12 months of the commencement of 90% of full production. Each measurement will be separated by a period of at least six months;
    - Annually for the following four years;
    - Every five years thereafter; and
    - At any time reasonably requested by the EPA.

Should the operation of the IMV and crawler be altered in any way which may change the magnitude or character of the underwater noise production, the noise shall be monitored within one month of the change to demonstrate that compliance with the management measures has been maintained.

For the purpose of the monitoring requirements, full production as mentioned above equates to an operational extraction of 8,000 tonnes per hour.

14.5 Data Analysis

14.5.1 Sea Noise Loggers

Signal processing and analysis will be undertaken on the noise logger data. This analysis and interpretation will take into consideration the site specific activities occurring during the monitoring period for each monitoring location as well as meteorological conditions and date. The predominant characteristics of the underwater noise environment in the vicinity of the Project Area will be identified, including but not limited to:

- Temporal and spatial variations in overall underwater noise levels;
- Spectral variations in underwater noise levels;
- Major noise contributors of various origins; and
- Correlations with other natural environment parameters such as weather, sea states and tides.

14.5.2 Vessel Based Surveys

The data collected during vessel based surveys at close range to the noise sources will be collected and processed to calculate the overall noise source levels and source spectra based on measured levels and estimated attenuation losses.

The measured noise data collected during the vessel based monitoring surveys will be compared with predicted levels (from the IA) for model validation purposes.

14.6 Reporting

The following reports will be generated for the Underwater Noise Monitoring Programme:

- Notification of any Compliance Limit Breach;
- A Daily Trip Report at the completion of each monitoring day;
- An Underwater Noise Monitoring Report at the completion of vessel-based surveys;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Underwater Noise Monitoring Programme.

15 RECREATIONAL FISHING MONITORING PLAN

15.1 Background

Recreational fishing is a popular activity in the STB and includes line fishing from boats, diving, and the shore (such as surfcasting and long-lining). Very little recreational fishing occurs more than 20 km offshore along the STB, with areas most commonly fished typically occurring within 10 km of the shore (RG&A, 2013).

The main public access and activity points for recreational fishers along the STB coast include: Ohawe Beach, Waihi Beach, the mouths of the Tangahoe and Manawapou Rivers, as well as from Patea, Waipipi, Waiinu, Kai Iwi, and Whanganui. Boat launching occurs at Ohawe, Patea, Waipipi, Waiinu, Kai Iwi and Whanganui; however, the use of these launching areas is significantly limited by weather and tidal conditions, with dangerous bar crossings or beach launchings necessary at these launching locations.

Shore-based fishing includes surfcasting and shellfish gathering. Surfcasting mainly occurs at Ohawe and Waihi Beaches, the mouths of the Tangahoe and Manawapou Rivers, Waipipi, Waverly, Wainui, Kai Iwi and Whanganui, while shellfish gathering typically occurs at Whenakura, Waitotara, Waiinu, Kai Iwi, Whanganui, south of Patea, and from Ohawe to the Manawapou River. Boating occurs throughout the STB but predominantly north of Patea. Diving is mainly for rock lobster at Ohawe, Graham's Bank, the North and South Traps (particularly from late October through to April), and on rocky seams off Waitotara and Waverly (RG&A, 2013).

Recreationally caught fish species identified as having a high probability of occurrence within the STB include barracouta, blue cod, carpet shark, eagle ray, frostfish, jack mackerel, john dory, kahawai, leatherjacket, red cod, red gurnard, rig, snapper, spiny dogfish, tarakihi, trevally, and blue warehou (MacDiarmid *et al*., 2013). Additional fish species have been identified within Ngati Ruanui's Deed of Settlement as taonga (treasured). These include: hapuku/groper, grey mullet, butterfish, blue moki, common smelt, black flounder, NZ sole, yellow-belly flounder, sand flounder, eels and elephant fish. Large game fish such as kingfish, tuna and marlin can be caught within STB during summer months as warm currents push down the coast. Rock lobsters are also recreationally important in the STB and have been identified as taonga by Ngati Ruanui.

A number of recreational fishing, diving and boating clubs have been established throughout the STB. Recreational fishing groups include New Plymouth Sportfishing and Underwater Club, Whanganui Manawatu Sea Fishing Club, Patea Fishing Club, Opunake Surfcasting/Angling Opunake, Kaonga Fishing Club, and Patea Surfcasters Club. Diving and boating groups active within the STB include Patea and District Boating, Cape Egmont Boat Club, Ohawe Boating and Angling, and Opunake Boat and Underwater Club.

15.2 Objectives

The primary objective of the recreational fishing monitoring programme is to monitor and report any impacts to key recreationally targeted fish species to determine if changes to recreational fishing activities and fish catch occur as a result of iron sand extraction activities.

15.3 Methods

The overall approach is to monitor for changes in the relative estimates of recreational fishing activity and catch during the monitoring period. The BEMP provided data that will be used as a standard from which any changes will be gauged.

There are four broad information needs to satisfy this objective:

1. Demographics and catch data of recreational fishers in the area. This information will be obtained by boat ramp surveys;
2. The distribution of recreational fishing vessels in relation to iron sand extraction activities. This information will be acquired using a combination of boat ramp surveys, recreational club surveys and boat ramp camera observations;
3. Attitudinal information of recreational fishers regarding their perceptions of the effects of iron sand extraction on recreational fishing. This information is to be obtained from recreational club surveys; and
4. Environmental data. Other aspects of this EMMP include studies being undertaken to measure changes in environmental variables during iron sand extraction. Correlations between recreational fishing data and environmental data will be investigated to assess any causative links to changing recreational fishing behaviour.

The recreational fish monitoring programme will utilise a general temporal and spatial sampling design and subsequent data analysis will be applicable to boat ramp and recreational club surveys.

Temporal sampling will be structured around three 'phases':

1. Pre-construction – This represents the BEMP;
2. During iron sand extraction activities – Monitoring programme to continue throughout the duration of iron sand extraction; and
3. Post-extraction – Monitoring will continue for a further four years following the completion of extraction activities or until the EPA approve a lesser time.

These three primary phases will be partitioned into seasons for analysis as appropriate.

It is expected that spatial sampling will be broadly structured around three locations: Graham's Bank, the Rolling Grounds and the North and South Traps as this has been indicated during the BEMP as the general areas where most of the recreational fishing occurs.

15.3.1 Boat Ramp Surveys

Information on recreational fishing effort and catch will be collected using boat ramp surveys. Surveys will be conducted with the assistance of recreational fishing, diving and boating clubs and at the following boat ramps and are shown in **Figure 14**.

Figure 14 Boat Ramp Survey Locations

Boat ramps surveys will occur on a mixture of weekdays and weekends, with ramp visits lasting for a standard period of time for each survey day. Due to the highly tidal nature of many of the boat ramps in the STB, ramp visits will need to be coordinated around the optimal tide; for example the Patea boat ramp and associated bar are difficult to navigate at low tide, while the Ohawe ramp is difficult at high tide.

For safety reasons, boat ramps will not be visited at night, and two staff will be utilised for remote locations. This will also help to maximise the survey opportunities during peak fishing periods.

Surveyors will ideally approach all incoming boats, but only those that have been actively fishing will be interviewed. One person per boat who is over the age of 15 will be asked to participate in the survey. Each survey will consist of a number of pre-determined questions based on fisher demographics, fishing effort and catch.

The specific survey questions will be confirmed prior to baseline surveys commencing and questions will be reviewed following the pre-operational phase. A summary of expected survey outputs is provided below:

- Estimates of relative ramp utilisation: number of boats using each ramp per survey day;
- Estimates of relative recreational fishing effort: hours spent actively fishing;
- Estimates of relative harvest rates and catch composition (number and species);
- Comparisons of size frequency distributions of key species landed by recreational fishers;
- Estimates of relative release rates for all species caught; and
- Identification of primary recreational fishing locations in relation to iron sand extraction activities.

The expected types of data to be collected are summarised in **Table 19**. Statistical analyses of these data are described in **Section 15.6**.

Table 19: Quantitative data yield per ramp visit

Variables	Description/Comment
Ramp utilisation	Number of trailers present per ramp visit
Number of interviews	Number of boats for which interviews were able to be obtained
Boat characteristics	Boat length, motor size
Fisher demographics	Number of fishers, fisher ages, genders
Fishing locations	Number of places fished, time spent at each location, sites visited
Fishing method	Line/diver/pot/net etc.
CPUE	Estimate of number of fish caught per angler hour ('catch per unit of effort')
Fish abundance retained	Total number of fish/species caught and returned to the ramp
Fish abundance discarded	Estimate of total number of caught fish returned to the water
Fish size	Lengths of retained fish (LCF length to caudal fork, TL total length)

15.3.2 Boat Ramp Camera Ramp Observations

Camera systems provide a cost effective and reliable means of monitoring trends in boat ramp traffic over time (Hartill, 2015); so to ensure accuracy and efficiency cameras will be set up at popular boat ramps once the necessary permissions are obtained. The cameras will be established in an appropriate position that allows a full view of the use of the launching ramp. Cameras are to capture a time stamped image of the ramp at set time intervals (specifics to be confirmed but the intervals must be appropriate to accurately capture ramp usage). The images will then be viewed as a time-lapsed video to determine the number of boats using the ramp over a given period of time.

15.3.3 Recreational Club Surveys

When monitoring recreational fishing, it is important to take into account community values and people's perceptions of their surroundings (Källqvist, 2009). Surveys targeting recreational fishing, boating and diving clubs will be utilised to gain an understanding of fishers' attitudes towards recreational fishing in the STB with regard to the quality of the fishing and their views on any potential impacts arising from iron sand extraction activities.

Data from recreational clubs will augment data collected during boat ramp surveys. Furthermore, fishers interviewed through recreational clubs are more likely to be the most active recreational fishers and therefore more likely to observe long term trends within the STB. Attitudes and information of surfcasters will also be incorporated through recreational club surveys.

Specific survey questions for recreational clubs will be confirmed before the pre-operational phase commences; however, questions will be based on a Likert-Scale (a scale used to assign a numerical value to a person's attitude or perspective on a topic) or similar, when possible to allow for statistical analysis. Attitudes to be investigated include: quality of the fishing, perceived interference between fishing and iron sand extraction, preferred times of fishing, perceived changes in catch rate compared with before iron sand extraction activities began.

15.4 Quality Assurance

All field data will be recorded on waterproof field sheets with a unique sample code, which will be logged into the master database.

Survey staff will have a good understanding of the project and associated requirements, and will be appropriately trained in survey/questionnaire methodology and health and safety requirements.

15.5 Data Management

All data will be entered into a purpose-designed database that conforms to TTR's electronic database information requirements. Examples of tables within the database and the data recorded will include:

- Sample information: unique sample identification, collection location, time, date, survey duration, comments;
- Demographic Data: information about the recreational fishers, vessel type, frequency of fishing etc.;
- Climate data: weather conditions, sea state, time of high and low tides;
- Taxonomic data: species, fish size; and
- Data Codes: data type, impact classification, impact code.

All data entered into the database will be checked by a second scientist. Error checking queries will be run to detect errors or omissions.

Data exported for use in statistical analyses will be locked to avoid corruption or accidental over-write. Excel spread sheets will be imported into a Project master database. Any changes to original datasheets will be saved as different versions to ensure overwrites do not occur.

15.6 Statistical Analyses

Data will be analysed statistically using a range of descriptive and inferential techniques.

Descriptive statistics will include means, standard errors, co-efficient of variation and, where appropriate, calculation of confidence limits associated with means.

Inferential statistics will be used to test hypotheses regarding changes in variables associated with recreational fishing among locations or monitoring phase.

Standard tests will include multivariate analyses to compare groups of species and univariate analyses to compare catch indices, and utilisation by fishers.

BEMP data has been used to assess the power of the survey design with regards to detecting meaningful impacts that may be attributable to the Project. The ability of these designs to detect changes will be examined by a suite of methods, potentially including comparisons of confidence limits and determination of power using simulated data (i.e. an effect size likely to reflect the magnitude of an impact) or standard power formulae. Given the complexity of the sampling design and the fact that impacts are likely to be interpreted through a series of statistically significant interactions, the use of simulated data built around an effect size and assumed variance is the approach favoured at this time.

15.7 Reporting

The following reports will be generated for the Recreational Fishing Monitoring Programme:

- A Daily Report at the completion of each monitoring day;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Recreational Fishing Monitoring Programme

15.8 Community Involvement

Community involvement is an important component of the recreational fishing monitoring programme. While boat ramp and recreational club surveys cannot occur without participation from the fishing community, another important community involvement component is the potential use of members of the community, to conduct ramp visits and collect survey data.

Those conducting the surveys will be appropriately trained with regards to survey techniques and any health and safety requirements.

An added benefit to the use of community members to conduct boat ramp surveys is education of the wider community and possible increased participation in boat ramp surveys. Although those conducting surveys will have no enforcement power, fishers may be hesitant to participate in surveys for fear of the consequences (such as fines or confiscation of property associated with Fisheries Officers). The use of community members in conducting surveys is likely to engender trust and encourage community participation.

16 BIOSECURITY MONITORING PLAN

16.1 Background

The potential for biosecurity issues with the Project are associated with the management of ballast water and hull fouling of vessels on site and the bulk carrier vessels that arrive into New Zealand waters. Vessels entering New Zealand waters must comply with the 'Import Health Standard for ships ballast water from all countries' issued under Section 22 of the Biosecurity Act 1993 and must complete a 'Ballast Water Declaration'. Any vessels arriving into New Zealand waters are also required to comply with the 'Craft Risk Management Standard (**CRMS**) for Biofouling on Vessels arriving to New Zealand' as found under section 24E of the Biosecurity Act 1993.

Further details on biofouling and the measures that will be implemented to minimise any biosecurity risk is provided for within the Biosecurity Management Plan.

16.2 Ballast water

Ballast water is essential for the safe and efficient operation of modern vessels; however, it can pose ecological, economic and health risks (human and environmental), particularly when ballast water has been taken on-board in a different area/country compared to where it is likely to be released. Ships ballast water may contain heavy metals and other pollutants, eggs, cysts, larvae and even adults of various species, invertebrates, and even dangerous bacteria and microbes. If organisms within ballast waters are able to survive the journey and the physical pumping in and out of the vessel, then if they find the environment where they are released to be suitable they may establish and even become reproductive. This then poses as a threat for the native environment and its species as the introduced taxa may quickly become dominant and out-compete natives.

New Zealand has become party to the International Convention for the Control and Management of Ship's Ballast Water and Sediments 2004 which requires new ships, and eventually all ships to operate ship-boar treatment systems to disinfect ballast water taken up in foreign ports.

All bulk cargo vessels utilised by TTR for transporting iron sand ore to overseas markets will enter New Zealand waters being fully compliant with requirements of the Ballast Water Management Convention (**BWM Convention**); that is, having 'clean' ballast water and 'clean' tanks. Conditions within TTRs Marine Consents require that all operational vessels carrying ballast water that travel to and from overseas ports, including bulk carriers are to have shipboard ballast water treatment systems operating. These systems must have Ballast Water Treatment that are on the MPI list of approved ballast water treatment systems, or be an equivalent system approved by the International Maritime Organisation.

The systems must meet the IMO discharge standards of mid-ocean ballast exchange prior to entering into New Zealand waters and have no adverse environmental impact on the marine environment. Any vessel which does not comply with the above requirements will not be used for any part of the iron sand extraction activities unless the master can demonstrate that the vessel complies with additional ballast water management options listed in the Ministry for Primary Industries (**MPI**) 'Import Health Standard: Ballast Water from All Countries, 16 December 2015 or any subsequent version thereof. Operational ballasting and de-ballasting of these vessels, such as during cargo loading activities, will take place as required within New Zealand's EEZ using 'clean' New Zealand waters.

16.3 Hull and equipment biofouling

All vessels arriving in New Zealand are required to comply with the IMO Biofouling Guidelines 2011 (Resolution MEPC 207(62), '2011 Guidelines for the Control and Management of ship's Biofouling to minimise the transfer of invasive aquatic species'). MPI provides bio-fouling regulations for vessels entering New Zealand waters including advice on the vessel's Biofouling Management Plans, Biofouling Record Books, advice on the correct choice of anti-fouling system and how it should be installed and repaired, in-water inspections and cleaning and maintenance procedures. Consent conditions require that International cargo vessels servicing the iron sand extraction activities will have a "clean hull" for "short stay vessels" as specified by the CRMS: Biofouling on Vessels Arriving to New Zealand. The CRMS is currently voluntary and will come into force on May 15th, 2018; however, most vessels are now compliant with this standard.

Clean structures, particularly anthropogenic structures such as vessel hulls, mooring lines and extraction equipment (hoses, crawlers etc.), without antifouling treatment provide ideal habitats for the settlement and attachment of new organisms which may be pests/invasive. These habitats do not have existing native communities established which could compete with new organisms and reduce their ability to settle, survive and grow, increasing the chances that a new arrival organism (if present) might become successfully established.

16.4 Potential Project Impacts and Receptors

The incursion of a pest/invasive organism or microbe/disease into New Zealand's coastal waters, or even onto the coastline (including offshore reef structures) could present a potentially huge environmental, economic and health risk to the country. Invasive marine organisms have the potential to out compete and displace native marine species which can have impacts on native kaimoana species as well as economic impacts on industries such as fishing, aquaculture and shipping.

16.5 Objectives

The overarching objective of the biosecurity monitoring programme is to minimise or prevent the entry into New Zealand waters or onto the coastline of harmful organisms contained within ballast waters and/or hull biofouling. To do this the monitoring programme aims to comply with all relevant regulation regarding biosecurity and will include regular inspections of all in-water assets for biosecurity incursions, and deal with these as appropriately designated.

16.6 Operational Response Measures

TTR will ensure that:

- All overseas vessels that are to be permanently located in the vicinity of the project area, including but not limited to the IMV and crawler; and
- All vessels servicing the iron sand extraction operation that regularly travel to and from overseas ports, including bulk carriers, shall meet the requirements of the CRMS and any vessel that does not comply with the above requirements will not be used for any part of the iron sand extraction activities authorised by the Marine Consents.

