# 4 ASSESSMENT OF EFFECTS

## 4.1 Introduction

In accordance with section 39(1)(c) of the EEZ Act, this section of the IA identifies the actual and potential effects associated with the establishment and operation of the project within the EEZ and the surrounding environment. The actual and potential effects of the project, including cumulative effects, are summarised and presented in the following sections:

- Economic effects;
- Social impacts;
- Sedimentation and optical water quality;
- Coastal processes;
- Ecology and primary productivity;
- Marine fauna;
- Marine mammals;
- Noise;
- Human health effects associated with the marine discharge activities;
- Cultural effects;
- Visual, seascape and natural character;
- Archaeology and heritage;
- Air quality;
- Existing interests;
- Other matters:
    - Environmental Monitoring Activities;
    - Anchor Deployment and Positioning;
    - Unplanned Oil / Fuel Spills; and
    - Jack Up Developments.

The assessments commissioned by TTR, which are summarised in the sections below, are considered to represent the best available information and are sufficiently comprehensive to provide a thorough and robust assessment of the actual and potential effects of the project. The assessments are based on relevant technical reports, workshops and discussions with science and planning experts, published reports and papers, and experience in marine ecosystems - including off the west coast of the South Island and in the South Taranaki marine environment.

With regard to the physical environment and ecological effects related to the project, Aquatic Environmental Sciences ("**AES**") have prepared an overview assessment of the ecological effects of the project (AES (2016a)).[43] This assessment also:

- Summarises what is known about the existing coastal environment based on previous published and unpublished reports and studies provided for the previous marine consent application by TTR, and new scientific assessments undertaken to provide greater certainty around the potential effects of the project;
- Assesses the ecological significance of the project on the coastal environment; and
- Described potential environmental threshold levels for environmental monitoring parameters.

AES (2016a) provides the basis for the summary of effects provided in Sections 4.4 and 4.6 of this IA.

## 4.2 Economic Effects

### 4.2.1 Introduction

Martin Jenkins (2015) undertook an economic impact analysis of the project for three study areas – local, regional and national.

The local study area consists of South Taranaki and Whanganui, where the project will occur. The regional study area is made up of four local authorities - South Taranaki, Whanganui, Stratford, and New Plymouth.

### 4.2.2 Assessment Methodology

The Jenkins (2015) assessment applies Input Output ("**I-O**") multiplier analysis approach, which is an internationally recognised method for identifying the economic effects that a defined expenditure has on a specified area in terms of GDP and employment.

The analysis identifies the direct expenditure within the study area associated with a project and assigns that expenditure to the relevant industry where it is likely to occur. It then applies regional multipliers to determine the direct, indirect and induced effects of that initial expenditure in terms of gross output, value added (GDP), and employment.

The I-O multiplier analysis approach was selected as it provides the ability to determine the economic benefit in terms of GDP and employment, at regional and local levels, particularly as the operational expenditure could be estimated and identified at a relatively detailed level. Furthermore, the analysis is not affected by changes in the price of iron ore or exchange rates.

Expenditure in each study area was based on TTR's operations budget and their understanding of where that expenditure was likely to be incurred.

The regional I-O tables and multipliers used were constructed from a detailed set of national industry accounts that measure the commodities produced by each industry and the use of

[43] Aquatic Environmental Solutions, 2016. *"Trans-Tasman Resources Ltd consent application: Ecological assessments"* January 2016.

these commodities by other industries and final users. Indirect and induced effects arise as an initial change in economic activity results in diminishing rounds of new spending as leakages occur through saving or spending outside the local economy.

This approach has been used widely in New Zealand and internationally to estimate regional economic impacts. It is consistent with that used in recent reports on the economic impact of the oil and gas sector on the Taranaki regional and New Zealand economies.

### 4.2.3 Summary of Economic Effects

#### 4.2.3.1 Generated Economic Activity

***Direct Expenditure***

Based on the project's operations budget there will be an annual average spend of approximately NZ$254 million, approximately half of which will be spent in New Zealand. The projected expenditure locally, regionally and nationally is set out in Table 4.1 below.

**Table 4.1: Operational expenditure in New Zealand, annual average**

| Industry | Expenditure (NZ $ mil) | | |
|---|---|---|---|
| | Locally | Regionally | Nationally |
| Fabricated metal product manufacturing | 21.3 | 21.3 | 21.3 |
| Exploration and other mining support services | 7.6 | 17.2 | 34.4 |
| Scientific, architectural and engineering services | 3.7 | 15.8 | 15.8 |
| Other transport | 2.0 | 10.4 | 10.4 |
| Basic material wholesaling | 0 | 6.5 | 32.6 |
| Legal and accounting services | 0 | 2.1 | 14.2 |
| Health and general insurance | 0 | 0 | 3.9 |
| Total | 34.6 | 73.4 | 132.7 |

Of the estimated NZ$254 million in annual spend, just over half (52.2%) is expected to be spent within New Zealand. Of this, NZ$73.4 million (55.3%) is expected to be spent in the regional area (Taranaki/Whanganui region), while just under half of that (47.1%; NZ$34.6 million) is expected to be spent within the local area (South Taranaki/Whanganui).

#### 4.2.3.2 Economic Impact Analysis

***National - New Zealand***

The analysis suggests that the project will generate NZ$159 million in GDP and employ 1,666 people (directly and indirectly) in the New Zealand economy each year for the duration of the project. The direct, indirect and induced impacts of the project on the New Zealand economy are presented in Table 4.2.

**Table 4.2: Economic impact of the project on the National area**

| New Zealand | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Output ($ m ) | 132.7 | 121.5 | 94.9 | 349.1 |
| GDP ($ m ) | 59.0 | 52.1 | 47.9 | 159.0 |
| Employment (FTE s) | 463 | 683 | 520 | 1,666 |

The operations budget suggests that NZ$132.7 million is expected to be spent directly on activities and businesses in New Zealand. The impact of this direct spend is estimated to generate NZ$59 million in GDP and directly employ 463 people.

To put this into context, the New Zealand economy has an estimated GDP of $224.6 billion and employs about 2.2 million people. The TTR project would have a relatively smaller impact nationally than it does at a regional or local level, increasing GDP by 0.7 of one percent and employment by less than one-tenth of one percent.

***Regional - Taranaki / Whanganui***

The project is expected to generate about NZ$50.6 million in GDP and employ 705 people (directly and indirectly) in the Taranaki / Whanganui economy each year for the duration of the project. The direct, indirect and induced impacts of the project on the Taranaki / Whanganui Region are presented in Table 4.3.

**Table 4.3: Economic impact of the project on the regional (Taranaki / Whanganui) area**

| Taranaki / Whanganui | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Output ($ m ) | 73.4 | 27.1 | 15.2 | 115.7 |
| GDP ($ m ) | 30.4 | 11.5 | 8.7 | 50.6 |
| Employment (FTE s) | 367 | 218 | 120 | 705 |

The operations budget suggests that NZ$73.4 million is expected to be spent directly on activities and businesses based in the Taranaki / Whanganui Region. The economic impact of this direct spend is estimated to be NZ$30.4 million in GDP and directly employ 367 people.

To put this into context, the Taranaki / Whanganui economy has an estimated GDP of NZ$10 billion and employs about 75,300 people. The project would have a similar impact as in the local South Taranaki / Whanganui area, increasing GDP by half of a percent and employment by almost one percent.

***Local - South Taranaki / Whanganui***

The project is expected to generate NZ$18.6 million in GDP and employ 299 people (directly and indirectly) in the South Taranaki / Whanganui economy each year for its duration. The direct, indirect and induced impacts of the project on the South Taranaki and Whanganui districts is presented in Table 4.4.

**Table 4.4: Economic impact of the project on the local (South Taranaki / Whanganui) area.**

| South Taranaki / Whanganui | Direct | Indirect | Induced | Total |
|---|---|---|---|---|
| Output ($ m ) | 34.6 | 6.6 | 3.9 | 45.1 |
| GDP ($ m ) | 13.6 | 2.7 | 2.6 | 18.6 |
| Employment (FTE s) | 173 | 83 | 43 | 299 |

The operations budget suggests that NZ$34.6 million is expected to be spent directly on activities and businesses based in South Taranaki / Whanganui. This expenditure is estimated to directly generate NZ$13.6 million in GDP and employ 173 people.

To put this into context, the South Taranaki / Whanganui economy has an estimated GDP of NZ$3.5 billion and employs about 32,400 people. The TTR project would increase GDP by half a percent and employment by close to one percent.

#### **4.2.3.3** Other Quantitative Impacts

***Royalties and Taxes***

As TTR is a mining permit holder they are required to pay royalties to the Crown in respect of all minerals obtained under that permit. The annual royalty is the greater of 2% Ad Valorem or 10% Accounting Profits. This revenue goes into the Crown's account and will likely be part of government expenditure, generating further employment, and is a component of GDP.

Royalties, taxes and profits will trend with iron ore price. The price of iron ore is unlikely to affect the economic impact of the project on the New Zealand economy as the majority of the economic impacts arise from the expenses associated with the project. The economic impact will continue unless the iron ore price falls below a break-even point for a prolonged period, forcing the project to cease operations.

Price rises in the price of iron ore will lead to greater royalties, taxes and profits, but these are less important to the economic effect analysis than operational costs.

The estimated minimum royalty payment to New Zealand each year, at an iron ore spot price of US$50/tonne, is approximately NZ$7 million, and the project would contribute approximately NZ$350 million per annum to New Zealand exports.

In comparison, petroleum, minerals and coal royalties in 2015 were about NZ$285 million of which minerals accounted for NZ$6 million (2%). Minerals and coal royalties were not expected to increase in 2016, while petroleum royalties were expected to decline by about 20%. If granted, the project would more than double the mineral royalty contribution to approximately NZ$13 million per annum and increase minerals contribution to royalties to about 5%.

As a New Zealand corporate, TTR must also pay income tax on assessable income up to a maximum rate of 28%.

***Exports***

Using the above example, iron sands exports from the project of NZ$350 million per annum would place it in the top 20 items exported from New Zealand. Combined with iron and steel, and articles of iron and steel, the category would have exports of close to NZ$1 billion.

Based on the recent historic lows in the iron ore spot price, a price of US$40/tonne would result in approximately NZ$312 million in annual exports. Total merchandise exports in the year to June 2015 were NZ$46 billion. Based on those figures, iron sands exports at NZ$312 million, would be 0.7% of total merchandise exports. If the price of iron ore were to be US$60/tonne, then iron ore exports would be approximately $430 million per annum and move up to $16^{th}$ on the New Zealand's list of principle exports, and, when grouped with iron and steel and articles of iron and steel, it would move into the top 10.

The New Zealand Government has set a Business Growth Agenda target of increasing exports to 40% of GDP by 2025. Step-change increases in exports, such as from this project, will go some way toward achieving that target.

***Employment***

The project will directly require over 200 people to operate the offshore vessels, with a further 50 staff required in support, engineering, administration, environmental and other contracting roles. This will be required for the majority of the requested 35-year consent term for the project.

Further, approximately 35 people will be employed in corporate roles within TTR. All of these roles will be New Zealand-based. About three-quarters of these will be based outside of the Taranaki region, while about 10% will be based in South Taranaki. These ratios are estimates based on the current scope and scale of the project and are subject to change.

The project will also purchase many services from a number of other independent businesses in the local and wider region. These services include fuel bunkering, environmental monitoring, repairs and maintenance, health and insurance, and business services.

With regard to employment, TTR is committed to working with the local community to encourage local engagement and participation on the project. This includes both in the delivery of support services, but also in encouraging local employment directly on the project.

***Heavy Fuel Oil Supply***

HFO supply in New Zealand is currently limited with supplies provided from Auckland. It is estimated that an annual spend of nearly NZ$30 million on HFO is predicted. Therefore, the project requires a tailored solution to meet its HFO demand.

There is potential for the HFO to be supplied through the Marsden Point refinery, this would see increased economic activity out of Marsden Point in terms of fuel processing and storage. A third party supplier would then be contracted to transfer HFO to the project area as required.

An alternative option is the development of a dedicated HFO bunkering facility in Wellington or New Plymouth. This would require an investment of NZ$50 million and create up to 14 new jobs. Further business for the new bunker would then be captured by vessels travelling through Cook Strait and ships calling into Wellington / New Plymouth so the establishment of the operation could have flow-on economic effects for the region also.  The final, preferred option will be determined if the application is granted.

#### **4.2.3.4** Qualitative Impacts

As well as the quantitative impacts in terms of GDP, employment and government revenue, there are several qualitative benefits from the project.

***Skills Development***

TTR recognises the benefits from ensuring local people are employed in all aspects of the project operation. Possibly even more important is ensuring local people benefit from training, as this is an investment that will benefit the individuals, the community, and ultimately the project itself.

TTR is exploring opportunities with local government, businesses and Industry Training Providers to assist in providing the services needed to support the project. Further, TTR are committed to establishing a marine and technical skills training facility in Hawera. This will provide, among other skills, Marine Certification training, which is a prerequisite for people seeking work on the project. This is provided for through the proposed consent conditions and is further discussed in Section 4.3 (Social Impacts) of this IA.

***Complementarity***

The Taranaki Region has well developed oil and gas, dairy and engineering sectors. Each year, the oil and gas sector contributes about NZ$1.6 billion to the Taranaki Region economy and employs about 7,000 people in the region.

As the oil and gas and dairy sectors have grown, businesses, particularly in the structural and mechanical engineering, have adapted and developed their capability to provide support services to both sectors. These capabilities and skill sets are likely to be similar to those required by this project.

Further, the range of support services required for the project are similar to those used for the oil and gas industry. This means that the infrastructure and services are already in place and the sector is not having to start from scratch or import all of its services. A higher proportion of activity will be captured within the region.

For the Taranaki region, which considers itself to be the energy capital of New Zealand, the project will further add to its reputation and capability to support natural resource extraction industries.

***Diversification***

Countries, and indeed regions, are continually trying to diversify their economies so they are not overly reliant on any one industry. Industry diversification is often an objective for regional or national economic development agencies.

The South Taranaki / Whanganui and Taranaki / Whanganui areas both have a strong dependence upon the dairy, and energy sectors. Adding iron ore extraction broadens the industry mix in the areas. This will be particularly welcomed by the engineering sector.

#### **4.2.3.5** Potential Costs

It has been argued that the project could have some level of adverse effects on other industries in the local and regional study areas, in particular, tourism and fishing. However, such effects are extremely difficult to determine or quantify and, as such, placing any monetary value on these effects is difficult.

There is limited activity in either of these industries in the study areas. As the project is offshore and is not visible from onshore, there is likely to be limited impact on tourism (Section 4.15.3). The commercial fishing industry is very small and in the event that there was an adverse impact, it would result in relatively low losses in activity * In accordance with the Marlborough Sounds Resource Management Plan (fully operative in August 2011), TTR will not undertake any activities that require a resource consent within Admiralty Bay; nor will they undertake any activities in relation to the project (Section 4.15.1). Recreational fishing is unlikely to be affected at all (Section 4.15.3). Overall, Jenkins (2015) concluded that, when considering the balance of economic effects of the project, the positive economic effects are significantly greater than any other effects.

This overall position was accepted by the DMC in their decision on the previous marine consent application, where they concluded that, while the value of the potential adverse effects is difficult to quantify, the project is likely to have a positive net economic benefit.[44]

#### **4.2.3.6** Response to Initial EPA Review Query

With regard to the matters raised in the EPA letter dated 10 May 2016 following an initial review of the particular technical reports provided by TTR, the following matter was raised by the EPA with regard to the presentation of the economic effects:

- *On 9 March 2016, TTRL provided written responses to the EPA regarding its concerns on GHD's report on the economic effects of TTRL's proposed activities. That document contained material explanations which directly addressed some of the concerns raised in the GHD report. As outlined in the meeting on 9 March 2016, we recommend that TTRL includes this information in its formally lodged documents and specifically within its economic analysis. Providing this information in its formally lodged documents will enable the EPA's reviewer, and other parties to the marine consent process, to take account of this additional information.*

TTR confirms that they have not updated the Jenkins (2015) report as TTR have supplied the GHD expert (through the EPA) with separate confidential information addressing the expert's concerns. This information was supplied to the EPA under the terms of the signed Confidentiality Agreement on 28 January 2016. TTR would expect the EPA expert to be able to update any final review report, referring to the confidential information without duplicating any of it in the final peer review report.

## 4.3 Social Effects of the Project

### 4.3.1 Introduction

Further to the economic effects considerations discussed in Section 4.2 above, the social impact assessment focuses on the existing social environment and how that might be affected by the project. This section of the IA looks at the potential social impact effects of the project in further detail based on Austin et al. (2016) who undertook a social impact assessment of the project.

### 4.3.2 Assessment Methodology

Austin et al. (2016) followed the four principle elements of social impact assessment methodology in completing their assessment:

1. Scoping;
2. Profiling;
3. Analysis of potential effects; and

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[44] TTR Marine Consent Decision, 15 June 2014. Para 753.

4. The identification of appropriate mechanisms to avoid or mitigate adverse effects.

The 'affected area' was defined at two scales in recognition that the potential effects could occur across a wide geographic area, with different communities and groups potentially affected in different ways:

- The 'local area' covered the coastal communities from Opunake to Whanganui city. It is the area with the closest association to the project operations.
- The 'wider area' covered the districts of New Plymouth, South Taranaki and Whanganui, which is the area most likely to experience employment-related effects.

The main findings on the potential social impact effects of the project are summarised below.

### 4.3.3 Summary of Potential Social Impacts

**4.3.3.1** Employment

The project is predicted to create approximately 250 new jobs within the local and wider areas, with the wages largely expected to be spent in the local area. This is considered to be a positive effect of the project.

The offshore operations will enable a fly-in-fly-out / drive-in-drive-out workforce, therefore the workers could reside across a large geographical area. Based on Taranaki's existing offshore drilling operations in oil and gas, the majority of employees are expected to be based in Taranaki, Manawatu-Whanganui and Wellington. Potential social effects of a fly-in-fly-out / drive-in-drive-out workforce are:

- Helping to spread the benefits of job creation throughout the "local" and "wider" area rather than clustering jobs around the few land-based locations of the project;
- Avoiding most of the social costs often associated with a large non-resident workforce concentrated within an existing community, because the TTR project workforce will be based in a highly regulated, offshore environment; and
- Avoiding capacity issues for local service providers, which can occur when a large new workforce is resident in one specific land based area.

**4.3.3.2** Local Businesses and Associated Employment

Positive social effects will be experienced in the communities with businesses providing services or supplies to the project. This will include manufacturing, maintenance, consumables and visitor accommodation. It is anticipated that these effects will occur in the local and wider area of the Taranaki Region, particularly New Plymouth, for the duration of the project with some of these effects already being experienced through the investigation phase of the project.

**4.3.3.3** Income Levels

Many of the positions required for the project are expected to be well paid because of the technical skills requirements and offshore experience requirements. Therefore, the project has the potential to help to offset the lower than average household incomes currently experienced in the local and wider areas.

### 4.3.4 Management of Potential Adverse Social Impacts

To further ensure that the social impacts of the project are positive, TTR is committed to the provision of various community focused consent conditions, provided for through the proposed consent conditions that:

- Establish an annual community based fund to be administered by the South Taranaki District Council, in collaboration with TTR, to assist in the establishment of projects for the benefit of the South Taranaki community, in particular for the social and economic wellbeing of the community;

- Establish and maintain a training facility located in the township of Hawera. The purpose of the training facility is to provide technical and marine skills based training to perspective trainee process operators and maintenance support staff from the South Taranaki community who then can be employed by TTR for the project; and

- Establish and maintain a geotechnical and environmental monitoring base located in the port of Whanganui. The purpose of the base is to support the iron sand extraction activities by providing, as a minimum:

  - A permanent berthing site for a vessel;
  - A secure laydown area;
  - A storage area and warehouse;
  - An operation and maintenance workshop;
  - Administration offices; and
  - Scientific Laboratory.

Further to the above matters, in order to ensure that the community and interested parties are kept informed of the project, TTR will provide up to date information on the project's activities and environmental monitoring outcomes, including the baseline environmental monitoring. The information will be made available through a website maintained by TTR for the duration of the project and through regular community meetings, facilitated by TTR. These meetings will further keep the public informed of the project's activities and other matters that may be of interest to the public. The matters have been provided for in the proposed consent conditions included as Attachment 1 of this IA.

## 4.4 Sedimentation and Optical Water Quality Effects

### 4.4.1 Introduction

It is inevitable that the recovery of iron sands from the project area will have some impacts on sedimentation and optical water quality at the seabed, and in the water column. In this regard, AES (2016a) concludes that the immediate environment (i.e. where the extraction and re-deposition operations are occurring) will be temporarily impacted to a significant degree. However, it is the spatial and temporal extent of the effects beyond the immediate environment that require a more detailed assessment.

AES (2016a) states there are three main sources of sedimentation and optical water quality effects as a result of the project:

- The production of a sediment plume during the extraction of iron sands and the deposition of de-ored sediments back to the seabed and potential re-suspension;
- Physical disruption of the seabed during the extraction and re-deposition phases; and
- Effects on optical properties of the water column through suspended sediments.

## 4.4.2 Sedimentation and Sediment Plume Effects

### 4.4.2.1 Introduction

The production and dispersion of a sediment plume during the extraction of iron sands from the seabed is one of the key features of the project. TTR has committed considerable resources into understanding the potential sediment plume in terms of source material, concentration, dispersal, and spatial and temporal variability.

Following receipt of the DMC's decision on the previous marine consent application, TTR commissioned an extensive peer review of its technical assessments. TTR subsequently commissioned additional technical work by NIWA and others in relation to the sediment plume and modelling to provide certainty and greater confidence in the source terms used and model assumptions (and thus the interpretation of the potential effects of the project).

A key work-stream related to gaining certainty over the way discharged de-ored sediment behaves in the marine environment, particularly potential flocculation and settling rates for finer particles within the discharge. To address this matter, HR Wallingford ("**HRW**") conducted laboratory tests using sediment samples from the South Taranaki marine environment to build on the earlier assessments. This included refining settling velocity of the finest fraction, the erosive forces required to re-suspend this fraction following settling and the 'trapping' of the finest fraction within the pit during the project's operations.

The findings from the tests undertaken by HRW (Wallingford (2014)),[45] along with the updated sediment plume modelling, have been incorporated into the overall environmental assessments (AES (2016a)).

### 4.4.2.2 Assessment Methodology

***<u>Bench Testing of Sediment Samples</u>***

HRW completed additional sediment testing and investigations, which resulted in the incorporation of the following factors into the sediment plume model:

- Flocculation – a mechanism whereby fine sediment combines into faster-sinking aggregates;
- Sediment settling rates – the rate at which sediments settle to the seabed and become trapped within sand matrix; and
- Sediment re-suspension – the critical shear stress required to re-suspend deposited material.

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[45] H.R. Wallingford, 2014. *"Support to Trans-Tasman Resources – Laboratory testing of sediments"* DDM7316-RT002-R01-00. October 2014.

HRW was supplied with three samples of sediment that was collected from below the seabed in the Sediment Modelled Domain ("**SMD**"). The samples consisted of the following:

- Post-grind tailings;
- Pre-grind ultra-fines; and
- Tailings.

Each sample was tested with a focus on the flocculation, settling rates and sediment re-suspension.

***<u>Flocculation and Sediment Settling Rates</u>***

A series of what are known as 'jar tests' were conducted by HRW in order to assess how the three samples behaved when immersed in water. Settling velocity measurements indicate that most particles less than 63 microns ("**µm**") in diameter will be subject to flocculation and settle rapidly to the seabed at speeds of approximately 10 millimetres per second ("**mm/s**") in saline water. In reality, this means that such particles will behave similarly to fine sand and remain near the seabed.

Analysis of the results of the suspension mass tests indicate the following:

- Approximately 67% of fine fraction material less than 38 µm falls rapidly to the seabed;
- Approximately 33% of fine fraction material less than 38 µm falls at speeds of less than 0.2 mm/s;
- Approximately 15% of fine fraction material less than 38 µm falls at speeds of less than 0.1 mm/s; and
- Approximately 0.5% of fine fraction material less than 38 µm falls at speeds of less than 0.005 mm/s.

For the slowest settling sediment there is an expectation that this sediment would be subject to further flocculation over time as it advects and disperses within the environment and interacts with other sediment.

***<u>Sediment Re-suspension</u>***

Testing by HRW revealed the critical shear stress required for freshly deposited sediment to be re-suspended was in the range of 0.2 – 0.3 Pa, rather than the 0.1 Pa originally assumed by NIWA as part of the technical assessments for the previous marine consent application by TTR.

***<u>Re-run of Sediment Plume Model</u>***

The sediment plume model uses the Regional Ocean Modelling System, which is a widely accepted ocean / coastal model with optional embedded models of suspended sediment and sediment - bed processes.[46] The model grid resolutions vary between the domains - 2 km grids for the outer domains and 1 km for the inner domains (with the option of using a 500 m resolution). The 500 m resolution is used to investigate the sensitivity of the model results to the grid resolution, primarily at a 100 m grid size ocean bathymetry.

The model required the input of those parameters outlined below:

- Median grain size;
- Grain density;
- Porosity (when in the sediment bed);
- Sediment class;
- Background sediments (river and sea derived);
- Input rates;
- Proportion of background sediment sizes;
- Settling velocity (when in the sediment bed);
- Critical bed shear stress for erosion;
- Erosion rate parameter;
- Iron sand recovery derived sediments;
- Hydro cyclone overflow discharge; and
- De-ored sediment discharge.

Based on Wallingford (2014), the modelling of near-field processes and plume around the discharge is based on effectively all the fine sediment fractions settling at 10 mm/s depositing on to the seabed within the excavated pit. The finer fractions with slower settling rates are expected to remain well mixed in the water column. An important aspect of the new modelling work is that the slowest settling fractions have been shown to combine in the process of flocculation to form faster settling aggregates.

The sediment plume dispersion model was rerun by NIWA incorporating the determined data on source rates, sediment parameters and processes, as well as improvements to the way background suspended sediments are treated. Two source locations were considered in the modelling – one at the inner edge of the project area ("**Location A**") and one at the outer edge ("**Location B**"). The analysis was based on the sediment being introduced over 1,000 days and the reporting has focused on the median (50$^{th}$ percentile) and 99$^{th}$ percentile of effects. The area being considered was broken into three regions:

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46 Haidvogel, D.B., Arango, H., Budgell, W.P., Cornuelle, B.D., Curchitser, E., Di Lorenzo, E., Fennel, K., Geyer, W.R., Hermann, A.J., Lanerolle, L., Levin, J., McWilliams, J.C., Miller, A.J., Moore, A.M., Powell, T.M., Shchepetkin, A.F., Sherwood, C.R., Signell, R.P., Warner, J.C., Wilkin, J. (2008). *"Ocean forecasting South Taranaki Bight Iron Sand Extraction Sediment Plume Modelling in terrain-following coordinates: Formulation and skill assessment of the Regional Ocean Modelling System"*. Journal of Computational Physics 227(7): 3595–3624.

- The Greater Cook Strait Region;
- The SMD; and
- The Patea Shoals.

The majority of the discussion on the sedimentation effects assessment is based on effects that occur in the SMD, as shown in Figure 3.1. This SMD covers approximately half of the STB (approximately 13,300 km$^2$) and covers the area where any potentially significant impacts from the project could occur.

#### **4.4.2.3** Findings on Sediment Plumes

The modelled background levels of suspended sediment concentration are shown in Appendices 4.1 and 4.2. By way of summary, the sediment plume is shown to predominantly travel in an east-southeast direction from its source. An important consideration is the naturally occurring background levels of suspended sediment concentrations experienced within the SMD.

Background suspended sediment concentrations are higher inshore and decline offshore, and away from the river sources. Median background near-surface concentrations reach over 20 mg/L and the 99$^{th}$ percentile is typically up to 100 mg/L close to the coastline (with a maximum over 200 mg/L close to major rivers) (refer to Appendix 4.1). The median concentrations at the seabed are over 100 mg/L and 99$^{th}$ percentile levels over 1,000 mg/L (refer to Appendix 4.2).

Median surface concentrations around the project site are typically 0.4 mg/L closer to the shore and approximately 0.05 mg/L in more offshore locations. Near-bottom suspended sediment concentrations are typically less than 1 mg/L, with a 99$^{th}$ percentile of less than 10 mg/L. Winter levels tend to be higher than those reached in summer.

The dispersion of suspended sediments in the SMD, and its effects on physical and biological environments, depends on a variety of factors – including tidal currents, larger scale current flows, upwelling off Farewell Spit, freshwater inputs from major rivers, wind direction and weather events. Modelling of the sediment plume in dominant southwest and southeast winds is shown in Appendices 4.3 and 4.4 respectively.

There is also a temporal consideration with a time series now modelled for suspended sediment concentration at locations 2 km, 8 km and 20 km from the project area. The modelling results show how the sediment plume's presence and severity will change over time and the 'spikiness' of the natural suspended sediment concentrations.

The net differences between 'background' and 'extraction plus background' at the locations 2 km, 8 km and 20 km away from the project area are:

- An increase in median suspended sediment concentrations at the 2km location from 0.4 to 1.5 mg/L and an increase at the 99$^{th}$ percentile from 5.5 to 6.8 mg/L;
- An increase in median suspended sediment concentrations at the 8 km location from 0.5 to 1.3 mg/L and an increase at the 99$^{th}$ percentile from 6.9 to 7.1 mg/L; and
- An increase in median suspended sediment concentrations at the 20 km location from 0.9 to 1.4 mg/L and an increase at the 99$^{th}$ percentile from 10.5 to 10.8 mg/L.

The examples of the model runs for sediment plume development showing median sedimentation concentrations in surface waters and on the seabed when iron sands extraction is occurring at Location A are shown in Figures 4.1 and 4.2 respectively.

Figure 4.1 shows that suspended sediment concentration in the plume will be very low, with suspended sediment concentrations of 1.45 mg/L around Location A. The comparison of background, with background plus iron sand extraction activities concentrations, shows a slight movement offshore of the 1 mg/L threshold of about 6 km outwards over the Patea Shoals. The ecological implications of such differences are discussed in Section 4.6 of this IA.

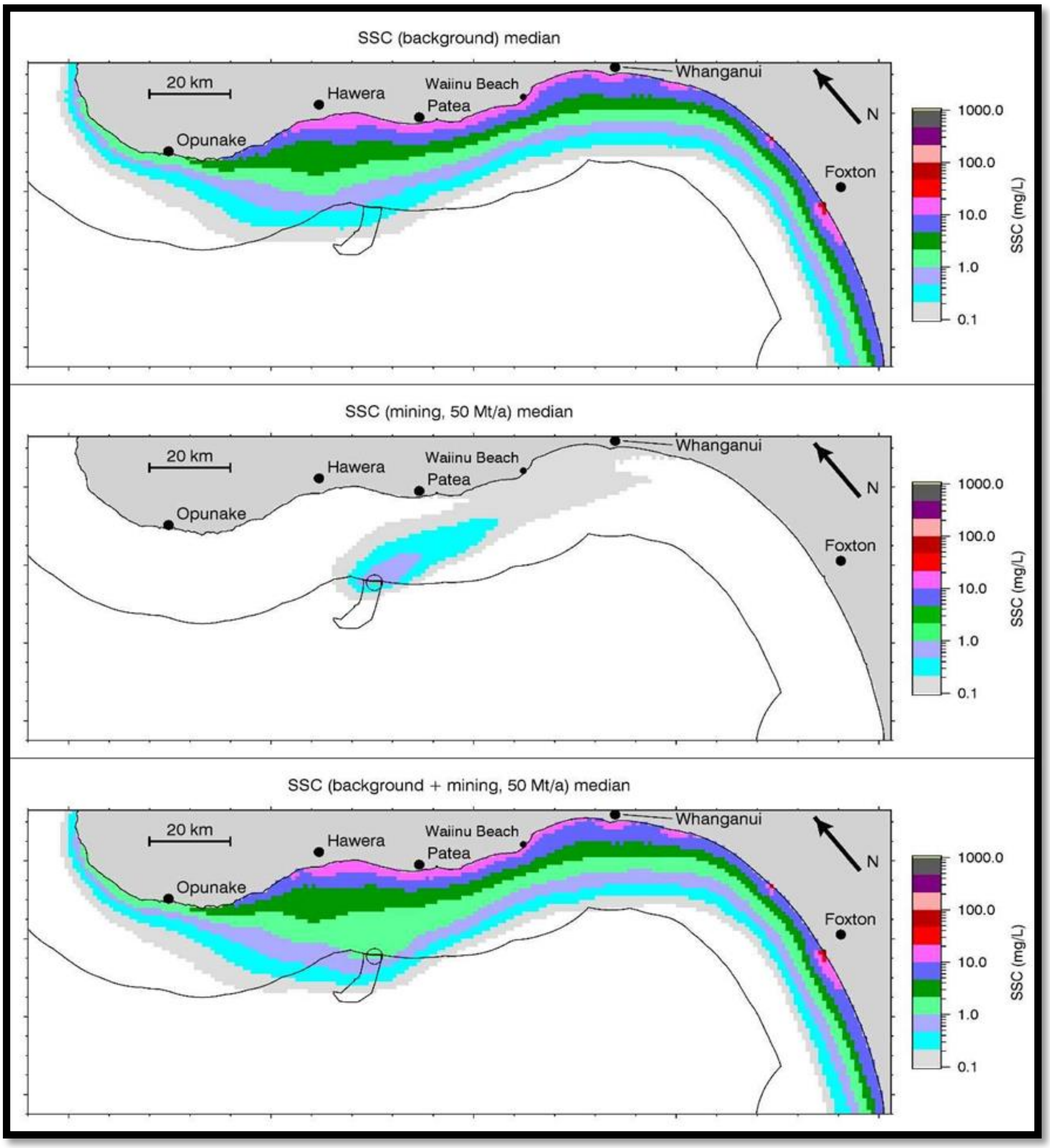



**Figure 4.1: Median near-surface concentration of suspended sediment from mining (50 Mt/a) at source Location A. Background SSC (top panel); mining-derived SSC (middle panel); and background plus mining-derived SSC (bottom panel). An open circle of 2 km radius in the middle and bottom panels indicates the source location of the sediment plume.**

Figure 4.2 shows that median background suspended sediment concentrations in the near-bottom waters can be in excess of 200 mg/L close to shore and 1,000 mg/L near the mouth of major rivers. When accounting for the sediment plume as a result of the project, the only perceptible difference is within 2 - 3 km of the source.