The painting system that will be used on the IMV will be specially considered for the 20 years on site operation of the Vessel. The underwater paint system and anti-fouling system will be in compliance with the Class requirements for in water survey. Each sea chest will be provided with a marine growth prevention system based on Copper electrodes and made suitable for two years operation. The electrodes will be supplied from the Vessel's electric system via transformer rectifiers. The mounting will be in compliance with the Class requirements for in water survey and will be readily accessible for replacement by divers.

TTR will have a team of divers that will also undertake in-water cleaning to ensure there is no marine growth growing on the vessel. These divers will be trained in identification of typical biofouling organisms and exotic species to be able to identify any potential threat from an invasive species. Should a known invasive/pest organism or new foreign organism be detected during routine cleaning or maintenance activities of TTR's vessels, equipment or moorings then this would trigger the first Operational Response. This will include further intense targeted surveillance of the specific vessel/equipment and surrounding assets to identify if there are any more invasive/pest organisms present and if so an idea of the extent will be determined. If this surveillance establishes that there has been a wider incursion then a further Operational Response will be actioned. This will involve the establishment of a containment/eradication plan which will be discussed with the regulators before being implemented at the affected locations.

Operational Response measures will also be in place for biosecurity assessments within the intertidal areas along the STB coastline. If a known invasive/pest organism or new foreign organism is encountered during the intertidal reef monitoring programme, this would trigger an Operational Response to be implemented resulting in increased surveillance at all of the intertidal reef monitoring sites. If such an event happened, a biosecurity expert would be engaged to facilitate the assessment and surveillance programme, as well as establishing whether the incursion is a result of TTR iron sand extraction activities or whether further management measures are required (i.e. eradication plan).

Following the additional reef surveys the presence/absence of the new/pest organism would be established, and the extent of the incursion would be clearer. If further Operational Response measures are recommended by the biosecurity expert engaged, TTR, TRC, TRG, MPI and the EPA will be involved with any management response.

16.7 Sampling Design and Methodology

Initially the biosecurity assessments as part of the biosecurity monitoring programme will be focused around opportunistic monitoring/sampling as part of maintenance activities. To keep vessels and equipment clean during the term of the consent, regular in-water cleaning will be undertaken by divers, with the removed materials being deposited to the seabed below. The divers undertaking the cleaning activities will be trained and adequately briefed and trained by a suitable biosecurity expert in regards to new organisms, or known pest/invasive species, and how to collect suitable samples for identification without risking further spread of the organism.

If divers identify a likely new/pest organism during the cleaning activities, the affected area would be placed on hold until positive identification of the organism in question was made. If the identification of the organism indicates a new species to New Zealand, or a known pest species, then a systematic search of the entire hull or equipment will be undertaken. This will determine the extent of the incursion, whether the systematic search will need to extend to surrounding areas, and will inform decisions on the next course of action to contain and/or eradicate the organism.

Opportunistic monitoring will also take place in conjunction with the intertidal reef monitoring occurring at selected intertidal reef sites along the South Taranaki Coastline in accordance with the subtidal and intertidal reef monitoring programme (**Section 11**). Quadrat surveys along transects at the low tide line will provide the opportunity to identify any new species that may have established on the rocky intertidal reefs in the STB. Scientists undertaking the transect surveys will be briefed and trained in field identification of possible marine invasive species and in the correct methods for collecting representative samples for formal identification by a taxonomist. Should a possible new organism be detected then photographs and specimens will be collected, and GPS coordinates recorded of the exact location. Photographs will include the background environment and any notable reference features present to allow easy relocation of the site should further visits be required. Operational Response measures will be very similar to those implemented when new organisms are detected on offshore vessels and response equipment would be made available for intertidal incursions.

A Biofouling Record Book will be kept and maintained, and within 20 working days of each anniversary of the commencement of consents to a nominated representative of the Aquaculture industry as appointed by Aquaculture New Zealand and to the EPA.

16.8 Laboratory Analysis

Any possible new organism found during vessel, equipment or intertidal/subtidal surveys will be formally identified by a recognised taxonomic laboratory. An experienced taxonomist will examine the preserved specimen to the lowest possible taxonomic level and compare their findings with known distributions of the organism. For that particular species, investigations will be undertaken for any alerts relating to the organism, such as on MPI's list of known pest species. If a new/pest organism is suspected then notification will be provided to the relevant regulatory bodies and correct identification will be confirmed by having a second taxonomist formally identify a specimen of the organism in question.

16.9 Timing and Frequency

Intertidal and subtidal surveys are scheduled to be conducted on a quarterly basis (seasonally), during the baseline and active extraction phases and so opportunistic biosecurity checks would occur at these times. Hull and equipment cleaning will be undertaken regularly.

16.10 Reporting

The following reports will be generated for the Biosecurity Monitoring Programme:

- A Daily Trip Report at the completion of each monitoring day;
- A Biosecurity In-water Inspection Report at the completion of each inspection;
- A Biosecurity Post-cleaning Report at the completion of any biosecurity cleaning activity;
- An Annual Monitoring Report to summarise the previous 12 months of data; and
- A Final Monitoring Report at the completion of the programme to summarise the findings of the Biosecurity Monitoring Programme.

In addition, any possible biosecurity incursions found during other ecological surveys (i.e. intertidal/subtidal surveys) will be noted in the respective reports relating to those surveys.

16.11 Community Involvement

Due to the strict health and safety regulations surrounding working aboard vessels in the open ocean and occupational diving, it will not be possible to safely involve members of the local community in biosecurity assessments on the vessels and equipment involved in extraction and export activities. There is however an opportunity to educate the local community about the sorts of pest species that TTR and MPI are watching for, and allow the local community to be the 'eyes on the ground' for any possible incursions of invasive/pest species along the STB coastline.

The local community will be encouraged to report sightings, and where possible collect representative samples, of any new or unknown taxa that they observe along the coastline. When credible reports are made, TTR staff or nominated contractors with suitable experience will visit the location of the report or sighting with the member of the community that made the report, to involve them in the process of identifying whether the taxa is new or invasive. Local community members will also be involved during the intertidal surveys along the South Taranaki coastline where biosecurity surveillance will be part of the transect surveys being conducted at these sites.

A synthesis of findings from the biosecurity monitoring programme will be presented to the community periodically in accordance with TTR's ongoing commitment to stakeholder engagement.

17 MANAGEMENT PLANS AND REPORTING

17.1 Management Plans

Detailed management plans will compliment this EMMP by describing how the various management commitments that are not already covered by the monitoring programmes (**Sections 5 – 17**) will be met. These management plans will give effect to the Marine Consent conditions that relate specifically to management requirements. In particular, TTR will produce the following management plans:

- Spill Contingency Management Plan;
- Collision (Loss of Position) Contingency Management Plan;
- Marine Mammal Management Plan;
- Seabirds Effects (Lighting) Mitigation and Management Plan;
- Biosecurity Management Plan; and
- Biofouling Management Plan.

All management plans will clearly state their objectives and the methods by which these objectives will be achieved. Management plans will be submitted to the EPA at least three months prior to the commencement of extraction for approval, but will be considered to be 'living documents' whereby revisions can occur at any time on the following terms:

- Amendments shall be submitted in writing to the EPA for approval. Minor amendments to take into account unforeseen circumstances on site, or circumstances that require immediate action do not need to be submitted in advance of the work being undertaken, but shall be submitted as soon as practicably possible; and
- Any changes to management plans shall be approved by the EPA as meeting the respective purposes and objectives of the management plans.

17.2 Reporting

Each monitoring programme will have a unique reporting schedule as detailed in the respective monitoring programme sections and **Section 4.6**; however, the overarching reporting requirements to both the EPA and the TRG in addition to the reporting requirements that relate specifically to monitoring are outlined below.

17.2.1 Operational Assessment Report

No less than three months prior to the commencement of any seabed extraction authorised by the marine Consent, and every 12 months thereafter, TTR will prepare and provide an Operational Assessment Report to the EPA which will include:

- An outline of the area where removal of seabed material, targeting the extractable resource of titanomagnetite iron sand will take place during the next 12 month period, and the timing thereof;
- Bathymetry of the seabed in the area where the removal of the seabed material is planned;
- Mineral grade projections and mine plan schedules;
- Definition of fine sediments in the area to be mined; and
- Procedure for avoiding identified fine sediments to the extent necessary to meet the PSD limits and to meet the SSC limits in **Table 2**.

17.2.2 Quarterly Operational Report

A Quarterly Operational Report will be submitted to the EPA summarising the iron sand extraction activities undertaken for the previous quarter (3 months) of operation. The information in these reports largely has an operational focus, but some environmental data may also be included, i.e. the number of delayed starts and other mitigations on account of marine mammals. The quarterly report will include, as a minimum, the following operational information:

- GPS positions of anchor placements on the seabed and coordinates illustrated on a map with the iron sand extraction area clearly marked;
- GPS positions of the crawler placement and tracks during iron sand extraction activities and coordinates illustrated on a map with the extraction area clearly marked;
- Any bathymetry measurements of the seabed measured in the reporting period where removal of seabed material has taken place. (Note: Bathymetry will be assessed on six-monthly basis);
- Quantity and rate of removed and deposited seabed material;
- Maximum and average depth of seabed removed by the crawler throughout each mining lane (from bathymetry);
- Average and maximum depth, and GPS position of any unfilled pits remaining after completion of a mining lane. (from bathymetry);
- Average and maximum height, and GPS position of any mounds created during the deposition of seabed material. (from bathymetry);
- Location and height above the seabed of discharge pipe whilst discharging seabed material;
- Details of any complaints received, including the Complaints Log;
- Details of any investigations, including recommendations, undertaken by TTR, the TRG or the KRG including a summary of any commentary or recommendations from the TRG and, where necessary, an explanation as to why any TRG recommendation has not been accepted; and
- Any other components required by conditions within the marine consents.

The Quarterly Operational Report will be provided to the EPA within 40 working days of each quarter ending (being 31 March, 30 June, 30 September and 31 December) during the iron sand extraction activities authorised by the Marine Consents.

17.2.3 Annual Report

An Annual Report will be provided each year to the EPA for the previous 12 month period from the commencement of iron sand extraction activities authorised by the Marine Consents. Following the 12 month period after the anniversary of the commencement of the iron sand extraction activities an Annual Report will be prepared. The Annual Report will include, as a minimum, the following information:

- An extraction schedule detailing:
    - The areas in which extraction and deposition is proposed to occur over the next 12 month period;
    - The timing of proposed extraction and deposition activities;
    - The volume and mass of materials extracted and deposited during the previous 12 month period;
    - GPS locations or chart references detailing the location of extraction and deposition in the previous 12 month period;
    - Depths of extraction that are scheduled to occur; and
    - All updates of the extraction schedule that were notified to the EPA.

- A summary report on all monitoring undertaken in the previous 12 months in accordance with the EMMP;
- Details of monitoring proposed for the next 12 months in accordance with the EMMP;
- Details of any breaches of the limits provided in **Table 2**, as well as any management/mitigation actions implemented in response to any exceedance including details of any investigation;
- Details of the TRG review of the annual monitoring data and the EMMP, along with recommendations for any actions or changes to the EMMP or the iron sand extraction activities, and how these were provided for as well as any reasoning as to why recommendations were not accepted; and
- A record of all fuel used and the sulphur content in any of the vessels used as part of the iron sand extraction activities.

TTR will provide the Annual Report to the EPA within 60 working days of the completion of each 12 month monitoring period.

17.2.4 Post-extraction Reports

Within 20 working days of each anniversary of the commencement of the post-extraction monitoring programme, TTR in consultation with the TRG will prepare and lodge an Annual Post-extraction Report to the EPA that includes as a minimum:

- The monitoring undertaken in the previous 12 month period;
- The monitoring to be undertaken in the next 12 month period;
- Data collected from the monitoring undertaken;
- A summary of any commentary or recommendations from the TRG and where necessary, an explanation as to why any TRG recommendation has not been accepted; and
- A summary report of the findings of the monitoring undertaken with conclusions drawn as to the recovery and overall biological health of the extraction area.

Within 60 days of the completion of the post-extraction monitoring programme, TTR following consultation with the TRG, will prepare and lodge an Annual Post-extraction Report to the EPA that includes as a minimum:

- A summary of all of the monitoring undertaken in the previous 48 month period;
- A summary of the findings of the monitoring undertaken with conclusions drawn as to the recovery and overall biological health of the iron sand extraction area; and
- Identification of any commentary or recommendations from the TRG and where necessary, an explanation as to why any TRG recommendations have not been accepted.

17.2.5 Complaints Register

TTR will maintain a permanent register of any complaints received by any person or company about activities authorised by the marine consents.

The register will include:

- Contact details of the complainant;
- Nature of the complaint and the time it was received;
- Location, date and time of the complaint and of the event associated with the complaint;
- The cause or likely cause of the event and any factors, such as weather conditions at time of the complaint (i.e. wind direction and speed, real time forecasting, rain, weather warnings, fog or any other weather related impact on the visibility) that may have influenced severity;

- Outcome of any investigation into the complaint, including the nature and timing of any measures implemented by TTR to remedy or mitigate any adverse effects, if associated with the event;
- Details of any steps taken to prevent the reoccurrence of similar events; and
- Any other relevant information.

This register will be held in the form of a Complaints Log at TTRs head office and made available to the EPA upon request. The log will be updated within 48 hours of any new complaint and will be included as part of the Quarterly Operational Report.

18 REFERENCES

Anderson TJ, MacDiarmid A, Stewart R, 2013. Benthic habitats, macrobenthos and surficial sediments of the nearshore South Taranaki Bight. NIWA Client Report NEL2013-012.

Arendt, K.E.; Dutz, J.; Jonasdottir, S.H., ; Jung-Madsen, S.; Mortensen, J.; Møller E.F.; Nielsen, T.G. (2011) Effects of suspended sediments on copepods feeding in a glacial influenced sub-Arctic fjord. *Journal of Plankton Research* 33: 1526–1537.

Battaerd, W.R. 1983. Zooplankton of the South Taranaki Bight. Report (Maui Development Environmental Study) No. 83-1. ix, 142 ill. 130 cm. p.

Bradford, J. M. 1977. Distribution of the pelagic copepod *Temora turbinata* in New Zealand coastal waters and possible trans-Tasman population continuity. *New Zealand Journal of Marine and Freshwater Research II*: 131-144.

Bradford, J. M. 1978. *Paracalanus indicus* Wolfenden and Corycaeus aucklandicus Kramer, two neritic pelagic copepods from New Zealand. *Journal of the Royal Society of New Zealand* 8: 133-141.

Bradford, J. M. 1980. New Zealand region, zooplankton biomass (0-200 m). New Zealand Oceanographic Institute chart, miscellaneous series 41.

Bradford-Grieve, J.M.; Murdoch, R.C.; Chapman, B.E. 1993. Composition of macrozooplankton assemblages associated with the formation and decay of pulses within an upwelling plume in greater Cook Strait, New Zealand. New Zealand Journal of Marine and Freshwater Research 27: 1-22.

Buckland ST., Anderson DR., Burnham KP., Laake JL. 1993. Distance sampling: estimating abundance of biological populations. London: Chapman and Hall. 446 pp.

Cahoon, L.B., Safi, K.A. 2002. Distribution and biomass of benthic microalgae in Manukau Harbour, New Zealand.
https://www.researchgate.net/publication/233161925_Distribution_and_biomass_of_benthic_microalgae_in_Manukau_Harbour_New_Zealand

Cahoon, L.B., Pinkerton, M.H., Hawes, I. 2015. Effects on primary production of proposed iron-sand mining in the South Taranaki Bight region. Unpublished report for TTR, September 2015.

Davies-Colley, R. J., et al. 1997. Matching natural water colours to Munsell standards. Journal of the American Water Resources Association 33(6): 1351-1361.

Dawson S., Wade P., Slooten E., Barlow J. 2008. Design and field methods for sighting surveys of cetaceans in coastal and riverine habitats. Mammal Review 38:19-49.

Hadfield, M, & Macdonald, H, 2015, "*Sediment Plume Modelling*", NIWA Client Report: WLG2015-22, prepared for Trans-Tasman Resources Ltd, 117p.

Hadfield, M., H. Macdonald. 2015. South Taranaki Bight Iron Sand Extraction Sediment Plume Modelling (2015 revision). NIWA report WLG2015-22 (project TTR15301) for Trans-Tasman Resources Ltd, September 2015.

Hammond PS., Macleod K., Berggren P., Borchers DL., Burt L., Canadas A., Desportes G., Donovan GP., Gilles A., Gillespie D., Gordon J., Hiby L., Kuklik I., Leaper R., Lehnert K., Leopold M., Lovell P., Oien N., Paxton CGM., Ridoux V., Rogan E., Samarra F., Scheidat M., Sequeira M., Siebert U., Skov H., Swift R., Tasker M., Teilmann J., Van Canneyt O., Vazquez JA. 2013. Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation* 164:107-122.
Hartill, B, 2015, "*Evaluation of Web Camera Based Monitoring of Levels of Recreational Fishing Effort in FMA1*", New Zealand Fisheries Assessment Report 2015/22, 16p.

James M, 2016, Trans-Tasman Resources Ltd Consent Application: Ecological Assessments, Aquatic Environmental Sciences Client Report prepared for Trans-Tasman Resources Ltd.

James MR; Wilkinson VH, 1988, Biomass, carbon ingestion, and ammonia excretion by zooplankton associated with an upwelling plume in western Cook Strait, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 1988, Vol. 22: 249-257.

Joint Witness Statement. 2014. Joint Statement of Experts in the field of effects on marine mammals including noise, Report to the EPA in relation to the TTR Marine Consent Hearing. 26 March 2014.

Källqvist, EMLA, 2009, "*Who is Catching What? – A Survey of Recreational Fishing Effort and Success on Taiapure and Mataitai Management Areas*", a thesis presented in partial fulfilment for the degree of Master of Science in Environmental Science at the University of Canterbury, Christchurch, New Zealand.

MacDiarmid, A, Anderson, O, & Sturman, J, 2013, "*South Taranaki Bight Fish and Fisheries"*, NIWA Client Report No: WLG2012-13, prepared for Trans-Tasman Resources Ltd, 70p.

MacDiarmid, A., Gall, M., Robinson, K., Steward, R., Fenwick, M. 2015. Zooplankton communities and surface water quality in the South Taranaki Bight February 2015. NIWA client report No: WLG2015-25 prepared for Trans-Tasman Resources Ltd.

MacDiarmid, A.; Anderson, O.; Sturman, J. 2013. South Taranaki Bight fish and fisheries. NIWA Client Report: WLG2012-13 prepared for Trans-Tasman Resources Ltd.

MacDonald, I, Budd, R, Bremner, D, & Edhouse, S, 2012, "*South Taranaki Bight Iron Sand Mining: Oceanographic Measurements Data Report"*, NIWA Client Report: HAM2012-147, prepared for Trans-Tasman Resources Ltd, 106p.

Pinkerton, M., Gall, M. 2015. Optical effects of proposed iron-sand mining in the South Taranaki Bight region. NIWA report number WLG2015-26 prepared for Trans-Tasman Resources Ltd.

RG&A, 2013, "*Trans-Tasman Resources Ltd Sea Bed Mining, South Taranaki – Recreation and Tourism Assessment of Effects",* prepared for Trans-Tasman Resources Ltd. 43p.

Taranaki Regional Council, 2004. Inventory of coastal areas of local or regional significance in the Taranaki Region.

Thomas LT., Buckland ST., Rexstad EA., Laake JL., Strindberg S., Hedley SL., Bishop JRB., Marques TA., Burnham KP. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47: 5-14.

Torres, LG., Gill, PC., Graham, B., Steel, D., Hamner, RM., Baker, S., Constantine, R., Escobar-Flores, P., Sutton, P., Bury, S., Bott, N., Pinkerton, M. 2015. Population, habitat and prey characteristics of blue whales foraging in the South Taranaki Bight, New Zealand. SC/66a/SH6, International Whaling Commission.

Wilber, D. H.; Clarke, D. G. (2001). Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. *North American Journal of Fisheries Management* 21:855-875.

Appendix 5.8: Draft Seabirds Effects Mitigation and Management Plan

SOUTH TARANAKI BIGHT OFFSHORE IRON SAND EXTRACTION AND PROCESSING PROJECT

SEABIRD EFFECTS MITIGATION AND MANAGEMENT PLAN

DRAFT – WITHOUT PREDJUDICE – FOR CONSULTATION PURPOSES ONLY

April 2025

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1 INTRODUCTION

A number of management actions will be adopted to minimise any potential adverse impacts (such as bird strike) on seabirds during the TTR iron sand extraction activities and/or to assist with quantifying the impacts of lighting on seabirds. The development of this mitigation and management plan is critical to the fulfilment of these conditions.

The purpose of this plan is to:

- Ensure there are no adverse effects on 'Threatened' or 'At Risk' seabird species[1]; and
- Ensure that adverse effects (from lighting, spills, elevated levels of sediment in the water column etc.) on all other seabird species are avoided to the extent practicable.

The plan sets out to address the following key objectives:

- To mitigate and where possible avoid adverse effects on seabirds from vessel lighting;
- To establish thresholds of adverse effects for threatened seabirds;
- To identify Environmental Management Measures that will be implemented when thresholds are reached; and
- To monitor bird strike and manage extraction activities to reduce bird strike incidence.

The following sections have been drafted in line with these objectives and relate to all vessels participating in the project at all locations (i.e. not only within the Project Area).

This plan outlines mitigation measures which will be implemented and will be used as a basis for compliance monitoring. It is important to note that the legislative requirements for health and safety of all crew members, as required by domestic legislation and international convention, shall take precedence should there be any identified discrepancies.

2 MITIGATION MEASURES

Artificial nocturnal lighting from any of the TTR project vessels (the Integrated Mining Vessel, IMV; the Floating Storage and Offloading Vessel, FSO; and other support vessels) could affect seabirds and increase the risk of bird strike in the South Taranaki Bight (STB). The following mitigation measures will be implemented to minimise or avoid any potential adverse effects from vessel lighting:

- **Design Features**: The design features listed below will be incorporated into new vessels (e.g. the IMV) during construction and will be retro-fitted to other vessels as possible:
  - Deck lights will be mounted in such a way to allow lighting to be directionally adjustable;
  - Deck lights will be individually circuited to allow individual lights to be turned off when not needed;
  - A shielding feature will be incorporated into individual deck light design to allow peripheral light emissions (horizontal and vertical) to be controlled;
  - Deck lighting will be mounted as low as possible to minimise the illuminated area;
  - Non-reflective paints will be used to minimise reflected light;
  - External vertical wires and vertical structures will be minimised as far as practicable;
  - The number of portholes and light bollards will be minimised; and
  - Black-out blinds or curtains will be installed on all portholes and windows.

[1] Threatened species include those listed as 'Critically Endangered', 'Endangered' or 'Vulnerable' by the IUCN Red List (IUCN, 2012) or those listed as 'Nationally Critical', 'Nationally Endangered', 'Nationally Vulnerable' or 'Nationally Increasing' by the New Zealand Threat Classification System (Robertson *et al.*, 2021).

- **Operational Practices**: The following operational practices will also be adopted:
  - Deck light use will be limited to the minimum required for safe navigation and operation of vessels;
  - Deck lights will be directed downwards onto work areas and shielded to reduce peripheral light emissions;
  - Where possible deck lights will be directed away from reflective surfaces;
  - Search lights will only be used in emergencies;
  - The lowest possible wattage of lights will be selected (without compromising safety)
  - The use of interior lights will be minimised as practicable by switching off unnecessary lighting and the possible use of timers in some areas;
  - Blinds or curtains will be kept drawn on all portholes and windows at night;
  - Decks will be kept as free from clutter as possible to reduce the entanglement and entrapment potential for seabirds that do become involved in a bird strike incident;
  - Hydrocarbon products (fuel oil, lube oil, hydraulic oil etc) will be securely stowed and a prompt clean-up will occur in the event of any spill onto the deck of any vessel;
  - A Spill Contingency Management Plan will be developed to promote the effective and rapid clean-up of any spills; and
  - Lighting inspections will be included as part of the operational audit requirements, and periodic reviews of on-board lighting behaviour on the IMV will be undertaken.

No specific mitigation actions are proposed to manage the potential effects of the sediment plume on seabirds as these effects are considered to be negligible on account of the mobility and wide foraging range of sea bird populations in the STB. Any bird strike casualties will however be responded to in accordance with the procedure outlined in **Section 3**.

3 BIRD STRIKE RESPONSE

The procedure outlined in **Figure *1*** will be followed during every bird strike incident. This procedure differentiates between live bird response and dead bird response.

It is important to note that the DOC must be notified immediately in the event that a seabird is killed, injured or oiled as a result of iron sand extraction activities.
It is important to note that some injured seabirds may not be releasable on account of the severity of their injuries and hydrocarbon residues can be problematic for seabirds as oiling will deem them unsuitable for immediate release.

The safe handling of seabirds is important to ensure the safety of the seabird casualty and of attending personnel. The following safe handling precautions should be followed:

- Wear gloves and eye protection when handling seabirds;
- Hold seabirds at waist level to avoid eye injuries;
- Take care not to damage or contaminate seabirds whilst handling;
- Be gentle but firm when handling seabirds;
- Promptly transfer captured seabirds to a lined[2] collection box; and
- Wash hands after handling seabirds.

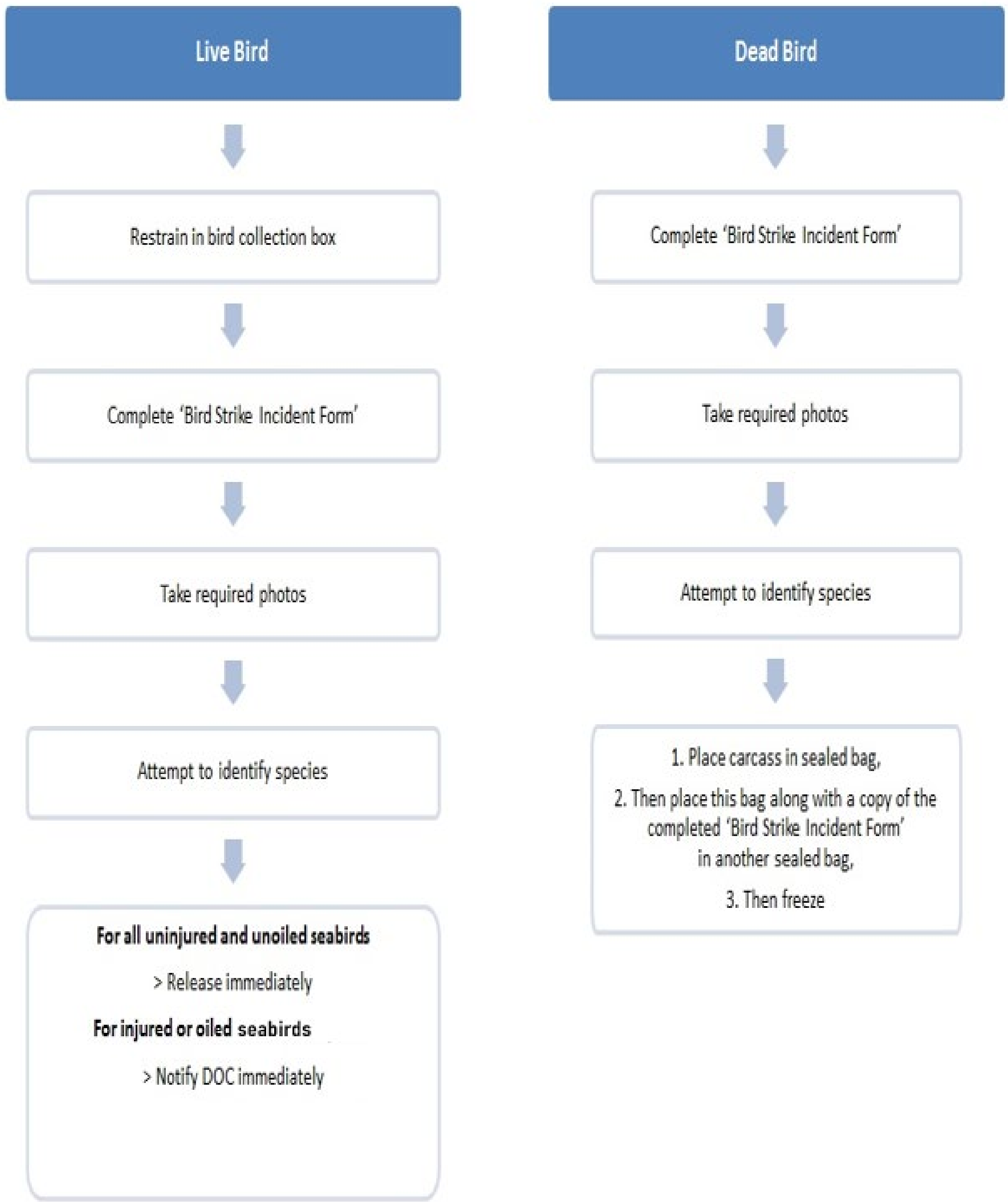
A 'Bird Strike Response Kit' will be available on-board the IMV for the purpose of bird strike response. This kit will contain the following items as a minimum:

- Seabird collection boxes (flat-pack corflute construction);
- Paper towels;

[2] Collection box should be lined with paper towels

- Gloves and safety glasses;
- Dead bird bags and cable ties of various sizes; and
- Bird Strike Incident Forms.

Figure 1: Bird strike response procedure



4 THRESHOLDS FOR ADVERSE EFFECTS ON SEABIRD SPECIES

Bird strike incidents resulting in injury or death will immediately become a cause for concern, at both an individual level but potentially also at a population level. Concerns would be elevated in significance relative to the number of individual birds impacted by either recurrent bird strike incidents or bird strike incidents involving multiple individuals. On account of this, TTR commits to work with DOC to develop Environmental Management Measures to eliminate or minimise adverse effects on seabirds. Threat classifications from both the New Zealand Threat Classification System (NZTCS) as defined by Townsend *et al*. (2008) and Rolfe et al. (2022), and the IUCN Threat Classification System (www.redlist.org) will be used to guide and develop thresholds, which when reached will prompt the implementation of Environmental Management Measures. It is likely that any proposed thresholds be based on the cumulative number of individuals affected from any one species over a defined time period. Where 'affected' means <u>any</u> bird strike regardless of the severity of injury (i.e. birds that are apparently unharmed and released will also contribute to the cumulative total).

In addition to the development of these thresholds, TTR will work with DOC to develop appropriate management responses to be implemented once the threshold level is reached.

5 MONITORING AND RECORD KEEPING

5.1 Bird Strike

Bird strike data will be critical to characterise seabird interactions through time. In order to maximise the value of these data, the following information must be collected for each bird strike event:

- Date and time;
- Weather conditions;
- Close up digital photographs of:
  - the whole bird;
  - the head from the side;
  - the head from the front; and
  - the dorsal and ventral surfaces of the wing.
- Whether the bird is released alive or is dead;
- Notes on any care provided to the bird (including euthanasia on DOC's recommendation);
- Species and threat status (both NZTCS and IUCN); and
- Cumulative totals of those species affected by bird strike through time.

A standardised datasheet will be used to record all bird strike events (the 'Bird Strike Incident Form') and data will be collated into a centralised electronic database from which summary reports will be compiled and cumulative totals will be instantaneously calculated with each new record. Annual summary reports will be provided to the Environmental Protection Authority (EPA), DOC and the Technical Review Group (TRG). In particular, the TRG will review seabird mortality every year for the first three years of operation (in accordance with a recommendation from the Joint Witness Statement, 2014).

5.2 Incidental observations

Incidental observations of seabirds have value with regards to distribution analyses and can contribute to defining the limits of a population's range. In line with this, TTR will maintain a list of all seabirds observed from the IMV, updating it as new sightings occur. This list should include the current threat status (NZTCS and IUCN) of each identified species and annual updates should be provided to the EPA, DOC and the TRG.

6 REDUCING OIL SPILL RISKS

The likelihood of unplanned oil spills and their associated risks to seabirds can only be minimised through effective management and operational controls to prevent a spill occurring. On this basis ship-to-ship fuel transfers will be undertaken in accordance with industry best practice and a comprehensive Spill Contingency Management Plan is to be prepared in consultation with Maritime New Zealand. Response protocol for any seabird that becomes oiled is provided in **Section 3.**

7 TRAINING

All employees and contractors will be made aware of the bird strike response and record keeping obligations during inductions. During inductions employees will also be advised of the light reduction policies as outlined in **Section 2**.

Select personnel will be designated to maintain the Bird Strike Response Kit and to maintain and add to the list of incidental seabird sightings. These personnel will receive additional training in bird handling, species identification and data management. It is proposed that these personnel also oversee the periodic consignment of frozen bird strike casualties to DOC.

8 PLAN REVIEW

This is a draft plan that will be revised once the final IMV design has been completed. This plan will be approved by DOC at least three months prior to the commencement of TTR's iron sand extraction activities, and a copy will be lodged with the EPA within this same timeframe. Specific lighting procedures will also be prepared closer to iron sand extraction activities commencing in order to support the mitigations outlined in this plan.

9 REFERENCES

IUCN. 2012. IUCN Red List Categories and Criteria: Version 3.1. Second Edition. Gland, Switzerland and Cambridge, UK. 32 pp.

Joint Witness Statement. 2014. Joint Statement of Experts in the field of effects on seabirds. Prepared in association with the TTR Marine Consent Hearing. 20 March 2014.

Rolfe, J., Hitchmough, R., Michel, P., Makan, T., Cooper, J.A., de Lange, P.J., Townsend, A.J., Miskelly, C.M., Molloy, J. (2022). "New Zealand Threat Classification System manual 2022, Part 1: assessments". Department of Conservation, Wellington.

Robertson, HA., Baird, KA., Elliott, GP., Hitchmough, RA., McArthur, NJ., Makan, TD., Miskelly, CM., O'Donnell, CFJ., Sagar, PM., Scofield, RP., Taylor, GA., Michel, P. 2021. "Conservation status of birds in Aotearoa New Zealand, 2021". New Zealand Threat Classification Series 36. Department of Conservation, Wellington, New Zealand.

Townsend, AJ. de Lange, PJ., Duffy, CAJ., Miskelly, CM., Molloy, J., Norton, DA. 2008. "*New Zealand Threat Classification System Manual*". Science and Technical Publishing, Department of Conservation, Wellington, New Zealand. 35pp.

Appendix 5.9: Draft Marine Mammal Management Plan

SOUTH TARANAKI BIGHT OFFSHORE IRON SAND EXTRACTION AND PROCESSING PROJECT

MARINE MAMMAL MANAGEMENT PLAN

DRAFT

April 2025

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1 INTRODUCTION

A number of environmental management actions will be adopted to minimise the potential impacts on marine mammals during the TTR iron sand extraction activities or to assist with quantifying the impacts on marine mammals. This Marine Mammal Management Plan (MMMP) summarises the management actions that relate to marine mammals, by addressing the following key objectives:

- To develop procedures and protocols to minimise the potential risks to marine mammals from the operations;
- To develop a training framework relating to marine mammal operational responses; and
- To develop strategies to support compliance with environmental management measures, consent conditions and relevant legislation (in particular the Marine Mammals Protection Act 1978 and Marine Mammals Protection Regulations 1992[1]).

These objectives serve to fulfil the purpose of this Marine Mammal Management Plan which is to:

- Ensure there are no adverse effects as a result of the activities authorised by TTR's marine consent on:
  - Blue whales;
  - Marine mammal species classified under the New Zealand Threat Classification System[2] as "Nationally Critical", "Nationally Endangered" or "Nationally Vulnerable"; and

- Ensure that adverse effects on marine mammals (other than those included above) are avoided to the greatest extent practicable: where adverse effects include effects arising from noise, collision and entanglement, spills, sediment in the water column etc.

Full details of the MMMP are specified in the Conditions document including Condition 66 with further details provided in Conditions 10 a-k, 11, 36, 47, 54, 66 and 88. Additional details relevant to marine mammals are also included in the Impact Assessment including Sections 6.4 (Pre-commencement Environmental Monitoring Plan) and 6.5 (Environmental Monitoring and Management Plan).