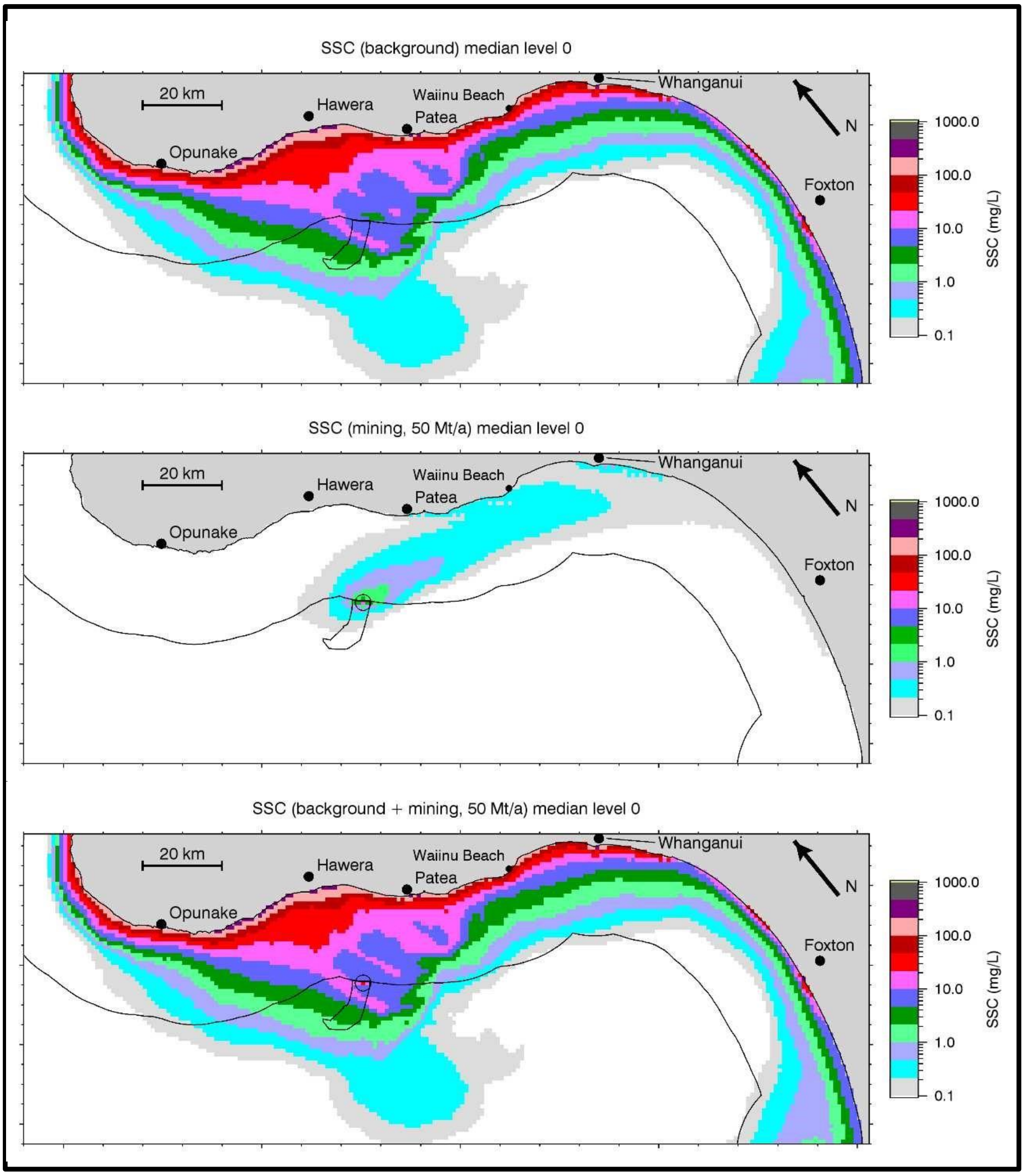



**Figure 4.2: Median near-bottom concentration of suspended sediment from mining (50 Mt/a) at source Location A. Background SSC (top panel); mining-derived SSC (middle panel); and background plus mining-derived SSC (bottom panel).**

Although the modelling shows the sediment plume interacting with the coast between Patea and Foxton, concentrations are only 0.1 - 0.2 mg/l. These levels are indistinguishable from background, naturally occurring levels.

The highest surface suspended sediment concentrations for Location A are 1.45 mg/L (median) and 8.2 mg/L (99th percentile) at the source, while 20 km down current of the source the surface concentrations are predicted to be 0.35 mg/L (median) and 2.8 mg/L (99th percentile). Again, the concentrations beyond the immediate project area are very small and generally indistinguishable from background levels. Suspended sediment concentrations for Location B were considerably lower than those at Location A.

#### **4.4.2.4** Sedimentation Effects as a Result of Deposition

The deposition of sediments as a result of release of the de-ored sediments has the potential to smother marine environments.

NIWA modelled the levels of deposition and reported the results for the maximum five and 365-day deposition rates. The results demonstrate that the deposition rate can only be distinguished from background rate out to a maximum of a few kilometres of the source of the sediment plume. Once the project is operating the deposition could occur over a reasonably extensive area, but at rates between 0.01 – 0.05 mm over five days. Such levels are indistinguishable from what occurs naturally and it is only at the source of the deposition, where ‘background plus extraction’ is distinguishable from 'background’.

The modelling shows that the maximum deposition at the source will be 0.6 mm and 1.1 mm for the five and 365 day accumulations respectively. Erosion, dispersion and resettlement of sediments from the excavated pits are likely to be at very low rates, with rates of less than 0.01 mm over two years up to 10 km away from the pit area.

Overall, suspended sediment concentrations in these plumes will be insignificantly small relative to the naturally occurring background levels of suspended sediments in the SMD.

#### **4.4.2.5** Response to Initial EPA Review Query

With regard to the matters raised in the EPA letter dated 10 May 2016 following an initial review of the particular technical reports provided by TTR, the following matters were raised by the EPA with regard to presentation of the sediment modelling results:

- *Some issues relating to the presentation of sediment modelling results and the degree of precision that is provided (Section 6.1.1 of the DHI report).*

TTR notes that the primary form of presentation of the results is via graphs with a logarithmic colour scale running from 0.1 to 1000 mg/L. The same colour scale is used for all plots and the large ratio (104) between the extremes of this range is necessitated by the very large spread in concentrations occurring in nature. Each band in the colour scale spans a factor of two (2.15 to be precise).

While it may seem excessive to show concentrations as low as 0.1 mg/L, where background concentrations offshore are typically ~ 0.5 mg/L or more, with the higher threshold of 0.3 mg/L adopted previously, modelling outputs resulted in a position of having plots of median surface suspended sediment concentrations for mining-derived sediment from Location B that were almost completely blank (i.e. below the threshold), but with discernible optical effects.

Regarding the accuracy of the model for mining-derived sediments, TTR note that it will not be possible to establish this directly until, and unless, the consent is granted and the proposal implemented. TTR note that the proposed consent conditions (refer to Attachment 1) include an Operational Sediment Model Validation process.

- *More detailed outputs of changes in light attenuation at specific sites to determine predicted changes in light levels over time to assist in determining the duration, frequency and pattern of any low-light events (paragraph 30 of the GHD report).*

While the above EPA comment suggests that a more detailed output may be useful, TTR note that paragraph 30 and 31 of the GHD review report states *"…As discussed above some additional outputs of the model could be useful, if provided, however they are mainly expected to be used by the ecology team undertaking the impact assessment on the marine and benthic ecology.*

*This optical effect study uses an optical model with a high level of complexity has very detailed inputs and is considered to represent best practice."*

On this basis, no further information has been provided.

- *More detailed outputs for TSS levels at specific sites within the STB to assist in determining the duration, frequency and pattern of any high TSS events (paragraph 28 of the GHD report).*

While the above comment suggests that a more detailed output may be useful, TTR note that paragraph 28 of the GHD review report states *"Considering that the modelling approach and methodology used are sound and that the input and parameters assumptions have been determined using additional lab testing, the results are considered to be a reasonable estimate of the predicted suspended sediment concentrations."*

On this basis, no further information has been provided in response to this comment.

#### **4.4.2.6** Summary

Increases to the suspended sediment concentrations around the project area and the SMD have been extensively modelled by NIWA using a wide range of input parameters to best understand the actual and potential sedimentation effects associated with the project.

Based on the modelled outputs of suspended sediment concentrations from the project it is concluded that effects near the project area will be moderate. Closer to the coast the effect of project derived sediment will be insignificant as project derived sediment levels are not discernible relative to the naturally occurring background levels in the high energy coastal environment. This conclusion is significantly different from that reached with the previous application and has been arrived at following considerable additional analysis of the way that project derived sediment will behave in the marine environment.

Potential effects of the sediment plume and management of those effects on water quality, ecology, fauna, and coastal processes is further discussed below in the relevant sections of this IA.

### 4.4.3 Optical Water Quality Effects

#### **4.4.3.1** Introduction

The optical effects of the project have been assessed in AES (2016a) and which incorporates elements of the sediment plume modelling undertaken by NIWA.

The sediment plume model outputs have been used to refine and model the impacts on optical properties of the water column. The changes of potential concern in terms of water column and seabed ecology are underwater visibility for visual feeders and light attenuation for primary producers (i.e. water column and seabed micro-algae and seabed and reef macroalgae). As for the sediment plume, there is considerable background variability in optical properties and the effects of the project are likely to be highly variable in time and space - depending on prevailing conditions.

The optical model outputs have been used to assess the impacts on optical water quality as a result of the project which are discussed below.

#### 4.4.3.2 Actual and Potential Effect on Optical Water Quality

To analyse the actual and potential effects on the optical water quality of the SMD from the project, three descriptive transects were placed through the main axis of the sediment plume as shown in Figure 4.3. They can be described as follows:

- Northwest to southeast from the coast at Hawera across the northeast corner of the project area to approximately 36 km offshore;
- West to east from beyond the western most point of the project area on the 12 NM line to Whanganui; and
- Along the coastline from west of Hawera to Tangimoana (between Whanganui and Foxton).

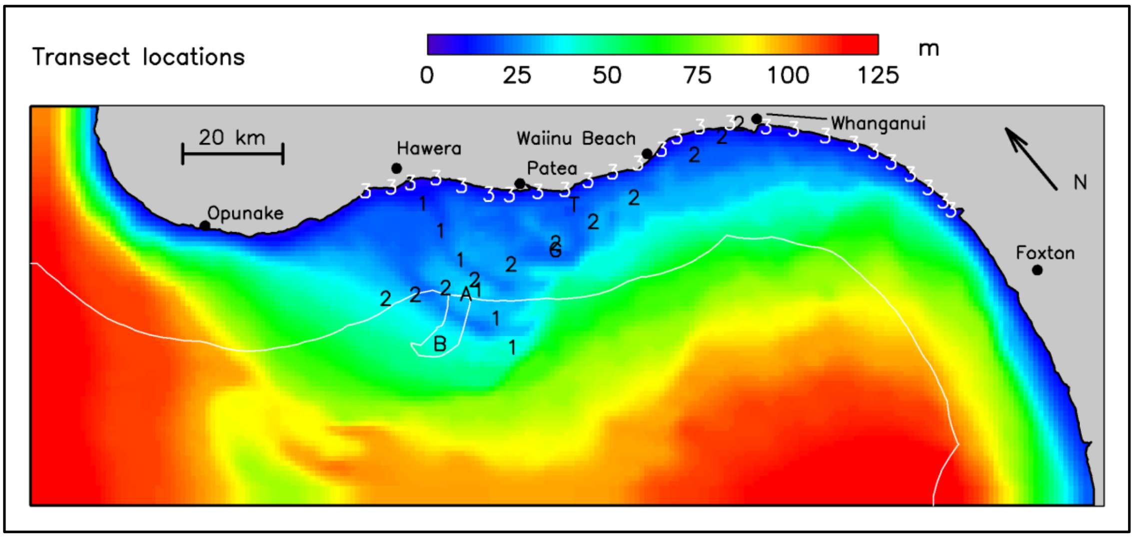



**Figure 4.3: Descriptive transects to show optical effects underlain by SMD bathymetry Note: A: Mining site (A) in plume modelling; B: Mining site (B) in plume modelling; G: Graham Bank; T: The Traps.**

**4.4.3.3** Eutrophic Zone Depth

Iron sand extraction activities at Location A (refer to Figure 4.3 above) will cause a discernible reduction in eutrophic zone depth (which is the depth at which the down-welling irradiance has fallen to 1% of its surface value).

The disturbance of the seabed associated with the iron sand extraction activities leads to increased suspended sediments in the water column. This increase has the potential to have a shading effect which can lead to lower euphotic zone depths. The degree to which euphotic zone depth is reduced depends on how the suspended sediment plume behaves.

The modelling outputs show that the movement of the sediment plume will most commonly be in an easterly direction from the project area. Because there is substantial variability in how the plume behaves, both in terms of the direction it moves and how rapidly the sediment disperses or settles, any temporary potential optical water quality effects reduce as the distance from the extraction area increases.

Overall, eutrophic zone depths are greater in deeper water, further from the coast, and smaller over shallower water and near the coast. This is a result of greater concentrations of suspended sediments, colour dissolved organic matter and phytoplankton in shallower water. Figures 4.4 and 4.5 show the results of the optical water quality modelling.

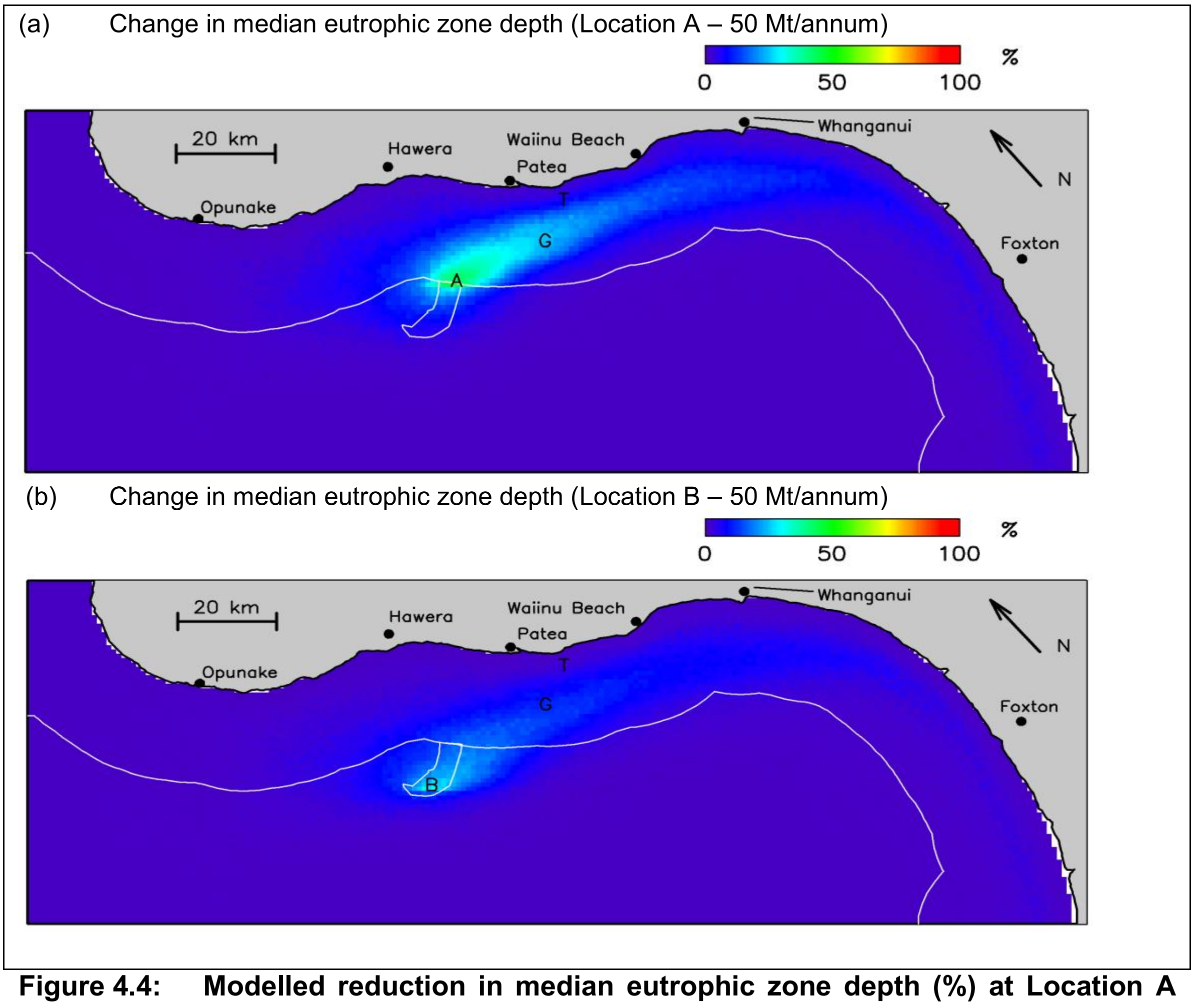



**Figure 4.4: Modelled reduction in median eutrophic zone depth (%) at Location A (top panel) and Location B (bottom panel).**

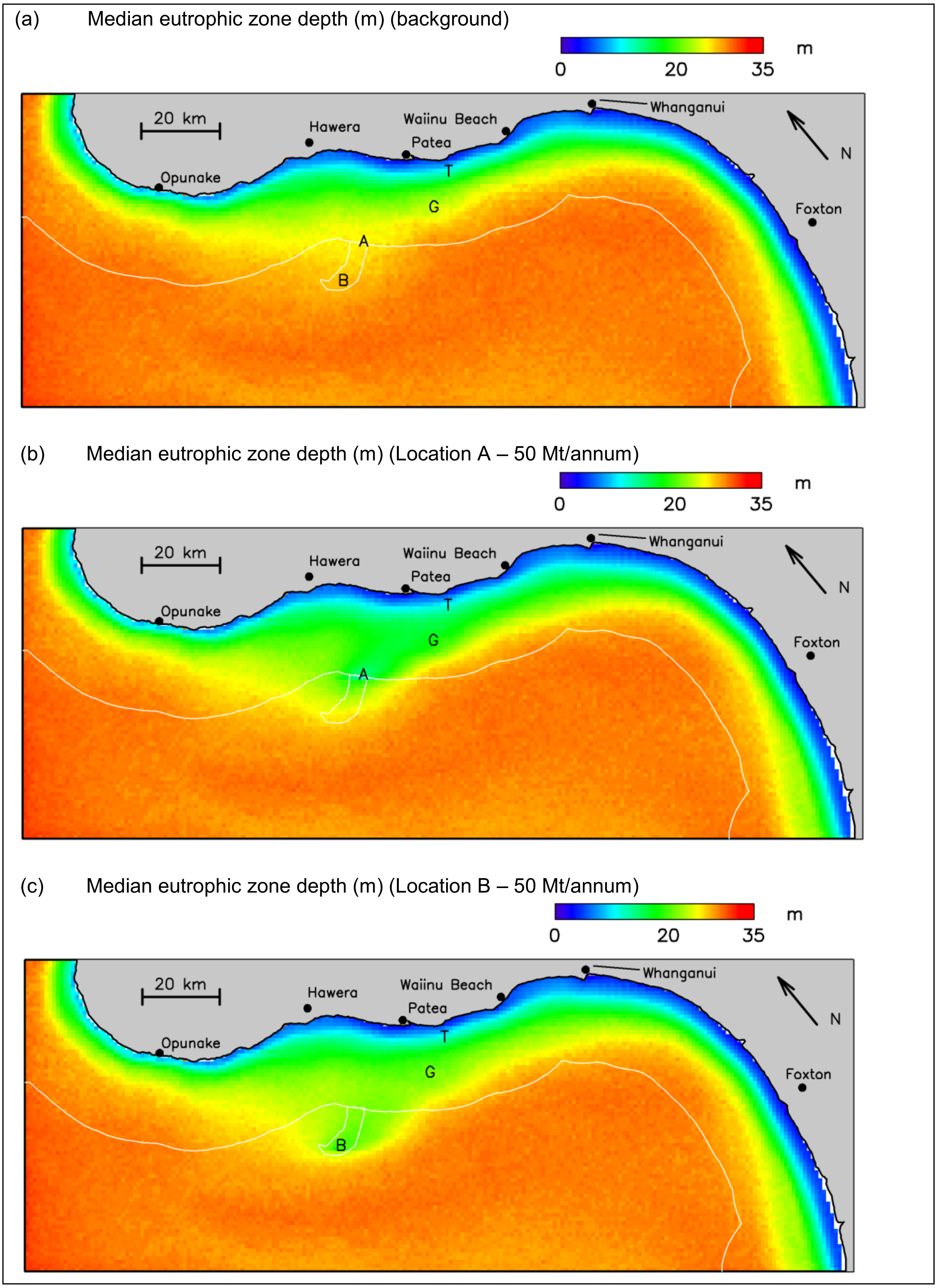


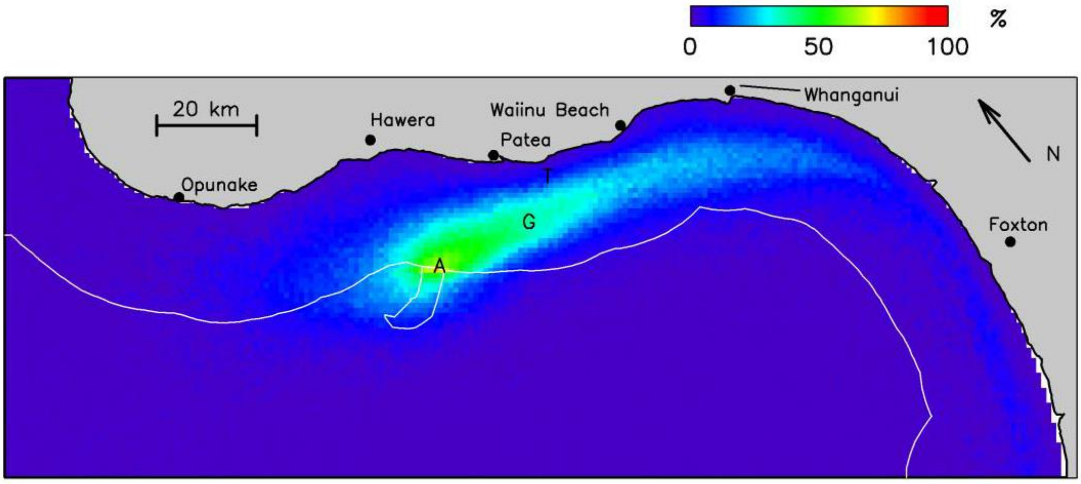

**Figure 4.5: Modelled eutrophic zone depth at Background Levels (top panel), Location A (middle panel), and Location B (bottom panel).**

#### 4.4.3.4 Horizontal Visibility

As a result of the increased depths of the eutrophic zone, the horizontal visibility (black disk visibility) decreases. Figures 4.6 and 4.7 show the percentage reduction in median midwater visibility and the modelled median midwater visibility in metres, respectively. The main patterns are:

- There are significant reductions in midwater visibility due to the project close to the extraction area, and these effects decrease with distance from the project area;
- Reductions in midwater visibility at a given time depend on the movement of the sediment plume and how rapidly the sediment discharged by the project is mixed and sinks out of the water column. The predominant area affected is a region around Location A with a tail stretching to the east; and
- There are likely to be only very small effects of the project on midwater visibility on the alongshore transect.

(a) Reduction in median midwater visibility (Location A)




(b) Reduction in median midwater visibility (Location B)

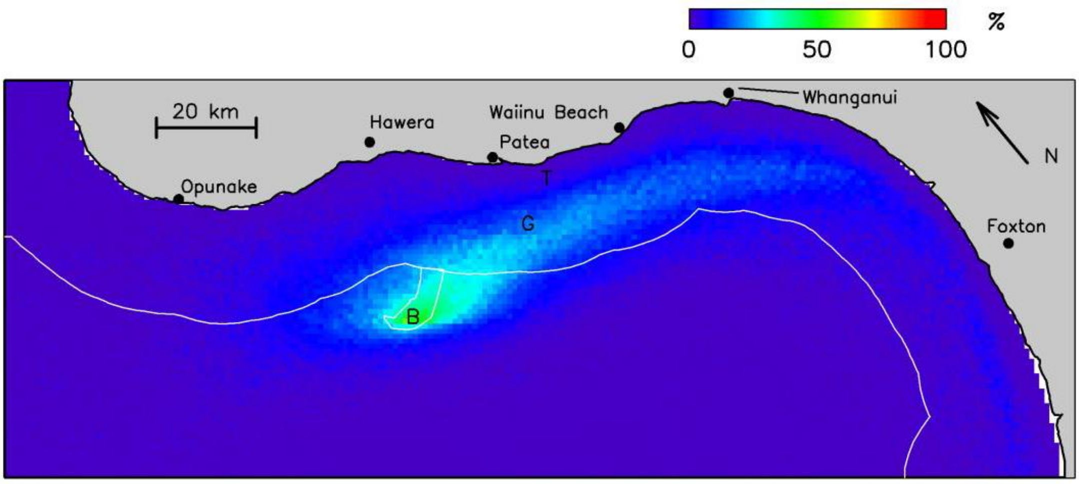



**Figure 4.6: Modelled change in midwater horizontal visibility at Location A (top panel) and Location b (bottom panel).**

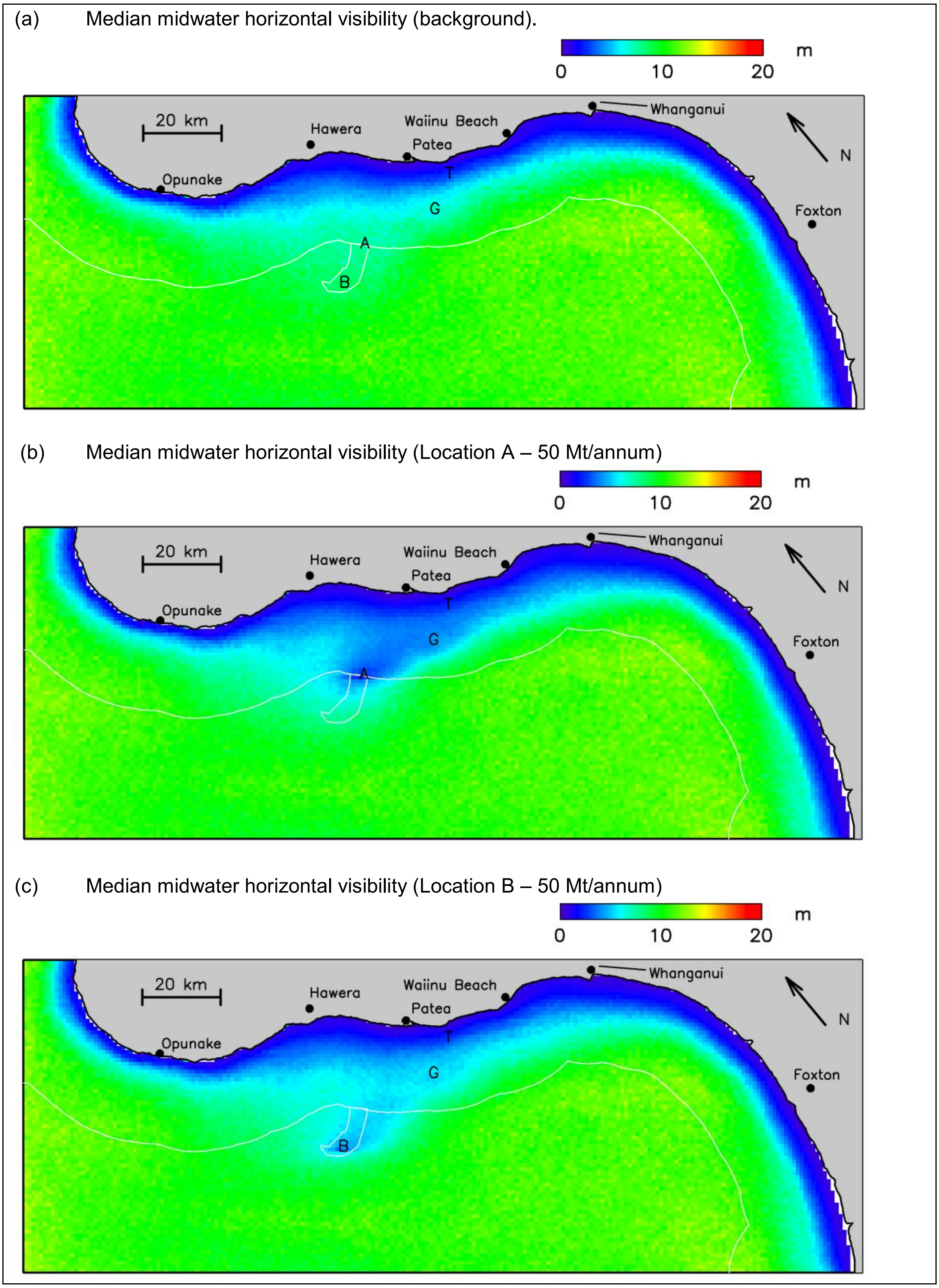



**Figure 4.7: Modelled midwater horizontal visibility at Background Levels (top panel), Location A (middle panel), and Location B (bottom panel).**

**4.4.3.5** The Traps and Graham Bank

Modelling data at the Traps and Graham Bank was extracted to investigate the site specific optical water quality effects at these locations in greater detail.

Median underwater visibility at the Traps will be reduced by 13 – 15% when extraction activities occur at Location A, and by 3 – 5% as a result of activities at Location B. The number of 'good visibility days'[47] at the Traps that will be lost due to the iron sand extraction activities are predicted to be between 24 – 26 days per year as result of iron sand extraction activities at Location A and between 6 – 10 days per year as a result of activities at Location B - out of a total of 125 good visibility days per year.

The median euphotic zone depth at the Traps is predicted to reduce by 11% due to iron sand extraction activities at Location A, and reduce by 3% due to activities at Location B. The number of days with more than 1% light at the seabed is predicted to reduce from 138 days/year to 106 days/year as a result of iron sand extraction activities at Location A and 127 days/year as a result of activities at Location B.

The optical modelling predicts that the median underwater visibility at Graham Bank will be reduced by 37 – 38% as a result of iron sand extraction activities at Location A and by 16 – 17% as a result of activities at Location B. The number of 'good visibility days' lost at Graham Bank due to iron sand extraction activities at Location A are predicted to be between 67 – 71 days per year and between 22 – 24 days per year as a result of activities at Location B - out of a total of 204 – 207 good visibility days/year.

The median euphotic zone depth at Graham Bank is predicted to reduce by 24% due to iron sand extraction activities at Location A, and by 12% as a result of activities at Location B. The number of days with more than 1% light at the seabed is predicted to reduce from 216 days/year to 121 days/year as a result of iron sand extraction activities at Location A and to 171 days/year as a result of activities at Location B.

**4.4.3.6** Water Colour

Estimates of the effect on sea colour as seen by an observer with a bird's-eye-view (e.g. persons in a plane) for three scenarios (no extraction (background), with extraction at Location A, and with extraction at Location B) have been provided.

Appendix 4.3 (1) shows the change in water colour as a result of 2.5 days of westerly winds, which is the most dominant wind direction in the project area. There is no evidence of colour differences within approximately 5 km of the coast, but clear differences were identified further away from the coast and especially around the source plume area.

Further examples of the sediment plume visibility are shown in Appendix 4.3 (2 – 4).

**4.4.3.7** Changes to Water Column Light Intensity

Changes to the intensity of light in the water column has the potential to affect the primary production of phytoplankton (Kirk (2011)).[48]

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47 Defined as a horizontal visibility of more than 5 m.

48 Kirk, J.T.O., 2011. *"Light and photosynthesis in aquatic ecosystems"* Cambridge University Press. Cambridge.

With regard to the project, the changes to the intensity of light in the water column is calculated based on the optical modelling. Appendix 4.4 shows the modelled change in the water column light intensity at Location A and B, while Appendix 4.5 shows the modelled water column light. A summary of the modelling results is contained in Table 4.5 below.

**Table 4.5: Modelled Effect of the Project on Water Column Light.**

| Measure of water column light | Background | Location A | Location B |
|---|---|---|---|
| Mean water column light as a proportion of surface light over the SMD (m) | 5.5 | 5.4 | 5.4 |
| Median change (%) | | - 0.3 | - 0.4 |
| Maximum change (%) | | - 45.5 | - 26.6 |
| Mean change over the SMD (%) | | - 1.9 | - 1.6 |

The results show that water column light generally increases with distance away from the coast because suspended sediment, colour dissolved organic matter and elevated phytoplankton concentrations near the coast reduce the penetration of light into the water, and because the water is shallower than further offshore.

Large reductions in light in the water column only occur very close to the location of extraction activities, with maximum reductions of 27 – 46% depending on where the iron sand extraction takes place (i.e. Location A or B). The mean change in water column light averaged over a large region is a more reliable measure of the predicted effect of the project on primary production in the water column. The mean change in water column light due to the project over the SMD will be small: -1.9% (extraction at Location A) and -1.6% (extraction at Location B).

These results have been used to inform the assessment of the effect of the project on primary productivity in the SMD which have been discussed in Section 4.6 of this IA.

#### **4.4.3.8** Changes to Light at the Seabed

Light reaching the seabed can be used by benthic algae for primary production. The amount of light reaching the seabed was modelled before and after iron sand extraction activities. A summary of the modelling results is contained in Table 4.6 below.

**Table 4.6: Predicted Changes to Optical Properties and Primary Production.**

| Parameter | Measure | Background | Location A | Location B |
|---|---|---|---|---|
| Integrated water column light as proportion of surface | SMD mean (m) | 5.5 | 5.4 | 5.4 |
| | Mean change over SMD (%) | | - 1.9 | - 1.6 |
| | Highest point change (%)* | | - 45.5 | - 26.6 |
| Water column PP | Mean change over SMD (%) | | - 1.0 | - 0.8 |
| | Highest point change (%)* | | - 22.7 | - 13.3 |
| Proportional seabed area with light > limit (mol/m$^2$/d) | Area with E>0.04 (% of SMD) | 28.6 | 26.6 | 26.9 |
| | Area with E>0.4 (% of SMD) | 11.2 | 9.4 | 9.7 |
| | Change in area with E>0.04 (%) | | - 6.8 | - 6.0 |
| | Change in area with E>0.4 (%) | | - 16.5 | - 13.8 |

| Parameter | Measure | Background | Location A | Location B |
|---|---|---|---|---|
| Light at the seabed | Mean total over SMD (Gmol/d) | 3.3 | 2.5 | 2.8 |
| | Daily mean E over area of seabed with E>0.4 | 0.86 | 0.66 | 0.72 |
| | Change in SMD total (%) | | - 22.8 | - 15.5 |
| | Highest point change (%)* | | - 95.1 | - 91.8 |

Notes: PP: Primary Productivity
SMD: Sediment Model Domain
*: Dependent on the spatial scale of the modelling

The average proportions of the seabed within the modelled area with mean light intensity greater than 0.04 and 0.4 light at the seabed per cubic metre per day ("**mol/m$^2$/d**") is estimated to be 29% and 11% respectively. As a result of the project the light intensity in these areas is predicted to reduce by 2% and 1 – 2% respectively.

The largest reductions are predicted to occur around the active extraction areas with maximum reductions of between 92 – 95% depending on the specific location. The maximum change should not be over-interpreted in terms of its ecological significance, and the mean change in total light at the seabed averaged over the modelled area is a more reliable measure of the predicted effects of the project on benthic algae. The effects of these reductions on the ecology are discussed in Section 4.6 below.

Based on the background optical model, the annual-average light at the seabed within the modelled area that receives more than 0.04 mol/m$^2$/d was estimated to be 0.86 mol/m$^2$/d where there was a mean seabed light in the modelled area of 3.3 Gmol/d.

With regard to the project, the mean seabed light is predicted to reduce to 2.5 Gmol/d (iron sand extraction at Location A) and 2.6 Gmol/d (iron sand extraction at Location B). These are equivalent to annual-average light at the seabed within the modelled area that receives more than 0.04 mol/m$^2$/d of 0.66 mol/m$^2$/d (Location A) and 0.72 mol/m$^2$/d (Location B). This is a reduction of 23% (Location A) and 16% (Location B).

This reduction reflects the fact that for much of the time the plume of fine sediment passes over relatively shallow seabed which would otherwise be relatively well lit. Most of the modelled area is deep and / or overlain by turbid water, and receives little seabed light. Therefore, the project would have an insignificant effect when considered against the naturally occurring background of levels within these areas.

#### **4.4.3.9** Optical Water Quality Effects Summary

There is substantial natural variability in optical water quality properties in the SMD, with greater natural turbidity and sediment effects closer to the coast due to the predominately natural processes occurring in this environment.

Any optical water quality effects experienced will rapidly decrease over distance from the extraction area. The natural background conditions would be resumed soon after any iron sand extraction activities cease.

The findings can be further summarised as:

- The recovery of iron sand and the resulting sediment plume is predicted to have insignificant effects on optical properties within 5 km of the coastline of the STB;

- Reductions in light availability in the water column are likely to be predominantly to the east of the project area, but over the SMD will average only 1.9% (extraction activities at Location A) and 1.6% (extraction activities at Location B) - with up to a 25% reduction within 20 km down current of the extraction site;

- The reduction in total light (not light used for primary production) at the seabed is likely to be mostly to the east of the project area and is predicted to be 23% and 16% of the SMD for Locations A and B respectively. Optical properties would return to previous levels within a few days of iron sand extraction activities ceasing;

- At the Traps, the euphotic depth will potentially be reduced by between 13 – 15% for extraction activities at Location A and 3 – 5% for extraction activities at Location B. The days that more than 1% light reaches the seabed will be reduced by 24 – 26 days, and 6 - 10 days respectively (out of 125 days/yr); and

- At Graham Bank, the euphotic zone depth will be reduced by 37 - 38% and 16 - 17% for extraction activities at Locations A and B respectively, and the days that 1% of surface light reaches the seabed will reduce by 95 and 45 days for extraction activities at Locations A and B respectively (out of 216 days/yr).

While there is potential for there to be a localised decrease in optical water quality in the immediate vicinity of the iron sand extraction activities, any effects will rapidly diminish as the distance from the source increases. Further, any effects within 5 km of the coastline are predicted to be minimal and consistent with naturally occurring background optical water quality levels.