Condition 66 specifies the content and implementation of the MMMP including:

- *The Consent Holder must prepare a Marine Mammal Management Plan ("MMMP") following consultation with the Department of Conservation and the KRG (if it has been formed), which must, as a minimum, set out:*
  - *How compliance with Condition 10 will be achieved; and*
  - *Procedures and protocols to minimise the risk of marine mammal entanglement; and*
  - *Set out indicators of adverse effects on marine mammals that utilise the South Taranaki Bight listed in Condition 10.a.; and*
  - *A framework relating to marine mammal operational responses; and*
  - *Integrate any obligations under the Marine Mammals Protection Act 1978 and Marine Mammals Protection Regulations 1992, or any superseding legislation.*

[1] This Marine Mammal Management Plan should be amended as necessary to any subsequent Regulations that may be enacted at a future date.
[2] Townsend *et al.* 2008

- *The MMMP must be prepared by a suitably qualified and experienced person(s) in general accordance with the draft MMMP dated April 2025, and submitted to the EPA for certification that the requirements of this condition have been met.*
- *The seabed material extraction activities authorised by these consents must not commence until the MMMP has been certified by the EPA.*
- *Any amendments to the MMMP must be submitted to the EPA for certification and may only be implemented following certification from the EPA that the amended MMMP meets the requirements of this condition. Where certification of an amended plan is not received, the Consent Holder must continue to use the plan which was in place prior to the lodgement of the amended plan.*
- *The activities must be undertaken in accordance with the latest certified MMMP, a copy of which must be held on-board each of the Consent Holder's project vessels and at the Consent Holder's head office.*

The following sections provide details of how the project will ensure compliance with Condition 10 a-k, outline procedures and protocols to minimise potential risks to marine mammals, and provide a framework relating to marine mammal operational responses.

2 COMPLIANCE WITH ENVIRONMENTAL MANAGEMENT MEASURES

As noted above, the Conditions define a wide range of mitigation that will be undertaken to minimise potential risks to marine mammals from the operation. This section will review all the agreed mitigation and provide clear definitions for what will be undertaken and how it will be undertaken. It is also noted that there is a Condition (11) related to the monitoring of underwater noise which, although being directly relevant to reducing potential impacts on marine mammals, is not discussed in this plan, but is covered extensively in the EMMP.

2.1 Hector's or Maui dolphins

While Hector's or Maui dolphin are not expected to be found within the operational area, there are some specific conditions relevant to these species. As specified in Condition 10(g), "*Any sightings of Maui or Hector's dolphins are immediately reported to the Department of Conservation*"

There is additional detail relating to any potential incidents with these species. Specifically, Condition 10(k) states that, "*If a strike, entanglement, injury or death involves Maui or Hector's dolphin, and the carcass is recovered, the Department of Conservation and the EPA must be notified immediately of that recovery. The consent holder must ensure the carcass is returned to shore as soon as practicable, but no later than five (5) working days following such event, for collection by the Department of Conservation subject to the Consent Holder's obligations under the Marine Mammals Protection Act 1978 or any subsequent Regulations*".

2.2 Duties under the Marine Mammals Protection Act

Condition 10(e) specifies that, "*All employees and contractors undertaking airborne, seagoing and watch-keeping duties are informed of their obligations under the Marine Mammals Protection Act 1978 and Marine Mammals Protection Regulations 1992 or any subsequent Regulations*".

This would normally be done through inclusion of the required material in the project induction that is undertaken by all appropriate personnel.

2.3 General operational responses

Condition 10(l) states that, "*Any other relevant operational response in relation to marine mammals that has been approved by the EPA is undertaken*".

2.4 Specific mitigation requirements

Conditions 35 and 36 provide clear instructions for how the operation will work with a specific focus on pre-start and soft-start procedures.

2.4.1 Pre-start Observations

Pre-start observations are fundamental to the correct implementation of soft-starts including potential delays to starting. Delayed soft starts are critical to ensure that machinery is not started whilst whales and dolphins are in the immediate vicinity. Pre-start observations and delayed soft starts are designed to allow whales and dolphins to vacate the area before underwater noise levels reach their full operating potential. Actions to ensure compliance with the relevant Conditions include:

- TTR will ensure that sufficient personnel are on-board the IMV as suitably trained observers;
- These suitably trained observers will be trained in accordance with the training requirements outlined in **Sections 5.1 and 8** and will be approved by the EPA in accordance with Section 67(3) of the EEZ Act;
- TTR will ensure that at least two suitably trained observers are on-board the IMV at all times in order to fulfil the requirements with regards to pre-start observations;
- A suitably trained observer will be appointed for each start-up procedure and will be excused from their standard duties whilst the start-up procedure is underway;
- Prior to any start-up procedure the suitably trained observer is to request from the master and/or bridge crew of any mining related support vessel that is in the vicinity of the IMV whether they have observed any recent marine mammal activity within 500 m of the IMV. The master and/or bridge crew are also requested to report to the suitably qualified observer any marine mammal activity they may observed during the start-up procedure. There is no expectation that a dedicated marine mammal watch will be maintained on any support vessel during the start-up procedure;
- During the start-up procedure, the suitably trained observer will be provided with an optimum vantage point on the IMV to ensure they can undertake their pre-start observation duties in an effective manner;
- Prior to each soft-start, a suitably trained observer will conduct at least 30 minutes of pre-start observations solely for the purpose of detecting whales and dolphins;
- Pre-start observations will focus on the 500 m radius (mitigation zone) around the IMV;
- The suitably trained observer will communicate the requirement for soft-start procedures to be delayed if they detect whales or dolphins within the 500 m mitigation zone;
- If a soft-start delay is required due to the presence of a whale or dolphin, the suitably trained observer will ensure that the soft-start is not reinitiated until the mammals are seen to leave the mitigation zone or have not been detected within the mitigation zone for a further 30 minutes from the last sighting.
- If a whale or dolphin is detected once the soft-start has commenced, equipment will be shut-down until the mammals are seen to leave the mitigation zone or have not been detected within the mitigation zone for a further 30 minutes from the last sighting.
- Shutdowns for whales and dolphins are not required once the soft start is complete and iron sand extraction activities are underway;

- Soft starts will only commence in daylight hours, during good sighting conditions (visibility to at least 500 m), and when at least 30 minutes of observations by a suitably trained observer indicate that it is safe to commence.
- The suitably trained observer will complete a ‘Start-up Summary Datasheet’ for each pre-start observation period. This datasheet will identify all required delays to soft-starts; and
- The suitably trained observer will complete a ‘Pre-start Observation Datasheet’ for each whale or dolphin sighting made during pre-start observations and soft starts.

2.4.2 Soft Start Protocols

The use of ‘soft starts’ during start-up procedure will be implemented and will serve to minimise the potential negative effects of underwater noise in the STB.

Soft starts involve a gradual increase in power over a minimum of 20 minutes whenever iron sand extraction activities commence or recommence after a break (e.g. when the IMV is relocated between mining blocks, or following the cessation of iron sand extraction activities for inclement weather or management actions etc.). The proposed start-up procedure is outlined in **Table 1.**

Table 1 Summary of start-up procedures

Commence **only** in daylight hours & good sighting conditions (visibility > 500 m)	
Stage 1	Suitably trained observer to commence pre-start observations (30 minutes + any necessary delays)
Stage 2	Stage one of soft start to commence (5 minutes)
Stage 3	Stage two of soft start to commence (5 minutes)
Stage 4	Stage three of soft start to commence (5 minutes)
Stage 5	Stage four of soft start to commence (5 minutes)
Stage 6	Full iron sand extraction activities to commence

3 REPORTING OF WHALE AND DOLPHIN SIGHTINGS

Condition 10(f) specifies that, “*All employees and contractors must record any sightings of marine mammals (except seals) including the date, time and, where possible, GPS position of the vessel. All records must be contained in an Observation Log and be made available to EPA and/or Department of Conservation staff upon request and Annual Report required by Condition 104*”

Condition 10(j) specifies that, “*Any marine mammal strikes, entanglements, injuries or deaths are reported to the Department of Conservation and the EPA as soon as practicable, but no later than five (5) working days, following any such event*”

Incidental observations of whales and dolphins are a valuable addition to the data that will be collected during the more formal marine mammal monitoring programme. Accordingly, high priority is placed on the reporting of such sightings and all employees and contractors will be required to report any incidental sightings of whales or dolphins either:

- Immediately for Hector's/Maui's dolphins (to the Department of Conservation)[3], or
- At the earliest possible convenience for all other whale and dolphin sightings.

TTR has developed a 'Marine Mammal Sighting Form' to facilitate the collection of incidental sightings data (Annex 1). All personnel will be made aware of these reporting requirements during the induction process (see Section 8).

These reporting requirements apply to personnel stationed on the IMV and personnel stationed on support vessels and helicopters. Incidental sightings will not only be collected from within the Project Area, but throughout the South Taranaki Bight (STB).

4 REDUCING THE RISK OF WHALE ENTANGLEMENTS

It is well recognised that mooring lines at sea can represent a potential entanglement risk to marine mammals. In relation to the TTR iron sand extraction activities, mooring lines may be used in association with support vessels and environmental monitoring equipment. Historically, marine mammal entanglements around New Zealand are typically associated with unattended fishing gear. The entanglement of humpback whales in lobster pot mooring lines (Pierre et al. 2022) does however provide evidence to suggest that lines do pose some risk to marine mammals; as do float lines between anchors and marker buoys. However, this risk is typically only associated with structures that are moored using light floating lines to a buoy at the surface and can be appropriately reduced though the use of thick, high tension mooring lines (Boehlert et al., 2007).

On this basis the following procedures will be adopted to minimise the entanglement risk to whales:

- Where possible, mooring systems that do not include a full-time line to a surface buoy will be used (e.g. use pop-up buoys with acoustic release technology or galvanic timed release mechanisms).
- If the use of a surface buoy is unavoidable:
    - Keep the line between the equipment and the buoy vertical and taut;
    - Minimise the extent of line that could be floating at the surface by avoiding excessive slack (i.e. adjust line to a length appropriate to the depth and sea conditions; and take up excess slack by coiling and tying off close to the buoy);
    - Use heavy gauge lines that are in good working condition;
    - Where possible avoid surface moorings in clusters;
    - Regularly check surface moorings to maintain tension;
- Retrieve any deployed equipment promptly when no longer required;
- Clearly mark all buoys; and
- Report entanglements to DOC as soon as practicable, as rapid reporting increases the chance of success of disentanglement.

In addition to the benefits to whales from these procedures, these procedures will also reduce the risk of loss of moored gear that an entanglement incident would pose to valuable environmental monitoring equipment and associated data.

In the event that a whale entanglement occurs and the whale remains trapped or dragging gear, DOC should be contacted immediately as they have specialists in whale disentanglement that may be able to respond. Note that the process of whale disentanglement is extremely dangerous and has led to the accidental death of responders in the past. On this basis, disentanglement of whales should not be attempted without prior communications with DOC.

[3] Condition 10(g)

5 MARINE MAMMAL INTERACTIONS WITH VESSELS

5.1 Marine Mammal Observers

Condition 10(c) specifies that "*At all times during the operational activities authorised by these consents, at least one (1) dedicated and trained marine mammal observer is on-board each of the operational vessels, but not including bulk carriers. While the vessel is in motion, the observer must be in a position where a clear field of vision is provided over the forward section of the vessel and beyond the bow*".

Condition 26 specifies that "*For the purpose of this condition, any observer engaged by the Consent Holder must be a trained or qualified observer as defined in the 2013 Department of Conservation Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (or any subsequent updated Code of Conduct*".

The key roles of the MMO will be to ensure that all required mitigation is undertaken with respect to marine mammals. Key elements of the role will include:

- Undertake visual observations for marine mammals around operational vessels at all times[4];
- Undertake pre-start observations (including ensuring that the 500 m mitigation zone is clear of marine mammals prior to starting) and ensure that soft-start protocols are implemented[5];
- Record, document and report any sightings of marine mammals around operational vessels including any incidents or accidents[6].

MMOs will coordinate and undertake marine mammal observations and required mitigation in association with vessel masters with the vessel master being the ultimate decision maker.

5.2 Camera surveillance

Condition 10(d) specifies that all operational vessels (i.e. the IMV and the Floating Storage and Offloading (FSO) vessels) will be equipped with a video camera to record footage of any contact with marine mammals while these vessels are operational. The camera will be placed in a prominent position with a clear field of vision over the forward section of each vessel, beyond the bow and to the sides of the bow. The camera must be recording at all times that the vessel is in motion. The purpose of the cameras is to record passage of the vessels and any contact with marine mammals while in motion.

A live feed of the camera footage will be available on the bridge of each operational vessel. Following each period of passage for each vessel, the footage will be reviewed by the MMO and any marine mammal interactions will be identified. Interaction details will be recorded onto a Marine Mammal Sighting Form and any identified incidences of 'ship strike' (collision between the vessel and a marine mammal) will be reported to DOC immediately. Ship strike footage will also be provided to DOC as soon as practicable.

[4] Condition 10(c)
[5] Condition 35 and 36
[6] Condition 36

Part of the role of the MMOs on the vessel will be to ensure that the camera is well looked after, has an unobstructed view and is serviced regularly to replace batteries and memory cards. Vessel Masters are responsible for ensuring that these cameras have an appropriate field of view, are recording when required (i.e., when vessels are in motion which is defined in Condition 10 as operational vessels that are moving under the power of their own engines and travelling at a speed greater than 5 knots) and that all video footage is downloaded and forwarded to the EPA and/or Department of Conservation staff.

5.3 Vessel behaviour around large cetaceans

Condition 10(h) specifies that, "*Masters of all vessels are instructed to reduce speed to a 'no wake speed' of no greater than 5 knots within 300 m of any large cetaceans and feeding aggregations of blue whales, and take all necessary steps to avoid contact with the animals and, where practicable, maintaining a distance of at least 300 m from the animal/s*".

This requirement is broadly consistent with requirements under the Marine Mammal Protection Act 1978 and Marine Mammals Protection Regulations 1992.

5.4 Helicopter operations

Condition 10(i) specifies that, "*Helicopters servicing the operation (subject to compliance with Safety and Civil Aviation Authority requirements) maintain a minimum altitude of 600 m (2,000 feet) except when landing and taking off*"

Flying at a minimum height of 600 m will ensure that any possible impacts of helicopter overflight of marine mammals will be minimised or eliminated.

6 REDUCING OIL SPILL RISKS

The likelihood of unplanned oil spills and their associated risks to marine mammals can only be minimised through effective management and operational controls to prevent a spill occurring. On this basis ship-to-ship fuel transfers will be undertaken in accordance with industry best practice and a comprehensive Spill Contingency Management Plan is to be prepared in consultation with Maritime New Zealand.

7 DATA MANAGEMENT AND REVIEW

The following actions will be implemented with regards to the management and review of marine mammal data:

- A standardised datasheet (the 'Marine Mammal Sighting Form') will be used to record incidental marine mammal sightings (**Annex 1**);
- Standardised datasheets (the 'Start-up Summary Datasheet' and the Pre-Start Observation Datasheet') will be used to record systematic marine mammal observations during start-up procedures (**Annex 2**);
- Incidental marine mammal sighting data and systematic marine mammal observation data will be collated into a centralised electronic database (the 'Marine Mammal Observation Log') from which the marine mammal section of the Annual Report will be compiled;
- The Annual Report will be provided to the Environmental Protection Authority (EPA), DOC and the Technical Review Group (TRG);

- The EPA and will be provided with a summary of pre-start observations (including delayed soft-starts) and any other marine mammal management responses as part of the Quarterly Mining Report and the Annual Report;
- In the event that collated data identifies areas of concern with regards to possible adverse effects or increased risks, then consideration of additional mitigations and/or a review of monitoring techniques will be undertaken by the TRG; and
- All record keeping and data entry will be kept up to date to ensure that data can be provided to the EPA at any time should they request it.

8 TRAINING OF PERSONNEL

Training with regards to marine mammal requirements will be provided to all employees and contractors, and a record of all training will be kept. It is acknowledged that some personnel will have increased responsibility for specific management actions; hence a proposed training framework is outlined below based on operational roles.

8.1 All personnel

All employees and contractors will receive basic training during the induction process to ensure they are aware of relevant environmental obligations (as stated in consent conditions, the Environmental Monitoring and Management Plan and relevant legislation). With regards to marine mammals these obligations are:

- The mandatory reporting (as soon as practicable) to DOC and the EPA of any ship-strike, entanglement, injury or death of a marine mammal (under s16(2) of the Marine Mammals Protection Act 1978);
- The immediate reporting of Hectors/Maui's dolphin sightings to DOC;
- The recording (as soon as practicable) of all incidental whale and dolphin sightings onto a 'Marine Mammal Sighting Form'. Note that sightings of seals need not be recorded; and
- Acceptable behaviour of vessels and aircraft around marine mammals (Part 3 of the Marine Mammal Protection Regulations 1992).

A package of material will be provided during inductions and will include a marine mammal species identification guide. Training in the identification of marine mammal species is important to ensure all marine mammal observation records are accurate and relevant. Training in the identification of Maui's/Hector's dolphins, will be paramount on account of the urgency of passing these sightings on.

8.2 Vessel masters, watch-keepers and marine mammal observers

An advanced training package and programme will be developed for vessel masters, watch keepers and marine mammal observers to ensure compliance with legislation and consent conditions while operational vessels are underway and to increase the accuracy of species identification and behavioural assessments.

It is critical that vessel masters in particular, understand fully their obligations with regards to vessel behaviour around marine mammals. As such, they will be required to demonstrate a thorough knowledge of:

- Their obligations under Part 3 of the Marine Mammal Protection Regulations 1992;

- Their obligation under consent conditions to reduce speed to a safe minimum within 500 m of any large cetaceans and feeding aggregations of blue whales, and take all necessary actions to avoid contact with the animals by detouring around and, where practicable, maintaining a distance of at least 500 m from the animal/s;
- Where relevant, their obligation under consent conditions to have a designated marine mammal observer watching for and recording marine mammal interactions while the IMV and FSO are underway;
- Their obligation to immediately report Hector's/Maui's dolphin sightings or incidents (ship strikes, entanglements, injuries or deaths) to DOC;
- Their obligation to record all incidental whale and dolphin sightings as soon as practicable onto a Marine Mammal Sighting Form;
- Their obligations under s16(2) of the Marine Mammals Protection Act 1978 and under consent conditions with regards to the notification to DOC and the EPA as soon as practicable of any marine mammal ship-strikes, entanglements, injuries or deaths; and
- Their obligations under consent conditions relating to the recovery of the carcass of a Maui's or Hector's dolphin following any accidental death (e.g. via ship-strike, entanglement etc.). Where possible the carcass will be recovered and returned to shore for collection by DOC.

8.3 Helicopter Pilots

Helicopter pilots will be fully briefed during induction on their obligations under Part 3 of the Marine Mammal Protection Regulations 1992.

In addition to these obligations, TTR has committed to ensure that helicopters servicing the operation shall (subject to compliance with safety and Civil Aviation Authority requirements) maintain to a minimum altitude of 600 meters (2,000 feet) except when landing and taking off. This requirement is over and above the standard legislative requirements.

In addition to the specific requirements above, helicopter pilots will also be trained in their obligations relating to:

- Immediately reporting Hector's/Maui's dolphin sightings to DOC; and
- Recording all incidental whale and dolphin sightings as soon as practicable onto a Marine Mammal Sighting Form.

8.4 Suitably Trained Observers

Personnel will be identified to receive additional specific training with regards to compliance associated with start-up procedures. Training will include the requisite skills to ensure that TTR is operating in accordance with consent conditions that require personnel to be suitably trained to undertake these observations and implement an appropriate management response in line with the environmental management measure described in **Section 2**.

This training package will cover the following topics as a minimum:

- The relevant Environmental Management Measure;
- Completion of 'Pre-start Observation Datasheets' and 'Start-up Summary Datasheets';
- Communications protocols;
- Measuring distance at sea;
- Equipment requirements;
- Advanced species identification; and
- Advanced behavioural assessments.

8.5 Environmental monitoring teams

During the induction of environmental monitoring teams, training will be given in accordance with the 'Procedure to Minimise Whale Entanglement' as provided in **Section 4.**

In addition to this, monitoring teams will also be trained in their obligations relating to:

- Immediately reporting Hector's/Maui's dolphin sightings to DOC; and
- Recording all incidental whale and dolphin sightings as soon as practicable onto a Marine Mammal Sighting Form.

9 COMPLIANCE WITH LEGISLATION

One of the objectives of this MMMP is to develop strategies to support compliance with the Marine Mammals Protection Act 1978 (**MMPA**) and the Marine Mammals Protection Regulations 1992 (**MMPR**). The obligations and requirements outlined in the legislation have been adopted throughout this plan; however a summary is provided in **Table 2** to demonstrate how compliance will be ensured.

Table 2 Legislative obligations relating to marine mammals

Legislative obligations	How addressed
MMPA s4(1)(b) No person shall take any marine mammal without a permit; where take means to catch, kill, injure, attract, poison, tranquilise, herd, harass, disturb or possess	No intentional 'take' of marine mammals shall occur during the project. The development of this Management Plan serves to reduce the potential for death, injury and disturbance to marine mammals
MMPA s 16(2) & (3) Any person who by any means accidentally or incidentally kills or injures any marine mammal shall report the event as soon as practicable. Every report shall include a) the location where the event took place; b) the species (if known) or a general description of the animal; and c) a description of conditions and the circumstances of the event.	Section 4 of this Management Plan requires that whale entanglements are reported to DOC as soon as practicable. Section 5 of this Management Plan requires that ship strikes are reported to DOC as soon as practicable. The requirement for all marine mammal sightings to be reported to DOC on the 'Marine Mammal Sightings Form' ensures all appropriate information is collected. Section 8.1 of this Management Plan requires all personnel to be trained in this legislative obligation.
MMPR Part 3 (s18, 19 & 20) Sets out requirements with regards to acceptable behavior around marine mammals. Specific behaviors are outlined for persons, vessels, aircraft or vehicles. Part 3 of the MMPR is provided in Annex 3.	Section 8 of this Management Plan sets out the training requirements to address these legislative obligations. In particular Section 8.1 requires that all personnel are trained to ensure they are aware of the acceptable behaviour of vessels and aircraft around marine mammals (in accordance with s18, 19 & 20). In addition to this general awareness:

	> Section 8.2 requires vessel masters, watch keepers and MMOs to receive detailed training on these legislative requirements. Their obligations under consent conditions (to reduce speed to a safe minimum within 500 m of any large cetaceans and feeding aggregations of blue whales, and take all necessary actions to avoid contact with the animals by detouring around and, where practicable, maintaining a distance of at least 500 m from the animal/s) will also be covered during this training; and > Section 8.3 requires helicopter pilots to be fully briefed on their obligations under Part 3 of the Marine Mammal Protection Regulations 1992. Section 5 of this MMMP also sets out the requirement for the mandatory watch-keeping of MMOs while the operational vessels are in motion. This will provide another mechanism to ensure compliance with Part 3 of the MMPR as MMO's will detect any marine mammals in the path of the vessel and alert the master to their presence so that avoidance measures can be taken where possible and if required.

10 REFERENCES

DOC, 2015. "Sighting and Stranding database excerpt". Department of Conservation, Wellington.

Boehlert, GW., McMurray, GR., Tortorici, CE. 2007. "Ecological Effects of Wave Energy Development in the Pacific Northwest". A Scientific Workshop October 11 – 12, 2007. NOAA Technical Memorandum NMFS F/SPO-92

Pierre J, How j, Dunn A. 2022. Whale entanglements with New Zealand pot fisheries: characterisation and opportunities for management. Final Report to the Department of Conservation, Conservation Services Programme Project MIT2021-02. Available at https://www.doc.govt.nz/globalassets/documents/conservation/marine-and-coastal/marine-conservation-services/reports/202122-annual-plan/mit2021-02-cetacean-interactions-with-pot-fisheries-final-report-redacted.pdf

Townsend, AJ., de Lange, PJ., Duffy, CAJ., Miskelly, CM., Molloy, J., Norton, DA. 2008. New Zealand Threat Classification System Manual. Science and Technical Publishing, Department of Conservation, Wellington, New Zealand.

ANNEX 1 MARINE MAMMAL SIGHTING FORM

This form will be utilised to collect data from all incidental marine mammal sightings. The following fields will be included on the datasheet (amended from DOC marine mammal sighting form):

- Report type (Ship-strike or Entanglement or Sighting);
- Observers name;
- Company;
- Vessel/Helicopter ID;
- Email;
- Date & time of sighting;
- Location description;
- GPS position of the vessel (Lat/Long) (preferable);
- Map ref (NZMS260, Topo50, other) (alternative);
- Distance from shore;
- Sighting from boat or aircraft;
- Water depth;
- Sea condition (Beaufort scale);
- Swell (none/light 0-1 m) (moderate (1-2 m) (heavy > 2 m);
- Photos/video taken;
- Animal type (hector's/Maui's) (other dolphin) (beaked whale) (toothed whale) (baleen whale) (seal);
  NB. An alert will be associated with the Hector's/Maui's check box to prompt the person recording the sighting to notify DOC immediately;
- Species ID: name (definite/probable/unsure);
- Number of animals (total);
- Number of juveniles (if present);
- Description of animal (colour, dorsal fine, blow shape);
- Total length of animals (adult m) (juvenile m);
- Description of behaviour; and
- A thorough description of any injuries, mortality, entanglement or other interactions. NB an alert will be associated with this data field to prompt the observer to notify DOC immediately.

On the reverse of the report form pictures of species likely to be seen in STB will be included.

ANNEX 2 DATASHEETS FOR PRE-START OBSERVATIONS

There are two datasheets that are associated with systematic pre-start observations and that should be completed by the suitably trained observers undertaking these duties. The fields to be included on these datasheets are listed below:

Start-up Summary Datasheet
- Date;
- At start of watch – time, lat/long, vis, BSS;
- At end of watch – time, lat/long, vis, BSS;
- Total duration of watch;
- Total number of sighting events;
- Sighting IDs (from Pre-Start Observation Datasheets); and
- Number of soft starts (start time, end time, any delays, related to what ID).

Pre-Start Observation Datasheet
- Sighting ID;
- Date & Time;
- Name of suitably trained observer;
- Location of IMV, Lat/Long;
- Species (name and confidence) or description of appearance;
- Number of adults, Number of calves, Total number of animals
- Length of adults/juveniles;
- First detected by (suitably trained observer, vessel master, crew etc.);
- BSS, Visibility, Swell height;
- Distance from IMV at first sighting;
- Closest subsequent distance to IMV;
- Delayed soft start required (yes/no, time);
- Behaviour at first sighting (travelling, feeding, milling etc.);
- Subsequent behaviours (avoidance, attraction and other changes in behaviour); and
- A thorough description of any Injuries, mortality, entanglement or other interactions.

ANNEX 3 Part 3 of the Marine Mammal Protection Regulations 1992

Section 18:
Any person coming into contact with a marine mammal shall comply with the following conditions:

(a) persons shall use their best endeavours to operate vessels, vehicles, and aircraft so as not to disrupt the normal movement or behaviour of any marine mammal:
(b) contact with any marine mammal shall be abandoned at any stage if it becomes or shows signs of becoming disturbed or alarmed:
(c) no person shall cause any marine mammal to be separated from a group of marine mammals or cause any members of such a group to be scattered:
(d) no rubbish or food shall be thrown near or around any marine mammal:
(e) no sudden or repeated change in the speed or direction of any vessel or aircraft shall be made except in the case of an emergency:
(f) where a vessel stops to enable the passengers to watch any marine mammal, the engines shall be either placed in neutral or be switched off within a minute of the vessel stopping:
(g) no aircraft engaged in a commercial aircraft operation shall be flown below 150 metres (500 feet) above sea level, unless taking off or landing:
(h) when operating at an altitude of less than 600 metres (2 000 feet) above sea level, no aircraft shall be closer than 150 metres (500 feet) horizontally from a point directly above any marine mammal or such lesser or greater distance as may be approved by the Director-General, by notice in the Gazette, from time to time based on the best available scientific evidence:
(i) no person shall disturb or harass any marine mammal:
(j) vehicles must remain above the mean high water spring tide mark and shall not approach within 50 metres of a marine mammal unless in an official carpark or on a public or private slipway or on a public road:
(k) no person, vehicle, or vessel shall cut off the path of a marine mammal or prevent a marine mammal from leaving the vicinity of any person, vehicle, or vessel:
(l) subject to paragraph (m), the master of any vessel less than 300 metres from any marine mammal shall use his or her best endeavours to move the vessel at a constant slow speed no faster than the slowest marine mammal in the vicinity, or at idle or “no wake” speed:
(m) vessels departing from the vicinity of any marine mammal shall proceed slowly at idle or “no wake” speed until the vessel is at least 300 metres from the nearest marine mammal, except that, in the case of dolphins, vessels may exceed idle or “no wake” speed in order to outdistance the dolphins but must increase speed gradually, and shall not exceed 10 knots within 300 metres of any dolphin:
(n) pilots of aircraft engaged in a commercial aircraft operation shall use their best endeavours to operate the aircraft in such a manner that, without compromising safety, the aircraft's shadow is not imposed directly on any marine mammal.

Section 19:
Every person coming into contact with whales shall also comply with the following conditions:

(a) no person in the water shall be less than 100 metres from a whale, unless authorised by the Director-General:
(b) no vessel shall approach within 50 metres of a whale, unless authorised by the Director-General:
(c) if a whale approaches a vessel, the master of the vessel shall, wherever practicable, (i)manoeuvre the vessel so as to keep out of the path of the whale; and (ii)maintain a minimum distance of 50 metres from the whale:
(d) no vessel or aircraft shall approach within 300 metres (1 000 feet) of any whale for the purpose of enabling passengers to watch the whale, if the number of vessels or aircraft, or both, already positioned to enable passengers to watch that whale is 3 or more:

(e) where 2 or more vessels or aircraft approach an unaccompanied whale, the masters concerned shall co-ordinate their approach and manoeuvres, and the pilots concerned shall co-ordinate their approach and manoeuvres:
(f) no person or vessel shall approach within 200 metres of any female baleen or sperm whale that is accompanied by a calf or calves:
(g) a vessel shall approach a whale from a direction that is parallel to the whale and slightly to the rear of the whale:
(h) no person shall make any loud or disturbing noise near whales:
(i) where a sperm whale abruptly changes its orientation or starts to make short dives of between 1 and 5 minutes duration without showing its tail flukes, all persons, vessels, and aircraft shall forthwith abandon contact with the whale.

<u>Section 20:</u>
Any person coming into contact with dolphins or seals shall also comply with the following conditions:
(a) no vessel shall proceed through a pod of dolphins:
(b) persons may swim with dolphins and seals but not with juvenile dolphins or a pod of dolphins that includes juvenile dolphins:
(c) commercial operators may use an airhorn to call swimmers back to the boat or to the shore:
(d) except as provided in paragraph (c), no person shall make any loud or disturbing noise near dolphins or seals:
(e) no vessel or aircraft shall approach within 300 metres (1 000 feet) of any pod of dolphins or herd of seals for the purpose of enabling passengers to watch the dolphins or seals, if the number of vessels or aircraft, or both, already positioned to enable passengers to watch that pod or herd is 3 or more:
(f) where 2 or more vessels or aircraft approach an unaccompanied dolphin or seal, the masters concerned shall co-ordinate their approach and manoeuvres, and the pilots concerned shall co-ordinate their approach and manoeuvres:
(g) a vessel shall approach a dolphin from a direction that is parallel to the dolphin and slightly to the rear of the dolphin.

Appendix 5.10: TTR – Sand Mining – Patea Matauranga Maori and Customary Fisheries Analysis Te Tai Hauauru Fish Forum

TTR - Sand Mining - Patea
Matauranga Maori and Customary fisheries Analysis
Te Tai Hauauru Fish Fourm

TANENUIARANGI MANAWATU INC.
2016

KARAKIA
MATUA TE PO, MATUA TE AO
MAI TE POUPOUTANGA A TANE-NUI-A-RANGI
KA PUTA A NGARU NUNUI, A NGARU ROROA
KI TE WHAI AO, KI TE AO MARAMA

Absolute night to the absolute day
The pillars of Tane-Nui-a-Rangi came forth whom went to the heavens
Bringing the great waves, the long waves
Into the world of discovery, the world of enlightenment

MIHI WHAKATAU
Tihei mauri ora
Kōriporipo ana te aroha ki te iwi kua riro ki te pō. Ka waiho mai muri ko ngā waihotanga ake e kai nei i te hinapōuri i te āo i te pō. Moe mai koutou i te moe tē whakaarahia, okioki atu rā.
Mai Parininihi ki te Kāhui Maunga, te Kāhui Maunga ki Ruahine pae maunga, Ruahine whakawhiti atu ki Tararua ka heke iho ki Whakarongotai nei rā ngā iwi o te Tai Hauāuru te mihi kau ake.
He rautaki tēnei e whakatakoto ana i ngā whainga a ngā iwi o Te Tai Hauāuru mō ngā tau e rima. Koia nei te huarahi hei whakatutuki atu ai i te kōrero:
He kupenga haonui
He iwi ka ora
E te iwi e, purutia tō mana, kia mau kia ita! Ita! Ita! Mau tonu!

This report is compiled by Tanenuiarangi Manawatu Inc on behalf of the Te Tai Hauauru Fish Forum. The contributors to this report are Dr. J. Procter, M. Takarangi, B. Potaka, S. Tamarapa, G. Huywler, C. Shenton, R. Warrington, and P. Horton.

Contents

1. Introduction

Trans-Tasman Resources (TTR) is undertaking a process to develop a sand mining operation off the Patea coastline. Through their assessments TTR indicated a number of potential impacts to the Taranaki Bight Coastline. The coastline that may be affected has a number of significant cultural values to Iwi that have inhabited the area for the past 1000 years. It has been agreed that the current approach to identify the impacts to through conventional western science is not compatible to accurately articulating the matauranga Maori that exist within the Iwi in regards to their use and connections of the potentially effected coastline.

This investigation attempts to bridge the gap between western science and matauranga Maori by better articulating the indigenous knowledge and presenting that information to TTR to be used as a basis for future monitoring plans.

The investigation involved contacting the relevant Iwi that have mana moana/mana whenua connections to the coastline and determine a process whereby their cultural information could be shared through tangata tiaki to discuss the potential impacts of the activity.

2. Consultation Framework

The Te Taihauauru Fisheries Forum (TTHFF) was established through the development of the Fisheries Management Area 8 (FMA 8) and in response to the Treaty of Waitangi Fisheries Settlement and the Maori Fisheries Act (2004). The TTHFF role is to essentially provide a mechanism for Iwi to engage with each other and the Ministry of Primary Industry in regards to commercial and customary fisheries issues. The forum consists of Te Rūnanga o Ngāti Tama, Te Rūnanga o Ngāti Mutunga, Te Ātiawa Settlements Trust, Taranaki Iwi Trust, Nga Hapū o Ngāruahine Incorporated, Te Rūnanga o Ngāti Ruanui Trust, Te Kaahui o Rauru (Ngā Rauru), Te Rūnanga o Ngāti Apa (North Island), Te Ātihaunui a Pāpārangi, Ati Awa ki Whakarongotai Charitable Trust, Muaupoko Tribal Authority Inc, Raukawa ki te Tonga Trust/Te Rūnanga o Raukawa, Te Patiki Holdings Trust Board (Ngāti Hauiti), Tanenuiarangi Manawatu Incorporated (Rangitaane o Manawatu). In 2012 the TTHFF produced a Fisheries Plan to progress their aspirations in regards to fisheries.

It is important to note that TTR has during 2013-2014 already applied to the Environmental Protection Agency (EPA) to seek permission to mine iron sands in the Exclusive Economic Zone (EEZ) and was not award consent to do so. The application had a number of failings surrounding the uncertainty of the impacts of the application with regard to the environment and marine ecosystem.

Trans-Tasman Resources in their earlier application prepared an Impact Assessment and through chapter 9 of that assessment provided a description of iwi potentially effected and attempted to analyse those effects. As stated in chapter 7 the analysis was a desktop study that relied heavily on data gathered from Treaty of Waitangi Settlements. Also within chapter 7, table 24 is an outline of the consultation process undertaken by TTR.

It became clear through the consultation process that the TTHFF required a differing approach to consultation, an approach that allowed for the better understanding and sharing of scientific data, knowledge/matauranga and the ability to make fully informed decisions and possibly suitable recommendations for future activity. It has also been agreed that the Te Taihauauru Fisheries Forum (TTHFF) is the representative organisation that will act as the conduit for this cultural analysis of customary fisheries information. This has implications for in conditions related to the activity and future mining operations.