## 4.5 Effects on Coastal Processes

### 4.5.1 Shoreline Processes and Coastal Stability

#### 4.5.1.1 Introduction

NIWA was engaged to model wave characteristics, coastal and sedimentary processes in the SMD and assess the effects of iron sand extraction on the landforms and geomorphic character of the shore, physical drivers (waves and currents) of coastal processes, sediment processes, and coastal stability.

As discussed in previous sections of this IA, additional investigations, including the NIWA sediment plume modelling and measurements of oceanographic processes in the SMD, have been undertaken to inform this IA.

The modelling and assessments have assisted in assessing the effects of sediment transfer on coastal processes and determining whether the project would influence shoreline geomorphology and coastal stability of the project area and the greater STB. The findings of the reports that have informed this IA are discussed in further detail below.

#### 4.5.1.2 Assessment Methodology

To assess the shoreline processes and coastal stability, extensive field investigations that were conducted by NIWA over two years, including the measurement of currents and the range of winds experienced in the STB.

Beach profile surveys and observations were made at eight sites between Ohawe and Kai Iwi, spanning a stretch of 70 km along the SMD coastline. The profiles were surveyed over an 11-month period (providing 352 profile records), and captured a wide range of wave conditions including sizeable storm events. In addition to beach profiles, surface sediments were collected from around the mid-tide mark at each of the profiles to determine sediment source and composition.

Data from field measurements informed modelling of tidal currents from which processes of coastal deposition and erosion could be inferred. As part of studies of sediment plume generation and advection, the fate of de-ored sediments returned to the seabed was investigated. Results from modelling evaluated the potential for seabed material to be transported away from the extraction area by waves and currents, and therefore the connection between seabed material at the project site, and sand deposition and erosion processes on the shore.

#### **4.5.1.3** Summary of Potential Effects

Potential effects of the project on shoreline processes and coastal stability include:

- Effects on sediment transfer and coastal deposition, affecting natural landforms and beach profile physical drivers of erosion affecting geomorphic character.

- Modify natural hazard processes and coastal stability.

***Sediment Transfer and Coastal Deposition***

The project will generate sediment plumes and increased rates of sediment deposition as a result of the disturbance of the seabed and these effects will be experienced within the project area and, to a much lesser degree, extend to the adjacent coastal area particularly to the east and south.

Plume modelling results demonstrate that the very fine sediment generated during the project operations would primarily drift in a southeast direction from the source towards the shore with the majority of the suspended material settling out prior to reaching the shore. The modelling shows that some of it does contribute to the naturally occurring sedimentation on the seabed in the near-shore environment in the area of Patea and Whanganui.

When considering the natural processes present in the deep water and near-shore environments, as well as the fine nature of the de-ored sediments, very little sediment originating from the operation is expected to arrive at the shoreline within the SMD.

With regard to the deposition effects of waves, changes in wave height and direction as a result of the project, these will be very minor and any associated change is considered to be insufficient and will not influence or contribute to the erosion of the already dynamic coastal environment. Therefore, the following conclusions with regard to coastal deposition can be reached:

- The natural landforms and geomorphic character of the beaches and cliffs is unlikely to change as a result of the project; and

- Changes in shoreline stability are highly unlikely.

Further, the grainsize of sediment on the beaches is unlikely to change as beach sediments primarily come from cliff erosion and river outwash.

***Coastal Stability and Hazards***

The geomorphic character of the cliffs will not change as a result of the project, but there could potentially be a change in the rate of erosion of the cliffs if the buffer of beach sands and gravel are stripped away.

However, as agreed by SKM (Huber et al. (2014)) as part of the initial EPA evaluation, the project operation is predicted to have only less than minor effects on the beach erosion and accretion. Under natural conditions these environments are highly variable particularly in the STB coastal environment, the influence of the project on the stability of the coastal zone is predicted to be minimal and therefore, the potential for the project to result in an increase in the occurrence of coastal hazards is also minimal.

#### **4.5.1.4** Management of Potential Effects on Shoreline Processes and Coastal Stability

Mitigation measures beyond the location of the project area, being far off shore, and the design of the project methodology are generally impractical, due to the large scale over which oceanographic and coastal processes operate.

In their decision on the previous marine consent application, the DMC concluded that they did not consider that the project would have a significant effect on the physical environment. [49] With this in mind, TTR's proposed mitigation measures are therefore focussed on monitoring the impact of project activities to determine whether the actual effects are consistent with those which have been predicted and assessed as part of this IA. If monitoring demonstrates that the shoreline process and coastal stability effects are greater than those predicted, and where this results in an adverse effect, operational response measures would be implemented to address these effects, including revising the extraction methodology.

### 4.5.2 Wave and Surf Characteristics

#### **4.5.2.1** Introduction

TTR engaged NIWA to complete near-shore wave modelling considering the impacts of the project on wave characteristics and eCoast Marine Consulting and Research ("**eCoast**") was engaged to further investigate the impact of the project on surf breaks in the STB (Mead (2015))[50].

The deposition of de-ored sediments will fill the majority of the extracted areas and in some cases result in mounds. These re-filled pits and mounds have the potential to alter the direction of wave approach and wave height in the project area, and therefore alter longshore transport of sediment, and the patterns of erosion and accretion at the shoreline. These matters are discussed below.

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49 TTR Marine Consent Decision. 15 June 2014. Para 530.

50 Mead. S., eCoast Marine. 2013. *"Potential Effects of Trans-Tasman Resources Mining Operations on Surfing Breaks in the Southern Taranaki Bight"* Memo 21 July 2013 updated November 2015.

#### **4.5.2.2** Assessment Methodology

Eight hypothetical configurations of the seabed were developed by NIWA to represent the possible states of the seabed during the project operations.

The worst case scenario consisted of an 8 – 9 m mound at the southwest end of the operational area and a 9 – 10 m pit at the northeast end.

The other seven configurations represented lesser levels of disturbance at intermediate stages in the project operations.

The complete set of hypothetical bathymetry modifications was tested using a set of scenario–based simulations, and each compared with a “baseline” simulation using unaltered bathymetry.

With regard to the surf break impacts associated with the project, Mead (2015) undertook the following:

1. Identification and description of surf breaks that could potentially be impacted;
2. Determination of the range of wave and wind conditions that result in good surfable conditions at each site;
3. Development of wave scenarios for modelling;
4. Development of bathymetry scenarios for mounds and holes generated during mining and incorporation into existing bathymetry (undertaken by TTR / NIWA);
5. Transformation modelling of the identified wave conditions using the existing and modified bathymetries for each case (undertaken by TTR / NIWA);
6. Development of difference plots and analysis of wave parameters (height and direction) at each of the surfing breaks; and
7. Assessment of impacts on surfing breaks.

#### **4.5.2.3** Summary of Potential Effects

***<u>Waves</u>***

The largest effect on waves as a result of the project will occur in the immediate vicinity of the pits and mounds that remain as a result of the project.

Most of the hypothetical configurations tested produced local changes in wave height of up to 20 – 30 cm, or 7 – 12%. These were correlated with changes in mean wave period of less than 0.5 seconds for the worst case scenario (an 8 – 9 m mound at the southwest end of the operational area and a 9 – 10 m pit), and less than 0.25 seconds for all other configurations. These localised project area effects were then considered as changes in wave characteristics at the shoreline, the worst case scenario effects, as modelled, are shown in Figure 4.8 below.

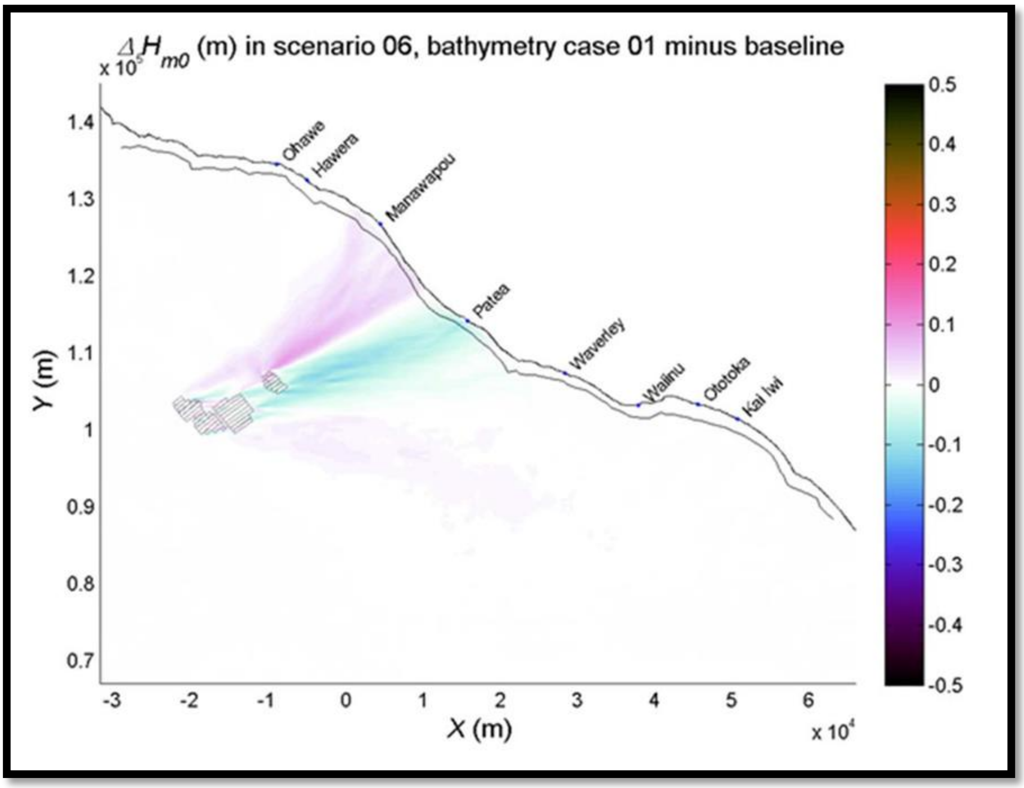


**Figure 4.8: Difference between significant wave height for case 1 and existing bathymetry, over the model domain, for environmental scenario 6 (2.4 m high waves from the SW). Note: The locations of the extraction areas are marked in grey. Beaches surveyed in related studies are named. The 10 m isobath (depth contour) is marked by a black line.**

By way of summary the following is predicted under the worst case scenario:

- Increases in wave height in the order of 100 mm around the Manawapou River outlet.
- Decreases in wave height in the order of 100 mm around Patea.
- An increase in wave period of less than 0.5 seconds north of Patea.
- A decrease in wave period of less than 0.1 seconds at Patea.

Full results of all eight configurations are set out in Table 4.7 below. By way of summary changes in waves height at the 10 m isobaths range from 0.8 – 8.6% or 4.1 – 11.3% across the full model domain. Changes in wave direction are 1 – 2 degrees, this is considered to be insignificant when compared with variability throughout the year.

**Table 4.7: Maximum changes in significant wave height predicted for the eight bathymetry modification cases.**

| Extraction case | Full domain H max (m) | Full domain H max (%) | 10 m isobath H max (m) | 10 m isobaths H max (%) |
|---|---|---|---|---|
| 1 | 0.282 | 11.3 | 0.104 | 8.6 |
| 2 | 0.222 | 8.3 | 0.042 | 3.6 |
| 3 | 0.284 | 12.7 | 0.044 | 3.3 |
| 4 | 0.263 | 7.1 | 0.046 | 4.1 |
| 5 | 0.219 | 7.2 | 0.050 | 4.5 |
| 6 | 0.249 | 7.2 | 0.016 | 1.3 |
| 7 | 0.173 | 6.0 | 0.021 | 1.8 |
| 8 | 0.092 | 4.1 | 0.009 | 0.8 |

Near-shore wave changes as a result of mooring the IMV within the project area were also modelled. The worst case scenario for this found that some vessel orientations produced changes in height of up to 15 mm at Patea and that other orientations produced changes in the order of 5 – 10 mm and these correspond to changes in the order of 0.8% and 0.4%, respectively.

Overall, the impacts of the project operations, including the project related vessels, on the wave environment within the project area and at the coast were considered to be insignificant.

***Surf Breaks***

As discussed above, the project operations will result in changes to the seabed (both local deepening and raising of the seabed in the form of pits and mounds), which can potentially affect waves by refraction (bending the wave path) and diffraction (lateral dispersion of wave energy) and locally by shoaling (changing the wave height) them as they pass over the modified seabed. This in turn could then potentially impact on surfing breaks on the coast.

Mead (2015) undertook extensive modelling of the wave environment and found that the principle changes in surf break characteristics arise from changes in the offshore wave climate. The modelling concluded that because the project area is located over 20 km offshore, the effects on wave characteristics, and therefore surf breaks, are considered to be insignificant.

This is demonstrated in the modelled output shown in Figure 4.9 below, which shows the predicted change in wave height for waves over 3 m at the coast. By way of summary, any changes to the wave characteristics at the shoreline will be in the order of ±100 mm. The potential impacts on wave heights are considered insignificant with respect to impacts on wave and surfing quality.

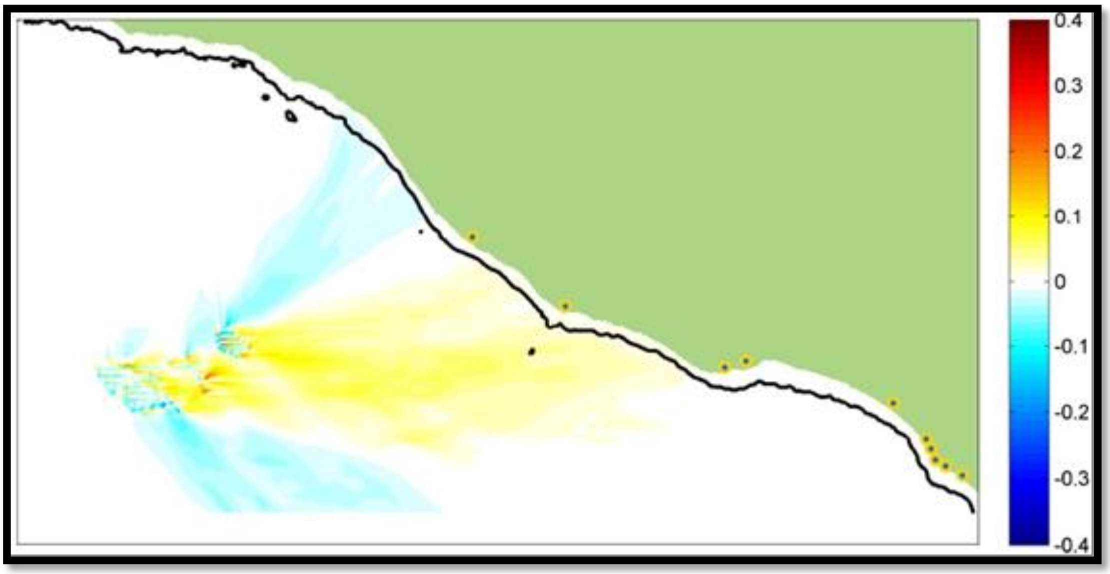


**Figure 4.9: Change in height of 3 m waves from the WSW, 16 second period.**

#### 4.5.2.4 Re-deposition Effects on Wave and Surf Characteristics

The effects on waves and surf characteristics are pre-dominantly related to the pits and mounds produced as a result of the project operations. Modelling predicts that for a 10 m deep pit and a 9 m high mound, at 35 m water depth, it will take approximately 100 years for waves and currents to reduce the pit volume by 90% and 20 years for the mounds to be reduced by 90%.

Residual pits and mounds will occur at the end of the lanes in which iron sand recovery and deposition occurs. In these circumstances it is likely that pit depths and mound heights will be significantly smaller than the case presented above and therefore, so will the time taken for pit infilling and mound deflation than presented above.

As with coastal processes, TTR's position on wave and surf characteristics, that any effects would be no more than minor, was accepted by the DMC in their decision on the previous marine consent application, which also concluded that these effects would be no more than minor. [51]

## 4.6 Ecology and Primary Productivity Effects

### 4.6.1 Introduction

With respect to the effects on the ecology and benthic environment, the DMC when considering the previous marine consent application by TTR found that:[52]

- The project area is a high-energy environment with mobile sediments, sand inundation of reefs, sand scouring of reef habitats and high water turbidity in nearshore areas. It is typical of soft-sediment habitats subject to regular disturbance, colonised by fast-growing, opportunistic species able to withstand temporary burial by natural sediment movement and to recolonize disturbed habitats rapidly;

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51 TTR Marine Consent Decision. 15 June 2014. Para 506.
52 TTR Marine Consent Decision. 15 June 2014. Para 290.

- No differences were found between the benthic communities in the project area and communities in similar habitats in adjacent areas in the STB;

- None of the species collected during the benthic surveys are listed as threatened in the New Zealand Threat Classification System lists;

- The project area will be significantly disturbed with near total mortality of benthic fauna and the deposited material returned to the seafloor;

- Recovery of the benthic environment will commence almost straight away after re-deposition of sediment, and is expected to be fully recovered within 10 years;

- Areas outside the project area will be subject to sedimentation and reduced light levels as a result of the sediment plume;

- The sediment plume will result in reduced energy input to the seafloor with consequent reductions in benthic productivity and flow-on effects through the food web. There may be a potential reduction of up to 36% in energy input to the seabed ecosystem;

- Assessment of the potential effects of the sediment plume on the benthic environment is based on the sediment plume modelling. The modelling was accepted by other experts as being the appropriate and best available methodology;

- There are more sensitive biogenic benthic areas to the south and west, and rocky reefs are located inshore of the project area. Based on the previous model outputs, there is unlikely to be any more than minor sedimentation from the sediment plume in these areas, apart from the Graham Bank; and

- The modelling results provided with the original consent application showed a significantly higher level of sediment likely to reach the North and South Traps than the revised modelling on which the expert witness discussions were based.

The revised assessment of effects is summarised below.

With regard to the ecological effects related to the project, the key potential impacts are:

- Loss or physical disturbance of seabed habitat and the communities associated with these habitats;

- Impacts on physiological processes including clogging of respiratory surfaces and feeding structures and processes for animal biota;

- Smothering of benthic habitats and communities;

- Avoidance of areas of disturbance and sediment plumes by fish, birds and mammals;

- Reductions in primary production in the water column (phytoplankton) and on the seabed or reefs (micro-algae living on the seabed ("**MPB**") and macro-algae) through reduced light availability;

- Reduced prey and prey detection for fish, birds and mammals; and

- Accidental release of contaminants (nutrients and toxic compounds).

When considering the effects of the project, any evaluation must take into account the severity, and the spatial and temporal extent, including recovery, of these effects.

The spatial effects depend on the scale of the impact, such as development of a sediment plume, compared with the distribution of different communities and their mobility, and with sedentary taxa and the communities expected to be most impacted.

It should also be acknowledged that the dynamic and complex nature of the environment of the STB, the range of habitats and the lack of defined boundaries for most physical and biological processes makes the assessment of effects on ecosystems particularly challenging.

These effects are discussed in further detail in the following sections of this IA.

### 4.6.2 Assessment Process

When assessing the overall ecological effects of the project, AES (2016a) has incorporated the approach adopted by Dr Dan McClary in his expert evidence on behalf of TTR for the previous marine consent application by TTR (McClary (2014)).[53] In addition, AES has relied upon international expertise and experience with projects involving dredging and reclamations in the coastal environment, as well as published and unpublished reports and papers.

Cahoon et al. (2015) also includes consideration of the spatial and temporal extent of the modelled sediment plume, more information on optical property relationships with suspended sediment, and closer examination of light-primary producer relationships.[54]

The updated assessment in this IA uses the same approach for the scale of effect as that developed for the Ministry for the Environment ("**MfE**") with expected severity of effects rated from negligible to severe (see Table 4.8 below for classifications). The assessment also includes more information on threshold levels, sensitivity of organisms to the potential effects and recovery times from the project.

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[53] McClary, D. 2014. Statement of Evidence in chief of Dr Dan McClary on behalf of Trans-Tasman Resources Ltd. 17 February 2014.

[54] Cahoon, L.B., Pinkerton, M., Hawes, I., 2015. *"Effects on primary production of proposed iron-sand mining in the South Taranaki Bight region" October, 2015.*

**Table 4.8: Consequence levels for the intensity of the activity. Summary descriptions of the six sets of consequence levels for the proportion of the habitat affected, the impact on the population, community or habitat, and the likely recovery period.**

| Consequence level | Proportion of habitat affected | Population/ community/ habitat impact | Recovery Period |
|---|---|---|---|
| 1 - Negligible | Affecting <1% of area of original habitat area | Interactions may be occurring but unlikely to be ecologically significant (<1% changes in abundance, biomass, or composition) or be detectable at the scale of the population, habitat or community | No recovery time required |
| 2 - Minor | Measurable but localized; affects 1-5% of habitat area | Possibly detectable with 1-5% change in population size or community composition and no detectable impact on dynamics of specific populations | Rapid recovery would occur if activity stopped – less than 8 weeks |
| 3 - Moderate | Impacts more common; >5-20% of habitat area is affected | Measurable with >5-20% changes to the population, habitat or community components without there being a major change in function | Recovery in >2 months to 1-<br>2 years if activity stopped |
| 4 - Major | Impacts very widespread; >20-60% of habitat is affected/ removed | Populations, habitats or communities substantially altered (>20-50%) and some function or components are missing/ declining/ increasing well outside historical ranges. Some new species appear in the affected environment | Recovery occurs in 2- years if activity stopped |
| 5 - Severe | Impact extensive; >60-90% affected | Likely to cause local extinctions of vulnerable species if impact continues, with a >50-90% change to habitat and community structure and function. Different population dynamics now occur with different species or groups now affected | Recovery period 1-2 decades if activity stopped |

Under the previous marine consent application by TTR, McClary (2014) identified 40 potential effects considered to be 'low' environmental risk and the following potential effects as being of 'moderate' to 'high' risk:

- Effects on benthos within the direct extraction and deposition area, particularly direct effects on the tubeworm *Euchone sp A*;
- Effects on benthos in the close vicinity of the extraction and deposition area;
- Potential impacts on biogenic offshore habitats due to potential 'choking' effects; and
- Potential effects of unplanned events including biosecurity incursions and oil spills.

The project related effects are discussed in further detail in the sections below and are based on the conclusions from AES (2016a) unless otherwise stated.

### 4.6.3 Effects on Ecology and Primary Productivity

#### **4.6.3.1** Physical Disturbance

With regard to disturbance, the area directly impacted by the project will be approximately 5 $km^2$ per year, which is extracted in blocks of 900 m x 600 m (0.54 $km^2$) which on average occurs over a 30-day period. The benthic habitat in this area, including at the surface and down to the maximum cut depth of up 11 m below the seabed, will be physically removed in totality.

McClary (2014) estimated that the area of the STB that falls between 20 and 40 m depth occupies an area of approximately 1,860 $km^2$. Thus, to put the project area into perspective, approximately 0.03% of this total area would be impacted per month or 0.3% per year by the project. In terms of the SMD, this represents 0.04% per year. The ongoing extraction of iron sand will mean blocks within the project area will be at different stages of recovery for the duration of the project.

The main direct physical impact on aquatic communities will be the physical removal of sessile and sedentary taxa, as well as relatively immobile taxa, within the project area. It is likely that all larger, hard-bodied organisms will be screened out at the intake point, but larger soft-bodied organisms will be destroyed if they are drawn up through the crawler intake pump. Smaller organisms such as bacteria and protozoa, and possibly some polychaete worms, will survive the extraction process and be re-deposited on the seabed in the de-ored sediments.

#### **4.6.3.2** Suspended Sediment Effects

The effects of increases in suspended sediment and sedimentation are shown schematically in Figure 4.10 below. The most likely potential effects are through directly impacting on physiological processes, smothering and indirect effects through reduced light impacting on primary production and biota that rely on phytoplankton, MPB and macro-algae.

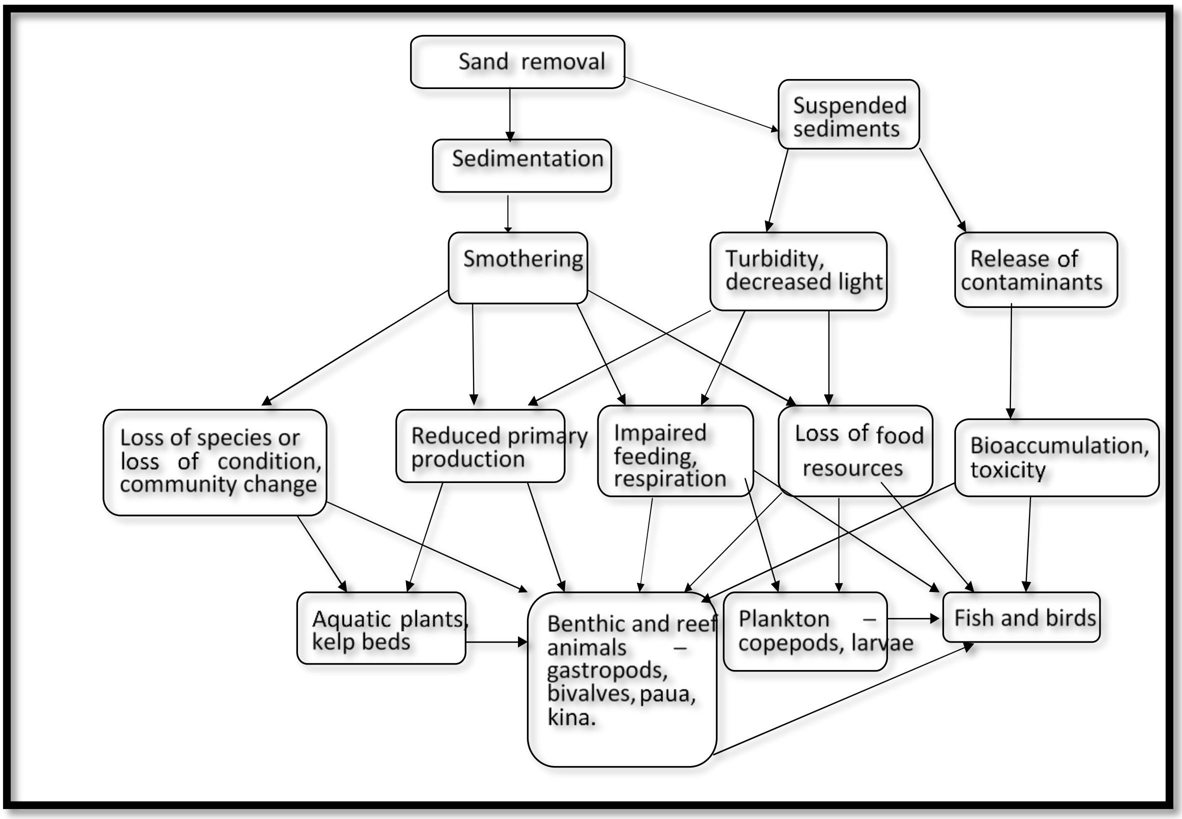


**Figure 4.10: Schematic diagram of effects of suspended and settled sediment.**

AES (2016a) identifies that the factors which drive primary production include physical processes such as major currents, winds, upwelling, nutrient supply, light availability, and grazing impacts by benthic and planktonic animals. Nutrient availability is considered to be a more important driver of water column phytoplankton production than light availability in these coastal systems but there will be spatial and temporal patterns in these drivers.

Assessing the impacts on primary producers is particularly challenging because of the dynamic and complex processes involved and that there are no fixed boundaries for these organisms. For example, while many primary producers, particularly phytoplankton, may have turnover rates of a few days and thus most of the primary production will be considered *in-situ*, others such as MPB and macro-algae will integrate conditions over much longer periods. The supply of nutrients advected into the STB from the upwelling areas as well as organic matter that is produced in these plumes, are likely to be very important to the STB and overall carbon flow in the region.

The potential effects of the sediment plume on primary production has been further assessed based on revised sediment plume and optical property models, literature searches of relevant information and additional local and international expert input in Cahoon et al. (2015). The background to the approach taken, the assessment of effects on primary production and results of that assessment have been revised from the earlier work carried out prior to the previous marine consent application in order to give greater certainty and address issues raised by the DMC. The following summary of effects is based largely on AES (2016a) interpretation of the Cahoon et al. (2015) findings unless otherwise referenced. Propagation and dispersal of a sediment plume will result in absorption and backscattering of light which will in turn reduce light availability for phytoplankton and benthic plants. Water column primary production averaged over the SMD would reduce by 1% and 0.8% when extraction is occurring at Locations A and B respectively, with the main reduction focused close to the extraction site. However, because of natural variability, these effects would be essentially indistinguishable when considered at the SMD scale.

The high natural interannual and seasonal variability in optical properties and primary production in the region mean that a chronic reduction of up to 1% due to the project is very unlikely to lead to fundamental changes in the structure and processes associated with primary production of phytoplankton.

Macro-algae will be found wherever there is a hard substrate and sufficient light (0.1 – 1% of surface light) reaches the seabed which includes rocky reefs, particularly inshore, the Traps area, areas with high levels of shell debris, and some cobbled areas on the deeper margins of banks.

Macro-algae, in particular kelp beds, are a very important habitat for a range of invertebrates (including the likes of kina and paua) and fish. Recruitment processes are important in determining the distribution and abundance of kelp populations. In a study off the Otago Peninsula Fyfe (2000)[55] found the kelp *Macrosystis pyrifera* has a "recruitment window" when light and temperature requirements are met and allow the establishment of sporophytes. Recruitment was observed along the Otago coastline through spring and summer months following thinning of the canopy during winter storms. Similar processes in macro-algae recruitment are expected to operate within the project area and the adjacent areas in the SMD.

Cahoon et al. (2015) predicted there could be some reductions in macroalgal growth but impacts are likely to be indistinguishable from natural variability at areas inshore where there are naturally high suspended sediment concentrations, including the Traps which is located some 20 km away.

There is little information on the distribution of MPBs in the SMD although photos of the seabed indicate features consistent with the presence of MPBs. The area where production by MPBs can be expected is the area bounded by the 30 – 35 m contour and compromises much of the Patea Shoals, particularly the eastern Patea Shoals, including Graham Bank.

The high variability in the amount of light reaching the seabed (annual average has a standard deviation of 25% and can vary by +36% and -32% compared to long term means) suggests that the communities in the region, particularly inshore, are pre-disposed to tolerate variability similar to that predicted for the effects of the sediment plume. Therefore, the project would be unlikely to lead to unnaturally low benthic production in the SMD, outside the natural envelope.

Reductions in light at the seabed will be highest close to the sites where operations are occurring (extraction and deposition). The reduction in light levels at these sites could be up to 95% but only a very localised effect (an extent of less than 10 km from the recovery site). This reduction in light and subsequent effects on primary producers at the seabed are likely to be highly variable and episodic, ranging from negligible to moderate, depending on the location, the prevailing wind and current conditions, as well as naturally high levels of suspended sediment entering the SMD from the rivers inshore.

AES (2016a) identifies that taking into account the latest refinements / updated information and revised understanding on the predicted sediment plume, benthic primary production

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55 Fyfe, J. E. 2000. *"Remote sensing of Macrocystis pyrifera beds near Pleasant River, Otago*". Master of Science thesis, University of Otago, Dunedin, New Zealand.

averaged over the SMD is predicted to reduce by 19% (extraction at Location A) and 13% (extraction at Location B).

Area specific reductions in benthic primary production (and thus carbon flux to seabed) could be reduced by up to 40% in the area to the east of the extraction area where the sediment plume moves over the relatively shallow (20 – 40 m deep) sandy area, which is part of the Patea Shoals and includes the Graham Bank. The growth effects on these areas may be impacted however, a complete loss of benthic biomass is not likely to occur.

The effects of optical properties on primary production of phytoplankton, MPBs and macro-algae is predicted to rapidly return to pre-project levels within a few months following the ceasing of extraction in an area. This is due to the natural processes occurring which would result in the suspended sediment being flushed out of areas where it has potentially accumulated.

The benthic and planktonic biological communities cover a range of feeding modes including filter feeders, visual predators, suspension feeders, and deposit feeders. Animals living on the seabed will rely on *in-situ* production as well as production that falls out of the water column.

There are few estimates of water column versus seabed primary production but this could vary from 2:1 to 10:1 and the fraction of primary production transferred to the seabed is likely to be approximately 15%. Cahoon et al. (2015) estimates that total primary production would be reduced over the SMD by 1.9% (range 1.6 – 2.2% depending on detrital flux rates and degree of primary production by MPB) for extraction at Location A and 1.4% (range 1.2 – 1.7%) for Location B. Energy flow to the seabed averaged over the SMD would reduce by 5.8% (range 3.1 – 11.9%) for Location A and 4.1% (range 2.3 – 8.3%) for Location B.

Additional effects such as those associated with release of nutrients in pore water will be negligible when compared to the existing background environmental effects.

Overall, there will be decreases in MPB production and organic carbon flux to the seabed and its communities in close proximity to the area of extraction operations that would exceed natural variability. However, because of inherent variability at the regional scale, effects would be indistinguishable from natural variability experienced for short lived biota.

Some effects at the local scale could be propagated more widely through more mobile animal taxa, but this is unlikely to lead to changes in the communities or consequential effects at the wider scale. AES (2016a) identifies that these conclusions represent sound scientific assessments and lie within the bounds of reasonable probability. AES (2016a) further stated that it must also be emphasised that these effects will be transient in nature due to the mobile extraction operations and thus no area will be impacted long term.

#### **4.6.3.3** Benthic Communities

The assessment of the effects of a sediment plume on the benthic communities requires a good understanding of:

- The communities present and the values (e.g. biodiversity, food for higher trophic levels) of those communities;
- The spatial and temporal scale of the severity and dispersion of the sediment plume;

- The tolerances of the communities to increased suspended sediment concentrations; and
- The potential for recovery from the effects.

Since the previous consent application was considered, more information has been collected and a more robust assessment has been undertaken in AES (2016a), as summarised in the sections below.

Open water ecosystems are dynamic and often in a state of perpetual change with periodic disturbances due to storm and other events. This perpetual change is not detrimental to benthic systems as it maintains diversity by resetting communities.

Benthic communities are often in a state of transition because of seabed disturbance by wave and current activity and can be represented by both opportunistic early successional taxa. This is dominated by small polychaetes and taxa which reproduce rapidly and disperse easily. Later this is dominated by more stable larger successional taxa (large gastropods and bivalves). Adults tend to be more tolerant of higher suspended sediment concentrations than larval forms and deposit feeders and burrowers more tolerant than suspension feeders.

Areas of ecological value in the project area and the wider region that would be potentially impacted are:

- North and South Traps – "urchin burrows", rocky outcrops with sea urchin (*Evechinus chloroticus*), red and brown algae and a diverse invertebrate and fish community;
- Graham Bank – coarse-sandy shelly habitat with scallops and hermit crabs;
- Inshore and mid-shelf reefs off Patea and Hawera – support very abundant and diverse algae, invertebrate and fish communities, mostly close inshore;
- Biogenic habitat off shore:
  - Bivalve rubble characterised by large populations of the robust dog cockle, *Tucetona laticostata* at depths of 26 – 83.5 m for live specimens and 44 – 69 m for shell hash;
  - Bryozoan rubble at depths greater than 60 m that support diverse benthic assemblages (bryozoan, sponges, ascidians etc, and
- Coralline red algae on shell rubble inshore and at the 40 – 50 m contour.

AES (2016a) identifies that the project area is dominated by a "wormfield" benthic community.

Although the direction of the sediment plume will be variable, depending on prevailing weather conditions, the prevailing direction that it will travel is to the north east. The benthic habitat and communities in this eastern area and across the Patea Shoals are very similar to those described for the project area itself in terms of epifauna in general, although some bivalves such as *Glycymeris modesta* were more abundant as well as a slightly more diverse echinoderm community being common to the northeast. The substrate also tended to get coarser to the east and northeast of the project area with more medium-coarse sand and fine gravels.

Outside the project area, the direct and indirect effects on benthic communities as a result of the sediment plume may manifest through:

- Smothering resulting in the loss of organisms;
- Clogging of gills and feeding apparatus and other physiological processes such as respiration;
- Loss or changes to food resources;
- Indirect effects of light attenuation and primary production of algae, macro-algae and MPB; and
- Impacts on larval supply and retention.

AES (2016a) identifies that based on the revised information, attenuation of light and its effects on primary production and carbon fluxes could manifest to higher trophic levels but would only really be a higher risk close to the specific extraction area.