TTR has also again re-engaged TTHFF to undertake further cultural analysis of their activity in a manner that was more consistent with Maori decision making principles and understanding of the marine environment particularly articulating the values tangata whenua hold towards the affected area.

3. The TTHFF Analysis

TTR and TTHFF have agreed that there is a distinct gap between the scientific understanding of the environment and Maori values and understanding of the same environment. The western-based scientific and environmental impact study will seek to determine individual effects in isolation of the environment as a whole whereas from a Maori perspective the interactions, relationships (and balance) of individual constituents can be more important to comprehend. Once these factors are better understood then a collective iwi decision can be made or the activity can be better mitigated in the future.

While this concept is relatively well established, simply developing techniques as a tool to gather information for an impact assessment on the (Te Tai Hauauru) environment may not work unless the underlying consultation framework is based on the unique cultural values of the individual Iwi who are mana whenua or mana moana.

Recognising that there is a gap between western science and matauranga Maori, collective iwi within Te Tai Hauāuru have attempted to bridge this gap. The Iwi understand that they cannot solve this problem within the scope of this activity, however by undertaking a process based on a Kaupapa Maori approach to collectively presenting their cultural values, better articulate their concerns, ask the related relevant questions and then explore the current knowledge base of

TTR, we can provide a more robust platform to share information and, in the future, make informed decisions.

This approach has involved wananga and hui with tangata tiaki and iwi-based Maori scientists to compile iwi concerns. The iwi have examined the new scientific analyses provided by TTR to assess if the issues from iwi have been captured. Gaps within existing data or other concerns are then to be presented to TTR to form recommendations and pathways for involvement in the monitoring of the activity in the future and enhance the iwi role of Kaitiaki or Tangata Tiaki with in the affected area.

3.1. The Project and Phases to Date

TTR and TTHFF have agreed on a program of work to best articulate and capture TTHFF interests and values in the marine area that is potentially to be affected. A detail of the work program is captured in appendix 1. The project to date has followed the stages briefly identified below.

1) Establish tikanga processes and protocols with the TTHFF,
2) Identify and collect, through wananga, hui and hikoi, matauranga Maori-based concerns and questions that can be used as a basis for analysing current impact assessments,
3) Present those significant customary interests identified in a series of map and through GIS.

3.2. TTR New Analyses of Effects

TTHFF recognises that TTR has undertaken a significant amount of new work on understanding the impacts associated with their proposed activity. Their approach has been to remove uncertainties associated with modelling the effects of their proposed activity or operations. The modelling has to date focussed on simulating the plume created from the extraction of the sands from the seabed. The strategy to remove the uncertainties associated with plume modelling has focussed on the optimisation of the model through better constraining the input parameters. This is the same model that has been consistently applied both in the previous EPA application and for the analysis associated with the new EPA application. TTHFF also note that the basis for much of the environmental re-analysis is built on the results of the new plume modelling. We also recognise that with respect to the new report on the effects of marine species that the further information provided has focussed on the potential impacts of individual species. It is TTHFF's opinion that this ecological analysis only highlights the paucity of data and information on the impacts on the physiology of those species examined.

While TTHFF accept that new results have been produced that show vary levels of impacts based on various statistical properties or the results, TTHFF is still of the opinion that there is a potential effect on the marine environment and a parallel potential effect on those customary values Maori have to that environment based on their indigenous knowledge. It must be noted that the new reports produced on the environmental impacts of the proposed activity is based on western science and not indigenous knowledge that may have a more intimate and different perspective on those environments and species impacted.

It is also recognised by TTHFF that TTR has also tried to alleviate some concerns of iwi and Maori by showing TTHFF representatives, first hand, similar operations presently occurring in the Atlantic Ocean off the coast of Namibia and South Africa. The operator in that case is De Beers Marine (pty) Ltd. (DBM) who has been undertaking sea floor extraction of sediments for over 20 years. TTR has stated that De Beers Marine will be responsible for the operational activities of TTR. This allows TTR to access DBM's technology and matured operational practises yet in doing this; TTR will also have to adhere to DBM operational policies and environmental practice guidelines which have been outline to TTHFF representatives.

4. TTHFF Position Statement

TTHFF has agreed to work with TTR to better articulate and present iwi concerns with regard to customary fisheries. In agreeing to do this the TTHFF has through hui agreed to state the TTHFF does not attempt to provide a comprehensive account of all individual iwi history, whakapapa, connections and tikanga practices within the marine environment. Instead, what we are presenting is an analysis of those customary (tangata whenua) interests in the coastline through providing sites of significance to customary species or fishing practices.

This analysis is not to provide support or oppose the application but to share knowledge with the applicant on those aspects of the marine environment that are important to iwi from a customary fishing activity. The knowledge shared through this report is seen as being equal to any other data or research conducted for the TTR application and should from a basis for both TTR and TTFHH to develop management and monitoring programs together in partnership and fully recognise kaitiakitanga.

It is not the forum's role to provide a response as mana whena/moana or comment on the suitability of the project. Each individual iwi has the right to comment on the proposed activity and application as it see fit. The TTHFF also recognises that those iwi closest (spatially) to the proposed activity has the mana to comment on the activity and where possible the TTHFF will support their decisions on the activity. However, the TTHF would be remiss in its role if it did not focus on protecting those customary fishing interests in FMA 8 that it has been tasked to do.

Another important principle that TTHFF recognises is rangatiratanga over the Marine environment and with respect to that TTHFF has not been drawn into an analysis or debate on the role of the Treat of Waitangi or the legislative recognition and interpretation of cultural values with respect to decision-making. Both parties have recognised their respective interests in the Marine environment and chosen to work in partnership to best respect each other's interests.

5. TTHFF Fish Plan 2012 – 2017

The Te Tai Hauauru Fish Plan (2012 – 2017) is a Ministry for Primary Industries, (MPI) recognised iwi management plan that should be taken into account by any activity proposing to occur in the FMA 8 fisheries area.

The plan has high-level goals of;

"Use Outcome
Fisheries resources are used in a manner that provides greatest overall economic, social and cultural benefit.

Environmental Outcome
"Mai i te kāhui maunga ki Tangaroa" – the capacity and integrity of the aquatic environment, habitats and species are sustained at levels that provide for current and future use.

Management Outcome
Iwi are working collectively within a sound and transparent framework to address fisheries matters of common concern. "

It is important to stress that Kaitiakitanga is paramount in this plan and the ability to ensure;

"Iwi fishers use traditional and contemporary mātauranga in iwi management strategies, and

The role of kaitiaki, whānau and iwi to responsibly manage fisheries is well understood and upheld.

The health of known habitats of significance are protected, monitored regularly and stable or improving.

Mātauranga Māori contributes to decision-making about fisheries and their habitats.

Iwi are able to utilise our tikanga in the management of our fisheries."

This plan identifies the key principles iwi have towards managing customary fisheries and also the key mechanism to ensure that customary fishing rights are enduring. Any management or monitoring regime to be adopted by any future activity should mirror or be consistent with this plan.

The Te Tai Hauauru Fish Plan (2012 – 2017) succinctly describes the following key concepts of kaitiakitanga and customary fishing interests:

Kaitiakitanga

"Kaitiakitanga is a broad concept that has important cultural and spiritual dimensions. Kaitiakitanga ensures sustainability of resources, in a physical, spiritual, economic and political sense. This authority to protect a resource stems from the broader viewpoint of whakapapa, the linkages back to atua effectively delegating responsibility (and obligations) to Maori for the protection of all things. In a more localised sense, kaitiakitanga is an exercise of obligation, mana, of prestige, of those groups who claim close ties to the region.

In terms of fisheries, the role of kaitiaki allows for Maori communities to have availability to an abundance of kai from both the freshwater and saltwater environments. The kaitiaki role is one that is locally defined and managed, commonly at a hapu level. It is not a position of ownership but an individual and collective role to safeguard 'nga taonga tuku iho' (those treasures that have been passed down) for the present and future generations.

In safeguarding these taonga, Maori fishing practices have been refined over hundreds of years to create a balance between use and the health of our aquatic environment. Refinement of our fishing practices occurs through wananga where we transfer our matauranga to the next generation who are able to continue with fulfilling our obligations and responsibilities to Tangaroa.

Without kaitiakitanga informing our decisions, our cultural identity and traditions become lost in modern society. Kaitiakitanga is based on matauranga. Our matauranga is founded on a holistic perspective; we are part of our environment. Our environment nurtures our mauri, and our mana remains powerful.

Maori customary rights to fisheries are many and varied. They contain both commercial and non-commercial elements that are managed at different levels within the iwi. Non-commercial customary fishing is controlled at the iwi, hapu or whānau level, while the responsibility for managing our rights to commercial fishing rests with our mandated iwi organisations and asset holding companies. We consider it will be to all our benefit for iwi, hapu and whanau to work together to manage our common fishing interests.
In this section, the forum details how Maori interests are currently represented, what the key concerns are and how concerns common to all iwi will be

addressed through the forum. The goal of finding a fair equilibrium between conservation of our resources and the different uses we make from them is paramount to our management approach.

Important species

Some iwi identify important species as “taonga”. Others may describe their important species differently – for example, as “those fish that you can catch”. However we describe such species, they are important to us for various reasons. For instance some may have primary significance because of our long association and use so that they form an integral part of our traditional cultural practices. Tuna, toheroa/tohemana, paua, piharau and kahawai are examples. Others may be important because of the income they generate for our people. Hoki and other deepwater stocks are examples. Yet others may have significance in both respects, such as rock lobster and snapper.

Some iwi have reached Treaty settlements with the Crown that identify important species (see below). Others have yet to finalise their Treaty settlements. In achieving the objectives of this plan, it will be important to identify those species that require management attention and to be clear about why. Therefore rather than provide an exhaustive list of every species found in Te Taihauauru and its significance to iwi, we intend to identify those species that are priorities for management action through on-going dialogue with each other and with relevant agencies, including through the annual review process with the Ministry for Primary Industries (MPI).

Non-commercial customary fishing

Fish are an important traditional food source for many iwi, hapu and whanau for whom special and enduring relationships to the sea exist, and places of customary food gathering importance still have relevance today.
Customary Use and Value Traditionally (pre-European settlement), the ocean and rocky Taranaki coastline provided an abundant supply of fish. Fish were caught, using hooks, nets, spears and traps. No activity was undertaken without due ritual.

Knowledge was closely guarded and taught in confidence. The traditional approach by tangata whenua is to use lunar cycles (maramataka) and seasonal queues (tohu) to assess availability of fish. Certain species had greater value, where value and use might relate to medicinal properties (rongoa), protein content (mouri) and spiritual importance (wairua). It is through educating and reacquainting our people with customary fishing and the importance of tikanga and kaitiakitanga can be better realised at the local level.”

6. Review of Past Submissions

The Te Tai Hauauru Fisheries Forum considers there to be some value in reviewing the past submissions (table, 1) from Maori organisation, groups and Iwi from the previous application. The purpose of reviewing the past submissions is to gain context and possibly further insights into the aspects of the coastal marine area that are valued by Maori and tangata whenua. There is also an opportunity to uncover further related customary fishing information that may be of relevance to this analysis. In reviewing these submissions it is important to focus only on those issues raised related to matauranga Maori and customary fishing. Similarly, while a number of submitters were Maori the focus of this report has been on the iwi/hapu or organisations that manage or protect customary interest.

Table 1. List of previous submissions reviewed.

SUBMISSION105529.xml	Hooper_to_Hutton	Hounuku		Hounuku	Sandy Aperehama Tawera	decline
SUBMISSION108984.xml	K_to_King	Kanihi-Umutahi and Ngaruahine Iwi	Kanihi-Umutahi and Ngaruahine Iwi	Noble	Tihi Anne Daisy	decline
SUBMISSION109060.xml	Maak_to_Marryatt_M	Mai Uenuku Kite Whenua	Mai Uenuku Kite Whenua	Huirama	David	decline
SUBMISSION107451.xml	Newman_to_NZSFC	Nga Hapu o te Uru o Tainui Customary Fisheries	Nga Hapu o te Uru o Tainui Customary Fisheries	Katipa	Joanna	decline
SUBMISSION108111.xml	Newman_to_NZSFC	Nga Marae o Nga Rauru Kiitahi	Nga Marae o Nga Rauru Kiitahi	Broughton	Anne-Marie	decline
SUBMISSION108624.xml	Newman_to_NZSFC	Ngati HauaWhanui Incoporated	Ngati HauaWhanui Incoporated	Adamson	Karl	decline
SUBMISSION108169.xml	Te_Tai_to_Titchener	Tanenuiarangi Manawatu Inc on behalf of Te Tai Hau-a-uru Fisheries Forum	Tanenuiarangi Manawatu Inc on behalf of Te Tai Hau-a-uru Fisheries Forum	Potaka	Ben	other
SUBMISSION104648.xml	Taana_to_Te_Rure	Te Ngaru Roa a Maui	Te Ngaru Roa a Maui	hamilton	malibu	decline
SUBMISSION109206.xml	Te_Ohu_Kaimoana_Trustee_Ltd	Te Ohu Kaimoana Trustee Ltd	Te Ohu Kaimoana Trustee Ltd	Woods	Kirsty	Grant_cond
SUBMISSION106952.xml	Taana_to_Te_Rure	Te Runanga o Ngati Apa	Te Runanga o Ngati Apa	Huwyler	Grant	decline
SUBMISSION108983.xml	Te_Tai_to_Titchener	Te Runanga o Ngati Ruanui Trust	Te Runanga o Ngati Ruanui Trust	Ngarewa-Packer	Debbie	decline

Hounuku

Sandy Aperehama Tawera
Oppose

The submitter has connections to iwi/hapu from the Raglan area. The submission is general in its nature and opposes the activity based on a number of questions and concerns over the operation of the activity. The main thrust of the submission is focussed on the lack of consultation that in turn fails to recognise kaitiakitanga.

With respect to matauranga Maori and taiao (environment) the submission identifies the potential to impact marine mammals. Details around the customary use or connection of those species to tangata whenua or mana moana are lacking. Specificity around the location of these species is also missing. General comments surrounding the impacts of the morphology of the current coastline are raised.

Kanihi-Umutahi and Ngaruahine Iwi

Tihi Anne Daisy Noble
Oppose

This submission is on behalf of the Ngaruahine Iwi and details their cultural, traditional and historical connections to the coast. The submission identifies the key cultural principles that Ngaruahine are guided by.

Ngaruahine identify as a concern the impacts on crustaceans and plankton. There are concerns on the impact of the primary production within the coastal area and the flow on effect that might have. There is also a concern of the possibility of the contamination of the food chain through the accumulation of metals that may be released in the mining. There is also concern with impacts on the morphology of the coastline particularly Hawera and Ohawe Beach.

The submitter does identify the North and South traps as ecologically important spawning and fishing areas for Ngaruahine.

Customary Fishing Site Identified – North and South Traps

Mai Uenuku Kite Whenua

David Huirama
Oppose

The submitter is concerned with impacts to the Raglan area. This submission is general in nature and highlights the potential breach of the Treaty of Waitangi yet does not elaborate on that breach. There is some concern that the activity may prohibit iwi from defining and managing customary fishing areas in accordance with Maori Fisheries legislation.

There are general concerns for the impacts on the environment. No specific sites or species are identified.

Nga Hapu o te Uru o Tainui Customary Fisheries

Joanna Katipa
Oppose

The submission is general in nature and opposes the activity based on a number of questions and concerns over the operation of the activity. The main thrust of the submission is focussed on the lack of consultation that inturn fails to recognise kaitiakitanga. The submission also makes mention of coastal morphology impacts and marine mammals.

No specific customary sites are mentioned or identified.

Nga Marae o Nga Rauru Kitahi

Anne-Marie Broughton
Oppose

The submission is focused on impacts on their culture. Nga Rauru considers that the activity will affect their customary rights to the coastal and marine area and will affect those customary species that were traditionally used as sustenance and as a resource.

The submission while brief does highlight a number of key species and sites. The key species are Inanga (whitebait), Pirahau (lamprey), Tuna (eel) and other traditional kai moana and notably seabirds. There are concerns around the impacts on primary production in the marine environment. Concerns over the the morphology of the coastline were also raised.

The submission also specifically identified the North and South traps as significant customary fishing grounds and is concerned with sediment plumes impacting those areas.

Customary Fishing Site Identified – North and South Traps

Ngati Haua Whanui Incoporated

Karl Adamson
Oppose

A brief submission that identifies impacts on reefs.

Te Runanga o Ngati Apa

Grant Huwyler
Oppose

The submission is focused on protecting their rights in their Ministry of Primary Industries (MPI) recognised customary fisheries area. General concerns were raised in regards to the impacts from the sediment plume and contamination from that plume. The submitter identified that iwi should have had more time to review the scientific information presented.

No specific sites or species were mentioned in the submission except their MPI recognised customary fishing area.

Te Runanga o Ngati Ruanui Trust

Debbie Packer
Oppose

The submission from Ngati Ruanui is very comprehensive and identifies some key cultural principles and practises that should be applied for ongoing management. The submission also highlights some Ngati Ruanui and indigenous rights that should be examined in future applications.

It is important to note that while specific sites (other than the North & South Traps, in foot notes) were not identified the submitter did make reference to taonga species that should be examined, specifically Pipi, Kina, Kuku, and Paua. The submitter does make reference to the importance of reefs in their customary area and succinctly states,

"These reefs are described as being responsible for some of the best fishing in Taranaki containing abundant food species such as corals, bryozoans, sponges, crustacea, mollusca and polycheates. These organisms are an intricate part of the marine ecosystem and draw the demersal fish such as snapper, blue cod, terakihi and gurnard near to shore." (Packer, 2014: p4, footnote 11)

Concerns were raised over the tubeworm that will be affected in the extraction zone and what flow on effects may occur in the marine ecosystem.

It is important to note that a number of times reference was made to matauranga Maori and other values that should be incorporated into ongoing monitoring and management of the operation and associated activities.

Customary Fishing Site Identified – North and South Traps

Te Ohu Kai Moana

Kirsty Woods
Conditional Support

The submission from Te Ohu Kai Moana does provide an accurate presentation of both Maori commercial and customary interests in the marine environment.

The background information outlines legislative processes that TTR should be aware of in the future management of their proposed activity.

This submission is relevant though as it does identify iwi that may be potentially effected and the species of interest to them namely snapper, hoki, rig, eel, surf clams and jack mackerel. The submission also identifies the requirement of MPI/Te Ohu Kai Moana to establish pataka kai or traditional storehouses that make customary fish available to iwi for cultural purposes.

Te Runanga o Ngati Ruanui Trust

Evidence

Graham Young

This evidence was heavily directed towards the consultation and engagement processes undertaken prior to the application. While concerns with this process are valid and highlight the need for a more robust engagement process in the future, no specific customary or species data was presented. The evidence also did not highlight any areas that would be affected or affected in a manner to impinge on customary rights.

Shi-Han Ngarewa

The evidence presented on behalf of Ngati Ruanui focussed heavily on issues of consultation and jurisdiction to operate in the Exclusive Economic Zone (EEZ) with regard to kaitiakitanga.

The submission presented concerns over the operation and potential effects from the activity. The concerns in the submission were general in nature only two specific areas were identified those being the North & South Traps and the Patea River Mouth area. The concerns with those sites were the loss of customary kaimoana species and the ability to manage and restore those sites under tikanga Maori principles. Other areas that were mentioned were spawning areas yet there was no site-specific information contained in the submission. Eels and marine mammals were specifically mentioned as a species of concern.

Nga Marae o Nga Rauru Kitahi

Evidence

Jacinta Ruru

The evidence presented is very detailed and well argued which focuses primarily on legislative issues and interpretations surrounding the recognition and inclusion of Maori values in the decision-making and possible management of the activity. There are some relevant interpretations that should be considered for future management of the activity and justification for why Maori/iwi should be included in ongoing monitoring and management.

The evidence does elevate Maori values in the sense that they should be given equal weight to other values of considered however with respect to specific sites or species the evidence is deficient in clearly defining iwi customary rights, use and resources that will be effected. The evidence does however conclude that waahi tapu and taonga (species) should be given a high recognition in terms of decision making and monitoring.

7. Nga Kaihautu Tikanga Taiao Report February 2014.

It is worthy to examine the Nga Kaihautu analysis of the activity and reports submitted by TTR.

The report reiterates the submitters concerns. The main concerns identified are;

- The quality of the consultation,
- The recognition of kaitiakitanga and impacts on iwi to be able to undertake that role,
- The lack of recognition of waahi tapu and other culturally significant resources,
- The potential to impact customary fishing and species,
- The long term impacts on iwi connections to the coastal area and the fear that these connections become secondary to other priorities in the coastal area.

The report identified some underlying principles that TTR should consider when preparing applications such as ensuring iwi have enough time to fully participate in the research phases of the application and also have the ability to provide input in the design of management practices developed pre-application. This is to ensure that kaitiakitanga is recognised to its fullest.

Nga Kaihautu did identify that customary fishing was a key aspect of the marine environment that should not be impacted in any way not even if the effects are consider minor. With respect to this species that were considered important for customary fisheries were primarily identified as Crayfish while reference was made to the entire ecosystem and possible contamination of that system from trace metals and their compounds.

Apart from issues surrounding consultation the report considers that TTR should recognise the following and incorporate these concepts into management plans;

- Kaitiakitanga,
- Waahi Tapu/Waahi Tapuna,
- Customary access.

8. Maps of Significant Customary Fishing Sites

Four maps have been created through hui and wananga with key tangata tiaki that outline TTHFF traditional sites and customary interests in the area that is potentially to be impacted by the activity. Data is also contained within a Geographic Information Systems (ESRI, ArcGIS) with respect the WGS84 datum and can be analysed in conjunction with any other environmental dataset.

Te Tai Hauauru Fisheries Forum

Significant Customary Fishing Sites

Figure 1.

Map of named sites of significance related to customary fishing interests for Te Tai Hauauru Fish Forum.

The map and sites have been compiled from hui and wananga of tangata tiaki.

The sites identified are those sites that the tangata tiaki consider are customary fishing sites that are still utilised presently.
The sites range from seafood gathering areas (e.g. shellfish), fishing sites of multiple species, and migration sites to spawning sites through to areas frequented by marine mammals.
The fishing sites cover both areas where single species are recognised and somewhat protected under traditional management regimes through to seasonal fishing areas targeting specific species.

The marine sites are also more indicative of areas where certain species are targeted or recognised as occurring whereas the inshore sites are more indicative of specific shellfish beds, spawning areas and migration pathways of native freshwater species.

0 5 10 20 30 40 Kilometers

Map Compiled for the
Te Tai Hauauru Fish Forum by
J Procter
TMI
PO Box 1341
Palmerston North

Datum WGS84
Data Sources

Linz - http:\\data.linz.govt.nz
LINZ Hydro data 1:90 000
ESRI World Imagery

Legend

Areas of Interest
TTHFF Sites
Depth Contour

1:250,000

Depth m
-4.3 - -4.2
-4.1 - -3.9
-3.8 - -3.2
-3.1 - -2.9
-2.8 - -2.7
-2.6 - -2.5
-2.4 - -2.2
-2.1 - -1.9
-1.8 - -1.6
-1.5 - -0.8
-0.7 - 2.0
2.1 - 10.0
10.1 - 50.0
50.1 - 100.0
100.1 - 300.0
300.1 - 500.0
500.1 - 1000.0
1000.1 - 3000.0
3000.1 - 6000.0
6000.1 - 10000.0

Te Tai Hauauru Fisheries Forum

Significant Customary Fishing Sites

Figure 3.

Map of sites of significance related to customary fishing interests for Te Tai Hauauru Fish Forum. Basic description of activities and the significance of the sites are displayed.

The map and sites have been compiled from hui and wananga of tangata tiaki.

The sites identified are those sites that the tangata tiaki consider are customary fishing sites that are still utilised presently.
The sites range from seafood gathering areas (e.g. shellfish), fishing sites of multiple species, and migration sites to spawning sites through to areas frequented by marine mammals.
The fishing sites cover both areas where single species are recognised and somewhat protected under traditional management regimes through to seasonal fishing areas targeting specific species.

The marine sites are also more indicative of areas where certain species are targeted or recognised as occurring whereas the inshore sites are more indicative of specific shellfish beds, spawning areas and migration pathways of native freshwater species.

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10.1 - 50.0
50.1 - 100.0
100.1 - 300.0
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500.1 - 1000.0
1000.1 - 3000.0
3000.1 - 6000.0
6000.1 - 10000.0

Te Tai Hauauru Fisheries Forum

Significant Customary Fishing Sites

Figure 2.

Map of sites of significance related to customary fishing interests for Te Tai Hauauru Fish Forum. The types or classification of the sites are displayed.

The map and sites have been compiled from hui and wananga of tangata tiaki.

The sites identified are those sites that the tangata tiaki consider are customary fishing sites that are still utilised presently.
The sites range from seafood gathering areas (e.g. shellfish), fishing sites of multiple species, and migration sites to spawning sites through to areas frequented by marine mammals.
The fishing sites cover both areas where single species are recognised and somewhat protected under traditional management regimes through to seasonal fishing areas targeting specific species.

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Areas of Interest
TTHFF Sites
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3000.1 - 6000.0
6000.1 - 10000.0

Te Tai Hauauru Fisheries Forum

Significant Customary Fishing Sites

Figure 4.

Map of sites of significance ans species related to customary fishing interests for Te Tai Hauauru Fish Forum.

The map and sites have been compiled from hui and wananga of tangata tiaki.

The sites identified are those sites that the tangata tiaki consider are customary fishing sites that are still utilised presently.
The sites range from seafood gathering areas (e.g. shellfish), fishing sites of multiple species, and migration sites to spawning sites through to areas frequented by marine mammals.
The fishing sites cover both areas where single species are recognised and somewhat protected under traditional management regimes through to seasonal fishing areas targeting specific species.

The marine sites are also more indicative of areas where certain species are targeted or recognised as occurring whereas the inshore sites are more indicative of specific shellfish beds, spawning areas and migration pathways of native freshwater species.

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10.1 - 50.0
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1000.1 - 3000.0
3000.1 - 6000.0
6000.1 - 10000.0

9. Commentary on Maps and Customary Fisheries Sites of Significance

Through the course of this analysis, 27 sites of significance (table, 2) were identified along with certain cultural attributes about each site. The figures (figs, 1-4) outline the details of each site yet it is important to provide a commentary on the relationship of these sites to sections of coastline.

North Taranaki to Patea

This section of the coastline is not considered to be effected by the TTHFF yet this area does contain significant customary fishing areas that are in contrast to the rest of the Taranaki Bight both from an ecological and cultural perspective. The coastline is a typical rocky reef coastline that has traditionally been used to collect species such as Paua, Crayfish, kina, Kelp and some fish species. From this perspective certain customary sites are considered to be contrasting "control sites" from the rest of the bight in terms of using those sites to assess the bight in a holistic manner.

The most significant site within this portion of the bight is the Patea river mouth that is a gateway for many native migratory (*catadromous*) species (i.e. eel, lamprey etc) for the majority of the eastern Taranaki.

Patea to Waitotara

The Patea coastline has the most ecologically significant customary fishing grounds with those being the North & South Traps and the Rolling Grounds.

North & South Traps

These sites were identified by a number of submitters and iwi as important customary fishing sites and sites of abundant ecological diversity due to the sea floor morphology. The sites are considered by iwi as an area of importance due to the mauri it contains due to its abundant ecological diversity and the contribution it makes to maintain the health of similar surrounding areas.

The Rolling Grounds

The Rolling Grounds are of equivalent significance to the North and South Traps yet are considered to be associated to the sea floor mobile sand dune system that occurs offshore. These sites are seasonal fishing grounds where specific species are targeted at certain times of year. The inter-dune areas or interfluves are considered as important feeding and possibly spawning ground of certain migratory marine fish species (particularly Rig) that inhabit these areas a certain point in their life span.

Table 2. Table of customary sites of significance.

ID	Ingoa	Class	Description	Species	X	Y
0	Ototoka	Te Hi Ika	Mussel Beds	Mussels	174.826334	-39.8665136
1	Kaitoke	Te Hi Ika	Tuna Heke	Eel	175.0299946	-39.9728895
2	Kai Iwi	Te Hi Ika	Spawning Site	Gurnard	174.9649304	-39.93779946
3	Waitototara	Te Hi Ika	Tuna Heke	Eel	174.684135	-39.85047094
4	Waimahora	Awa	Shellfish Gathering	Pipi (Surf Clams), Toheroa, Eel	175.1859463	-40.147629
5	Tawhirihoe	Turanga Waka	Boating site	Kahawai, Snapper, WhiteBait, Eel	175.2239678	-40.30326235
6	Omarungehe	Taupuni	Fish Processing Camp	Kahawai, Snapper, Gurnard, Kingfish, Eel	175.1458495	-40.04931575
7	Urutaukawe	Taupuni	Fish Processing Camp	Kahawai, Snapper, Gurnard, Kingfish, Eel, Hapuka	175.1295498	-40.05265816
8	Herewahine	Taupuni	Fish Processing Camp	Kahawai, Snapper, Gurnard, Kingfish, Sperm Whale	175.111456	-40.05002177
9	Pakauhau	Taupuni	Fish Processing Camp	Kahawai, Snapper, Gurnard, Kingfish, Eel, Shags	175.1199466	-40.05497964
10	Moanaroa	Te Hi Ika	Seafood Gathering Area	Pipi, Tuangi, Tuatua, Toheroa	175.1557371	-40.14927672
11	Waikakahi	Te Hi Ika	Seafood Gathering area	Kahawai, Snapper, Gurnard, Kingfish, Eel	175.1972036	-40.18494937
12	Waipatiki	Takutai	Shellfish Gathering	Pipi, Tuangi, Tuatua, Toheroa	175.2067942	-40.21200843
13	Pukepuke	Te Hi Ika	Fishing Area and Tuna Heke	Eel, Pipi, Whitebait, Kahawai, Snapper	175.2262108	-40.34416142
14	Kaitoke Ngutuawa	Te Hi Ika	Fishing Area	Rig	175.0209154	-39.97805724
15	Mahanga Taitonga (South Traps)	Te Hi Ika	Fishing Area	Snapper Bluecod, Crayfish, Rig, Tarakihi	174.5464322	-39.86682722
16	Patea	Awa	River Mouth Fishing Area	Eel, Kahawai, Whitebait	174.487464	-39.77497602
17	Tuteremoana	Akau	Waahi Tapuna and Reef	Snapper, Gurnard, Rig	174.7940296	-39.91826637
18	Mahanga Tuaraki (North Traps)	Te Hi Ika	Fishing Area	Snapper Bluecod, Crayfish, Rig, Tarakihi	174.5199111	-39.85169633
19	Tahuahua (Rolling Grounds)	Te Hi Ika	Sand Gully Area and Spawning/Feeding Area	Rig, Warehou, Kingfish, Trevally, Gurnard	174.3734312	-39.95800189
20	Tahuahua (Rolling Grounds)	Te Hi Ika	Sand Gully Area and Spawning/Feeding Area	Rig, Snapper, Kingfish, Trevally, Gurnard	174.4979384	-39.89867529
21	Manawapo	Awa	River Mouth Fishing Area	Eel, Kahawai, Whitebait	174.345008	-39.6547077
22	Weira Ara	Ara	Whale Pathway	Whale	174.4429849	-39.92926239
23	Manahi	Akau	Reef	Mussels, Paua, Kina, Crayfish	173.783707	-39.40107838
24	Weira Kowhanga	Kowhanga	Whale Nursery	Whale	174.6234515	-39.88394159
25	Puketapu	Akau	Reef	Mussels, Paua, Kina, Crayfish	173.9352804	-39.52651232
26	Ratana	Takutai	Waahi Tupuna/Important Beach	Pipi, Tuangi, Tuatua, Toheroa	175.0794733	-40.0476947

Waitotara to Kai Iwi

This area is identified as an important whale nursery or feeding area where certain whale species visit at various times of year during their life span.

Kai Iwi to Kaitoke (Whanganui)

This portion of coastline has a number of significant sites whose details around the customary interests are quite specific. The most prominent site would be Tuteremoana, which is a fishing reef and considered by some as a Pa site yet it is clearly a waahi tupuna sites referring to the Kurahaupo ancestor Tuteremoana.

The river mouth sites are significant for similar attributes as other river areas with respect to migratory freshwater species e.g. eel and lamprey. This stretch of coastline is significant for the fact that there is a dramatic change in the geography and morphology of the coastline as it becomes more dominated by a sandy coastline and seabed with species of interest such as Rig, Kahawai and Gurnard.

The ototoka mussel beds were specifically mentioned for not only their mussel resource but also for the fact that iwi have been monitoring and managing that site in accordance with their tikanga to restore this site which has been successful. This is also a present day exemplar for the practise of kaitiakitanga.

Kaitoke, Ratana to Tangimoana

This long and monotonous sandy coastline is in direct contrast to the Taranaki coastline. Similarly, the sites and the connections the iwi who occupy and utilise this area are also very different. The shellfish along this coastline seem to take prominence. It is important to also note that related to the shellfish are the crustaceans and Snapper/Kahawai/Gurnard that are believed by iwi to exist in symbiosis with the shellfish and are hence considered part of an intricate ecosystem that has not been well described by western science. Along this coastline the sand, its movements and the dunes are highly recognised morphological features that play an important part within the culture, history and whakapapa of the iwi. Within these features many fishing camps and fish processing areas were established that formed central points within the iwi social and economic structures.

Marine mammals were recognised as being associated with Ratana and this association is well documented with the recent history of Ratana.

Tangimoana to Manawatu River

This stretch is again similar to the previous coastline but is recognised for more abundant shellfish beds and freshwater fish migrations e.g. whitebait and eel.

South of the Manawatu River

While site in this stretch of the coastline were not mapped it has been suggested that areas directly south of the Manawatu and specifically toheroa beds provide a good control site. It is considered that these toheroa beds are outside of the effected area yet and only impacted by naturally occurring high sediment loads from the Manawatu River. Similarly the Toheroa is also seen from a cultural perspective as separate from the wider marine ecosystem of the Taranaki Bight and more related to terrestrial freshwater systems.

10. Concluding Comments

The Te Tai Hauauru is an important marine ecosystem to Maori and it is the role of TTHFF to protect those customary interests in FMA 8. TTHFF has developed a detailed plan that describes those interests, how to protect those interests and a vision for the future. TTR has already recognised those interests and undertaken a process to better define those significant values in relation to their proposed activity. The values (customary sites and species) identified in this analysis should form the basis for both TTR and TTHFF to work in partnership to develop appropriate monitoring plans, acceptable limits of change within the marine environment resulting from the activity and plans to mitigate any possible future impacts.

TTR has already previously applied for permission under the Exclusive Economic Zone (and Continental Shelf) Act 2012 (EEZ Act) through EPA to undertake mining activities to extract iron ore from sea floor sands. This application was dismissed due to uncertainties surrounding defining environmental impacts. TTR has undertaken considerably greater amount of work and research to remove those uncertainties particularly through optimising existing models to determine the sediment plume (Hadfield and MacDonald, 2015) and through conducting further examination of impacts on marine species MacDiarmid et al., 2015).

The new research and model has been optimised to show more accurate potential impacts in the marine environment however TTHFF are still of the opinion that there will be an impact. While TTHFF understands that the modelling shows, what could be considered as minor impacts TTHFF has not yet from a matuaranga Maori perspective considered whether the impact is minor or not. There is still very little data on the impacts of species from sediment or on the migratory paths of those species. TTR should within its adaptive management plan allow for a period of frequent reviews and adjustments to that plan in the earlier stages of the activity to ensure TTHFF has enough knowledge to be comfortable with the ongoing management of the activity and more conclusively decide that the impacts are minor in nature.

Ruckstuhl et al. (2013) provides a good overview of the Maori principles that should be taken in account when planning for or undertaking any mining operation in New Zealand. One of the key responsibilities for Maori is kaitiakitanga. This principle is inextricably linked to mana whenua and their self-identity and ability to assert rangatiratanga (leadership and decision-making). The ability to enact kaitiakitanga is also a means of expressing ahi kaa (occupation) which also exhibits customary rights or traditional use of a resource. In a holistic sense to enact kaitiakitanga would also involve maintaining, protecting and enhancing the mauri of the ecosystem. It is important that these concepts and practises are recognised by TTR and included in operational and/or monitoring policies and practices going forward. It is important for TTR to do this to be socially responsible and gain ongoing support from Maori now and in the future as well as also have a platform from which TTR and TTHFF can solve any issues that may arise in the future.