Although some effects on the benthic habitat close to the operation are unavoidable, comparison of suspended sediment concentrations that would be experienced by benthic biota with tolerance levels allows assessment of the potential significance of increased suspended sediment concentrations from sediment plume development. Although information is limited for some taxonomic groups there is a good body of information from New Zealand studies on the effects of suspended sediment on a range of benthic biota including molluscs, polychaete worms, and sea urchins, and kelps and other macro-algae.

AES (2016a) stated that studies by Hawkins et al. (1999)[56], Clarke & Wilbur (2000)[57] and Hewitt & Norkko (2007)[58], found suspension feeding animals, such as cockles and mussels, can actually benefit from suspended sediment as it aids processing of foods or they can adapt their feeding processes to changes in suspended sediment levels. Condition of cockles (*Austrovenus stuchburyi*) did not decline until suspended sediment concentrations reached 400 mg/L and development of oyster eggs was impacted at levels over 188 mg/L and larvae at suspended sediment concentrations of 750 mg/L. The greenshell mussel (*Perna canaliculus)* can adjust its filtering processes very effectively and will continue filtering even at levels of 1000 mg/L (Hawkins et al. 1999). Some species are more sensitive with condition of the horse mussel (*Atrina)* impacted by levels over 80 mg/L (Ellis et al.

56 Hawkins, A.J.S.; James, M.R.; Hickman, R.W.; Hatton, S.; Weatherhead, M. (1999). *Modelling of suspension-feeding and growth in the green-lipped mussel Perna canaliculus exposed to natural and experimental variations of seston availability in the Marlborough Sounds, New Zealand*. Marine Ecology Progress Series Vol. 191: 217-232.

57 Clarke, D.G. & Wilber, D.H. (2000). *Assessment of potential impacts of dredging operations due to sediment resuspension*. DOER Technical Notes Collection (ERDC TN-DOER-E9).

58 Hewitt, J.E. & Norkko, J. (2007*). Incorporating temporal variability of stressors into studies: An example using suspension-feeding bivalves and elevated suspended sediment concentrations*. Journal of Experimental Marine Biology and Ecology 341: 131-141.

2002[59]). Some deposit feeding polychaete worms, heart urchins and pipis show some effects if concentrations are over 80 mg/L (Hewitt et al. 2001, Nicholls et al. 2003[60]).

Polychaete tube worms dominated the community at the project site itself and heart urchins are an important taxa on reefs and in habitats at depths over 60 m. James et al. (2009)[61] suggested that concentrations of 100 mg/L over short periods (days/weeks) was a reasonable level that would prevent risk of impacts on the more tolerant taxa in Otago Harbour and Blueskin Bay.

Taking into account that the communities in the STB, including those that may be potentially impacted, may include some more sensitive species then periodic levels high sedimentation (over 80 mg/L) could be tolerated by most species. These limits are summarised in Table 4.9.

AES (2016a) notes that duration of increased suspended sediment exposure should be taken into account as most taxa could tolerate short increase events. It is acknowledged that the sediment plume effects on the benthos more than a few kilometres away from the extraction source is likely to be transient, because of the variable currents and wind conditions influencing the plume's behaviour.

**Table 4.9: Suspended sediment concentration that have been found to affect benthic invertebrates.**

| Author | Species | Sediment Concentration* |
|---|---|---|
| Hewett et al. 2001[62] | Cockle (*Autrovenus stutchburyi*) | 300-400 mg/L |
| Hewett et al. 2001 | Pipi (*Paphies australis*) | 75 mg/L |
| Nicholls et al. 2003 | Gastropod (*Zeacumantus lutulentus*) | >750 mg/L |
| Hawkins et al. 1999 | Green lipped mussel (*Perna canaliculus*) | 1,000 mg/L |
| Schwarz et al. 2006[63] | Kelp (*Ecklonia radiata*) | 20 mg/L |
| Schwarz et al. 2006 | Paua and kina larval mortality | 35 mg/L |
| Schwarz et al. 2006 | Paua and kina | 18-74 mg/L |

* Levels that had an impact on condition/growth

In the SMD the inshore region naturally experiences suspended sediment concentrations with a median of 10 mg/L and over 100 mg/L at times in surface waters and a median of 100 mg/L and peaks of 1,000 mg/L near the seabed. The suspended sediment concentrations resulting from project operations would add less than 2 mg/L to suspended sediment concentrations in surface waters near the coast and most of the time would add <0.2 mg/L to this area. Thus, the effects on the inshore biota would be expected to be indistinguishable from the effects of naturally occurring background suspended sediment concentrations.

59 Ellis, J.; Cummings, V.; Hewitt, J.; Thrush, S.; Norkko, A. (2002). *Determining effects of suspended sediment on condition of a suspension feeding bivalve (Atrina zelandica): results of a survey, a laboratory experiment and a field transplant experiment*. Journal of Experimental Marine Biology and Ecology 267: 147-174.

60 Nicholls, P.; Hewitt, J.; Halliday, J. (2003). *Effects of suspended sediment concentrations on suspension and deposit feeding marine macrofauna*. NIWA Client Report HAM2003-077, Project ARC03267. Pp 1-6.

61 James, M.; Probert, K.; Boyd, R.; Sagar, P. (2009). *Biological resources of Otago Harbour and offshore: assessment of effects of proposed dredging and disposal by Port Otago Ltd*. NIWA Client Report HAM2008-152, Project: POL08201.

62 Hewitt, J.; Hatton, S.; Safi, K.; Craggs, R. (2001). *Effects of suspended sediment levels on suspension feeding shellfish in the Whitford embayment*. Prepared for the Auckland Regional Council. Report no. ARC01267. 32 p

63 Schwarz, A.; Taylor, R.; Hewitt, J.; Phillips, N.; Shima, J.; Cole, R.; Budd, R. (2006). *Impacts of terrestrial runoff on the biodiversity of rocky reefs*. New Zealand Aquatic Environment and Biodiversity Report No. 7. Ministry of Fisheries.

The highest levels of suspended sediment concentrations in surface waters at the extraction site itself would be 1.45 mg/L as a median and 8.2 mg/L as the 99$^{th}$ percentile and less than 2.8 mg/L at 20 km downstream, thus effects, if they were to occur would be indistinguishable from natural variability beyond the immediate area of disturbance. Near the seabed, suspended sediment concentrations would be up to a median of 1 mg/L and 99$^{th}$ percentile of 5 mg/L up to 20 km away from the source and up to 14 mg/L at the source itself.

Small grazing and suspension-feeding invertebrates found on rocky reefs are an important trophic link between primary producers and fish, with kelp often being the main habitat. In addition to being indirectly impacted by decreased light levels for plant growth, these communities can be impacted directly by clogging of feeding apparatus or smothering of food resources such as epiphytes.

Epifaunal abundance, biomass and productivity were found to be 50% lower at turbid sites (up to 16 mg/L) than "cleaner" sites (undetectable to 7 mg/L) off the Whitianga Harbour by Schwarz et al. (2006). Using a range of natural concentrations Schwarz et al. (2006) found a drop-off in mussel and oyster condition at suspended sediment concentrations over 26 mg/L and sponges at over 15 mg/L.

With regard to the project, even if very small suspended sediment concentrations in the plume reached the inshore region off Patea they would have minimal effects. In addition, the documented inshore communities along this coast are required to tolerate considerably higher levels of suspended sediment concentrations which occur, for example, during natural storm events and often persist for a period after the storm event has passed.

Benthic algae and kelp beds support diverse and abundant invertebrate and fish communities inshore and on mid-shelf reefs. Increased suspended sediment concentrations can reduce light availability which in turn can impact on the growth and condition of reef macro and micro-algae and the animals that rely on them.

The larger kelps, such as *Macrocystis pyrifera,* are often subject to die-off during winter storms and have “recruitment windows” when light and temperature requirements allow establishment of sporophytes. Time averaged suspended sediment concentrations at inshore sites off New Plymouth in depths of less than 0.5 m where the common kelp *Ecklonia radiata* occurs, were found to range from 3.4 - 150 mg/L naturally (Schwarz et al. 2006).

AES (2016a) states that the small increases in suspended sediment concentrations, if they were to occur inshore, would be indistinguishable from the naturally occurring background suspended sediment levels.

The project generated sediment plume would infrequently go offshore from the extraction area and the sediment plume modelling results indicate that the bryozoan beds offshore at depths greater than 60 m would rarely experience any sediment plume influence and if they did so suspended sediment concentrations would be less than 1 mg/L. Further, the seabed in deeper areas is also likely to naturally be sediment depositional zones as they are rarely disturbed by wave activity due to their depth being beyond the limit of wave influence.

MacDiarmid et al. (2015a) reviewed the spatial and foraging ecology of key invertebrate fauna in the STB to provide some scale to the potential effects of the project. Most of the invertebrate species gathered recreationally or for cultural reasons are found inshore in the intertidal or subtidal zone and include various mussel species, crabs, mud-snails, pipis, surf clams (purimu), rock oyster (karaura), paua, sea tulip (kaeo) and cats eyes (pupu). As discussed above, these species presently occur in coastal environments and experience episodic periods of high suspended sediment concentrations due to river inputs and resuspension during storm events.

***Summary – Effects of Suspended Sediments on Benthos***

Direct effects of suspended sediment on these communities include smothering, effects on feeding and other physiological processes, and indirect effects of changes to food availability, and larval supply. Most of the effects have been assessed as low risk or indistinguishable from natural variability, apart from potential interference with physiological processes and reduced carbon flux in areas close to the extraction activity.

Most taxa have been shown to be relatively tolerant of significantly higher levels of suspended sediment than will be experienced as a result of the project operations even that occurring close to the site itself. Suspended sediment concentrations in the plume that could potentially reach the inshore reefs, kelp beds and associated fauna are low compared with naturally occurring background levels and thus will have minimal effects. Similarly, more diverse offshore bryozoan beds would only be impacted occasionally and not at levels that would cause adverse effects.

#### **4.6.3.4** Zooplankton and Larval Fish

Neritic or coastal zooplankton contain a range of taxa including copepods, salps, and larval crustacea, bivalves and fish. The distribution of many benthic invertebrates depends on dispersal by currents for recruitment and colonization. Most species are able to tolerate relatively high levels of suspended sediment concentrations, at least for a short period, and in the case of copepods will have several generations a year. Thus populations are able to rapidly recover following disturbance events.

Suspension and filter-feeding zooplankton can be affected by high levels of suspended sediments. Arendt et al. (2011)[64] found 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)[65] finding fish eggs and larvae were only impacted if suspended sediment concentrations were over 500 mg/L. Any impact if it were to occur would be short-term as these populations will move through the region with the currents and zooplankton have rapid generation times of days to months. Suspended sediment concentration in near surface waters are predicted to increase by up to 3 mg/L away from the source and in a well-defined plume.

As discussed in Section 4.4.3.3, effects on primary producers can also impact on higher trophic levels that depend on phytoplankton as their major food resource. However, these indirect effects, if they were to occur, would not alter the zooplankton community or impact on production.

In the Joint Expert conferencing under the previous consent application, experts agreed that the additional sedimentation from the project operations will have no additional level of effect over that which is occurring naturally. The experts also agreed that the effects of the project

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[64] 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

[65] 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.

on rock lobster larvae would be minor, as inshore reefs are located within naturally turbid waters, indicating a tolerance of species to such conditions. Further, it was agreed that monitoring of zooplankton would not be necessary.[66]

Subsequently, with respect to the effects on zooplankton in their decision on the previous application the DMC found that the effects on zooplankton were driven by the predicted changes in primary production.[67]

Overall, as concluded in AES (2016a), the neritic zooplankton community and its distribution depends on the prevailing currents and advective processes as well as *in-situ* primary production. Away from the source suspended sediment concentrations are predicted to be well below levels that would impact on these communities. Zooplankton communities can be highly transient, depending on the currents, and if impacted, affected inconsequential and populations would recover rapidly.

While the ecological effects resulting from the project are expected to be indistinguishable from natural variability, the proposed Baseline Environmental Monitoring Plan ("**BEMP**") and Environmental Monitoring and Management Plan ("**EMMP**") provide for ecological monitoring within the project area and the STB, and identify the different parameters being monitored and the associated monitoring programmes. These have been discussed in further detail in Section 5 of this IA and provided for through the proposed consent conditions included as Attachment 1 of this IA.

#### **4.6.3.5** Response to Initial EPA Review Query

With regard to the matters raised in the EPA letter dated 10 May 2016 following an initial review of the particular technical reports provided by TTR, the following matter was raised by the EPA with regard to primary productivity:

> *To further quantify the effects on primary productivity within the South Taranaki Bight (STB) and at specific sites of ecological significance it is recommended that TTRL provide:*
>
> - *A hydrodynamically driven model of primary production that includes phytoplankton and microphytobenthos production (Section 4.3.1 of the DHI report).*

TTR has considered this issue at length and in summary TTR considered this approach, but concluded that:

1. This approach was not scientifically feasible based on existing knowledge;
2. It was not reasonable to expect the amount of field research needed to gather the information to be carried out as part of the application process;

It is further noted that the Joint Witness Statement of Experts in the fields of Optical Effects[68] (26 March 2014), Paragraph 23 stated that *"We all agree that changes to PP by phytoplankton, benthic microalgae and seaweed as a result of changes in the predicted*

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66 TTR Marine Consent Application by Trans-Tasman Resources Ltd. Joint Statement of Experts in the Field of Fish and Zooplankton. Dated 20 March 2014. Para 25 & 37

67 TTR Marine Consent Decision. 15 June 2014. Para 252.

68 Joint Statement of Experts in the Field of Optical Effects Dated 26 March 2014. Para 23

*changes in light would be both scientifically challenging and unreasonably expensive to measure. High uncertainty in predictions of changes to PP would likely remain even after considerable scientific study."*

Overall, it is TTR's position that the provision of a hydrodynamically driven model is not likely to provide substantial improvements in the ability to forecast effects on primary productivity.

### 4.6.4 Ecological Effects from Sediment Deposition

Sedimentation impacts will be most prominent where the de-ored sediments are re-deposited. Close to the operations area suspended sediment will also settle out of the water column potentially smothering the local benthic community.

As described in Section 4.4, many taxa found in the inshore environment will be exposed to naturally high levels of sediment deposition, while offshore in deeper water is a general deposition zone for fine sediments originating from land based sources.

AES (2016a) considers that there is now a reasonable body of evidence on the effects of sedimentation on benthic communities, including a number of New Zealand studies in harbour environments (refer to Table 4.10 below). Experiments in a range of studies, mostly on the Manukau Harbour, have shown that generally most soft-bottom species can only escape a maximum burial depth of 2 – 10 cm depending on the species and type of material deposited (Norkko et al. 1999[69], 2001[70]).

**Table 4.10: Tolerance levels for a range of invertebrates and microalgae to sediment deposition.**

| Author | Species | Sediment Deposition |
|---|---|---|
| Norkko et al. 2001 | Various benthic species | 3-7 mm clay |
| Doorn-Groen 1998[71] | Sessile animals including corals | 1.7 mm/14 days |
| Norkko et al. 1999 | Shrimps and crabs | 9 cm |
| Devinny & Volse 1978 | *Macrocystis* mortality of germlings (90%) | 10 mg $cm^{-2}$ (~0.45 mm Hepburn evidence) |
| Schiel et al. 2006 | Macro-algae germlings attachment | 2 mm |

Some benthic taxa, such as the bivalves *Nucula* and *Macomona* and some polychaete worms, can survive and escape burial under at 20 – 30 cm of sand while 50% of *Zethalia zelandica,* a small trochid wheel shell did not survive burial in 17 cm of sand or 3.8 cm of mud (Paavo & Probert 2005[72]). This clearly demonstrates the difference in effects between sandy versus muddy depositions.

69 Norkko, A.; Thrush, S.F.; Hewitt, J.E.; Norkko, J.T.; Cummings, V.J.; Ellis, J.I.; Funnell, G.A.; Schultz, D. (1999). *Ecological effects of sediment deposition in Okura estuary*. NIWA Client Report ARC90243 prepared for Auckland Regional Council, North Shore City Council, and Rodney District Council. July.

70 Norkko, A.; Talman, S.; Ellis, J.; Nicholls, P.; Thrush, S. (2001). *Macrofaunal sensitivity to fine sediments in the Whitford embayment*. NIWA Client Report ARC01266/2.

71 Doorn-Groen, S.M. (2007). *Environmental monitoring and management of reclamations works close to sensitive habitats*. Terra et Aqua 108. 3-18 p.

72 Paavo, B.; Probert, K.P. 2005. *Infaunal assemblages in coastal sediments at dredge dredged sediment disposal sites of Otago, New Zealand*. Marine Sciences Department (University of Otago) report. 111 pp.

The deposition of clay material, will have the greatest effect with experiments in the Auckland Region demonstrating that layers as thin as 3 – 7 mm had some impact on macrofauna and rapid accumulations of 20 mm can smother entire benthic communities (Norkko et al. 1999). The material being re-deposited at the project area will primarily consist of fine sediments with very little clay, further reducing the potential for smothering effects occurring.

Cockles (tuaki), pipis and tuatua are important for recreational and cultural harvesting in coastal environments. AES (2016a) identifies that pipis are active burrowers and can be found buried in up to 100 mm of sand and larger ones can even tolerate up to 400 mm. While limpets and whelks are highly sensitive to the silt /clay content of the substrates, some surface grazing animals like the gastropod snail *Zeacumantus lutulentus* are relatively robust to high levels of settled sediments and some crabs show a preference for fine silts and muds. Shrimps and some crabs can survive up to 9 cm of deposition but cockles and other molluscs generally start responding at levels of 20 – 30 mm, depending on the grain size.

Most MPBs are adapted to dynamic environments and episodic events and disturbances due to sediment resuspension and deposition. Many species are also motile and will migrate through thin layers of deposited sediments.

Sedimentation can impact on macro-algae and rocky shore communities through effects on settlement, recruitment, growth, and survival. Indirect effects include loss of photosynthetic capacity with a film of a few millimetres of sediment potentially reducing photosynthesis of plants. While most established alga can survive burial for short periods, attachment of germlings can be impacted by a light dusting of sediment (Schiel et al. 2006[73]) and relatively heavy settlement (2 mm) can prevent attachment altogether.

Some intertidal algae can remain intact after three months of burial but growth is inhibited, while others do not survive burial under thick sediments for a month. Deposits of up to 3 - 7 mm can have a negative effect on microphytes (microscopic benthic algae) and repeated additions over several months have been found to have a cumulative negative effect. Coralline crusts have been found to be unaffected by burial in sand for a few months at a time.

Average sedimentation rates over the SMD are estimated to be 0.5 - 1 mm/yr in the sediment plume which is virtually indistinguishable from naturally occurring background levels and will have negligible, if any, effects on benthic communities outside the excavation pit and immediate surrounding area.

In the extraction area, where the sediment is re-deposited initially, there will be no living benthic community but the community would rapidly recover through settlement of larvae and transport of adults into the area through water movement through the site. Very few animals would be able to migrate through the several metres of deposited sediment in the operational area and thus the degree of recovery will depend on the level of recruitment from outside sources, the way the material is deposited, and the length of time since the seabed was excavated.

The sampling of infauna commissioned by TTR focused on organism in the 5 cm surface layer. Holes from deep burrowing mantis shrimps are commonly found in inshore sandy habitats but NIWA found very few surface holes/burrows and caught no shrimps in dredge tows across the Patea Shoals.

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73 Schiel, D.R; Wood, S.A.; Dunmore, R.A.; Taylor, D.I. (2006). *Sediment on rocky reefs: Effects on early post-settlement stages of habitat-forming seaweeds*. Journal of Experimental Marine Biology and Ecology. 331:158-172.

#### **4.6.4.1** Response to Initial EPA Review Query

With regard to the matters raised in the EPA letter dated 10 May 2016 following an initial review of the particular technical reports provided by TTR, the following matter was raised by the EPA with regard to sedimentation effects:

- *The impacts of elevated Total Suspended Solids (TSS) on the larvae of species, other than crayfish, and whether larval settlement periods are likely to be impacted by TTRL's activities have not been considered (Section 4.3.2 of the DHI report).*

TTR respond to this comment as follows:

Two aspects should be considered here.

- For the soft sediment species occurring near the mining area or in the main part of the plume larval settlement periods are poorly described or unknown. There is generally a spring and summer peak in larval production and settlement but this will not be the case for every species. The most practical measure of impact will be to monitor of benthic species in the mined areas, and to monitor benthic community structure at a range of sites outside estimated to be at a greater or lesser risk of impact (gradient design) from the plume or deposition of sediments. This has been provided for within through the BEMP and EMMP (refer to Section 5 of this IA) which provide for ecological monitoring before and during extraction activities.

- For larvae of rocky reef species that occur near-shore, the mining will only slightly increase suspended sediment concentrations or decrease light conditions in the water column thus effects on larval and adult populations will be minimal.

#### **4.6.4.2** Summary – Effects of Deposition

There are two sources of material that would deposit on the seabed: material that has had the iron sand removed and is re-deposited on the seabed near the excavation activity; and finer material that settles after being dispersed by the sediment plume. The predicted levels of sedimentation has been modelled over five and 365-day accumulation periods and indicate that average sedimentation rates over the SMD will be 0.5 - 1 mm/yr which will be virtually indistinguishable from natural levels and is negligible compared with known tolerance levels for benthic invertebrates and macro-algae.

### 4.6.5 Recovery from Suspended Sediments and Deposited Sediment Effects

AES (2016a) identifies that recovery of the ecological environment will depend on the type of sediment present, extracted and deposited, the severity of the effect, potential for migration into the area, and the availability of larval and adult recruits.

Experiments carried out as part of studies around maintenance dredging by Port Otago Ltd provide some indication of recovery following disposal of dredge spoil (Paavo & Probert 2005). In those experiments, muddy spoil from Dunedin Harbour was deposited off Aramoana and the recovery was followed and showed that it took up to 180 days for the disposal site to recolonise and have a similar community to a site protected from disposal. It should be noted that recolonisation was much quicker for sand disposal with the community being similar to pre-deposition within 12 days.

For the project area, beyond the extraction area, where predominantly sandy material will be deposited, recovery would be expected to be quicker because only a thin layer would settle out from the sediment plume. The re-deposited material will be similar to that extracted in terms of particle size which will aid recovery of the communities. Recovery in the extraction area as the sand is re-deposited would be expected to be longer, as it would rely on recruitment and advection from outside the area, although this recovery would start as soon as the material is deposited on the seabed.

Surveys following dredging at the Port of Auckland and the disposal of 262,000 $m^3$ of dredged material in the Hauraki Gulf found there was an initial increase in abundance and diversity of benthic communities then a decline (Gowing et al. 1997[74]). Early successional communities, which included the likes of tube-dwelling polychaetes, were evident immediately after disposal followed by an increase in longer lived successional stages eight and 11 months after disposal (found at 45% of sites at the disposal site compared to 68% at control sites after 11 months). A number of overseas studies (Newell et al. 1998) have shown that while communities associated with muds may recover within months, communities in sand deposits are likely to be in a transitional stage and take up to two – three years to recover. Some longer lived species in these communities, such as heart urchins and large bivalves, which are found in the STB, could take several years to fully recover in the actual area where sands are extracted but there would be some movement into the area immediately after the recovery activities move to the next extraction block.

Seabed material from the STB was used by NIWA to experimentally assess the recolonisation expected to occur in the STB. The experiments had to be conducted in Wellington Harbour because of the exposed nature of the STB, and although the focus was on assessing the effects of removing iron from the sediments, the results do provide some indication of recovery. Beaumont et al. (2013) identified that the experiment was run for seven months after which time several "opportunistic species" (e.g. copepods and small polychaetes such as *Capitella capitata*) were found to have recolonised the sediments.

Beaumont et al. (2013) identifies that the existing environment in the project area is a very exposed, highly dynamic sandy environment where much of the benthic community will be exposed to episodic disturbances from wave events and river inputs during high rainfall events. The existing community is dominated by short-lived, opportunistic and early successional stages. The abundant polychaete worms *Euchone* and *Aricidea,* as well as syllid and photid polychaete worms and isopod *Pseudaega* spp, found in the area of potential impact, are known as early colonisers and along with the low abundance of longer lived organisms is indicative of an environment that is regularly disturbed.

The community further offshore (60 m water depth) is dominated by later successional stages (certain bryozoans, sponges, larger gastropods and higher numbers of motile taxa) while the bivalve rubble habitat in shallower waters supports early successional stages (encrusting corraline algae, small encrusting invertebrates). The dominance by early successional stages in the area potentially impacted suggests that recovery should be relatively rapid and likely to be at the scale of months to a few years. Recovery of some taxa such as small polychaete worms would be expected to start within a few weeks of the extraction operations moving to another block within the project area.

***Summary – Recovery from Suspended Sediments and Sedimentation***

[74] Gowing, L.; Priestley, S.; Kennedy, P. 1997. *"Monitoring the Hauraki Gulf dredgings disposal site using REMOTS and other established sampling techniques".* Presented at the Pacific Coasts and Ports '97. Christchurch, Centre for Advance Engineering, University of Canterbury.

The recovery of the benthic environment as the iron sand recovery operations moves across the site will depend on the type of sediment, the severity of effects from excavation and the sediment plume and availability of re-colonisers and recruitment. The existing community is dominated by short-lived, opportunistic and early successional stages but with populations of some larger longer-lived taxa also occurring. The dynamic nature of the environment means abundance and diversity for most groups is relatively low. The offshore community is more diverse and contains larger and late successional stage taxa.

The dominance by opportunistic taxa in the region directly impacted by excavation and the sediment plume means recovery is likely to be rapid once the excavation and re-deposition moves away, with recovery of the likes of polychaete worms likely to start immediately. Larger, long-lived taxa may take several months to a few years to recover. There is likely to be a gradation in recovery as the activities move to new blocks each year.

### 4.6.6 Ecological – Cumulative Effects

The project has the potential to create elevated suspended sediment concentrations, above those which are naturally occurring, immediately around the operational area. However, this effect will not present issues in respect of cumulative ecological effects with any other activities as there are no other activities within the STB area that will generate sediment plumes as a result of their ongoing operation.

Further, from the standpoint of primary production and most other ecological components, it is very difficult to estimate or assess cumulative effects, as most of the effects of the project's operations on the biota are transient in space and time. There are not considered to be any obvious project related activities that would result in cumulative impacts for other parts of the ecological system.

Overall, it is concluded that the potential cumulative effects are difficult to assess in this case due to the nature of the activity and the existing environment. Further, it is reasonable to summarise cumulative effects on the basis that the project will not result in adverse cumulative effects as any effects will only be present while project operations occur and once completed, the areas will being to recolonise almost immediately and any additional plume effects above the naturally occurring background levels will be removed.

### 4.6.7 Trace Metal Effects on Sediment and Water Quality

Contaminants, such as heavy metals and PCBs, can potentially affect offshore biota through direct toxic effects and bioaccumulation into the food web. Contaminants in the sediments of the STB, such as heavy metals, were assessed by AUT (2013).

As part of their assessment, AUT (2013) completed an analysis of the sediment content of the acid volatile sulphides and simultaneously extracted trace metals to determine the concentrations of trace metals in suspensions of sediment in seawater. The assessment further investigated whether the grinding of enriched iron sand increases the potential of the sand to release trace metals when suspended in seawater. The findings of AUT (2013) have been summarised below.

#### **4.6.7.1** Assessment Methodology

To inform their assessment, sampling of seawater and sediments was undertaken at five sites within the project area. One sediment core sample and 20L of seawater was collected at each of the sample sites with a further sample of sediment slurry and another 20L of seawater collected at a later date from two further targeted sites.

The samples were subject to a range of analysis and testing upon which the findings of AUT (2013) are based. These findings have been summarised below.

#### **4.6.7.2** Summary of Potential Trace Metal Effects

***<u>Dilute-acid Soluble Metals in Deep Sediment</u>***

The concentrations of dilute-acid soluble cadmium, copper, lead and zinc in deep sediments were of the same order of magnitude as their maximum concentrations in surface sediment sampled.

For cadmium, copper and zinc, there was no evidence for the consistent trend of increasing concentrations with increasing sediment depth below the seabed. The sediment concentrations of lead decreased with depth below the seabed at three of five sites.

Overall, the testing results infer a low probability of adverse effects of these dilute-acid soluble metals on benthic ecosystem functioning.

The concentrations of dilute-acid soluble chromium and nickel in deep sediment were often one order of magnitude higher than their maximum concentrations in surface (reference site) sediment.

Furthermore, at four of the five sites, chromium and nickel concentrations increased with increasing depth below the seabed. Additional analyses of sediment slurry collected to a maximum depth of 18 m below the seabed did not reveal evidence for such a trend.

No consistent increase with depth in the concentrations of dissolved nickel in the slurry was found. The concentrations of chromium in the slurry were below the detection limit.

***<u>Trace Metals in Sediment Suspensions</u>***

For all metals except nickel, the concentration in seawater suspensions of deep sediment (elutriate) were either below detection limit (chromium, copper, lead, zinc) or, if a metal was detected (cadmium), the concentration did not exceed the ANZECC and ARMCANZ[75] guideline for the protection of 99% of marine species. The detection limit of copper was below the guidelines for the protection of 95% of marine species.

The concentrations of nickel in the seawater suspensions of deep sediments (all five sites) and surface (reference site) sediment (three of five sites) were equal or larger than the ANZECC & ARMCANZ guideline concentrations for the protection of 99% of marine species. However, the nickel concentration never exceeded the guideline concentrations for the protection of 95% of marine species. Assuming that the nickel concentration in STB seawater equals the detection limit for nickel, it would only require an 83-fold dilution of the elutriate extract to decrease the highest nickel concentration measured to below guideline concentrations for the protection of 99% of marine species.

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[75] ANZECC & ARMCANZ, 2000. *"Australian and New Zealand Guidelines for Fresh and Marine Water Quality"*. National Water Quality Management Strategy Paper No 4. Australian and New Zealand Environment and Conservation Council, Agricultural and Resource Management Council for Australia and New Zealand, Canberra.

The concentration of copper in seawater suspensions of the enriched iron sand was negatively linearly correlated (r = -0.89) with the size of the suspended iron sand particles. The average elutriate copper concentrations of as-received and the coarse iron sand fraction exceeded the ANZECC and ARMCANZ guideline for the protection of 99% of marine species. Based on the conservative assumption that STB seawater contains 0.25 parts per billion copper only a 20-fold dilution would be required to decrease the concentration to below the concentration limit for the protection of 99% of marine species.
In contrast, the average copper concentrations in elutriates of medium and fine coarse iron sand exceeded the guideline for the protection of 80% of marine species. Here, a 160-fold dilution would decrease these concentrations to below the concentration limit for the protection of 99% of marine species.

With regard to mercury, a natural source of mercury is from volcanic and geothermal activity, however in volcanic sources it is related to the emission of gaseous mercury into the atmosphere and generally not concentrated within volcanic sediment. Given that the source material of the iron sand is volcanic rock and ash, which has formed at over 700 degrees, and that the vapour temperature of mercury is 356 degrees, there is a very low probability of accumulated mercury within the offshore sediment deposits in the STB. Where mercury occurs in volcanic hot springs and epithermal deposits it predominately forms as the sulphide mineral cinnabar. Microscope or Qemscan (Quantitative Evaluation of Minerals by Scanning electron microscopy) analysis has not observed this mineral in the Taranaki offshore iron sands.[76]

***<u>Effect of Grinding on the Dilute-Acid Soluble Metal Content of Enriched Iron Sand</u>***

A sample of magnetically enriched iron sand was ball milled to three average sizes, 276 µm, 183 µm and 23 µm. TTR will be grinding sediment to a P80 of 120 µm (P80 i 80% of the passing size). The average concentrations in this iron sand of dilute - acid soluble chromium, nickel and zinc decreased after each of the first two grinds but increased after the third grind to 171%, 150%, and 162% of that in the extract of the original material.

In contrast, for copper and lead, the average concentrations in the extracts of the first two grinds did not significantly differ from that of the original material, but the third grind increased these concentrations to 193 µm and 132% of the concentration in the extract of the as-received iron sand.

The concentrations of dilute-acid soluble cadmium were below reporting limits in both the original material and ball-milled magnetically enriched iron sand.

Elutriate tests with magnetically enriched and ball milled iron sand were conducted to investigate if grinding of iron sand will increase trace metals concentrations in the seawater that feeds the iron sand through TTR’s grinding mills.

These tests revealed concentrations of cadmium, lead and nickel below the limits of reporting for all sediment samples. Chromium was detected only in elutriates of the fine sediment fraction; zinc was detected in elutriates of all sediment samples. For both metals, the concentration averages for each sand size fraction did not exceed the ANZECC & ARMCANZ guideline for the protection of 99% of marine species. Therefore, a low probability of adverse effects of these metals on ecosystem functioning of the STB water column is inferred.

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[76] Statement of Evidence of Matt Brown on Behalf of Trans-Tasman Resources, 15 February 2013, adaption of paragraph 59.

***Bioaccumulation Effects of Mercury***

With regard to mercury, in his evidence presented on behalf of TTR in the hearing on the previous application[77], Dr Vopel identified that:

> *"Mercury was not included in our analyses because I did not expect the offshore iron sand of South Taranaki Bight to contain elevated quantities of anthropogenically or naturally derived mercury. The volcanic activity that produced the iron resource in South Taranaki Bight will not have resulted in accumulation of mercury in the offshore iron sands. Volcanoes discharge mercury into the atmosphere along with high temperature ejecta. Ultimately, the oceanic environment receives part of this mercury through atmospheric deposition but this deposition is a global rather than a local process. Overall, the average yearly emission of mercury from volcanoes into the atmosphere is small relative to natural terrestrial fluxes to the atmosphere and modern anthropogenic (pollution) mercury fluxes.*
>
> *I note that Chrystall and Rumsby (2009)[78] identified geothermal emissions as a natural sources of mercury in New Zealand with local effects on freshwater biota, that is, increased mercury concentrations in fish caught in geothermally-influenced lakes (Kim 1995)[79] or in sediment of a lake that contains a natural geothermal spring. The authors noted that most concerns are over the issue of accumulation of anthropogenic mercury in aquatic ecosystems. I argue that such accumulation is unlikely in the offshore sand of South Taranaki Bight. Elevated mercury concentrations in offshore sediment have been detected elsewhere near oil drilling sites (Gulf of Mexico) and such concentrations were associated with discharge of cuttings drilled with synthetic-based mud (Trefry 2007)[80] or, for methyl mercury, related to higher sediment organic matter content in the vicinity of offshore oil production platforms (Delaune et al. 2008)[81]."*

On this basis, any bioaccumulation effects that relate to mercury have not been considered further as part of this application. Bioaccumulation in seafood with regard to human health effects have been discussed further in Section 4.10 which focuses on copper and nickel.

## 4.7 Marine Fauna Effects

### 4.7.1 Fish

#### 4.7.1.1 Introduction

TTR commissioned NIWA to undertake an assessment of potential effects on fish and fisheries in the STB (MacDiarmid et al (2015b)). NIWA also undertook an assessment on the potential effects of light from project operations on fish (Thompson (2015b))[82].

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77 Statement of Evidence in Chief of Dr Kay Vopel on behalf of Trans-Tasman Resources, 15 February 2013, Paragraphs 66-67.

78 Chrystall L, Rumsby A (2009) Mercury inventory for New Zealand. Technical Report prepared for the Ministry for the Environment. Pattle Delamore Partners Limited, August 2009.

79 Kim JP (1995) Methylmercury in rainbow trout (Oncorhynchus mykiss) from Lakes Okareka, Okaro, Rotomahana, Rotorua and Tarawera, North Island, New Zealand. Science of the Total Environment 164:209–219.

80 Trefry JH, Trocine RP, McElvaine ML, Rember RD, Hawkins LT (2007) Total mercury and methylmercury in sediments near offshore drilling sites in the Gulf of Mexica. Environ. Geol. 53:375–385.

81 DeLaune RD, Devai I, Hou A, Jugsujinda A (2008) Total and methyl Hg in sediment adjacent to offshore platforms of the Gulf of Mexica. Soil & Sediment Contaminations 17:98–106

82 Thompson, D. 2013. *"Effect of ships lights on fish, squid, and seabirds".* NIWA Client Report WLG2013-16. Updated November 2015.

Information on the distribution and abundance of reef fish, pelagic fish and demersal or seabed associated fish species have been described using predictive models based on survey information conducted around New Zealand, together with a set of environmental predictor variables developed by NIWA (Smith (2008))[83]. The model predictions were produced by applying a statistical analysis to diver surveys of fish abundance using environmental and geographic variables as predictors. The general features of the distribution, abundance and ecology of rock lobsters were also identified on the basis of extensive studies conducted elsewhere in New Zealand.

The potential effects of the project on fish have been identified as:

- Entrainment of fish within project equipment;
- Loss or physical disturbance of seabed habitat and the communities associated with these habitats;
- Impacts on physiological processes, including clogging of respiratory surfaces and feeding structures and processes for animal biota;
- Smothering of benthic habitats and communities;
- Displacement from areas of disturbance by sediment plumes;
- Reductions in primary production in the water column (i.e. phytoplankton) and on the seabed or reefs through reduced light availability;
- Reduced prey and prey detection for fish; and
- Noise effects on some fish species.

These effects have been discussed in further detail below, although noise effects are discussed in Section 4.9 of this IA.

***Entrainment of Fish in Project Equipment***

MacDiarmid et al. (2015b) identifies that the majority of fish species will avoid becoming entrained in any operational machinery associated with the project, particularly the crawler, as they will typically be able to avoid areas of the physical disturbance.

It is, however, possible that the intake water velocity near the extraction nozzle of the crawler (up to 6 m/s) will cause the occasional entrainment of smaller fish - due to these fish not being able resist the suction. The likelihood of such occurrences are very low due to the likely low abundance of fish in the project area during operations and the natural instinct of fish to move away from disturbed areas, including noise sources. Therefore, any potential effects of entrainment are unlikely to be significant. This conclusion was also accepted by the DMC[84] in their decision on the previous marine consent application, who noted that the various experts agreed that there would be little opportunity for fish to become entrained and that any potential effects would not be significant.

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83 Smith, A.N.H. 2008. *"Predicting the distribution and relative abundance of fishes on shallow subtidal reefs around New Zealand"*. NIWA Client Report WLG2008-9.

84 TTR Marine Consent Decision. 15 June 2014. Para 375.

***Disturbance and Sedimentation Effects***

MacDiarmid et al. (2015b) identifies that the direct and indirect effects of suspended sediment on fish populations must take into account the level of suspended sediment generated by the project compared with the naturally occurring background levels, the tolerance levels of different species, and the duration and spatial extent of the effect above tolerance levels.

The potential effects of the sediment plume and associated changes in turbidity and suspended sediment from the project include:

- Impacts on physiological processes such as respiration and feeding;
- Impaired visibility for prey detection;
- Loss or changes in feeding area and food resources; and
- Loss or changes in spawning areas.

With regard to sediment effects on fish species, Lowe (2013)[85] and Page (2014)[86] have identified that suspended sediment concentrations of 2 mg/L and 3 mg/L are the lowest levels that would be avoided by pelagic and demersal fish respectively. Acute and chronic impacts would be expected to be at much higher levels. In a recent study on juvenile snapper in estuaries Lowe (2013) reported 35 - 40 mg/L as the level that started affecting foraging strategies, and declining condition. Page (2014) provides a very comprehensive list of published threshold concentrations with most species only impacted beyond avoidance or a reduction in feeding, at levels well over 500 mg/L. As discussed in Section 4.4.2 of this IA, such levels would not be encountered within the project area (not even right at the extraction / deposition source).

Based on the sediment plume modelling by NIWA, the only location where suspended sediment concentrations would be perceptible above natural background limits is within 2 – 3 km of the source. In this regard, the median concentration of suspended sediments in surface waters at the source (Location A) will be 1.45 mg/L and the 99$^{th}$ percentile concentration will be 8.2 mg/L. At a location approximately 20 km down current the median concentration will be 0.35 mg/L and a 99$^{th}$ percentile concentration being 2.8 mg/L. Near the seabed the median suspended sediment concentrations at the source will be 14 mg/L and the 99$^{th}$ percentile concentration 45 mg/L, while at a location approximately 20 km down current the median concentration will be 1 mg/L and the 99$^{th}$ percentile concentration up to 5 mg/L.

As previously noted in this IA that inshore areas of the STB already experience naturally high levels of suspended sediment concentrations. The levels resulting from the project would be within the range of natural variability of suspended sediment concentrations experienced by fish populations in the STB.

As noted in Section 3.6.1 of this IA, Ching et al. (2015) used spatial information on the occurrence and foraging of different fish species, a suspended sediment concentration of 3 mg/L and the potential dispersion of the sediment plume to assess the scale of potential effects from the project. The assessment demonstrated that less than 1% of the area

85 Lowe, M.L. (2013). *Factors affecting the habitat usage of estuarine juvenile fish in northern New Zealand*. Doctor of Philosophy in Marine Science. University of Auckland, Auckland: 238.

86 Page, M. (2014). *Effects of total suspended solids on marine fish: pelagic, demersal and bottom fish species avoidance of TSS on the Chatham Rise*. NIWA Client Report No: WLG2014-7, 25 p.

occupied by the different fish species found in the STB would potentially be impacted by the project and that any effects would be negligible or minor.

Fish are also ‘fully motile’, which means they have the ability to select their preferred habitat, and as a result, avoid or remove themselves from unfavourable habitats (e.g. areas of high sedimentation). This would further reduce the potential for the sediment plume from the project to adversely affect fish species.

The only species identified as being potentially affected in a more than minor way was the eagle ray. This is due to 8% of its core distribution in the STB coinciding with the area potentially impacted by the sediment plume. However, as this species typically concentrates in inshore areas at certain times of the year, where suspended sediment concentrations are naturally high, the use of 3 mg/L concentration as a threshold for effects is likely to be very conservative when considering potential impacts on eagle rays. Eagle rays are also commonly encountered in harbours and estuaries where suspended sediment concentrations can be very high. Therefore, MacDiarmid et al. (2015b) concludes that the overall effect on eagle rays, and other ray species, will be no more than minor.

In addition, and as has been found with dredging programmes elsewhere New Zealand, the disturbance of sediment could enhance the availability of food for fish (at least initially) as invertebrates are disturbed and potentially made available for fish.

Finally, it is noted that the joint expert conferencing[87] held as part of the previous marine consent application by TTR recorded agreement between the various experts that the increase in sediments in the water column is unlikely to cause sub-lethal effects or growth effects - except at the immediate source of the sediment plume. Further, it was agreed by the experts that any detectable direct effects of decreases in water clarity on fish populations are highly unlikely.

***<u>Spawning and Feeding</u>***

While there is the potential for the sediment plume from the project to affect spawning sites, particularly during the earlier phase of spawning, the project area and area potentially affected by the sediment plume is not identified as being an important spawning area or juvenile nursery for any fish species.

For fish that spawn inshore, any effects are likely to be within the range of background levels of suspended sediment concentrations that the fish populations naturally encounter due to the nature of the high energy environment of the STB.

Therefore, any potential effects of suspended sediment concentrations on spawning would likely be no more than minor given the relatively small scale of the project area in the context of the STB. This position was accepted by the DMC in their decision on the previous marine consent application, who found the loss of spawning area is not significant as the project area forms a small percentage of the STB and the region does not support an extensive fish nursery.[88]

With regard to feeding effects and food sources, the project area has not been identified as providing extensive feeding grounds for fish species within the STB. Further, the loss of any feeding areas is not likely to be significant as the methodology for the extraction of iron

87 Joint Statement of Experts in the Field of Effects on Fish and Zooplankton dated 20 March 2014.
88 TTR Marine Consent Decision. 15 June 2014. Para 372.

sands from the seabed (being extraction of segmented blocks of a total project area) allows for the re-colonisation of marine areas immediately after project operations cease.

***Light Effects***

Artificial night lighting influences fish foraging, schooling behaviour, spatial distribution, predation risk, migration and reproduction. These effects can combine to affect the community ecology of fishes and both their prey and predators.

An artificial nocturnal lighting source from a vessel operating in a relatively fixed location, or over a relatively small spatial extent, could potentially affect marine fish in the following ways:

- Small fish species may be attracted to an artificial light source because the artificial light also serves to focus their marine plankton prey;
- Feeding increases with prey density in high light conditions;
- An increase in abundance of relatively large predatory fish around the illuminated area(s); and
- Behaviour changes of fish to maintain their position within the illuminated area(s).

With regard to the project, any such effects of vessel lights will be extremely localised and minimal. In this regard, while local increases in fish abundances may occur it is highly likely that any such attraction of fish towards the IMV will have a negligible effect at a population level. This is due to the small number of fish that could aggregate in the water column around the IMV at any one time, as well as the spatial scale of the IMV in the context of the STB.

#### **4.7.1.2** Response to Initial EPA Review Query

With regard to the matters raised in the EPA letter dated 10 May 2016 following an initial review of the particular technical reports provided by TTR, the following matter was raised by the EPA with regard to fisheries:

> *The assessment of impacts on fish species is sometimes described at the scale of the relevant Fisheries Management Area (FMA) and sometimes at the scale of the STB. To provide a greater understanding of impacts on fish species, and potentially fishers, at a local scale it is recommended that:*
>
> - *Impacts on fish species are presented at the scale of the STB as well as the relevant FMA. (Section 4.3.3 of the DHI report).*

TTR notes that the difference in approach is because for quota species, such as barracoota, a stock area has been assigned by MPI Fisheries Assessment Working Groups and impacts have been assessed against these. For non-quota species, such as eagle rays, no similar reference area is available and the technical advisors have used distribution in the modelled domain area as the conservative approach.

Additionally, TTR consider that the scale of FMA is appropriate for species managed by quota as impacts need to be assessed for the population. MPI have deemed these areas appropriate for populations of quota species based on species biology, ecology, movements etc.

#### 4.7.1.3 Management and Monitoring of Potential Effects on Fish

Joint expert conferencing held as part of the previous marine consent application by TTR concluded that baseline monitoring of fish stocks should occur for a minimum period of one year.[89] The experts were in agreement that although specific monitoring of species abundance around the project area was not warranted, reef fish should be monitored at the North and South Traps, Graham Bank, and at the biogenic shell and bryozoan areas south of the project area.

These recommendations have been provided for in the EMMP (discussed in Section 5.5 of this IA) and incorporated into the proposed consent conditions provided in Attachment 1 of this IA.

### 4.7.2 Seabirds

#### 4.7.2.1 Introduction

Thompson (2015b) considers the potential effects of artificial lights from ships on fish, squid, and seabirds in the project area, while Ching et al. (2015) assesses the ecological effects of the project on seabirds – with a particular focus on Gibson's albatross, Westland petrel, sooty shearwater, red-billed gull and little blue penguin. The following section provides a summary of these reports.

The assessment of potential effects on seabirds included a review of beach patrol surveys. These surveys involved volunteers collecting dead birds washed up on beaches, who complete patrol cards and return them to the Ornithological Society of New Zealand, who calculate annual tallies. In addition, information from other published and unpublished sources was used to determine the species of seabirds that are likely to be associated with the STB.

#### 4.7.2.2 Effects on Seabirds

The potential for effects on seabirds from the project include:

- Species presence and habitat effects;
- Sedimentation and foraging effects; and
- Effects from vessel lighting.

With respect to species presence and habitat, it is considered that the STB supports a relatively modest seabird assemblage and does not support large breeding colonies for any species. Because many of the typical species occurring in the STB are relatively coastal in their distribution, they are unlikely to be impacted by the project. Such species include blue

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89 Joint Statement of Experts in the Field of Effects on Fish and Zooplankton dated 20 March 2014, para 33 and 34.

penguin, shags, gulls and terns, although the latter two species can extend to more offshore areas. By contrast, albatross and petrel tend to be more pelagic and wide-ranging in their distribution and will likely occur anywhere throughout the STB.

Potential effects on seabirds recorded in the area of the STB potentially affected by the sediment plume from the project will be negligible because of their mobility and wide foraging range.
Ching et al. (2015) selected five representative species for more in-depth assessment - the Gibson's albatross, Westland petrel, sooty shearwater, red-billed gull and little blue penguin.

It was concluded that the STB was not a particularly important area for Gibson's albatross and that the project would have negligible effects on this albatross.

The Westland petrel is considered to be of high conservation value (although not on the threatened list) due to its restricted mainland breeding distribution and modest population size. The at-sea distribution of this species during the winter breeding season spans central New Zealand, including the STB. It is likely that this species could occur in the project area, but it is noted the project area is relatively small compared to the overall distribution of Westland petrels (i.e. less than 0.1%). As such, any potential effects will be negligible.

Sooty shearwaters are found throughout New Zealand when breeding. Based on a relatively conservative estimate of their spatial distribution, the extent of the sediment plume from the project with surface level suspended sediment concentrations above 2 mg/L would represent less than 0.01% of foraging area. Sooty shearwaters wide ranging foraging and depth range, compared with the area potentially affected by the project, means any potential effects will be negligible.

Red-billed gulls are found around the entire coastline of New Zealand, including the STB. The STB does not have a major breeding colony and the area potentially affected by the sediment plume represents less than 0.1% of the coastal distribution of this species. Therefore, any potential effects will be negligible.

Little blue penguins are found in coastal areas around New Zealand. The closest breeding sites are over 50 km away from the extent of the sediment plume from the project and the area potentially affected is less than 0.1% of the area available. As such, any potential effects on little blue penguins will be negligible.

With regard to sedimentation and foraging effects, it is noted that the dredging programme for Port of Melbourne included threshold suspended sediment concentration limits for protecting terns and gannets of 25 mg/L. In contrast, suspended sediment concentrations at the surface will only be up to 8 mg/L at source and less than 3 mg/L 20 km down current. As such, the levels will be well below those used to protect these bird species present and, therefore, any potential effects as a direct result of the sediment plume will be negligible.

With regard to lighting effects, it was agreed by experts as part of the joint conferencing for the previous marine consent by TTR that lighting was potentially the most significant effect for seabirds due to the risk of collision with vessels.[90] Deck lights and standard navigational lighting on the operational vessels, particularly the IMV, FSO vessel and AHT, have the potential to attract nocturnal birds. These lights may also attract squid and fish, which may in turn attract birds for feeding. However, it is considered that the remoteness and distance offshore of the project area from major breeding colonies of seabirds will assist in ensuring any potential effects from vessels are minimised. Further, vessel design and on board management practices will assist to further reduce the potential for any adverse effects on

90 TTR Marine Consent Decision. 15 June 2014. Para 400.

seabirds. In circumstances where collisions do occur, it is unlikely that any collision incidents would have a significant effect at a population level because the number of individuals affected would be small.

It is considered that the project would be unlikely to have any measurable population level impact on seabirds.

#### **4.7.2.3** Management of Potential Effects

Overall, it is considered that the project will only result in indirect negligible effect on seabirds.

Artificial lighting emitted from operational vessels will increase the presence of artificial nocturnal light locally, but is unlikely to have any measurable population level effects on seabirds. However, to ensure that there are appropriate measures in place to minimise any adverse effects on seabirds, the following procedures will be implemented:

- Alerting vessels to the risk associated with the use of lights and other deck lighting, particularly on nights when visibility is poor and in the vicinity of seabird islands;
- Black-out blinds will be mandatory on all portholes and windows with external lighting kept to the minimum required for safe navigation and operation of vessels;
- Keeping deck lights to a safe minimum when at anchor or close inshore overnight; and
- Providing information on how to treat and release birds found on deck.

TTR will also prepare a Seabird Effects Mitigation and Management Plan in consultation with DOC. The purpose of the plan is to minimise any adverse effects on classified seabird species at a population level, and to ensure that there is no adverse effects on seabirds resulting from lighting, oil spills and the sediment plume. Further details on the development and implementation of this plan is provided in the proposed consent conditions provided as Attachment 1 of this IA and the draft Seabird Effects Mitigation and Management Plan has been provided as Appendix 5.3 to this IA.

Section 5 of this IA provides an overview of the proposed monitoring and management framework for the project. This includes discussion on the BEMP and the EMMP that will ensure that any effects associated with the project are appropriately monitored and managed throughout the proposed 35 year term of the consents.

Overall, it is considered that the potential effects of the project on marine fauna will be minor and will be further minimised through the proposed monitoring, management and mitigation measures provided for through the various management plans and the proposed consent conditions.

## 4.8 Marine Mammals

### 4.8.1 Introduction

Torres et al. (2015) undertook habitat modelling of southern right whales, Hector's dolphin and killer whales, while Cawthorn (2015) undertook a cetacean monitoring for the project.

Further, the effects of the project on marine mammals has been assessed in MacDiarmid et al. (2015a).

The potential effects of the project on marine mammals include:

- Avoidance of areas of disturbance and sediment plumes;
- Reduced prey and prey detection;
- Displacement from habitat;
- Risk of collision with project related vessels; and
- Noise effects.

The effects of the project on marine mammals is discussed further in the sections below, although potential noise effects are considered in Section 4.9 of this IA.

#### **4.8.1.1** Whales

Blue whales have been observed in the western and central parts of the STB, predominantly at depths of between 50 – 150 m. However, MacDiarmid et al. (2015a) concludes that they are unlikely to occur within the project area, which is thought to be at the edge of their feeding grounds. Further, whales would seek to avoid the specific areas within the project area where iron sand extraction activities are occurring due the noise and disturbance effects.

In addition, the extent of the area where suspended sediment concentrations will be above 2 mg/L as a result of the project (being the level which would cause some disturbance to the feeding and foraging activities of blue whales) represents only 0.2% of the known foraging area of blue whales – excluding the shallower areas of the STB. As such, MacDiarmid et al. (2015a) concludes that any displacement or impacts on blue whale feeding would be negligible.

As noted in Section 3.7 of this IA, southern right whales prefer sheltered shallow coastal waters. No southern right whales have been observed within the project area, with the only sightings in the STB being to the north of the project area. Ching et al. (2015) concludes that the project would not impact on southern right whales when considering their typical range, habitat and behaviour.

Similarly, killer whales are found throughout New Zealand and the STB is only a moderately favourable habitat. Given that the prey of killer whales (e.g. school shark and rays) are found throughout the STB, it is unlikely that the project will impact on the habitat of killer whales.

Pilot whales commonly feed on squid and have a wide distribution around the coastline of New Zealand. The project area, and wider area of the STB potentially impacted by the project, is minimal compared to the total area of foraging and feeding habitat for pilot whales. As such, any potential effects are deemed to be negligible for this species.

#### 4.8.1.2 Dolphins

MacDiarmid et al. (2015a) identified that the majority of the STB is unsuitable habitat for Hector's dolphin, as well as the sub-species Maui's dolphins - which is at a very high risk of extinction. Hector's and Maui's dolphins prefer areas of low water clarity and are opportunistic feeders. Ching et al. (2015) concludes that the project is likely to have negligible effects on Hector's dolphin due to the absence of sightings in the STB, their preference for areas of low water clarity, and the likely negligible effects of project on prey species.

With respect to the common dolphin, it is found throughout the coastal waters of New Zealand. A common prey is jack mackerel which is widely distributed in the STB and along the coastline.

When considering the large area occupied by the common dolphin around New Zealand, and its ability to range over an extensive area, Ching et al (2015) concludes that any potential effects on the common dolphin population in the STB will be negligible.

#### 4.8.1.3 Seals

The New Zealand fur seal is found throughout New Zealand and has been increasing in numbers in recent years. They typically forage offshore at night, but do forage inshore as well. Tracking has shown that mean foraging trips are approximately 100 km, meaning that the project area could be accessed from the nearest colonies (Stephens Island and Sugar Loaf Island).

At sea sightings have observed fur seals in the project area and the area potentially affected by the sediment plume. Based on its foraging area, potential displacement and extent of potential effects on marine ecology and fisheries, Ching et al. (2015) concludes that any potential effects on fur seals will be negligible.

#### 4.8.1.4 Vessel Collision

As the project will result in a number of vessels operating within the project area and the STB at any one time, there is the potential for collision impact effects on marine mammals. It was accepted by the DMC as part of their decision on the previous marine consent application that the risk of collision is low due to the relatively low speeds of vessel operating in the project area and the relatively low number of vessels involved in the project compared to the number already operating within, and travelling through, the STB.[91]

While the risk of a collision is low, any collision could result in minor injuries, maiming or the death of marine mammals. Given this, the potential effects are difficult to quantify. However, the potential for effects will be minimised by the use of personnel training and operational measures (which are discussed below).

It should also be noted that marine mammals, like fish, will avoid the project area if underwater conditions are not suitable. Further, and as discussed above, MacDiarmid et al. (2015a) concludes that the project area is not of particular biological importance to any marine mammal species – and marine mammals are only likely to be present in the broader area at certain times of year. This conclusion was accepted by the DMC in their decision on the previous marine consent application.[92]

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91 TTR Marine Consent Decision. 15 June 2014. Para 333.
92 TTR Marine Consent Decision. 15 June 2014. Para 350.

### 4.8.2 Management of Potential Effects on Marine Mammals

While the project will have negligible to minor effects on marine mammals, TTR is proposing a number of mitigation measures relating to potential effects on marine mammals. These are specified in the proposed consent conditions included as Attachment 1 of this IA, and include:

- The establishment of protocols should marine mammals be encountered during the project;
- The provision for marine mammals observers, and mounted cameras, on project vessels during start-up operations and while vessels are in transit;
- The development of a Marine Mammal Management Plan as well as notification requirements to DOC for incidents and sightings;
- Operational controls relating to the avoidance of potential collisions with marine mammals; and
- Monitoring of marine mammals is provided for in the proposed BEMP and EMMP.

The proposed consent conditions are generally consistent with those which were proposed as part of the previous marine consent application, but have been further developed through consultation with DOC and other stakeholders. These conditions will assist in ensuring that any potential adverse effects on marine mammals are minimised and that management protocols are in place to address any potential unforeseen effects.

Finally, the DMC concluded in their decision on the previous marine consent application, that the final consent conditions proposed were comprehensive and likely would have addressed any concerns associated with marine mammals.[93]

## 4.9 Noise Effects

### 4.9.1 Introduction

Hegley Acoustic Consultants were commissioned by TTR to undertake an assessment of the noise related effects of the project, with a particular focus on any noise impacts on marine mammals present in the area (Hegley (2015)).[94]

Hegley (2015) identifies that no measurements of existing noise conditions at the project site have been undertaken due to adverse sea conditions. However, measurements have been undertaken in a calm harbour mouth with no shipping activity in order to provide an understanding or possible noise conditions in calm sea conditions. Noise measurements were also undertaken at the Port of Lyttelton, with cargo ships arriving and departing, to demonstrate sound peaks of the ships passing at low speed within 100 m of the receiver.

As detailed in Section 3.11.3 of the IA, a significant number of ship movements occur within 10 NM of the project area and this will have the effect of increasing existing noise levels by up to 132 dB as a ship passes.

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93 TTR Marine Consent Decision. 15 June 2104. Para 350 – 351.

94 Hegley, N., 2013. *"Trans-Tasman Resources Ltd – Offshore Iron Sand Extraction and Processing – Assessment of Noise Effects"* Report No 9101. Updated November 2015. 24 pp.

### 4.9.2 Summary of Noise Effects

Hegley (2015) assessed the potential noise emitted by the crawler (pump motor drive and the extraction pump booster of a cutter suction dredge (excluding the cutter head)).

TTR have referenced the agreed noise limits against the studies and reports provided by De Beers Marine from the Institute for Maritime Technology (South Africa) [95]. These reports provide empirical data of the level of noise generated by crawler operations. From these reports it can concluded that the levels of low frequency noise produced by vessels of the off-shore mining industry are essentially the same as merchant vessels.

#### **4.9.2.1** Crawler Noise

Hegley (2015) assumes that if the crawler noise is at least at the background sound, less 10 dB, it will be heard. Thus, the masking effects of the existing noise environment can be predicted based on the sea noise being around 132 dB. This means if the crawler is operating at no more than approximately 122 dB, the sea noise will mask most generated noise. Hegley (2015) identifies a noise level of 122 dB will be achieved at approximately 300 m from the crawler. The assumed levels of the crawler sound spectrum, used by Hegley in his report was verified by the Institute for Maritime Technology report, which was introduced by Hegley in his evidence with the original TTR marine consent hearing of 2014. This report supports the adoption of the agreed (DOC) noise conditions.

#### **4.9.2.2** Vessel Noise

Based on noise measurements of container ships, the noise from the IMV will likely be 188 dB at 1 m when transiting, the FSO vessel will be 185 dB at 1 m when transiting, and the AHT's will be 170 dB at 1 m.

Measurements from *MV Overseas Harriette* demonstrate that noise levels from vessels will be approximately 14 dB lower when they are operating in the project area and vessel speeds are low. Hegley (2015) expects a similar relationship for vessels associated with the project.

#### **4.9.2.3** Noise Effects on Marine Fauna

Noise generated by the project has the potential to affect the underwater environment for fish and sea mammals. Figure 4.11 shows the audiograms (i.e. the noise levels which can be heard) of three dolphins and whales species found in coastal waters off Northern Europe and Figure 4.12 shows the reported hearing thresholds for the beluga, humpback and killer whales compared to humans.

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95 Coley, N.P. 1995. Institute for Maritime Technology, Environmental Impact Study: *Underwater radiated noise II, Document No: TV0010-950048-730.*

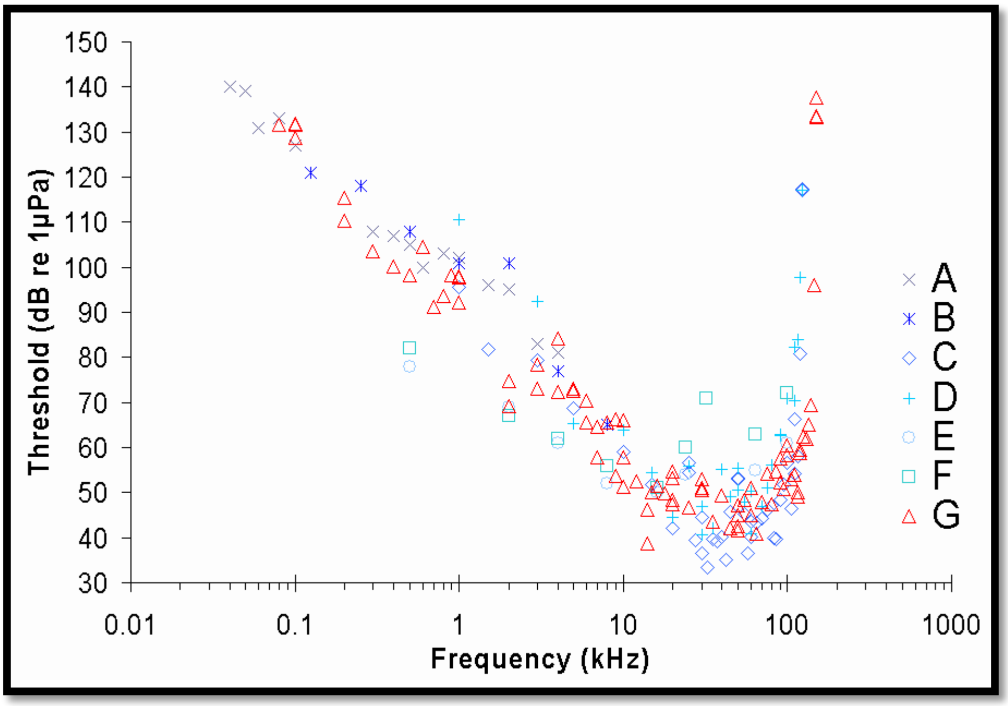


**Figure 4.11: Hearing thresholds for White whales and Bottlenose dolphins Note: (A) White whale from Johnson et al. (1989); (B) White whale from Awbury et al. (1988). (C) & (D) White whale female and male from White et al. (1978). (E) & (F) White whale female and male from Ridgway et al. (2001). (G) Bottlenose dolphin from Johnson (1967).**

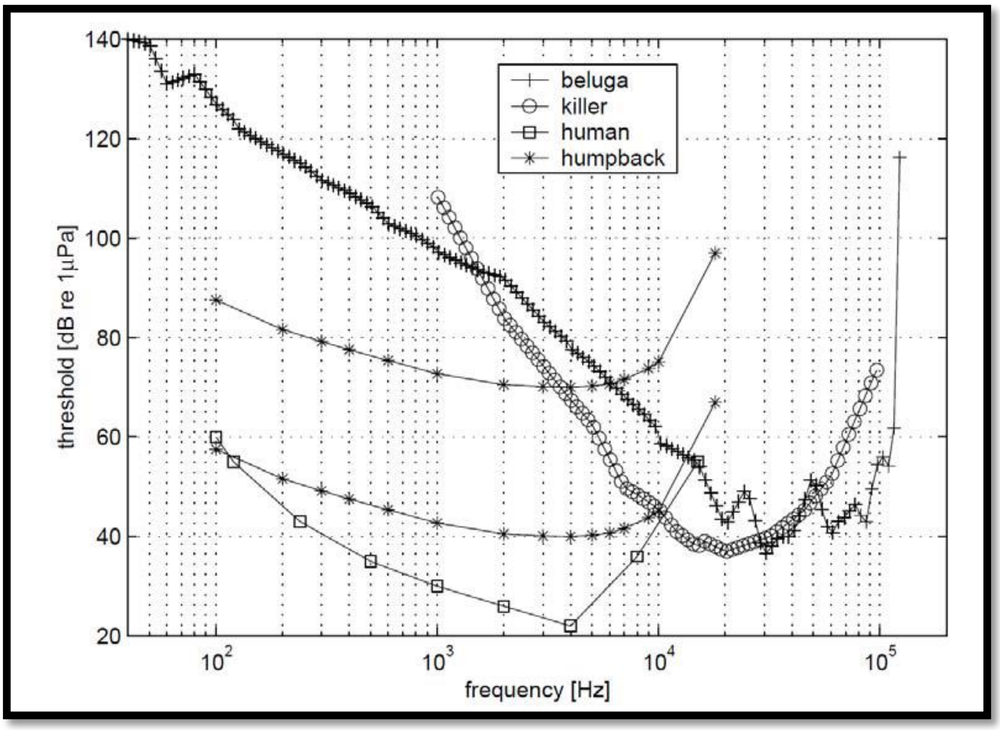


**Figure 4.12: Audiograms of Beluga, Killer and Humpback whales, and Humans**

With regard to operational noise, typical acoustic characteristics of the re-deposition sonar are:

- Frequency: 20 – 200 kHz.
- Beamwidth: 4° - 4.5°.
- Pulse length: 100 µs.

Hegley (2015) identifies that previous studies have shown that marine mammals tend to be adapted for living in noisy underwater environments, and typically have hearing thresholds that are much less sensitive than those adapted for the atmospheric environment. For this reason, it is considered that marine species are able to tolerate much higher levels of noise.

The frequencies used by porpoise (and assumed to be similar for Hector's dolphin) are:

- Low frequency sounds at 1.4 – 2.5 kHz for communication;
- Sonar-clicks (echolocation) at 110 – 140 kHz;
- Low-energy sounds at 30 – 60 kHz; and
- Broadband signals at 13 – 100 kHz.

All of these frequencies are well above those predicted to occur from the project.

While the hearing of the dolphin and whales is best between about 10 – 100 kHz, they can hear to relatively low frequencies - providing the noise level generated is relatively high. As an example, for the sound to appear as loud for the dolphin at 1 kHz as at 10 kHz it would need to be approximately 40 dB louder at 1 kHz than 10 kHz.

As noise from the project is generally toward the lower end of the hearing threshold for dolphins and at the lower end of their vocalisation range, it is concluded that effects will be less than had the sound been above 10 kHz.

The potential effects of the project associated with noise as identified by Hegley (2015) are:

- The masking of marine mammal communication systems, echolocation signals and passive listening capabilities; and
- Disturbance of normal behaviour resulting in displacement from habitat areas.

The potential impacts types from noise are:

- Permanent threshold shifts that result from unrecoverable tissue damage;
- Temporary threshold shifts that result in a temporary reduction in hearing sensitivity and;
- Behavioural response threshold shifts.

Table 4.11 below sets out the approximate noise levels of the project (above the threshold of hearing for dolphins and whales).

**Table 4.11: Noise level (dB re 1 µPa) above the threshold of hearing.**

| Distance from extraction (m) | Level Above the Threshold of Hearing | |
|---|---|---|
| | Suction Dredge | Cutter Suction |
| 50 | 51 | 59 |
| 100 | 45 | 53 |
| 250 | 37 | 45 |
| 500 | 31 | 39 |
| 1000 | 25 | 33 |
| 1500 | 21 | 29 |

Note: Shaded areas indicate general iron sand extraction noise is expected to be masked by the ambient sound

Overall, and assuming there are marine mammals present during the iron sand extraction activities, there is not expected to be any more than some temporary alteration to the behaviour of marine mammals in the vicinity of the project area.

With regard to fish, there is an extraordinary diversity in hearing resulting in different auditory capabilities across species. While many fish species hear in the range of about 30 Hz to 1 kHz, some fish can hear up to 3 kHz. It is concluded that there will not be any negative communication effects for fish when considering the noise generated as a result of the project.

#### **4.9.2.4** Response to Initial EPA Review Query

With regard to the matters raised in the EPA letter dated 10 May 2016 following an initial review of the particular technical reports provided by TTR, the following matter was raised by the EPA with regard to noise effects:

- *Some issues relating to noise have not been addressed in TTRL's application documents such as the noise that may be generated from the drilling by the Geotechnical Support Vessel (Section 4.3.4 of the DHI report).*

As identified in the last paragraph of Section 4.9.2, since the submission of Hegley (2015) report, TTR have obtained studies and reports provided to De Beers Marine from the Institute for Maritime Technology (South Africa). These reports provide empirical data of the level of noise generated by crawler operations. These reports demonstrate that the levels of low frequency noise produced by vessels of the off-shore mining industry are essentially the same as merchant vessels.

Further, the conditions, as outlined in Section 4.9.2.5 and as agreed between TTR and DOC, are considered to be reasonable and achievable to mitigate any adverse effects on marine mammals.

#### **4.9.2.5** Management of Potential Effects on Noise

Joint expert conferencing on noise effects was undertaken as part of the previous marine consent application by TTR.[96] While there was no agreement on noise limits and frequencies produced, the experts agreed that setting a noise limit at a distance from the iron sand extraction activities is an appropriate management approach.

96 TTR Marine Consent Application – Joint Witness Statement - Noise Conditions. 11 April 2014.

Further, in setting a noise limit, the experts agreed it was important to consider not only the sounds level but also the frequency spectra of any noise. It was also generally agreed that a condition of the following nature would address the noise effects associated with the project:

> *"The consent holder shall comply with the following requirements in relation to underwater noise:*
>
> *a) The combined noise from the IMV and Crawler operating under representative full production conditions shall be measured nominally 10m below the sea surface at 300m, 500m, 750m and 1000m from the port or starboard side of the IMV. The combined noise level at 500m shall not exceed 130dB 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 500m across all frequencies shall not exceed a sound pressure level of 135 dB re 1µPa RMS linear; and*
>
> *b) Measurements shall be undertaken in calm sea conditions (e.g. Beaufort sea state less than 3 (beginning of white-capping)), with no precipitation and no external noise sources (e.g. passing ships)."*

TTR has provided for the inclusion of further operational measures that will assist in reducing any potential noise effects on marine mammals. These include:

- The provision of a Marine Mammal Management Plan, which will seek to ensure any adverse noise effects are avoided to the extent practicable; and
- The use of suitably trained observers to conduct pre-start observations over a 500 m radius surrounding the IMV for at least 30 minutes to ensure no whales or dolphins are present; and
- Any start-up will be completed as a 'soft start'. That is, equipment shall be gradually increased in power over a minimum period of 20 minutes.

TTR has included conditions of this nature in the proposed consent conditions provided as Attachment 1 of this IA.

## 4.10 Human Health Effects of the Marine Discharge Activities

### 4.10.1 Introduction

Regulation 35 identifies of the EEZ Regs 2015, identifies that where an application is made for a marine discharge consent, in addition to the matters identified in section 39 of the EEZ Act, an IA must be supported by an assessment of the health effects that may result from the discharge activities.

For the purpose of this application, the marine discharge consent activities relates to the discharges of harmful substances from the project's operations being the following 'mining discharges':

- The release of seabed material (sediments) as a result of seabed disturbance during grade control drilling activities;
- The release of seabed material (sediments) as a result of the seabed disturbance during the crawler extraction operations;

- De-ored sediments and any associated contaminants discharged back to the water column from the IMV, and their deposition back on the seabed; and

- The release of seabed material (sediments) as a result of taking of sediment and benthic samples associated with environmental monitoring.