Ruckstuhl et al. (2013) also specifically identifies sea floor mining and makes comment that very little is known about the impacts of the activity on New Zealand marine ecosystems and therefore a precautionary approach should be taken towards developing, implementing and monitoring these activities.

This analysis has provided an overview of those traditional sites and customary species that are important to the TTHFF. Recommendations are also provided based on the knowledge (matauranga) that should form the basis of going forward in partnership should the activity be granted by the EPA/Government.

11. Recommendations from TTHFF

- TTR should develop a formal Memorandum of Partnership or Memorandum of Understanding with TTHFF. As part of this agreement TTR and TTHFF will recognise the kaitiakitanga role of TTHFF iwi and develop an agreed upon monitoring plan. TTR should resource the monitoring plan as appropriate.

- TTR should recognise and actively incorporate kiatiakitanga into its future management and monitoring programs. This should take the form of;
    - Providing TTHFF the results of its environmental monitoring program and Including TTHFF membership on any environmental review committees

    - Provide TTHFF members the opportunity to participate in future monitoring operations and research.

    - Provide TTHFF the opportunity to review and provide comment on any environmental management plans.

- TTR should develop a set of cultural based indicators and sites that should be used for future monitoring and adaptive management processes.

- TTHFF should be engaged and resourced to monitor these sites in accordance with TTR's adaptive management process. A list of possible monitoring sites and species are provided below based on this analysis.

Monitoring Site	Indicators	Species/Details
North and South Traps	Primary production	Ecological integrity/Diversity/Abundance
The Rolling Grounds	Rig	Abundance and health
Ototoka	Mussels	Abundance
Whanganui/Kai iwi	Gurnard/Kahawai/Tuna (eel)	Abundance (particularly number of eel within glass eel migrations)
Waitotara - Tangimoana	Whales	Occurrences
Moana roa	Pipi (surf clams)	Abundance and distribution
Pukepuke	Tuna (glass eel)	Abundance
FMA 8	Blue cod, snapper	Health of samples

Control Monitoring Site	Indicators	Species/Details
Manahi	Reef species	Ecological integrity/Diversity/Abundance
Puketapu	Reef species	Ecological integrity/Diversity/Abundance
South of the Manawatu (Hokio)	Toheroa	Abundance and distribution

- Conditions should be created whereby if negative impacts are discovered through monitoring on the above sites TTR will undertake all practical steps to determine if their activity is the cause of the effect. If TTR are found to be the cause of any negative impact then actions must be undertaken by TTR through adjusting its activity to mitigate and lessen the impact on the above sites.
    - If the sites or species impacted cannot be rectified by TTR then TTR should mitigate the loss in other means. This should be formalised in the MOU/MOP.
- TTR should be required to invest in a financial bond to compensate for any negative impacts on customary fishing activities.
- TTR will agree to remove all equipment or machinery from the sea floor within a reasonable timeframe should there be any event that results in equipment becoming stranded.

12. References

Hadfield, M., Macdonald, H. (2015). Sediment Plume Modelling Prepared for Trans-Tasman Resources Ltd. NIWA Client Reprort No: WLG2015-22.

MacDiarmid, A., Thompson, D., Grieve, J. (2015). Assessment of the scale of marine ecological effects of seabed mining in the South Taranaki Bight: Zooplankton, fish, kai moana, sea birds, and marine mammals. Prepared for Trans-Tasman Resources Ltd. NIWA Client Report No: WLG2015-13.

Ruckstuhl, K., Carter, L., Easterbrook, L., Gorman, A. R., Rae, H., Ruru, J., Ruwhiu, D., Suszko, A., Thompson-Fawcett, M., Turner, R. (2013). Maori and Mining. Te Poutama Maori, University of Otago, The Maori and Mining Research Team. Retrieved from http://hdl.handle.net/10523/4362

13. Te Tai Hauauru Iwi (customary fish forum members)

Te Atiawa (Taranaki) Settlements Trust
PO Box 280, New Plymouth

Te Rūnanga o Ngāti Mutunga
PO Box 32, Urenui, Taranaki

Te Kaahui o Rauru
PO Box 4322, Whanganui

Te Rūnanga o Ngāti Apa
PO Box 124, Marton

Te Whiringa Muka Trust
PO Box 125, Whanganui

Ati Awa Ki Whakarongotai Charitable Trust
PO Box 509, Waikanae

Muaupoko Tribal Authority Incorporated
PO Box 1080, Levin

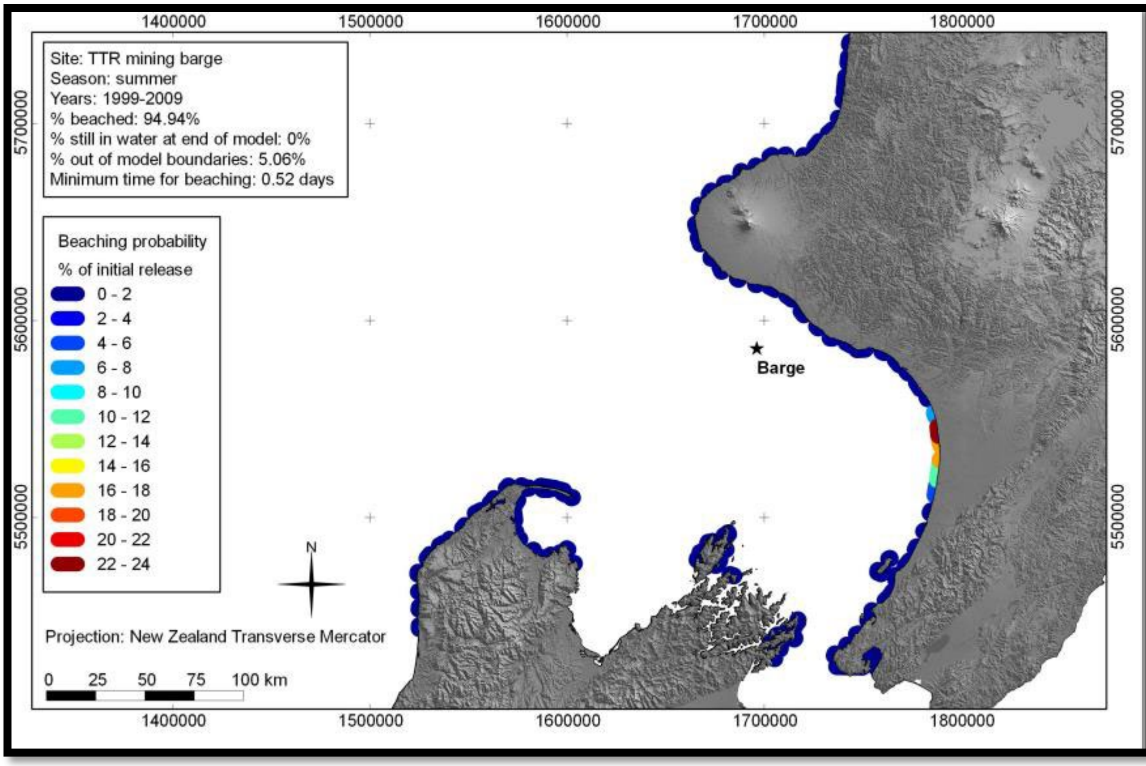
Te Rūnanga o Raukawa/Raukawa Ki Te Tonga Trust
PO Box 15012, Otaki

Te Pātiki Trust – Ngāti Hauiti
43 Te Hou Hou Rd rd1, Marton

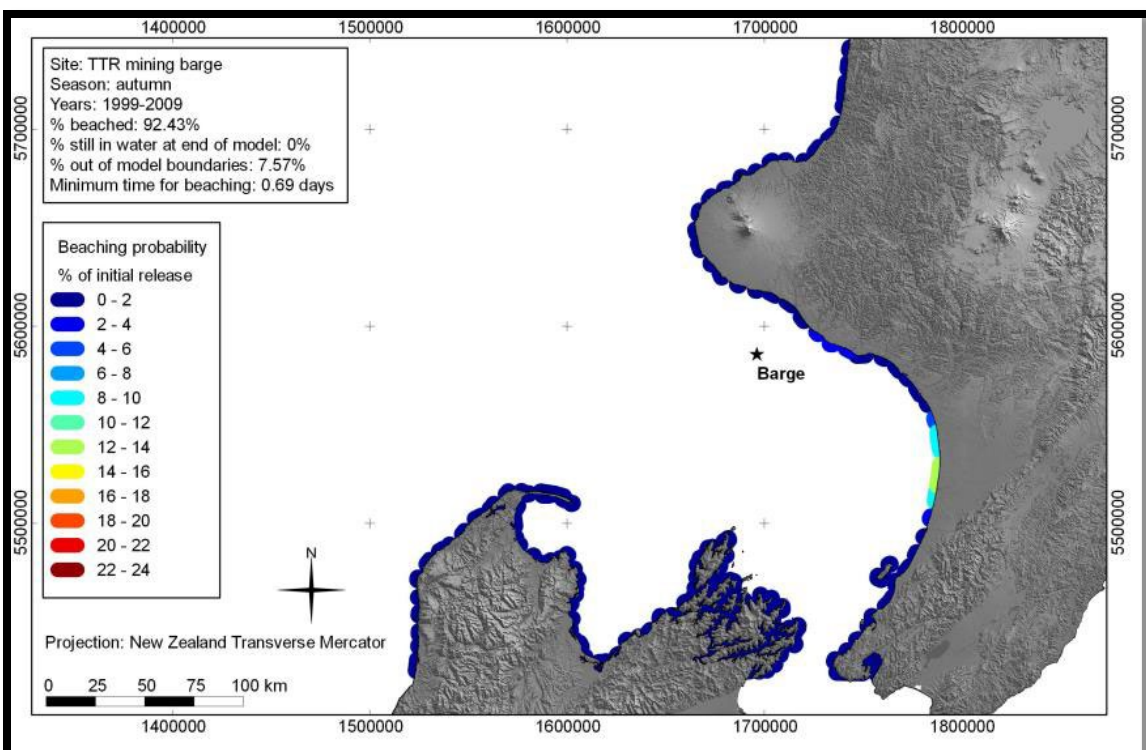
Te Ohu Tiaki o Rangitaane Te Ika a Maui Trust
PO Box 1341, Palmerston North

Appendix 1

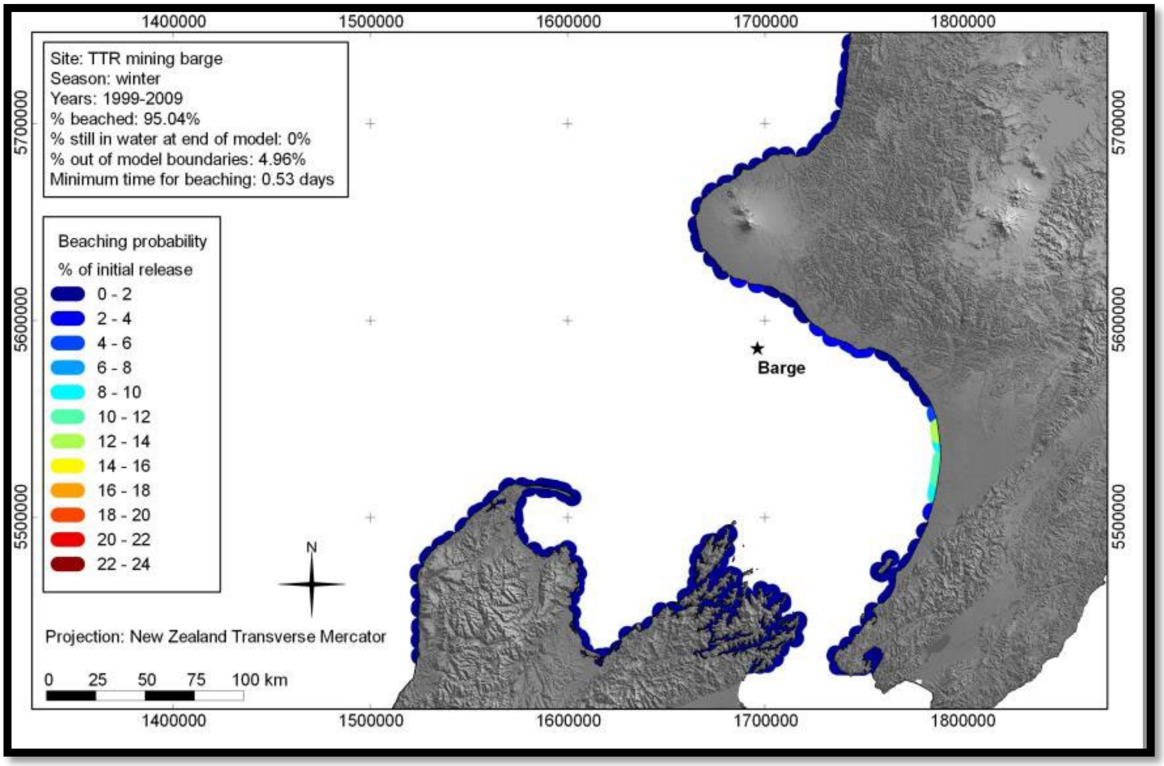
Milestones and Outputs	Success Indicators
Review the already documented cultural information and data presented in the previous application and hearing. *Output: Brief overview (table) of Iwi interests in the Te Tai Hau a Uru area in relation to Te Hi Ika.*	• Completion of review of actual previous reports • Engagement with selective representation of Iwi Groups • Consultation and engagement with Regional and Local Authorities • Interaction with wider range of Stakeholders (other Community Groups) • Selective review of previous submissions
Gather data on taonga species and sites of significance (with respect to Te Hi Ika and the Te Tai Hau a Uru area) from TFF Iwi, kaitiaki and tangata tiaki to develop a frame work of indicators (tohu) for future monitoring. *Output: Report and maps of areas and species to be monitored as control and potentially impacted locations.*	• Further engagement with relevant Iwi Groups and representatives • Specific identification of site of significance and compilation and completion of subject Reports and Maps
A) Integrate mātauranga Māori with western science to develop long term monitoring approaches, and limits for a TTR adaptive management plan. B) Provide any suggested consent conditions. C) Determine appropriate review mechanisms and time frames. *Output: Inclusion of indicator species and sites of significance within an adaptive management plan with agreed upon limits of impact and appropriate related TTR adaptive management strategies.*	• Collation of Matauranga Maori and western science data in conjunction with representatives of the subject Iwi Groups and interests producing recommended approaches to monitoring and set limits for TTR Adaptive Management Plan. • Completion of sufficient investigative work to produce suggested salient consent conditions. • After further consultation with Iwi and Stakeholders recommendations in respect of review mechanisms and timeframes.
Provide recommendations on the ongoing relationship between TFF and TTR as well as the inclusion of TFF within appropriate management and decision making structures within the TTR business and operation should the project proceed. *Output: Report.*	• Completion of comparative models with all relevant Stakeholders to reach and report on appropriate recommendations indicated in the Milestone and Outputs identified in this fourth and final stage of the body of work.



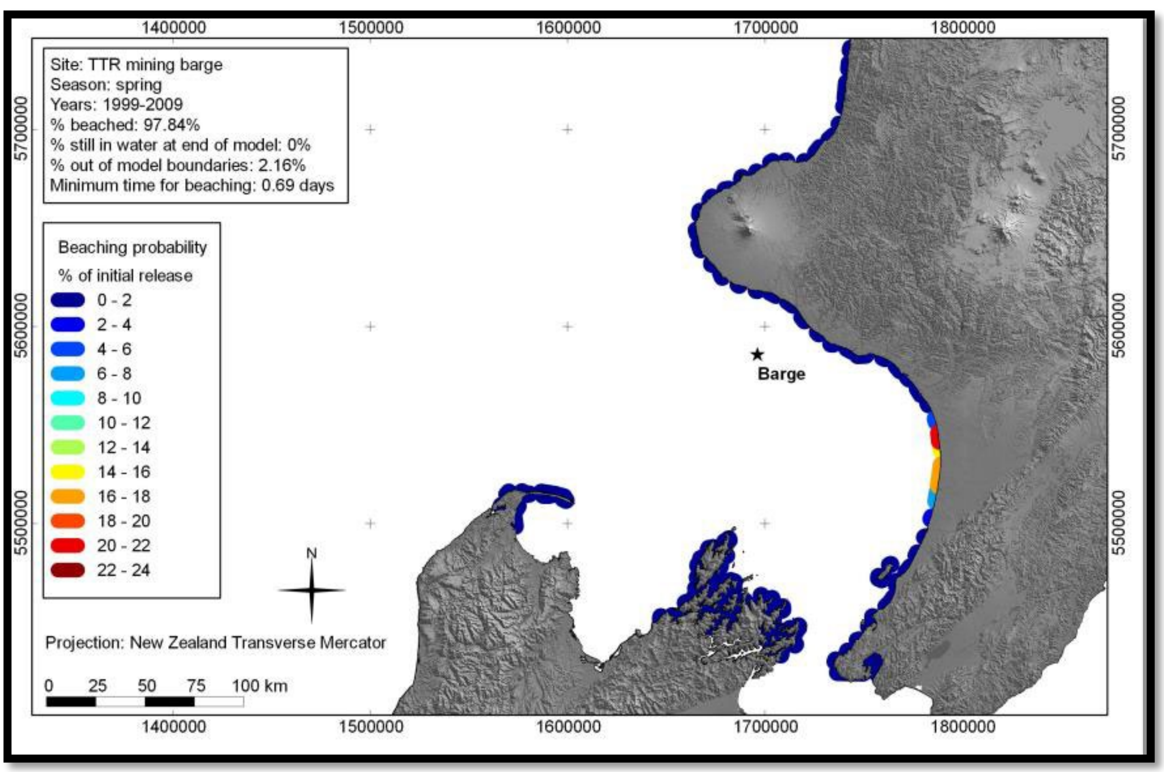
Appendix 5.11: Summer season beaching probability based on an 11-year trajectory database.



Appendix 5.12: Autumn season beaching probability based on an 11-year trajectory database.



Appendix 5.13: Winter season beaching probability based on an 11-year trajectory database



Appendix 5.14: Spring season beaching probability based on an 11-year trajectory database.