As part of the previous application, TTR engaged Dr Francesca Kelly to prepare an evidence brief (Kelly (2014)[97]) for the EPA hearing that focused on the likelihood of risk to human health from contaminants. The evidence brief focused on where exposure to contaminants might arise through seafood consumption and contact recreation exposure. These potential health effects have been discussed in further detail below.

Kelly (2014) also considered the human health risks of the discharge to contaminants to air from the operational vessels. These effects are not a direct effect from the marine discharge consent activities so have not been discussed in the section further however, they have been considered in Section 4.14 of this IA which looks specifically at the air discharges associated with the project.

There are no other actual or potential adverse effects of the project on human health.

### 4.10.2 Human Health Effects of the Discharge Activities

#### **4.10.2.1** Contaminants Present within the Discharges

When considering each of the marine discharge activities to determine the potential extent of any health effects that may arise, it is important to understand the contaminants that are present in each discharge.

With regard to the contaminants present in the 'mining discharges' associated with the disturbance of the seabed during grade control drilling, crawler operation and monitoring, it is only the naturally occurring trace metals within the seabed that will be present.

When considering the nature of the trace metals present, it is noted in Section 4.6.7 above that there is the potential for trace metals (copper, zinc, etc) that are present in the underlying seabed material to be disturbed, excavated and redistributed over the seabed during project operations.

With regard to the de-ored sediments, as outlined in Section 2.3.3 of this IA, the processing of the seabed material to remove the iron ore concentrate is done by magnetic grinding and filtering. No chemicals are added or used in the processing, therefore the remaining de-ored sediments comprise of only natural seabed materials extracted from the seabed with the iron ore concentrate removed, thus the only potential contaminants within this discharge is any existing contaminants naturally occurring in the marine environment typically in the form of trace metal compounds.

As far as the potential distribution of any contaminants, de-ored sediments, including any trace metals, are slurried with resalinated water and discharged back into the water column within the project area which is beyond the 12 NM mark. Further, there is the potential for the sediment plume from the extraction and discharge process to extend towards the coastline and inside the 12 NM mark.

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97 Statement of Evidence in Chief of Dr Francesca Kelly on behalf of Trans-Tasman Resources Ltd. 15 February 2014.

When considering the potential human health effects of the trace metal component of the seabed materials, Kelly (2014) selected copper and nickel because of the potential for the release of concentrations during the project operations based on the properties of the seabed materials identified in the assessment described in Section 4.6.7 of this IA. The potential human health effects that may arise as a result of these trace metals are typically derived from consumption of seafood that may have been exposed to these contaminants in the marine environment and then harvested for consumption.

For the reasons outlined in Section 4.6.7.2, mercury has not been considered with regard to human health effects.

Kelly (2014) identified that the New Zealand Drinking Water Guidelines, which are primarily based on the World Health Organisation guidelines, identifies that copper in concentrations usually encountered in food or water is not considered a direct health risk, with nickel not being identified in the Guidelines due to the assessed low toxicity. Further, direct information from Total Diet Studies[98] provides information about patterns of food type exposure in the New Zealand population.

Kelly (2014) concluded that any elevations of copper or nickel in seafood, if they were to arise, will be below the amounts of any consequence for human health as a result of consumption of contaminated food.

Copper and nickel are also known to have ecological effects on fish, invertebrate and shellfish growth at concentrations below those that have adverse effects on human health. These effects have also been considered in Section 4.6.7.

There is nothing about the effects of the project on the physical environment relating to the physiological aspects of human health to the extent that the generic concerns of the project might result in anxiety or other mental health issues. It is beyond the ability of TTR to influence this and any attempt at establishing a causal link would be impossible to determine.

## 4.11 Cultural Effects

### 4.11.1 Introduction

This section of the IA summarises the assessment of effects of the project as they relate to the cultural values of iwi within the STB.

The assessments are primarily based on consultation undertaken to date and, where consultation has not been successful, an independent expert report has been prepared. TTR consider that this information represents the best available information at the time of lodging the application.

One of the key concepts raised during consultation with iwi was kaitiakitanga and the important role iwi and hapū play in the management of resources as kaitiaki. TTR understands 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. The authority to protect a resource stems from the broader viewpoint of whakapapa with kaitiakitanga is an exercise of obligation, mana, of prestige, of hapū and iwi.

98 http://foodsafety.govt.nz/policy-law/food-monitoring-programmes/total-diet-study/

The Te Taihauāuru Iwi Fisheries Forum Fisheries Plan 2012- 2017 makes the following statement about kaitiakitanga which summarises much of the concerns iwi have regarding the cultural impacts and the effect on iwi of the Project:

> *Without kaitiakitanga informing our decisions, our cultural identity and traditions become lost in modern society. Kaitiakitanga is based on mātauranga. Our mātauranga is founded on a holistic perspective; we are part of our environment. Our environment nurtures our mauri, and our mana remains powerful*[99].

This section of the IA also summarises TTR's proposed mitigation measures to provide for any adverse effects on cultural values that may occur as a result of the project.

### 4.11.2 Cultural Values Assessment

Following the unsuccessful approaches to engage with Ngāti Ruanui as part of the pre-application process, TTR engaged Tahu Potiki, an independent cultural expert from the Ngāti Tahu and Ngāti Mamoe iwi, to prepare a Cultural Values Assessment ("**CVA**")[100] for the iwi groups who have a connection with the STB and the project area, with a focus on Ngāti Ruanui's cultural values.

The CVA addresses the following:

- Methodology used in the CVA;
- Ngāti Ruanui and the STB;
- Maori and Ruanui World View;
- Effects of the Project on Cultural Values.

These matters have been summarised below.

<u>*Methodology used in the CVA*</u>

In preparing the CVA, the primary source of information was an analysis of iwi submissions received as part of the previous EPA application process. These submissions identified some of the issues of importance from a cultural perspective. Where available, other publications and documentation on cultural values within the STB were also used.

The CVA process would have ideally been informed by a Cultural Impact Assessment ("**CIA**") from Ngāti Ruanui and included extensive communication with primary source informants, particularly Ngāti Ruanui representatives / elders. However, neither of these have been possible as, despite numerous approaches to Ngāti Ruanui authorities, spokespeople and knowledge holders, there has been a collective refusal to meet with any TTR representatives to discuss the application. A detailed summary of TTR's consultation process with Ngāti Ruanui has been provided in Section 6.3.2 of this IA.

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99 Te Taihauāuru Iwi Forum Fisheries Plan 2012-2017, pp. 6

100 Cultural values Assessment and Analysis by Tahu Potiki. May 2016

*Ngāti Ruanui and the STB*

TTR acknowledges that Ngāti Ruanui holds mana whenua, and are kaitiaki, over areas of the STB including areas that will be affected by the project. It is on this basis that their cultural view and values are considered important and are relevant to the project. TTR has attempted to provide for a modern sensitivity to cultural concepts and landscapes therefore, allowing these matters to be taken into consideration and provided for as part of the project however, this has been hindered by the lack of direct consultation with Ngāti Ruanui.

The CVA identifies that its purpose is not to convey the view of Ngāti Ruanui in any way. Rather, the intention is to outline general Maori values and concepts in the hope to provide some understanding of the potential impacts of the project on Ngāti Ruanui and to assist in considering measures to mitigate any impacts should the marine consent and marine discharge consents be granted.

The boundaries of Ngāti Ruanui are well defined and recognised on the STB coast as extending from the mouth of the Waingongoro River to the mouth of the Whenuakura River. This incorporates the culturally significant Patea River and several important fishing reefs and wahi tapu sites adjacent to the coastline.

Historical account of Ngāti Ruanui's use of the coastline are detailed and show an intimate knowledge the resources the coast had to offer. It was a means of sustainability, a travel highway and a place of ritual or the kaitiaki and atua.

The coast supplied the people of Ngāti Ruanui with a constant supply of food resources. Reefs provided koura, paua, kina, pupu, papaka, pipi, tuatua, and many other species of reef inhabitants. More mobile kaimoana species such as hapuka, moki, kanae, mako, and patiki swim between the reefs off the Ruanui coastline.

Names such as Rangatapu, Ohawe Tokotoko, Waihi, Waokena, Tangahoe, Manawapou, Taumaha, Manutahi, Pipiri, Kaikura, Whitikau, Kenepuru, Te Pou a Turi, Rangitawhi, and Whenuakura depict the whereabouts of either a fishing ground or reef of significance to Ngāti Ruanui.

All along the STB shoreline from Rangatapu to Whenuakura food can be gathered and the Ngāti Ruanui people were skilled in catching and gathering kaimoana. Historically, the Ngāti Ruanui fishermen were considered very resilient and would stay at seas for days at a time. Food gathering and mahinga kai practices have been maintained and continue amongst present day Ngāti Ruanui.

Traditions of taniwha and sacred rocks are abound and it led the Ruanui people to be regularly involved in spiritual rituals in an effort to protect the people from misfortune and to assure bountiful harvests from the ocean.

*Maori and Ruanui World View*

The CVA identifies that there is a generic 'Maori World' view that affects the perspective of all things Maori and cultural values, and is one that is typically understood across all iwi. This view is based on whakapapa (genealogy or lineage) and tells a linear tale from a void through until the creation of humankind. There are subtle differences in different iwi versions but the central themes and characters are consistent and based, on the information available, it is considered that Ngāti Ruanui's beliefs are no different from a traditional view.

The Ngāti Ruanui whakapapa is considered to follow the general Polynesian creation story in that ancestors originated from Hawaiki and arrived in the region in the waka over the sea.

This provides a strong connection with the ocean and Tangaroa (god of the oceans), and identifies the spiritual relationship between Ngāti Ruanui and Tangaroa. This connection establishes a mauri to the sea and waterways of Ngāti Ruanui's rohe.

With regard to cultural values, the Maori World view is that all things come from the original point of creation which is a source of divine power, being mana. Mankind and other earthly manifestations are not the mana itself, they are merely a vessel or channel for mana. The residual impact of mana is tapu (sacred). Where there is mana the influence creates an effect that is holy or tapu and this can be transferred to people or places. Behaviour associated with tapu is one of the most culturally persistent beliefs amongst Maori meaning that certain places are avoided or treated with reverence because of traditional associations with powerful ancestors.

Taonga (treasure or valued objects) are another culturally persistent Maori concept. Traditionally the term was employed to determine something treasured in the whakapapa based Maori world. All taonga also had a kawai tupuna or whakapapa that connected it to a kaitiaki (guardian) or atua (ancestors with continuing influence or gods). In modern times the concept of taonga has been redefined by the Courts and the Waitangi Tribunal. It has a legal status that continues to be debated and is, arguably, distant from the original Maori use of the word.

Wahi tapu (sacred place or site) are a form of taonga. Wahi Tapu are sites that were considered sacred for a number of different reasons but primarily due to their association with an ancestor or ancestral events that caused the area to become affected by tapu. The general location of these areas would be known by the people but the laws of tapu would control their behaviour in terms of accessing them. These sites can include the land, sea, forests, lakes and rivers as well as place and things associated with life and death.

To determine exactly what creates wahi tapu and what does not is somewhat problematic. If it was merely ancestral association or connection with an ancestor then the entire country could be considered a wahi tapu but instead there are certain activities or events that lend themselves to this character and, it would be fair to say, in a hierarchical manner.

Wahi Tapu ki te Moana, sacred sites on the water and coast, were also a common occurrence. In the Maori world view, there is much evidence to suggest that certain ocean features had a status assigned to them and in some instances a wider importance is suggested. Cook Straight, for example, is a scared site but it is important to note that despite the entire waterway being considered tapu it does not preclude fishing or utilisation of the ocean space. There is reference to other rituals being observed and kaitiaki within the strait as well.

Mauri is the actual life force connection between gods and earthly matter. The Maori world view is that all things have a mauri including inanimate objects so it can be found in people, animals, fauna, fish, waterways, rocks, mountains. The mauri is, as a life force, is also the generator of the health of a person or place. If mauri is damaged, then the owner or the seat of that mauri is vulnerable or also damaged. However, if mauri is damaged the Maori world view is that it can be restored. There are considered to be many examples of fishing and coastal mauri amongst Ngāti Ruanui.

*Effects of the Project on Cultural Values*

With regard to the impacts of the project on the mauri of the coastal area, if one considers the coast from a purely traditional cultural perspective as a series of toka and fishing grounds imbued with mauri and tapu the question is then whether project has or will affect the mauri.

If the fisheries have abandoned an area and other life are noticeably absent then the mauri is potentially considered to be damaged. There are other signs of a depleted mauri but tohunga (cultural experts) are best placed to assess the state and consider remedies with regard to cultural effects.

However, if these resources were affected then measures could be taken to restore the mauri using traditional methods. There is no evidence that suggests that the presence of 'foreign' activities along the coastline would not, if impacted, allow the mauri to be re-established although, if totally destroyed or diminished, it is somewhat problematic to fully restore. It is important to note that it can be restored to a certain level where it has been affected.

Where mauri has been affected, a common restoration practice is the use of ritual solutions, including rahui (restricted access or exclusion) or karakia (prayer or blessing), that allow for damaged mauri to be strengthened however, these rituals are not effective if mauri has been destroyed completely.

In contemporary Maori environmental management, tangata whenua have the role of kaitiaki (or guardians) of their coastal resources. As such they have assumed the responsibility to ensure that the mauri (or life essence) of these resources is safeguarded.

A contemporary interpretation of mauri needs to be considered in the context of environmental mitigation and this is an appropriate response to the modern mauri analysis. The basic premise is that mitigation of environmental effects are claimed to be cultural mitigation that draws on Western interventions.

In contrast, if one was to adhere strictly to the traditional metaphysical or spiritual approach to mauri, remedies exist within a Maori world view that would also allow for its restoration. For example, Ngāti Ruanui still employ the ritual restoration as is evidenced in 2013 following the death of a whale on Patea Beach. Local iwi placed a rahui over the site for the period of one month thus restricting certain activities in the area. Further, it is understood that local tohunga continue to monitor the Taranaki coastline and ocean resources and perform karakia to protect the spiritual integrity and ensuring the ongoing health of the mauri.

The CVA identifies one matter that has been difficult to assess is the potential for damage to mauri. TTR is unaware of any submission or evidence from Ngāti Ruanui raising specific issues regarding mauri of particular fishing grounds or fishing reefs provided as part of the previous application process. That said it would be understandable for the iwi to be concerned about such things and to seek reassurance as to what mitigations might be available.

The CVA identifies that the knowledge of mauri can be considered in two parts. Firstly, there is the general religious philosophy of mauri as a life force principle as outlined above. It represents health and vitality and is the key indicator of the state of a fishing ground or hunting area. Secondly is the knowledge held locally about the personal atua, the protective kaitiaki and the form they are known to take and the general observation of the state of taonga species throughout the seasonal calendar. The CVA identifies that despite concerns that may be harboured by the iwi they certainly hold the requisite skills to competently administer appropriate spiritual interventions and direction.

Ngāti Ruanui have submitted that TTR have not paid regard to the taonga status of the Ngāti Ruanui fishery. TTR consider recognition and protection of sacred areas and taonga species to be a priority where they are provided with accurate and credible information. In the absence of any direct engagement by Ngāti Ruanui, TTR have had no choice but to regard the information provided by the Iwi Fisheries Forum (as discussed in Section 4.11.3 below) to have fulfilled this objective.

That said there is currently no indication that any specific traditional fishing grounds have been identified as being threatened by the project. In fact, the CVA identifies that the general monitoring of recreational and commercial fisheries is a comprehensive response to overall fisheries management.

There have been several other concerns raised by Ngāti Ruanui including matters of a technical nature, fisheries impact and consultation. Despite the lack of consultation and engagement, to address the concerns, TTR have included proposals for monitoring, detailed scientific analysis provided where available and opportunities for Ngāti Ruanui to take a central role in monitoring and communication. The CVA identifies that the measures (identified in Section 4.11.4 below and as provided for in the Proposed Consent Conditions provided as Attachment 1 to this IA) proposed by TTR to address the actual and potential cultural effects of the project provide a genuine transparent commitment to meet the concerns raised by Ngāti Ruanui and other tangata whenua within the STB.

One of the concerns left unaddressed are the cultural impact matter. Despite attempts from TTR to work with Ngāti Ruanui to provide a CIA an agreement has not been reached nor has one been produced. On this basis, the CVA, which has been summarised above, is an attempt to provide a comprehensive view of cultural concerns one would expect to be considered in decision making regarding the potential for the project to impact on the cultural values of iwi within the STB.

### 4.11.3 Te Tai Hauauru Fisheries Forum

The Iwi Fisheries Forum was established through the development of the FMA 8 and in response to the Treaty of Waitangi Fisheries Settlement and the Maori Fisheries Act. The Iwi Fisheries Forum consists of representatives of the following iwi:

- 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); and
- Tanenuiarangi Manawatu Incorporated (Rangitaane o Manawatu).

As a result of extensive consultation, the Iwi Fisheries Forum provided TTR with the Forum Report on the customary values and matauranga Maori matters affected by the project (refer to Appendix 4.6). This section discusses those values and the means by which TTR proposes to provide for these values.

TTR note that following the release of the Forum Report, Ngāti Ruanui confirmed that they did not endorse the Forum Report or its findings.

The purpose of the Forum Report is to help to bridge the gap between western science and matauranga Maori by better communicating the local indigenous knowledge and identifying aspects that can be incorporated into the monitoring and management associated with the project. The findings of the Forum Report have been used by TTR to develop management and monitoring programmes in partnership with the Iwi Fisheries Forum and fully recognise kaitiakitanga. However, the Forum Report further notes that it is not the role of the Iwi Fisheries Forum to speak on behalf of all those who have mana moana/ mana whenua and that each iwi should also have the right to comment on the application.

The investigations that informed the report involved hui with relevant iwi that have 'mana moana / mana whenua connections' to the STB coastline. The cultural information was shared through Tāngata Tiaki (individuals who authorise customary fishing within their rohe moana) in the discussion on the effects of the project, as well as extensive hui with TTR.

In preparing the report, the approach taken involved the iwi and the Iwi Fisheries Forum examining the updated application and scientific information provided by TTR to assess if the iwi issues have been identified and provided for. Where data gaps or concerns were identified these were presented to TTR to enable them to form recommendations and pathways for involvement in the monitoring of the project and to enhance the iwi role of Kaitiaki or Tāngata Tiaki within the affected areas. Further, the Iwi Fisheries Forum reviewed the past submissions received from Maori on the previous application to *'gain context and possibly further insights into the aspects of the coastal marine area that are valued by Maori and tāngata whenua'* with a focus on matauranga Maori and customary fishing.

The Forum Report identifies that a detailed work programme has been provided (Appendix 1 of the report) and that the process to date has followed the stages below:

- Establish tikanga processes and protocols with the Iwi Fisheries Forum;
- 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; and
- Present those significant customary interests identified in a series of map and through Geographic Information Systems (provided in Section 8 of the Forum Report).

The Forum Report further identifies that *"it 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 (tāngata whenua) interests in the coastline through providing sites of significance to customary species or fishing practices."*

The Forum Report places significant emphasis on the Forum Fisheries Plan, which is identified as a MPI recognised iwi management plan that should be considered with regard to any activity occurring within FMA 8 which the project area is located within. The Forum Fisheries Plan is relevant for consideration for any management or monitoring of cultural matters associated with the project with the key principles of the Forum Fisheries Plan being to provide for kaitiakitanga, protection of important and / or taonga customary species, and provision of non-commercial customary fishing for future generations.

The Forum Report identifies there were 27 different sites of significance with regard to customary fisheries shown in the maps in Section 8 of the Forum Report. These sites and the areas in which they are located can be summarised as follows:

- *North Taranaki to Patea* – not considered to be affected by the project. 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 and traditionally has been used to collect species such as paua, crayfish, kina, kelp and some fish species. It is recommended that this area is used as a 'control site' for monitoring of customary fishing interests.

- *Patea to Waitotara* – potentially affected by the project. This area has the most ecologically significant customary fishing grounds of the Taranaki area being the North and South Traps and the Rolling Grounds.

    - *North and South Traps* - important customary fishing sites and sites of abundant ecological diversity due to the seabed morphology. The sites are considered significant due to the mauri it contains based on its abundant ecological diversity and the contribution it makes to maintain the health of surrounding areas.

    - *Rolling Grounds* - of equivalent significance to the North and South Traps and are considered to be associated to the mobile sand dune system that occurs offshore. Sites within the Rolling Grounds 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.

- *Waitotara to Kai Iwi* - potentially affected by the project. Identified as an important whale nursery or feeding area where certain whale species visit at various times of year.

- *Kai Iwi to Kaitoke (Whanganui)* – unlikely to be affected by the project. A number of sites located along this section of the coastline. 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 site (places that are important to Maori for their ancestral significance and their associated cultural and traditional values). The river mouth sites are significant with respect to migratory freshwater species e.g. eel and lamprey. This stretch of coastline is significant as there is a dramatic change in the coastline as it becomes more dominated by a sandy coastline and seabed with species of interest such as rig, kahawai and gurnard. Further, 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* – unlikely to be affected by the project. This long sandy coastline is in direct contrast to the Taranaki coastline. Similarly, the sites and the connections with the iwi who occupy and utilise this area are also very different. The shellfish along this coastline takes 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. 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.

- *Tangimoana to Manawatu River* – not considered to be affected by the project. 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* – not considered to be affected by the project. While sites in this stretch of the coastline were not mapped it has been suggested that areas directly south of the Manawatu River and specifically toheroa beds provide a good control site. It is considered that these toheroa beds are outside of the affected area and are 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.

The Forum Report identifies the following recommendations with regard to the project and providing for cultural values:

1. TTR should develop a formal Memorandum of Partnership ("**MoP**") or Memorandum of Understanding ("**MoU**") with the Iwi Fisheries Forum. As part of this agreement TTR and the Iwi Fisheries Forum will recognise the kaitiakitanga role of the Iwi Fisheries Forum's iwi and develop an agreed upon monitoring plan. TTR should resource the monitoring plan as appropriate.

2. TTR should recognise and actively incorporate kaitiakitanga into its future management and monitoring programmes. This should:

    a. Provide the Iwi Fisheries Forum with the results of its environmental monitoring programme and Including the Iwi Fisheries Forum membership on any environmental review committees;

    b. Provide the Iwi Fisheries Forum members the opportunity to participate in future monitoring operations and research; and

c. Provide the Iwi Fisheries Forum the opportunity to review and provide comment on any environmental management plans.

3. TTR should develop a set of cultural based indicators and sites that should be used for future monitoring and adaptive management processes.

4. The Iwi Fisheries Forum should be engaged and resourced to monitor these sites in accordance with TTR's monitoring process. A list of possible monitoring sites and species are provided below based on this analysis.

| ***Cultural Monitoring Sites*** | ***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 (eels) | Abundance (particularly the number of eels in glass eel migrations) |
| Waitotara – Tangimoana | Whales | Occurrences |
| Moana Roa | Pipi (surf clams) | Abundance and distribution |
| Pukepuke | Tuna (glass eel) | Abundance |
| FMA 8 | Blue Cod and Snapper | Health of species |
| Manahi | Reef species | Ecological integrity/ diversity/ abundance |
| Puketapu | Reef species | Ecological integrity/ diversity/ abundance |
| South of Manawatu (Hokio) | Toheroa | Abundance and distribution |

5. 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 its activity is the cause of the effect. If TTR is 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.

a. If the sites or species impacted cannot be rectified by TTR then TTR should mitigate the loss in other ways. This should be formalised in the MOU/MOP.

6. TTR should be required to invest in a financial bond to compensate for any negative impacts on customary fishing activities.

7. TTR will agree to remove all equipment or machinery from the seabed within a reasonable timeframe should there be any event that results in equipment becoming stranded.

TTR has committed to providing for the recommendations in the Forum Report through the provision of the following aspects in the proposed consent conditions included as Attachment 1 to this IA:

1. The Kaitiakitanga Reference Group ("**KRG**") (Condition 34) should include at least one delegated Iwi Fisheries Forum representative as this will provide for the kaitiakitanga role and allow for input into the proposed Kaimoana Monitoring Programme ("**KMP**") (Condition 38), the BEMP and EMMP, as well as enabling

input into the review of environmental monitoring results from a cultural perspective;

2. Further to the inclusion of an Iwi Fisheries Forum representative in the KRG, TTR proposed that an Iwi Fisheries Forum Representative is offered a position in the Technical Review Group (Condition 28). With regard to involvement in future monitoring and reviews, TTR has identified that iwi representatives shall be responsible for the monitoring work under the KMP and the KRG will be provided with monitoring results and asked to review and provide input from a cultural perspective;

3. It is proposed that cultural based indicators be incorporated into the KMP (Condition 38);

4. The parties responsible for the monitoring of cultural sites is provided for through the provisions of the KMP and identifies that iwi representatives shall be provided the opportunity to undertake the monitoring;

5. The proposed conditions provide a mechanism for responding to breaches of pre-determined environmental performance thresholds;

6. Proposed condition 83 provides for a $100,000,000 public liability insurance cover that provides for the cost of environmental restoration in the event that it is required as a result of an unplanned event that has occurred, as a result of the any activities authorised by any consent granted.

7. Proposed condition 64 provides for any machinery or associated equipment lost overboard of any vessel associated with the project, as soon as practicable, be recovered where recovery is viable.

It is considered that through the adoption of the proposed consent conditions, any actual or potential effects of the project on the cultural values identified by the Iwi Fisheries Forum will be avoided, remedied or mitigated.

### 4.11.4 Cultural Effects Mitigation

Based on the positive consultation achieved with some tangata whenua interests and the directions received with regard to addressing the cultural impacts of the project, TTR has proposed specific tangata whenua focused consent conditions be included in any marine consent and marine discharge consent granted for the project.

While it is accepted that the focus of these conditions is on the ‘physical’ aspects of the cultural impacts of the project, TTR considers that the proposed consent conditions also are a way to of providing for the ‘intangible’ or ‘metaphysical’ cultural impacts (e.g. effects on mauri) associated with the project.

TTR proposes the following conditions with regard to tangata whenua and cultural values:

- That the relationship of tangata whenua with the STB be recognised and provided for through the provision of a Kaitiaki Reference Group. The purpose of the KRG is to:
    - Recognise the kaitiakitanga of tangata whenua and their relationship with the STB;

- o Review and advise TTR on the suitability of the KMP (discussed below);
- o Provide for the ongoing involvement of tangata whenua, who have a relationship with the STB as kaitiaki, in monitoring the effects of the project;
- o Provide for kaitiaki responsibilities and values to be reflected in the monitoring of the project area and of the surrounding marine environment undertaken under these consents, 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 insofar as it relates to the cultural values of the STB and the effects on those values from the project and, in the event that changes to effects are identified, advise TTR on possible monitoring or operational responses;
  - ▪ To advise TTR on the appropriateness of any operational responses as they relate to cultural values, proposed by others;
  - ▪ To provide a means of liaison between tangata whenua and TTR through providing a forum for discussion about the implementation of these consents; and
- o Be responsible for receiving requests for, and facilitating the provision of, any cultural ceremonies by tangata whenua and other tangata whenua groups who have a relationship with the STB.

- Provide for the preparation, implementation and management of a specific KMP with the objective to provide for the monitoring of species important to customary needs, including from customary fishing grounds around the project area and STB, of Maori who have a relationship to the STB;
- Where practicable, TTR will use its best endeavour to engage tangata whenua representatives, including but not limited to Ngāti Ruanui and Te Tai Hauauru Regional Fishing Forum representatives, to undertake monitoring identified in any KMP related to the project; and
- Following the commencement of project operations, TTR will provide Ngāti Ruanui an annual fund of [$TBC] per year to be used for environmental initiatives and/or for the cultural well-being of Ngāti Ruanui.

Conditions providing for the above, as well as further matters related to cultural values, have been provided for in the proposed consent conditions provided as Attachment 1 of this IA.

## 4.12 Visual, Seascape and Natural Character Effects

### 4.12.1 Introduction

Boffa (2015) has assessed the natural character, landscape, seascape, and visual amenity values related to the project as well as the potential effects of the project on these values. The findings of their report have been summarised below.

### 4.12.2 Assessment Methodology

To inform Boffa (2015), visibility mapping using the zone of theoretical visibility approach was undertaken to establish from what location, both onshore and offshore, aspects of the project would be visible. Because the IMV will be in different locations within the project area during its lifetime, two locations were selected for the zone of theoretical visibility analysis, namely:

1) The shoreward limit of the project area (22.2 km offshore) (Figures 4.13 and 4.14 below); and

2) The centre of the project area (28 km offshore) (Figures 4.15 and 4.16 below).

The justification behind this is that the project will be most visible from the shoreward limit, while the centre of the project area provides a theoretical median visibility.

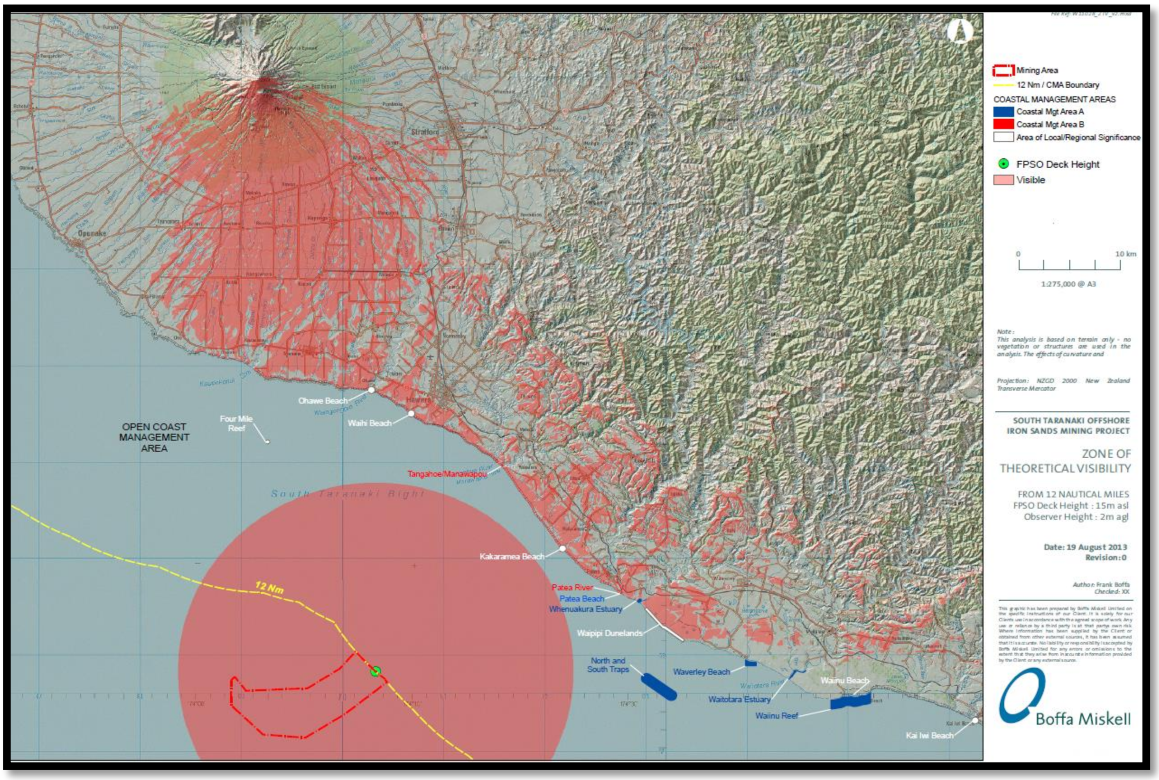


**Figure 4.13: ZTV from 12 NM IMV Deck Height: 15 m above sea level, Observer Height: 2 m above ground level**

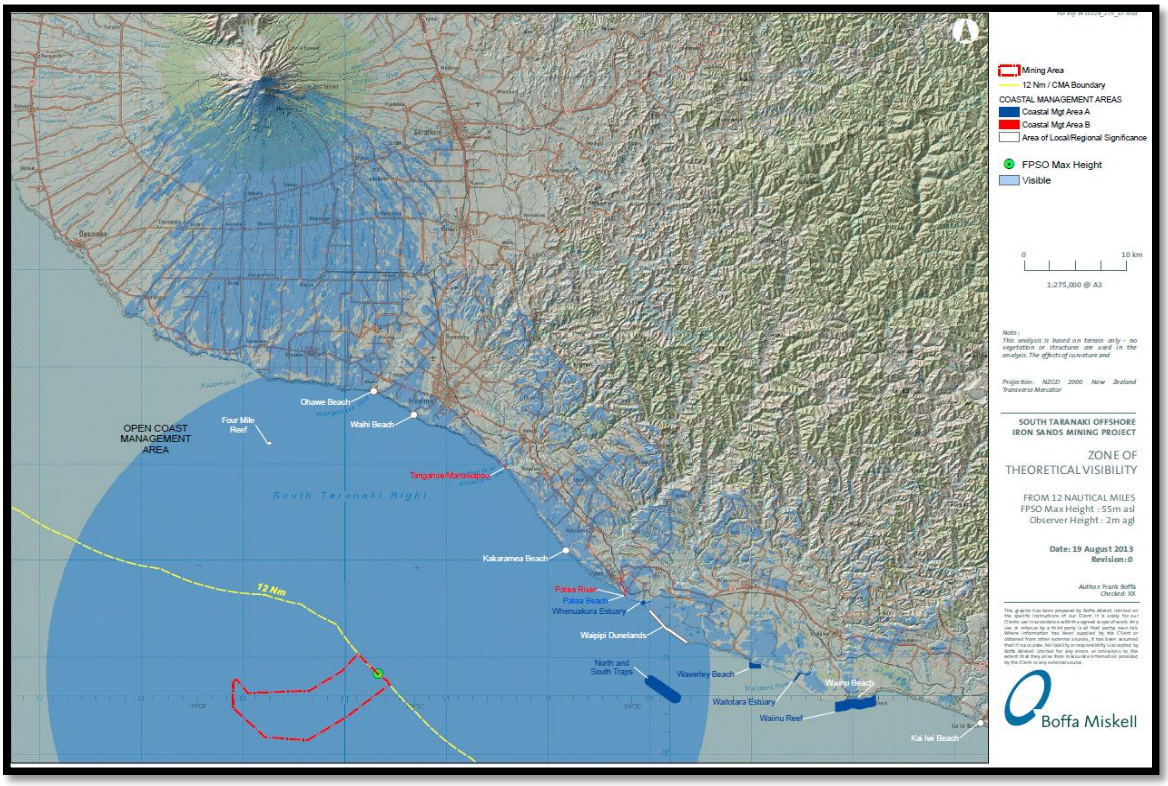


**Figure 4.14: ZTV from 12 NM IMV Deck Height: 55 m above sea level, Observer Height: 2 m above ground level.**

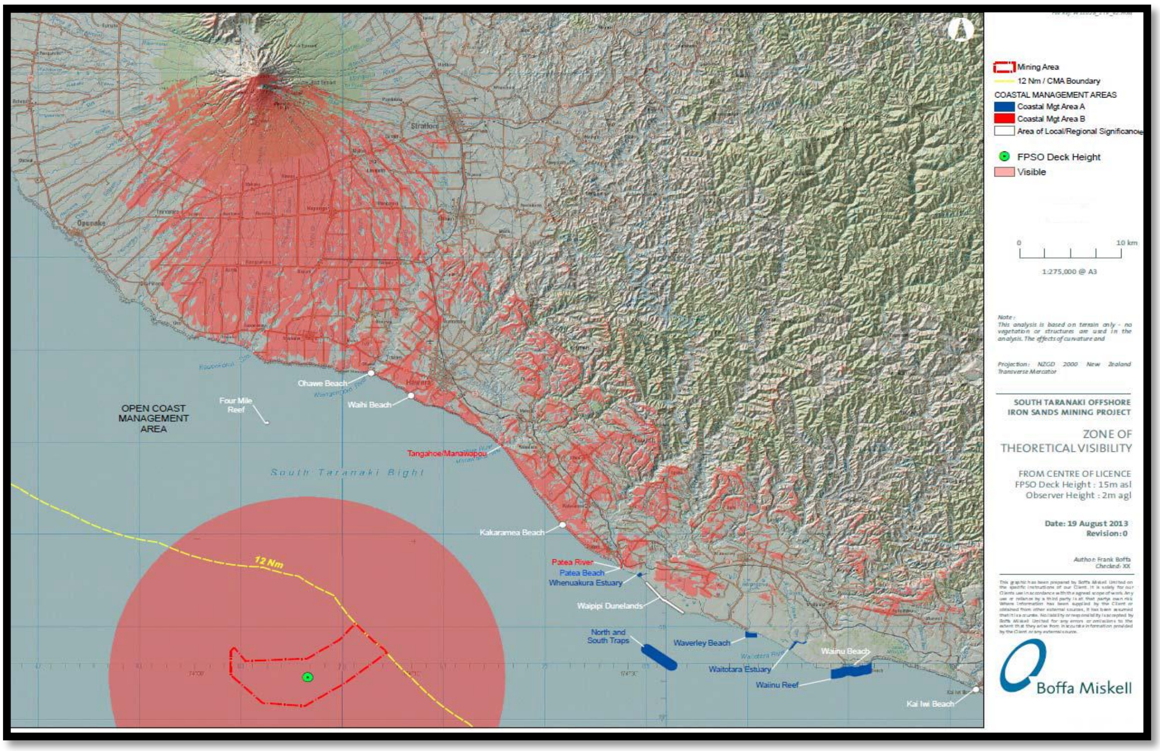


**Figure 4.15: ZTV from centre of Application Area IMV Deck Height: 15 m above sea level, Observer Height: 2 m above ground level.**

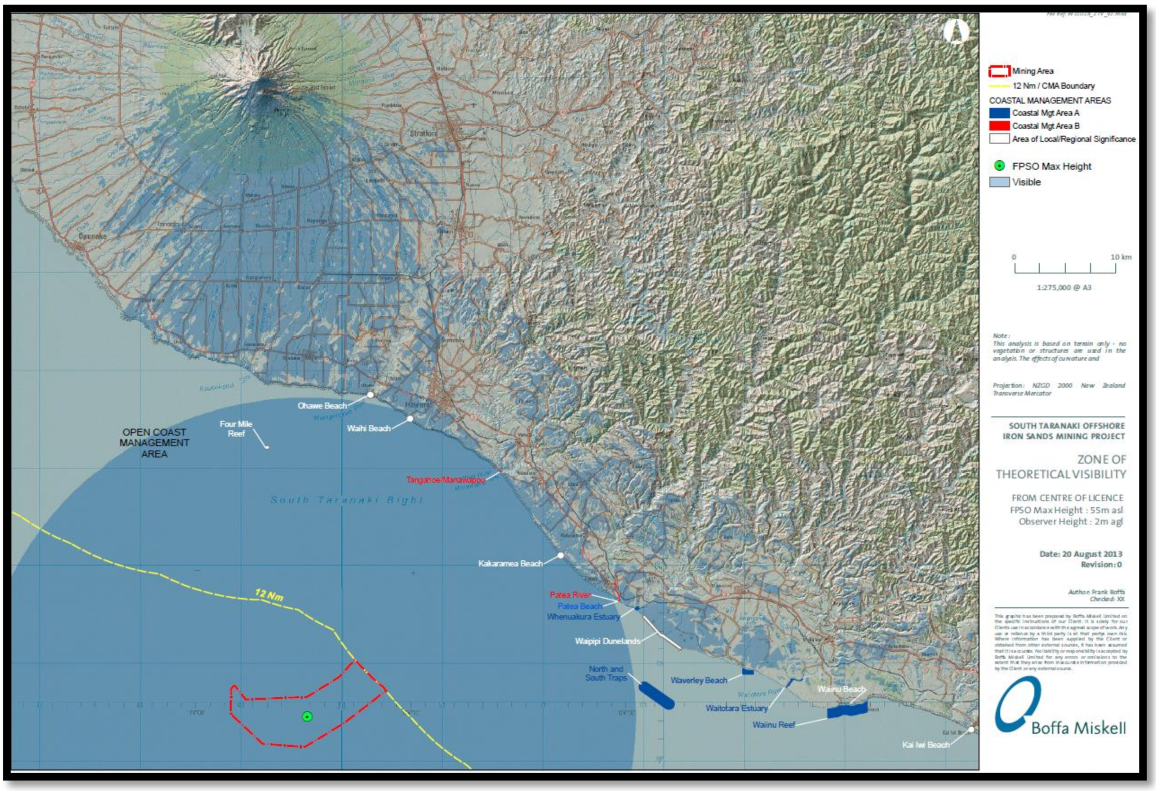


**Figure 4.16: ZTV from centre of Application Area IMVIMV Deck Height: 55 m above sea level, Observer Height: 2 m above sea level.**

### 4.12.3 Summary of Potential Effects

As outlined in Boffa (2015), the visual, natural character and landscape effects are categorised as follows:

- Visual effects from specific viewing points and audiences.
- Effects on natural features and natural landscapes.
- Effects on natural elements, patterns and processes (the natural character of the coastal environment).

While the visibility of the IMV will be high from marine areas within 10 – 15 km of the vessel itself, the visual effects are assessed as being low overall and are unlikely to be perceived as being visually intrusive or adverse. While the IMV is large, its associated and smaller support vessels will also be present, and in some cases visible from the coastline for extended periods of time, the surface marine activities associated with the project are considered to be minor overall. Further, where project related vessels are visible, they will likely be seen as an "appropriate" working seascape activity especially in an already busy STB marine environment.

In addition to vessels, the project operations will generate a sediment plume that will extend beyond the project area due to the plume's transient nature. However, as described in Section 4.4, the presence of the plume will be decreasing as distance from the source of the disturbance increase. The visual effects of this sediment plume are considered to be relatively low, as for the most part the plume will not be visible from land-based viewpoints.

Further, these land-based viewpoints areas already experience a high degree of visual disturbance due to the high energy environments close to the coast.

Boffa (2015) identifies that there is the potential for a visual impact of the sediment plume on recreational boaters but any potential effect will be highly variable and dependent on weather and sea conditions and the offshore location of the recreational vessels. While the size and pattern (scale) of the sea surface colour change may be extensive and significant in its seascape context, its significance in terms of recreational / amenity values will be lower, given the relatively low levels of recreational activity that occurs within the project area. It is important to acknowledge that any sediment plume, however, will only be evident during times when iron sand recovery is being undertaken, which is considered to be approximately 70% of the year, and accordingly this effect is reversible.

Visual effects of the sediment plume on recreational and commercial aircraft will be the most apparent, however, any effects will only be experienced by transient visitors to the area and will be highly dependent on the weather conditions and seas state at the time.

With regard to natural landscape and features, Boffa (2015) considers that the offshore location of the project effectively avoids any direct effects on any areas that have outstanding natural features, landscapes or seascapes within the STB as these areas are typically within the CMA environment. This position is consistent with Policy 15(a) of the New Zealand Coastal Policy Statement ("**NZCPS**") which seeks the avoidance of adverse effects on such landscapes and features in the coastal environment.

Additionally, by working within a defined project footprint, smaller than the total project area, and re-distributing de-ored sediments into already works areas will further assist in avoiding and mitigating the potential for project related adverse effects in the natural landscape and feature values. Overall, Boffa (2015) states that the significance of effects on natural features and landscape is low and can be classified as minor.

Natural character is used to describe that naturalness of an area in terms of its natural elements, patterns and process. The effects of the project on the natural character on the STB coastal environment need to be considered. Boffa (2015) found that due to the location and position of the project area being over 12 NM offshore, the overall effects of the project on the natural character of the area were deemed to fall into the moderate to minor significance category. This position was accepted by the DMC in their decision on the previous marine consent application.[101]

A summary of the effects as a result of the project, with the level of effect outlined in bold, is provided below:

- Offshore Vessels – **Minor**;
- Natural Features and Landscapes / Seascapes – **Minor**;
- Sediment Plumes – **Moderate**; and
- Natural Character – **Moderate to Minor**, however within the vicinity of the project area considered to be major.

[101] TTR Marine Consent Decision. 15 June 2014. Para 566.

### 4.12.4 Visual Cumulative Effects

In terms of visible cumulative effects, the sediment plume will not add appreciably to the natural background levels of suspended sediments within the inshore and nearshore coastal marine environments of the STB. There will however, be increased visual effects in terms of the offshore and distant offshore coastal environments where currently there are no visible sediment plumes in the surface water under the majority of the offshore conditions.

Boffa (2015) found that from some CMAs, cumulative effects may be more apparent than others however, given the limited extent of elevated coastal viewpoints and the variability of the plume, cumulative effects are not likely to be perceived as being significant or adverse.

From aircraft, cumulative effects will be apparent and are likely to be widespread in extent but visibility will be directly related to the sea surface state.

Overall, based on Boffa (2015), the assessment is that the significance of any visual cumulative effects will be no more than minor.

TTR's position on the project's impact on natural character, natural features and landscapes being minor to moderate (localised within the iron sand recovery area) was supported by the DMC in their decision on the previous marine consent application, who concluded that visual effects associated with project vessels were minor, any visual effects of the sediment plume would be moderate, and any impacts on natural features and landscape / seascape and natural character, other than within the actual operations area, would be minor, particularly in the inshore and nearshore waters and coastline environments. [102]

## 4.13 Archaeology and Heritage Effects

### 4.13.1 Introduction

Clough (2015) assessed the archaeological values of the project area and the potential effects of the project operations.

Clough (2015) focusses on the potential for historic shipwrecks to be discovered within the project area during the iron sand recovery operations.

### 4.13.2 Assessment Methodology

The Clough (2015) assessment methodology involved:

1. Reviewing multi-beam sonar data collected during bathymetric surveys undertaken by NIWA by covering five locations within the project area;

2. A desk-based review of literature relevant to shipwrecks along the South Taranaki coast to provide historical detail and supplement the bathymetric survey data; and

3. Review of information relating to recorded archaeological sites on the landward side of the South Taranaki coastline close to the project area was also reviewed to provide further background information.

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[102] TTR Marine Consent Decision. 15 June 2014. Para 570 - 572.

### 4.13.3 Summary of Archaeological and Heritage Effects

Clough (2015) identifies that when determining archaeological and heritage effects related to the project, a legally protected archaeological site is defined as a shipwreck or debris that pre-date 1900 and is an indicator of having archaeological or heritage value.

The coastal waters of the Taranaki Region has a detailed history of shipwrecks with at least 126 documented shipwrecks - 64 of which pre-date 1900. Twenty-three vessels are recorded to have been lost in the vicinity of Patea, and 28 in the vicinity of Whanganui. Of the recorded shipwrecks with their known location that pre-date 1900, 14 are in the vicinity of Patea and 20 in the vicinity of Whanganui. However, there are no known shipwrecks located within the project area.

Furthermore, based on the review of the NIWA multibeam sonar data (Pallentin et al. (2015))[103], there is no significant wreckage or any signs of significant debris exposed on the seabed within the project area.

While the location of the numerous documented shipwrecks in the Taranaki Region have not been confirmed, Clough (2015) concluded that there is a low potential risk of wreckage buried beneath the seabed being uncovered during the project operations.

With regard to archaeology and heritage effects, Cough (2015) concluded that:

- There should be no constraints on the project on archaeological grounds, as no shipwrecks are known to be present within the project area;
- The potential for previously unrecorded shipwrecks within the project area is low;
- Further archaeological investigations / monitoring of the project area is not necessary; and
- If a pre-1900 shipwreck is encountered during the project operations, a discovery protocol for shipwreck finds should be implemented.

### 4.13.4 Management of Potential Effects on Archaeology

Based on the recommendations from Cough (2015), TTR proposes to implement the following protocol in the event of the accidental discovery of a pre-1900 shipwreck during project operations:

- Should a number of artefacts / debris or a substantially intact wreckage be discovered in a discrete area, work would cease in the immediate area while the find is identified;
- In the first instance, efforts will be made to identify what the items are and the likely age of the discovery. This would involve the items being photographed, the location recorded and a recorded description of the find. The collected information would then be sent to an archaeologist consultant for identification and assessment;

103 Pallentin. A., Gerring. P., Wolez. S., Fenwick. M. *"Multibeam Survey in Southern Taranaki Bight. Prepared for Trans-Tasman Resources Ltd"* Updated November 2015

- If the wreckage is not a legally protected archaeological site (i.e. post 1900), a record of the article would be made and works would resume; and

- If a discovery is confirmed to pre-date 1900, it is a legally protected archaeological site under the Heritage New Zealand Pouhere Taonga Act 2014 ("**Heritage Act**"). Consequently, it will be necessary for TTR to contact Heritage New Zealand Pouhere Taonga ("**Heritage New Zealand**") and obtain an archaeological authority before works affecting the site are resumed.

This protocol is reflected in the proposed consent conditions provided as Attachment 1 of this IA.

In their decision on the previous marine consent application, the DMC noted that they did not dispute the conclusions on archaeological and heritage effects and confirmed that there should be no constraints on the project on archaeological grounds. Further, the DMC concluded that the information provided was certain and adequate for assessment purposes and were satisfied that the conditions proposed by TTR would appropriately address any archaeological remains that may have been discovered if consent had been granted.[104]

Overall, the project will not result in any adverse effects on any known archaeological features or heritage values. If undiscovered features are encountered during the project, sufficient procedures will be implemented to ensure that any effects will be appropriately provided for through consultation and, where necessary, approval from Heritage New Zealand.

## 4.14 Air Quality Effects

### 4.14.1 Introduction

Tonkin and Taylor Limited ("**T&T**") were engaged to assess the dispersion and effects of emissions from the combustion of HFO to produce energy from the proposed gas turbine (T&T (2015a))[105], or reciprocating engines (T&T (2015b))[106], located on the IMV. These reports provide further information in response to matters raised in the first application process.

### 4.14.2 Assessment Methodology

Discharges to air from the HFO gas turbines or reciprocating engines comprise combustion products. The air pollutants considered in T&T (2015a & b) included fine particulate matter ($PM_{10}$), sulphur dioxide, nitrogen dioxide and carbon monoxide from the operation of seven engines located on the IMV vessel, consisting of six 12V46 engines and one R1, seven cylinder engine. The emission rates considered were based on information provided by the proposed engine suppliers, as well as the United States Environmental Protection Agency Applicability Determination Index emission factors and calculations by T&T, using plant and process data supplied by TTR.

T&T (2015a & b) used a 3D meteorological dataset developed for the project area using terrain and land use information, observations from six meteorological surface sites and 3D upper air data developed by another meteorological model. The maximum ground level

104 TTR Marine Consent Decision. 15 June 2014. Para 579 & 582.

105 Tonkin and Taylor, 2013a *"Offshore Iron sands project – Air Dispersion Modelling Study – Gas Turbines"* T&T Ref: 29303, 31 pp. August 2013. Updated November 2015.

106 Tonkin and Taylor, 2013b *"Offshore Iron sands project – Air Dispersion Modelling Study – Reciprocating Engines".* T&T Ref: 29303, 32 pp. October 2013. Updated November 2015.

concentrations of pollutants were predicted by using air dispersion modelling (the CALPUFF dispersion model) over a 52 km x 40 km grid (100 m grid resolution) surrounding the project area, including the coastline to the northeast of the project area.

The CALPUFF dispersion model was used to predict contaminant concentrations in the vicinity of the project operations. The results of modelling were compared to relevant air quality assessment criteria, including the Ministry for the Environment Ambient Air Quality standards ("**MfE AAQS**") and National Environmental Standards for Air Quality ("**NESAQ**"), to assess the potential effects to human health and the environment.

### 4.14.3 Summary of Potential Effects

The modelling predicted that maximum offshore ground level concentrations of $NO_2$ and Sulphur Dioxide ("**$SO_2$**") (1 hour (99.9%) and 24 hour averages) exceed the relevant New Zealand air quality standards and guidelines (MfE AAQS and NESAQ) (Table 4.12 below).

**Table 4.12: Maximum allowable ground level concentrations of contaminants.**

| Contaminant | Time Average | Maximum Ground Level Concentration (µg/m$^3$) | | Air Assessment Criterion (µg/m$^3$) |
|---|---|---|---|---|
| | | Offshore | Onshore | |
| **Particulate matter (PM10)** | 24 hour | 4.4 | 0.6 | 50 |
| | Annual | 0.14 | 0.024 | 20 |
| **Nitrogen dioxide** | 1 hour (99.9%) | 313 | 60 | 200 (9 exceedances allowed per 12 months |
| | 24 hour | 160 | 22 | 100 |
| | Annual | 5.3 | 0.9 | 40 |
| **Sulphur dioxide** | 1 hour (99.9%) | 453 | 87 | 350 (9 exceedances allowed per 12 months) |
| | 24 hour | 231 | 31 | Must not exceed 570.<br><br>120 |
| **Carbon monoxide** | 1 hour (99.9%) | 75 | 14 | 30,000 |
| | 8 hour | 67 | 12 | 10,000 |

These exceedances are predicted to occur in the vicinity of the IMV and beyond the 12 NM limit therefore, T&T (2015a & b) concluded that the public are unlikely to become exposed to these air discharges. However, there is the potential for staff on board the IMV to be exposed to elevated concentrations of $NO_2$ and $SO_2$ however, these discharges will occur from the exhaust system of the vessel which is located well above the working areas of the IMV.

T&T (2015a & b) identify that the predicted ground level concentrations of all contaminants onshore are below the relevant health-based air assessment criteria. It is noted that 20 µg/m$^3$ is the World Health Organisation 24-hour average guideline, which does not currently have any regulatory status in New Zealand.

### 4.14.4 Management of Potential Effects on Air Quality

In assessing discharges to air, T&T (2015a & b) considered that emissions from fuel combustion for energy production in gas turbines of reciprocating engines will have only minor effects on air quality.

In joint expert conferencing for the first hearing on the first application, held on 26 March 2014[107], experts noted that the air concentrations of $SO_2$ exceeded the MfE AAQS but the predicted air discharge concentrations for the project would be within the New Zealand Workplace Exposure Standards. Therefore, they concluded that discharges would not impact human health or air quality, have a no more than minor effect and could be addressed by conditions of consent. This was accepted by the DMC in their decision on the previous marine consent application.[108]

To provide for the high $SO_2$ discharges, the experts agreed that it was appropriate to include a condition that would limit the sulphur content of any fuel used in the project related vessels, being that a content of 3.5% wet weight sulphur content is the appropriate limit based on air quality and health effects.[109] This limit has been provided for in the proposed consent conditions provided as Attachment 1 of this IA.

Further, as identified in their decision on the previous marine consent application, the DMC agreed with the experts that the project's air discharges would have a no more than minor effect and found that the human health effects, of which air discharge effects are associated, were manageable and could have been addressed by consent conditions.[110]

## 4.15 Effects on Existing Interests

### 4.15.1 Commercial Fishing Effects

#### 4.15.1.1 Introduction

TTR commissioned Gibbs (2015) and MacDiarmid et al. (2016) to assess the potential impacts of the project on commercial fishing interests present in the STB.

Additionally, to further understand the effects of the project on commercial fishing interests, TTR has also undertaken direct consultation with commercial fishing industry representatives. This consultation process has been summarised in Section 6.3.13 and the assessment of the effects of the project on commercial fishing interests have been summarised below.

Further to the commercial fishing impacts discussed below, the potential impacts of biosecurity effects on aquaculture activities within the coastal waters of Admiralty Bay was also assessed by TTR. An assessment of biosecurity effects is included as Section 4.15.2 of this IA.

107 TTR Marine Consent Application – Joint Statement of Experts in the Field of Air Quality and Health Effects. 26 March 2014.

108 TTR Marine Consent Decision. 15, June 2014. Para 452.

109 TTR Marine Consent Application – Joint Statement of Experts in the Field of Air Quality and Health Effects. 26 March 2014. Para 30.

110 TTR Marine Consent Decision. 15 June 2014. Paras 483 & 484.

#### 4.15.1.2 Assessment Methodology

In preparing their report, Gibbs (2015) completed a desktop study of the commercial fishing industries in the STB, sorted by fishing method. This was followed by an assessment of the potential impacts on commercial fishing, which are categorised as:

1. Impacts arising from the spatial exclusion of commercial fishing activity;

2. Effects of the project operations on fish species that are caught by commercial fishers in the immediate project area;

3. Effects of the project's extraction activity on fish species that are caught by commercial fishers in offsite areas (e.g. coastal reefs); and

4. Broader impacts, including impacts on quota value and downstream businesses.

MacDiarmid et al. (2016) looked at the catch and effort data from the MPI database "Wharehou" for the study area which includes the project area and used this information to draw conclusions on the commercial fishing activity within the project area.

The data consists of all fishing and landing events associated with any set of fishing trips that reported a positive catch or landing of any species between 1 October 2006 and 30 September 2015. MacDiarmid et al. (2016) summarises the effort and catch for each fishing method over the last nine completed fishing years based on statistical analysis methods and for each of the principal methods of capture, which indicates the spatial distribution of the fishery in the STB. The spatial distribution of the effort and catch was then compared to the estimated area where the suspended sediment concentrations resulting from the project related sediment plume will potentially be above the 2 mg/L threshold (a conservative indicator for that may result in fish avoiding an area, as discussed in Section 4.7.1 and below) 50% (median) and 1% ($99^{th}$ percentile) of the time.

#### 4.15.1.3 Summary of Potential Effects

***Species Abundance***

During the project operations, commercial fishing may be affected by the abundance of fished species within the project area and in the adjacent coastal waters.

The main driver that has the potential to impact on the abundance of fish within the project area is the sediment plume however, noise and other vessel related effects also have the potential to affect abundance. The sediment plume also has the potential to impact the rock lobster industry along the Taranaki coast.

Section 4.4 of this IA discusses the sedimentation effects and the modelling undertaken to quantify the extent of the area affected by the project related sediment plume.

As identified in Section 4.7.1, 2 mg/L and 3 mg/L are the lowest suspended sediment concentrations that would be avoided by pelagic and demersal fish respectively however, it was noted that acute and chronic impacts would be expected to occur at significantly higher levels. Lowe (2013) reported that suspended sediment concentrations of 35-40 mg/L as being the level that started affecting foraging strategies, and declining condition for juvenile species. Further, a separate study, Page (2014), looking at the fish species avoidance of total suspended sediments on the Chatman Rise provided a comprehensive list of threshold concentrations that showed that most species were only impacted beyond avoidance or a reduction in feeding, at suspended sediment concentrations levels well in excess of 500 mg/L.

With regard to this project, such levels would not be encountered even right at the project's extraction and discharge source or near the seabed where naturally occurring levels are the highest. Appendix 4.7 shows the contours where suspended sediment concentrations are above the 2 mg/L threshold at which marine fish avoid sediments 50% and 1% of the time when extraction occurs at the innermost (Location A) and outermost (Location B) points of the project area.

***Displacement of Catch and Spatial Displacement***

With regard to the proportion of total catch displaced by the project, MacDiarmid et al. (2016) plots show that the highest level of overall commercial fishing effort in the STB occurs off the coast between Hawera and Whanganui near the 50 m depth contour. The highest concentration of catch is beyond the 50 m contour, reflecting the large catch from the mid-water trawl fishery.

The MacDiarmid et al. (2016) analysis indicated that the bottom trawl and set net fisheries have the greatest amount of overlap with the project area, therefore both of these fisheries will experience some spatial displacement as a result of any exclusion zones around the project related vessels.

While it is proposed that over the requested consent term of 35 years the IMV will recover iron sands from the whole of the project area, it is likely that all other vessels will only be excluded from the project's extraction area (approximately 4 x 4 km) for approximately 10 days at a time. A smaller exclusion area may also be established around vessel transfer areas where they do not occur within the active extraction area. This level of exclusion will continue for the project duration, and the precise location of the exclusion zones will vary as the active extraction area shifts. While there will be a small exclusion area, the rest of the project area will be open to all marine traffic.

Fishery-specific factors that contribute to impact of spatial exclusion include:

- The spatial distribution of the harvested species;
- The proportion of total catch taken in the excluded area;
- The practicality and cost of catching the species at other locations;
- Cumulative impacts of all spatial exclusions in the fishery; and
- Sustainability and utilisation implications arising from displaced fishing effort (e.g., displaced effort can put pressure on other parts of the fish stock or may increase tensions between recreational and commercial fishers).

The project has the potential to displace set net catch of school sharks within the immediate vicinity of the area being worked. While the overall proportion of school sharks taken from the project area is likely to be small, this fishery is already constrained by regulatory limits to protect Maui's dolphin. This has pushed set net efforts south into the STB and into waters beyond the 7 NM line.

The amount of displaced catch as a result of the project will be relatively small in comparison to the overall catch volumes, as such there will be no negative impacts on quota value, downstream businesses or fish stocks. Further, because of the wide distribution of the trawling fishery any current catch within the project area could, in future, be caught elsewhere with minimal increase in fishing cost.

The specific effects of the project have been considered further below.

#### **4.15.1.4** Bottom Trawling

MacDiarmid et al. (2016) identified that the main species caught by bottom trawling in most years was red gurnard, with 150–324 trawls per year and an average total catch of over 260 tonnes per year for the period. Several other species were consistently caught, including tarakihi, blue warehou, trevally, John Dory, flatfish, leatherjacket, barracoota, and snapper. Target bottom trawling for jack mackerel, although less common than for these other species, produced a total catch for the period of 895 tonnes, similar to that of leatherjacket and barracoota.

Bottom trawling was spread out over much of the STB which includes the project area, with the main areas of effort and catch near the 50 m depth contour, particularly adjacent to New Plymouth, between Opunake and Hawera, south of Whanganui, and in the southwest corner of the study area, to the north of Tasman Bay.

The percentage of species catch falling within the area where suspended sediment concentrations are above the 2 mg/L threshold 1% of the time when project operations occurs at the innermost (Location A) and outermost (Location B) points of the project area, is on average less than 5% for most species.

For leatherjackets and trevally about 5-10% and 7-12% of the total catch respectively fall within the 1% area. The proportion of species catches falling inside the areas where suspended sediment concentrations are above the 2 mg/L threshold at which marine fish avoid sediments 50% of the time is less than 1% for all species.

Based on the MacDiarmid et al. (2016) findings, any effect on the catch displaced from the trawl fishery as a result of the project is likely to be minimal, and is unlikely to result in any wider negative impact on commercial fishing or fisheries. Further, any displaced bottom trawling catch can be caught elsewhere in the FMA 9 with minimal increase to overall cost.

#### **4.15.1.5** Midwater Trawling

MacDiarmid et al. (2016) found midwater trawling in the study area mostly targeted jack mackerel, with a small amount of barracoota, and single trawls targeting hoki. In terms of both effort and total catch, midwater trawling for jack mackerel has been the most important fishery in the area, with almost 90,000 tonnes caught during the period, from just over 4,500 trawls.

Midwater trawling tends to be in deeper water with most reported trawls well beyond the 50 m depth contour and focussed on a region parallel to the coast between Opunake and Whanganui. Fishing effort and catch has been most intense in the northern part of this area.

MacDiarmid et al. (2016) found no overlap between midwater trawling in the STB and the predicted areas affected by the project operations.

#### **4.15.1.6** Set Netting

MacDiarmid et al. (2016) found that set netting in the STB targeted four main species or species groups: rig, school shark, blue warehou, and flatfish; with a moderately consistent level of effort in each year. Other species consistently targeted, but with total catches of 400 tonnes or less, were butterfish, grey mullet, kahawai and yellow-eyed mullet. Several other species were very occasionally targeted.

Set netting was widespread throughout the study area, but focused on the coastline around New Plymouth and between Hawera and Whanganui around or within the 50 m depth contour.

There was a lower level of set netting effort recorded between this latter area and Tasman Bay and also along other parts of the coastline, but no effort or catch recorded in the central south region of the area.

The distribution of set netting catch and effort in the STB does not appear to have changed much before and after the introduction of set-netting restrictions. However, the total catch for all set netting combined in the study area averaged 500 tonnes per year before the set netting restrictions came into effect and 400 tonnes per year thereafter; a decrease of about 20%.

The percentage of species catch for the study area falling within the area where suspended sediment concentrations are above the 2 mg/L threshold, 1% of the time is 17% for rig, 13% for carpet sharks and trevally, 10% for school shark, 8% for snapper, 7% for spiny dogfish, insignificant levels for northern spiny dogfish and common warehou, and 13% for other species combined. The proportion of species catches falling inside the areas where suspended sediment concentrations is above the 2 mg/L threshold 50% of the time is less than 1% for all species.

MacDiarmid et al. (2016) found that the set net catch and effort displaced by the project operation will primarily affect the school shark target fishery. The overall proportion of school shark catch displaced from the project area is unknown but is likely to be small due to the small spatial extent of the active extraction areas where exclusion will occur. MacDiarmid et al. (2016) noted that in the case of set netting, even a small amount of displaced catch may still be perceived as significant by affected fishers because this fishery has been subject to extensive area closures to protect Maui’s dolphin.

#### **4.15.1.7** Cray-Fishing

MacDiarmid et al. (2016) concluded that because rock lobsters spend most of the year associated with subtidal reefs, most of the commercial catch is likely to be taken at these localities. However, in winter and summer larger (greater than 1.5 kg) rock lobsters may move offshore to depths greater than 25 m to feed on shellfish such as dog cockles, scallops and horse mussels and commercial fishermen may seasonally target rock lobsters on these shellfish beds.

From what could be attained, MacDiarmid et al. (2016) concluded that it is highly likely that most, if not all, commercial rock lobster fishing within the STB takes place close inshore outside the areas affected by project operations. However, there is the potential for these fisheries to be affected by the project related sediment plumes, this has been discussed further in Section 4.15.1.10 below.

#### **4.15.1.8** Abundance of Commercial Fish Species

The effects of the project on the fish populations and mortality have been discussed in Section 4.7.1. MacDiarmid et al. (2015b) concluded that deaths of demersal and pelagic fish species caused directly by the project are unlikely and that the use of seawater to pump iron sands to the IMV is likely to have negligible effects on the larvae of fish species or their planktonic prey.

Based on these conclusions the project is unlikely to affect the abundance of commercially fished species in the project area or beyond.

#### **4.15.1.9** Spatial Distribution

MacDiarmid et al. (2015b) has suggested that demersal and pelagic fish species will move away from the project operations area due to underwater noise, surface lights, vessel movements and the sediment plume.

As commercial fishing will also be excluded from the project operation area, any temporary change in distribution of commercially fished species at the site is unlikely to have a negative effect on commercial fishing. Such displacement may even mitigate any effects of spatial displacement of fishing activity if the displaced fish are able to be caught elsewhere in the FMA.

Once iron sand extraction in a particular block has ceased, the resumption of commercial fishing in that area will be dependent on the recolonisation of the area by commercially fished species. MacDiarmid et al. (2016) concluded that there is unlikely to be any short or long-term effects on commercial fisheries as a result of changes to fish distribution within an area which has previously been worked. This position is based on:

- The seabed environment in the vicinity of the project operation is highly dynamic, with high rates of natural disturbance;
- The sandy habitats have relatively low species abundance and richness; and
- There is no significant relationship between iron concentration and community structure (meaning that pre- and post-mining species composition is likely to be similar).

In addition, once the project operation shifts to a new area, the worked area will start to recolonise and re-establish rapidly, further demonstrating the short-term nature of any potential effects.

#### **4.15.1.10** Offsite Impacts

Offsite impacts on commercial fishing may occur if the project affects the marine environment in ways that alter the productivity, abundance or distribution of fisheries resources of commercial significance.

If sediment disperses further out into the EEZ (away from the coast), it is unlikely to have an adverse effect on pelagic and demersal fish species as these species are mobile and can move away to unaffected areas. Sediment from the project is therefore unlikely to have an adverse effect on commercial fisheries seaward of the project area, such as the mid-water trawl fishery for jack mackerel and barracoota.

Sediment dispersing onto coastal reefs of the STB may result in reef ecosystems and associated species being affected through physical burial, ablation, clogging of respiratory systems and a reduction of primary production through shading.

The level of impact is dependent on the amount of sediment introduced into the reef environment, the nature of the sediment (e.g. size) and its persistence in the reef environment.

The predominant commercial fishery likely to be affected is rock lobster and impacts include:

- Smothering of juvenile lobsters (juveniles are less mobile and therefore less likely to migrate to unaffected reefs);
- Trophic level impacts (rock lobsters are predatory species and may be affected if their prey is smothered); and
- Impacts on larval dispersal.

The degree of impact on fisheries along the Taranaki coast will depend on the amount of sediment that is introduced into the reef environment over and above the naturally occurring background range, and the persistence of this sediment in the coastal environment. As described in the Coastal Processes section of this IA (Section 4.5), the naturally high levels of wave energy in the STB is likely to prevent the accumulation of additional sediments within the reef ecosystems along this coast.

There are several inshore shellfish species present in the STB that are not currently fished commercially but have the potential to be developed in the future, namely paua and surf clams.

As a sedentary species, paua is unlikely to be able to move away to unaffected reefs and is therefore vulnerable to sediment effects. Paua are grazers and may be indirectly affected if their algal food sources are smothered.

Surf clams are found in, and immediately beyond, the surf zone of exposed sandy beaches, out to 10 m deep. The mobile surf zone environment is unlikely to be affected by sedimentation from the project.

#### **4.15.1.11** Management of Potential Effects on Commercial Fishing

TTR does not propose that commercial fishing be excluded from the entire project area while extraction operations are occurring. Instead a 1 NM buffer from the centre of the IMV, incorporating the IMV, crawler, anchors and FSO vessel, is proposed. This will be a dynamic buffer moving approximately every ten days when the anchor moorings are moved. The establishment of this discrete buffer area within the project area will allow for commercial fishing to occur in the remaining project area.

Additional mitigation measures have been proposed to minimise the impacts of the project on commercial fishing in the STB and include:

- Establishing a coordinated approach between works in the project area and commercial fishing activities;
- Developing a contact list of companies and vessels operating in the project area;

- Designing and implementing a communication system to alert vessel operators to the intended location and duration of project operations on a regular basis;
- Developing a more precise understanding of the location and seasonality of set net effort in the project area, and designing the operational extraction plan to minimise any impacts on this fishery;
- Undertaking the project operations in a manner that minimises the risk of sediment dispersal in the wider marine environment; and
- Enabling a process through which TTR and the commercial fishers can coordinate the development of the iron sand extraction area for the succeeding 12-month period.

In preparing the new application, TTR commissioned both an independent review of the commercial fishery in the STB and undertook extensive consultation with the commercial fisheries industry.

As a result, TTR considers that they have an improved understanding of the potential impacts on the commercial fishing industry. Further, the implementation of mitigation measures and ongoing consultation with the industry will result in effects of the project on the commercial fisheries and the commercial industry being minimised. The mitigation measures, as they specifically relate to commercial fishing and aquaculture, have been provided for as Attachment 1 of this IA.

**4.15.1.12** Commercial Fishing Exclusion – Cumulative Effects

Subsequent to approval from MNZ, as discussed in Section 4.15.1.11, TTR is proposing a limited safety buffer zone located around the IMV during project operations. This will occupy approximately 10 $km^2$, based on a dynamic 1 NM radius around the IMV.

The proposed buffer zone has the potential to compound the impacts on commercial fishing arising from the existing Maui's Dolphin Threat Management Plan boundaries, and other exclusion zones in the STB associated with oil production (Kupe pipeline and platform exclusion zones).

In particular, fishing exclusion associated with the project will potentially further displace, albeit only short-term, set net catch and effort for school shark. As noted in Section 4.15.1.6 of this IA, the overall proportion of school shark taken from the project area is likely to be small.

However, even a minimal amount of displacement may be considered significant by the affected fishers due to the history of spatial exclusion in the nearshore parts of the set net fishery where rig and blue warehou are targeted. Regulatory closures to protect dolphins have pushed additional set net effort south into the Taranaki Bight and outwards into deeper waters beyond 7 NM. These cumulative effects may potentially leave some set net fishers with limited flexibility to respond to even small additional exclusions in the future.

As the amount of displaced catch in both the trawl and set net fisheries will be small, it is unlikely that there will be any wider negative impacts on the commercial fishing industry – in particular, no negative impacts on quota value, downstream businesses, or fish stock sustainability are anticipated as a consequence of spatial displacement.

Overall, the scale of the proposed exclusion area is relatively small in the broader context of the STB. Accordingly, it is considered that the potential risk of any cumulative impact from a navigational sense is low.

### 4.15.2 Effects on Biosecurity

#### **4.15.2.1** Introduction

Barry Forrest, Senior Marine Ecologist at the Cawthron Institute, assisted TTR in their assessment of the potential biosecurity effects of the project.

Marine biosecurity effects relevant to the project relate to the prevention, detection, and management of NIMS and harmful marine organisms ("**HMO**") that may be on or within project vessels before they enter New Zealand waters. NIMS and HMO are primarily associated with the use and management of ballast waters and vessel biofouling.

In terms of sensitive areas, particular importance was placed on the Admiralty Bay aquaculture industry as this has the potential to be adversely affected by NIMS and HMO due to the potential use of Admiralty Bay for shelter during adverse weather events. Admiralty Bay aquaculture consists of longline mussel farming and it contributes to the NZ$276 million (2014) in exports from the Marlborough aquaculture industry.

It is noted that the biosecurity matters are managed by MPI under the Biosecurity Act 1993 however, consideration of these effects with regard to the project is warranted under the section 59(2)(b)(i) requirements of the EEZ Act that relate to the effects of activities not regulated by the EEZ Act.

#### **4.15.2.2** Summary of Potential Effects

***<u>Ballast Water</u>***

Ballast water is used on large vessels for balance and is typically pumped in to maintain safe operating conditions throughout a voyage. This practice reduces stress on the hull, provides transverse stability, improves propulsion and manoeuvrability, and compensates for weight lost due to fuel and water consumption. Ballast water is taken on board at the port of departure and commonly discharged upon arrival at the destination.

There is the potential that the project could involve a significant discharge of ballast water in comparison with the volume typically discharged in New Zealand ports due to the CEV arriving empty and departing full. Ballast water and the associated suspended sediment within that water can harbour a wide variety of marine organisms, including NIMS and HMO, at various life stages that have potential to adversely affect New Zealand's existing marine life, and aquaculture industry.

***<u>Vessel Biofouling</u>***

Vessel biofouling is the accumulation of NIMS and HMOs on the external surfaces of vessels or equipment, and in niche areas of vessels, such as recesses and 'sea chests'[111].

Approximately 87% of New Zealand's 200 NIMS are likely to have been transported by vessel biofouling.

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111 A recess in the hull that provides an intake reservoir from which piping systems draw raw sea water.

Vessels typically accumulate biofouling as antifouling coatings age and niche areas, such as sea chests, can often be significantly fouled, even when marine growth prevention systems are used. Additionally, the operational profile of some of TTR's project vessels (slow moving or stationary for extended periods of time) has the potential to make them prone to biofouling.

Other possible mechanisms involving the transportation of organisms include transportation via the anchors deployed at a range of locations that could result in HMO transfer via sediment movement from one location to the next location.

***Aquaculture***

The potential for HMOs, especially those transported through vessel biofouling, to establish in Admiralty Bay is of particular relevance to the aquaculture industry. TTR proposes to use Admiralty Bay for shelter during adverse weather events. As such, there is potential for the Admiralty Bay aquaculture industry to be exposed to NIMS and HMO. If NIMS or HMO are transferred into these areas they can have a detrimental effect on the aquaculture activity through adverse effects on growth and contamination of species, and in some cases mortality.

**4.15.2.3** Management of Potential Biosecurity Effects

Given the difficulties in addressing NIMS once established, managing the activities that introduce them to New Zealand waters and contribute to their spread is the considered to be the best approach.

In TTR's case this involves ensuring good biosecurity practices for vessel or equipment movements, in particular those vessels originating from overseas. TTR's mitigation methods for biosecurity effects from ballast water and vessel biofouling are detailed below.

***Ballast Water***

Vessels entering New Zealand waters are required to mitigate risks from ballast water under the Import Health Standard 2015[112] ("**IHS**"), MPI has encouraged operators to adopt these standards for vessels in the EEZ. The IHS stipulates that sediment from ballast tanks must not be discharged into New Zealand waters, this includes sediment that has settled and been removed from ballast tanks and other such equipment.

Additional ballast water management options include ballast water treatment ("**BWT**"). When the IMO Convention for *"The Control and Management of Ships' Ballast Water and Sediments 2004"* comes into force[113] BWT systems will be required on all vessels and the system must, as a minimum, be on the MPI List of Approved BWT systems, or be an equivalent system approved by the IMO. The proposed consent conditions include the requirement for all vessels to have BWT systems on board to the minimum standard identified above.

Further, to ensure that potential effects on aquaculture in relation to Admiralty Bay are minimised, TTR has committed to not discharge ballast water directly into Admiralty Bay, unless under emergency situations and there is no other realistic alternative. This has also

[112] Ministry for Primary Industries - *"Import Health Standard – Ballast Water from all Countries"* 16 December 2015.
[113] This will occur 12 months after 30 countries ratify the convention, likely to occur in the near future.

been provided for through the proposed consent conditions provided as Attachment 1 of this IA.

## ***Vessel Biofouling***

Biofouling on vessels arriving in New Zealand is managed by MPI under the Craft Risk Management Standard[114] ("**CRMS**"), which becomes mandatory in 2018. The CRMS requires that vessels arrive with a "clean hull"[115] as defined in relation to thresholds of allowable macrofouling. For long stay vessels (>21 days), allowable biofouling consists of a slime layer and goose barnacles on any hull surface.

The initial development of the project will involve the import of long stay vessels and equipment from overseas. These will largely remain in place for the duration of the project. In addition to meeting the CRMS for long stay vessels, TTR will ensure that to the extent feasible, vessels and equipment will be "squeaky clean" (i.e. no slime layer or goose barnacles present) upon arrival into New Zealand.

Short stay vessels, such as the CEVs, will be required to adhere to the short stay standards. For these vessels, the most practical way to address biosecurity issues is to follow 'best practice' approaches such as the application of antifoul coatings, the operation of marine growth prevention systems on sea-chests, and in-water inspections with biofouling removal as required.

Further, the IMO guidelines advocate that operators develop a vessel specific Biofouling Management Plan and maintain a Biofouling Record Book detailing all inspections and biofouling management measures undertaken on the vessel. TTR has provided for the provision of a Biosecurity Management Plan consistent with the MPI and IMO guidelines, for each vessel, as part of the proposed consent conditions provided as Attachment 1 of this IA. As part of the Biosecurity Management Plan, TTR will require as a minimum, annual hull inspections with spot cleaning to remove high risk biofouling (including target HMOs), and the inspections and cleaning would include niche areas, such as sea chests, for their project vessels.

## ***Aquaculture***

The occurrence of HMOs at the project area itself is unlikely to present a significant risk to aquaculture as the potential for any HMO spreading to Admiralty Bay by natural dispersal is greatly reduced. This is due to the distance and the low suitability of intermediate habitats (deep, soft sediments) between Admiralty Bay and the project area. Therefore, the primary concern is from project vessels entering Admiralty Bay and transferring of such organisms.

The primary management method is to prevent HMOs from entering New Zealand waters, involves ensuring good biosecurity practices for vessels or equipment originating from overseas.

As discussed above, restrictions on vessel entry and discharges within Admiralty Bay and the requirement of a Biosecurity Management Plan prepared for each vessel are provided for in the proposed consent conditions. It is considered that these management approaches

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114 Ministry for Primary Industries, 2014. *"Biofouling on Vessels Arriving to New Zealand – CRMS BIOFOUL"* 15 May 2014.

115 CRMS, Part 2.1(1). Defined under 2.1(2) as *"…no biofouling of live organisms is present other than that within the thresholds below"*.

will ensure that any potential biosecurity effects that may result from the project are negligible.

#### **4.15.2.4** Summary

Overall, with regard to the project's biosecurity effects, the potential risk to Admiralty Bay and regional aquaculture values is small as the risk arises from infrequent and short duration visits by vessels seeking shelter within the area.

If the border management measures outlined above are implemented, the potential for TTR project vessels to transport new-to-New Zealand HMO is extremely low.

Overall, provided the proposed measures are implemented and complied with, it is considered that any biosecurity effects related to the project will be negligible.

### 4.15.3 Recreation and Tourism Effects

#### **4.15.3.1** Introduction

As outlined in Section 3.11.2, Greenaway (2015) identifies the recreational and tourism activities that occur in the STB, and assessed how the project would affect tourism and recreational values and users.

Greenaway (2015) is based on an extensive literature review, outcomes from consultation meetings and stakeholder interviews, a coastal recreation survey and site counts, a low-level overflight of the STB and project area, site visits, and a review of relevant technical reports prepared for the project.

Overall, the STB is a regionally important setting for marine recreation activities, in particular, fishing, diving and surfing. The extent of the sediment plume produced by the project and the impact of the project on wave characteristics, coastal morphology and stability have been covered in Sections 4.4 and 4.5 respectively.

The potential impacts on the recreation and tourism activities within the STB are discussed below.

#### **4.15.3.2** Summary of Potential Effects

Greenaway (2015) identified that the regionally important coastal and marine recreation and tourism settings in the STB are centred around the main public access and activity points, located at Ohawe Beach, Waihi Beach, the mouths of the Tangahoe and Manawapou Rivers, Patea, Waipipi, Waiunu, Kai Iwi and Castlecliff. Further, the STB recreational areas include the coastal fishing and cray-fishing resource extending approximately 20 km off shore (at The Traps and Graham Bank). On the coast, the level of shellfish gathering is difficult to quantify, but Greenaway (2015) considers it a locally important recreational activity.

The coastal and near coastal areas extending north from Patea to Cape Egmont are relatively lightly fished in comparison to that south of Patea and in the North Taranaki Bight. Greenaway (2015) found that very little recreational fishing occurs more than 20 km offshore along the entire west coast of the North Island and within the vicinity of the project area.

Tourism activity in the STB region is limited to six beach camp sites and three fishing charter operations, one operating from Whanganui and the other two from Patea.

Greenaway (2015) concluded that the various scales (shown in bold below) of potential effects of the project on recreation and tourism interests as a result of the project are:

- Changes to water clarity from the project – **Minor** (see Section 4.4.3).

  Potential effects related to water clarity include:

  - Turbidity effects, underwater visibility and the smothering of biota;
  - The location of the sediment plume in relation to diving and recreational areas and the effects of increased sediments on reef systems; and
  - Resuspension of returned sand (loose mining tailings) during storm events or other wave actions and the potential for long-term turbidity effects.

- Changes on coastal wave pattern of surfing breaks – **Minor** (see Section 4.5.2).
- Changes to sediment budget and the effects on beach and sand bar replenishment – **Minor** (see Section 4.5.1).
- Recolonisation rates of biota in the project area and trophic effects on the recreational fishing resource – **Minor** (see Section 4.6).
- Toxicity of returned sand to the seabed and effects on biota and in turn the recreational fishing resource – **Minor** (see Section 4.6).
- The effects of the new development on the 'clean green' environmental reputation of New Zealand and the "100% Pure" tourism brand – **Minor**.

#### **4.15.3.3** Management of Potential Effects on Recreation and Tourism

Due to the minor effects on recreation and tourism there was little consideration of effects, mitigation and management in Greenaway (2015) and on this basis, there are no conditions included in the proposed consent conditions that related to adverse effects on recreation and tourism.

The one exception is that recreational fishing has been included as a parameter to be monitored in the proposed BEMP and EMMP for the project to assist in expanding the data source on recreational fishing within the STB.

Further to the above, the DMC findings on recreation and tourism effects as part of their decision on the previous marine consent application, concluded that it was considered unlikely that the project would impact New Zealand's global tourism reputation on the basis that the effects of the project were consistent with those described in the application.[116]

[116] TTR Marine Consent Decision. 15 June 2014 – Para 711.

## 4.15.4 Navigation and Commercial Shipping Effects

### 4.15.4.1 Introduction

As identified in Section 3.11.3, Marico (2015) undertook a comprehensive investigation of marine traffic movements and navigational safety within the STB.

R N Barlow and Associates Limited was engaged to further provide an assessment of the maritime and navigational impacts of the project (Barlow (2015)[117].

The following section contains a summary of the navigational safety and commercial shipping effects related to the project and within the STB based on the Marico (2015) and Barlow (2015) reports.

### 4.15.4.2 Assessment Methodology

In preparing its report, Marico (2015) reviewed 12 months of AIS transponder data (which records vessel movements) in the STB. The only vessels missing from the data set were small, typically recreational, vessels not fitted with AIS transponders.

### 4.15.4.3 Summary of Potential Effects

Both Marico (2015) and Barlow (2015) found that there was considerable variability in shipping activity, but that data showed that the project area has low levels of existing transit activity.

There are well demarcated shipping routes for dry cargo and liquid tanker transport between New Plymouth, Nelson and through the Cook Strait, and these routes are well away from the project area as the area is not located in the most direct route between these ports.

Near project traffic density was found to be generally low to very low, with only a handful of vessels transiting through the project area in the 12-month data period (58 vessel movements in the 12-month period or one movement every six days). The majority of vessels operating adjacent to the project area were engaged with servicing the Kupe gas rig operation.

Barlow (2015) considers the project area is located in an area of very low traffic density and the project would have very little impact, if any, on navigational safety in the STB. Additionally, the IMV and project related vessels will typically be located within smaller, 900m x 900m, working blocks within the 67 $km^2$ project area.

Additionally, the project area is removed from regular marine traffic routes and activities, and Barlow (2015) considers that it would not be in conflict with other marine traffic and commercial shipping activities in the STB area.

The data collected has shown there to be both a low number of vessel encounters, indicating a low risk of collision and the marine environment provides for sufficient space for vessels to navigate around the project area at a safe distance.

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117 Barlow, R. N. 2015. *"Trans Tasman Resources Ltd, South Taranaki Bight, Offshore Iron Sand Extraction and Processing project – Report on the Maritime and Navigational Impacts of the project"* November 2015.

As part of the project, TTR intends to apply to MNZ to establish an exclusion zone (buffer zone) around the IMV and other project related vessels when anchored within the extraction lanes to safeguard other ocean users, members of the public and project vessels from harm. The exclusion zone applied for will extend in a circle with a radius of approximately 1 NM from the IMV to extend beyond the extremities of the anchor pattern and cover the area where support vessels are manoeuvring and/or are constrained in their ability to manoeuvre. It is considered that this measure will further ensure that any effects on marine traffic are avoided.

Any exclusion zone around the project related vessels is unlikely to affect recreational opportunities in the project area. Marico (2015) indicates that the project area is very lightly used by any vessels and, because of the nature of the seabed material, is unlikely to support much marine life which would be of interest to recreational fishers or divers. The site is well removed from recreational boat launching and mooring sites.

#### **4.15.4.4** Management of Potential Effects

Given the low level of marine traffic through the project area, Barlow (2015) considers that the project could use standard marine watch-keeping systems to avoid interface with other vessels. Based on the existing marine traffic data there is no need for any remote management of vessel traffic through the project area. TTR will ensure that all vessels involved in the project are fitted with AIS data transponders to assist in the management of marine traffic.

With regard to protocols for transferring of fuels, during the joint expert conferencing[118], the following management protocols were agreed:

- All other vessels contracted for bunkering and the associated machinery will be of relatively recent design and will comply with international standards;
- System designs will be informed by international best practice in bunker fuel handling, formal risk analysis and assessment, and will incorporate all reasonably practical measures to ensure safe bunkering and fuel transfer, and also to enable safe vessel and iron sand recovery operations;
- The operating procedures for fuel transfers should be incorporated into the “Project Safety Case” and approved by MNZ;
- Hydrodynamic studies should be undertaken for transfer operations to ensure the operating procedures and upper operating limits are properly determined during the risk analysis and Hazard and Operability Study;
- In addition to prevailing and forecast meteorological conditions, transfer operations carried out away from the project area must be undertaken in a manner that does not create a navigation hazard to shipping and occurs out of recognised shipping routes.
- Transfer operations should be undertaken with the receiving vessel at anchor or under the dynamic position system or making steerageway only;

118 Joint Statement of Experts in the Field of Navigational Safety dated 26 March 2014, para 25.

- The project operations manuals and contingency plan should be constructed around a comprehensive "Project Safety Case", which should be applied to all project operations.

- The "Project Safety Case" should also provide the basis for applications to MNZ for fuel and product transfer operations at sea, as required under the Marine Protections Rules Part 103[119].

Various management protocols have been proposed to further ensure that effects on navigation are mitigated and, where possible avoided. The measures have been addressed through the requirement of a Collision (Loss of Position) Contingency Management Plan for the project which has been provided for through the proposed consent conditions provided as Attachment 1 of this IA.

Further to the traffic issues, due to the nature of the project there is the potential for items to be dropped overboard from project related vessels. These items have the potential to impact on other marine traffic particularly bottom trawlers. In order to address any potential impacts, as part of the operational protocols, TTR requires that if any item, equipment or machinery greater than 1 m x 1 m in size is lost overboard from any project or operational vessel, it shall be collected from the seabed as soon as is practicable.

Where it is not practicable to recover the item, TTR will record the location and depth where the item was lost overboard and the type of item lost. This information will then be provided to the EPA, the Coastguard and the Harbour Master (if within the 12 NM limit) and placed on the TTR website within 24 hours of the item going overboard. It is considered that this protocol will ensure that any potential adverse effects that may result from items being lost overboard will be avoided. This has also been provided for in the proposed consent conditions.

When considering the above information and the proposed management protocols, the overall effects of the project on navigation and commercial shipping are considered to be no more than minor. This position was supported by the DMC in their decision on the previous marine consent application, who concluded that their findings on marine traffic effects are likely to be no more than minor. [120]

### 4.15.5 Effects on Other Existing Interests

#### 4.15.5.1 Kupe JV

As discussed in Section 3.11.5, Kupe JV are a party with an 'existing interest' that may be affected by the project. However, TTR's mineral mining permit (no. 55587) contains clauses 11 to 17 that provide for the interaction between the project and Kupe JVP. On this basis it was generally accepted by the DMC as part of the previous marine consent application by TTR, that Kupe JVC's interests have been recognised and provided for in the mineral mining permit.[121] Their interests have been considered further through consultation with Origin Energy (the operators of the Kupe JVP field) as discussion in Section 6.3.12 of this IA and additional measures have been incorporated into the proposed consent conditions included as Attachment 1 of this IA.

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119 Maritime New Zealand *"Marine Protection Rules Part 103: Notifications – oil & noxious liquid substance"* Retrieved 1/12/15. http://www.maritimenz.govt.nz/Rules/List-of-all-rules/Part103-marine-protection-rule.asp

120 TTR Marine Consent Decision. 15 June 2014. Para 726.

121 TTR Marine Consent Decision 15 June 2014. Para 720.

**4.15.5.2** Existing Marine Consent Holders

As discussed in Section 3.11.6, there are four parties who currently hold existing marine consents under the EEZ Act. While all of these marine consents are considered existing interests in accordance with section 4(b) of the EEZ Act, it is noted that three of the existing marine consents will likely be expired by the time iron sand extraction activities occur within the project area, following the proposed baseline monitoring programme of two years, therefore they are not deemed to be affected by the project.

Further, Figure 4.17 below shows the oil and gas fields of the Taranaki Region which the existing marine consents relate to. The TTR project area is located next to the Kupe field and is in excess of 50 km away from the sites related to the existing marine consents, particularly those linked to the Maui natural gas field. Based on the assessment of effects in Section 4 of this IA, any effects of the project will generally be localised around the project area with the potential for the sediment plume to extend towards the coastal environment. Therefore, it is not considered that the existing marine consent holders are affected by the project.

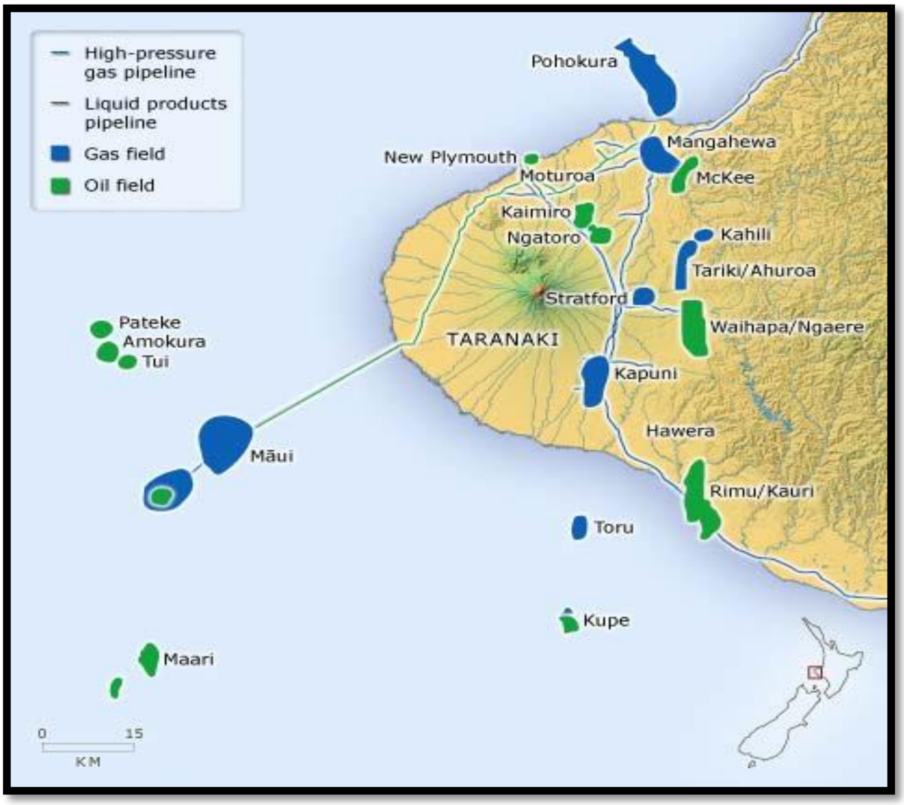


**Figure 4.17: A general indication of the Taranaki Region's oil and gas fields. The TTR project area is located adjacent to the Kupe field in the bottom right of the image.**

**4.15.5.3** Settlement of a Contemporary Claim

As discussed in Section 3.11.9, there are 'existing interest' considerations for parties with regard to the settlement of contemporary claims under the Treaty of Waitangi. The Maori Commercial Aquaculture Claims Settlement Act 2004 provides for the settlement of contemporary Treaty of Waitangi claims to commercial aquaculture. TTR note that within the STB there are no aquaculture settlement areas gazetted but is it noted, while not affected as part of the project, Ngati Koata have interests in the Marlborough Sounds.

The effects of the project on Ngāti Koata interests (the potential for biosecurity effects on aquaculture) is discussed above in Section 4.15.2 of this IA and concluded that any effects of the project will be appropriately avoided, remedied or mitigated through the proposed consent conditions which have been prepared following consultation (refer to Section 6.3.7) with Ngāti Koata.

## 4.16 Other Considerations

### 4.16.1 Environmental Monitoring Activities

#### **4.16.1.1** Introduction

As previously described in the IA, a BEMP and an EMMP have been developed for the project. Both of these documents provide for a range of individual monitoring programmes to ensure that any project related effects are detected and quantified for the various environmental receptors in the STB. The following environmental monitoring activities are proposed to occur in the EEZ:

- Deployment of moored equipment;
- Vertical profile measurements;
- Acoustic surveys;
- Water sampling;
- Zooplankton sampling;
- Epibenthic surveys via video transects and drop cameras;
- Benthic grab sampling; and
- Bathymetry surveys.

Table 4.13 below provides a summary of the environmental monitoring components which will take place during the BEMP and EMMP, and defines which activities will be undertaken in the CMA and the EEZ.

**Table 4.13: Summary of individual monitoring programmes and techniques.**

| **Monitoring techniques** (with the potential to physically interact with the seabed and/or water column) | **Individual Monitoring Programmes** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Water quality/sedimentation** | **Model validation** | **Oceanography** | **Primary productivity** | **Zooplankton** | **Subtidal benthos** | **Subtidal/intertidal reefs** | **Marine mammals** | **Underwater noise** | **Kaimoana** | **Will this occur in EEZ?** | **Will this occur in the CMA?** |
| **Deployment of moored equipment** (turbidity loggers, PAR sensors and Aqua Troll units, LSST frames, ADCP / AWAC meters, sediment traps, acoustic devices for marine mammal detection, sea noise loggers) | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | ✓ | ✓ |
| **Vertical profile measurements** (Chl-a, conductivity, temp, pH, PAR, SSC, DO, depth) | ✓ | ✓ | | ✓ | | | | | | | ✓ | ✓ |
| **Acoustic surveys** (underwater noise compliance) | | | | | | | | | ✓ | | ✓ | ✓ |
| **Water sampling** (metals, nutrients, conductivity, temp, pH, turbidity, clarity, colour, phytoplankton and micro-zooplankton) | ✓ | ✓ | | ✓ | | | | | | | ✓ | ✓ |
| **Zooplankton sampling** (zooplankton) | | | | | ✓ | | | | | | ✓ | ✓ |
| **Epibenthic surveys** (Video tows and remote drop cameras) | | | | | | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| **Benthic grab sampling** (macrofauna and physio-chemical surveys) | | | | | | ✓ | | | | | ✓ | ✓ |
| **Bathymetry surveys in EEZ** (Seabed mapping of project area and reef mapping) | | | ✓ | | | | ✓ | | | | ✓ | ✓ |
| **Diver Surveys and hull cleaning** (for routine maintenance) | | | | | | | | | | | ✓ | X |

Each monitoring activity and the potential effects of the activity are summarised below.

#### **4.16.1.2** Deployment of Moored Monitoring Equipment

As part of both the baseline and environmental monitoring programme, the deployment of semi-permanent monitoring equipment will be required.

***Mooring of the Equipment***

Specific mooring configurations that will be utilised for each deployment is still to be confirmed but the typical configuration will consist of the following; each mooring will consist of two large anchor blocks with a heavy chain connecting the two which will be connected to a surface buoy that will be appropriately marked (i.e. flashing lights, coloured yellow, radar reflector) and suitable for the weather conditions the buoy will experience within the STB.

The footprint of the mooring blocks placed on the seabed for noise monitoring is likely to be between 1 $m^2$ to 2 $m^2$ and between 4 $m^2$ to 8 $m^2$ for the water quality and sedimentation monitoring moorings.

The instruments will be attached below the surface buoy and on the seabed to record all the required data. Following deployment, a 'Notice to Mariners'[122] will be issued for each mooring deployment and those moorings that are placed within the CMA will go through the requisite consenting process with the TRC.

Additional ground line moorings for some instruments may be used, which are spatially separated from the mooring blocks by a ground line to a weighted plate or similar which is also deployed on the seabed. The weighted plate is likely to have a footprint of approximately 0.6 $m^2$ and could weigh up to 150 kg. The ground line between the two mooring components could be up to 100 m in length and would typically consist of a 12 mm double braid sinking rope.

***Potential Effects***

Localised disturbance to the seabed will occur during the deployment of each mooring. This disturbance will involve the crushing of any sessile benthic organisms or displacement of mobile benthic and epibenthic organisms in the immediate vicinity of the mooring as it makes initial contact with the seabed.

Once moorings are established, any disturbance to the seabed is expected to be minimal as equipment will be static on the seabed, and given the mobile nature of the sediments in the STB it is likely that the moorings and chain will become covered by sediment. If the mooring blocks are not covered, they may provide suitable settlement habitat for benthic invertebrates due to the presence of a hard substrate in an otherwise mobile sandy benthic environment.

Where ground line moorings are used the ground line will be sufficiently weighted that it is likely it will settle into the substrate and remain stationary, therefore minimising the potential to drag across the seabed causing disturbance.

The total area of seabed disturbed by each noise monitoring mooring deployment would be in the order of 2 – 4 $m^2$. It is initially proposed that two moorings for monitoring noise will be deployed in the EEZ resulting in a total disturbance of approximately 4 – 8 $m^2$ of seabed from the placement of the mooring block. This would increase as other additional moorings are deployed as part of the environmental monitoring programme. For each water quality and sedimentation mooring that is deployed the total area of disturbance would be in the order of 4 $m^2$ to 8 $m^2$ for each deployment.

Given the mobile nature of the sediments in the STB, the opportunistic species that have been found to occur there (i.e. polychaetes) and the fact that no extremely sensitive habitats or species have been found to date surrounding the project area, any environmental effect on the marine benthic environment from the placement of the mooring blocks in the EEZ is considered to be negligible.

122 http://www.linz.govt.nz/sea/maritime-safety/notices-mariners

#### **4.16.1.3** Vertical Profile Measurements

***Potential Effects***

Vertical profile measurements will be collected from 19 sampling sites in the EEZ on a monthly basis during the BEMP and will increase to a fortnightly basis once iron sand extraction activities commence. The effects of vertical profile measurements will be negligible as all measurements are instrument based, and the sampling equipment will only be present in the water column for the period of time taken to deploy the water sampler to the required depth, gently touch the seabed and then to subsequently retrieve it to the surface.

#### **4.16.1.4** Acoustic Surveys

***Potential Effects***

Any effects from acoustic surveys on the water column will be negligible as no physical sample is collected, the hydrophone will not come in contact with the seabed and will only be present in the water column for a short period of time at each distance set back (approximately 1 hour).

#### **4.16.1.5** Water Sampling

***Potential Effects***

Water samples will be collected from 19 sampling sites in the EEZ on a monthly basis during the BEMP and on a fortnightly basis once iron sand extraction activities commence. Approximately 5 L of water will be collected for both seabed and surface samples resulting in approximately 30 L of water collected at each sample station. Not all 30 L will be used for laboratory testing and the remaining water will be discharged back over the side in the same location it was collected. Therefore, from the 19 sample sites within the EEZ, each sampling event will remove approximately 570 L of water from the STB.

Given the size of the STB, the effects of the water take as a result of the sampling will be negligible on the marine environment. Further, the sampling equipment will only be present in the water column for the period of time taken to deploy the water sampler to the required depth and to subsequently retrieve it so there will not be any effects associated with that aspect of the monitoring.

#### **4.16.1.6** Zooplankton Sampling

***Potential Effects***

The removal of all zooplankton captured in each descent of the net through the water column is inevitable and although this may represent hundreds of individual animals per descent, the scale of this impact is negligible given the very low volume of water column sampled during zooplankton tows compared to the volume of water and the natural variability in zooplankton populations within the STB.

Zooplankton species are typically short-lived with high reproductive outputs which allow them to persist in marine environments where the constant threat of predation is overcome by high mortality rates. These life history strategies mean that zooplankton species are resilient to environmental disturbance.

The effects of zooplankton sampling will be negligible and sampling equipment will only be present in the water column for the period of time taken to deploy the net to the required depth and to subsequently retrieve it. The sampling net will not make contact with the seabed due to the procedures that will be in place to ensure this therefore, any effects as a result of zooplankton sampling will be negligible.

**4.16.1.7** Epibenthic Surveys

***Potential Effects***

In the large part, the intention of the drop camera and video tows is to operate them just above the seabed, which will:

- Minimise disturbance to the seabed; and
- Facilitate better imagery through the reduction of suspended sediment associated with seabed contact.

Given this proposed methodology for seabed observations, minimal disturbance to the seabed is predicted to occur.

**4.16.1.8** Benthic Grab Sampling

***Potential Effects***

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 frame of the grab to ensure sufficient penetration to collect the required depth/volume. For the grab sampler, each sample collected will disturb 0.2 $m^2$ of seabed and will remove 0.02 $m^3$ of substrate, and as each site is sampled in triplicate, this will represent a disturbance of 0.6 $m^2$ and removal of 0.06 $m^3$.

Using the proposed benthic sampling approach, in the first three years of monitoring there will be 19 sites within the EEZ. This equates to 11.4 $m^2$ of seabed disturbed and 1.14 $m^3$ removed for every sampling programme, and to enable an assessment of seasonality, the benthic sampling programme will be undertaken quarterly. Therefore, for each monitoring year the benthic grab sampling will disturb an area of 45.6 $m^2$ and will remove 4.56 $m^3$ of seabed. Following the completion of the iron sand extraction programme there will be four years of environmental monitoring taking place or until a point which the EPA approves for the monitoring programme to cease.

After each year of iron sand extraction, in order to assess the recovery of the benthic environment (both sediment structure and infauna/macrofauna) three additional sampling sites will be included in the area when extraction has recently occurred. Therefore, after the first three years, the increase in area of disturbance each year will be 1.8 $m^2$ and 0.18 $m^3$ removed.

Grab samplers are routinely used for deep water monitoring in the marine environment and each deployment will result in a slight depression in the seabed once the sample is removed; however, due to the benthic currents observed in the STB, these depressions are not likely to remain for long.

The scale of these discrete sampling events is very small when considered in the context of the large area over which it will occur; whereby the 19 sampling sites are sparsely spaced over a total area of approximately 400 $km^2$. Hence, given the scale of the monitoring programme it is considered that the small amount of disturbance will have no significant environmental effects on the benthic environment. There have not been any known taxa or communities of special conservation or scientific interest identified thus far that could be influenced by the placement of the sample site within the environmental monitoring programme.

#### 4.16.1.9 Bathymetry Surveys

***Potential Effects***

Despite the fact that Multi-Beam Echo Sounder ("**MBES**") surveys produce sound waves, there are currently no requirements under the DOC's 'Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations'[123] in relation to undertaking MBES surveys. Likewise, it has been determined from previous surveys that operators conducting MBES surveys have not had to comply with the EEZ Act. For this reason any effects of MBES surveys on the marine environment are considered to be negligible.

### 4.16.2 Anchor Deployment and Positioning

Anchoring of the project related vessel, primarily the IMV, will cause direct disturbance of the seabed during anchor placement, removal and re-deployment. No sensitive marine habitats have been identified in the anchoring area and IMV anchoring will occur in the vicinity of the extraction area which itself will be subject to significant disturbance.

The anchor deployment for the IMV involves installation of four standard Stevpris-type anchors, each attached by anchor chain and 90-110 mm diameter, tensioned steel cables directly to the IMV. The anchors are moved during the course of the crawler extraction programme (Section 2.3.3.2), but other than the direct disturbance caused by the anchor placement, removal and redeployment, the anchor system will have only a limited range of sweep during project operations. This four-point anchoring system will have a lesser environmental effect than conventional anchoring with a 360 degree sweep.

Furthermore, anchor deployment will be largely within areas which will be or have been subject to extraction and re-deposition so that effects of anchoring will be negligible considering these areas would have already been, or will be, subject to seabed disturbance and sediment removal.

There will be some areas of seabed disturbance outside of the project's extraction area but this will be restricted to when the IMV is working the extraction lanes adjacent to the project boundary. This will require the laying of anchors outside of the project area for short periods of time until the IMV moves further into the project area. Any disturbance associated with this anchor placement is considered to be no more than minor as the surrounding seabed is typical soft sand and sediments and any anchor sweep will be minimal.

There is the potential for there to be an effect on the benthic environments surrounding the project area however, the risk of adverse effects is considered to be low due to the area of disturbance when considered against the total seabed area within the STB.

123 http://www.doc.govt.nz/Documents/conservation/native-animals/marine-mammals/seismic-survey-code-of-conduct.pdf

### 4.16.3 Unplanned Oil Spill Events

#### **4.16.3.1** Introduction

TTR's application process is not requesting consent from the EPA to authorise any unplanned oil or fuel spills as these activities are regulated by the Maritime Transport Act. However, TTR considers it prudent to assess the potential effects of such an activity as part of this IA in order to understand what type of controls and mitigation measure should be incorporated into the operational management plans as part of the project.

The potential ecological effects of unplanned oil spills relate to the ecotoxic characteristics of spilt material and in the case of oil spills, to physical smothering of mobile and sessile marine biota. Therefore, it is necessary to understand the expected trajectory of any oil spills if an unplanned discharge event occurs to identify which environments are likely to be impacted, as this enables more detailed contingency planning and mitigation measures to be provided for in the event that an unplanned discharge activity does occur.

#### **4.16.3.2** Oil Spill Trajectory Modelling

As part of the first application process, in order to better understand the likely oil spill trajectory, TTR engaged MetOcean Solutions Limited to prepare an oil spill trajectory report (MetOcean (2104))[124] which used modelled data to predict the trajectory of varying sizes of spill events.

To inform MetOcean (2014), an 11-year database containing all the likely trajectories for an oil spill from the IMV located in the centre of the project area was produced. Oil spills were tracked continuously from 1999 to 2009 until they beach or leave the modelled region. This technique provides a robust statistical basis to quantify the most likely pathways for oil in the unlikely event of a spill from the IMV (another project related vessel), and from this knowledge an assessment of the coastal areas that are most likely to be affected can be reliably determined. Results from the trajectory database were examined for the seasonal conditions, showing the relative probabilities for beaching and statistics for beaching times.

MetOcean (2014) identified that the hydrocarbon used in the modelling was 380 HFO as this is consistent with what will be used by the IMV. Modelling outputs showed that weathering of this oil is expected to result in around 20% of the released volume evaporating or being dispersed 120 hours from initial release. The results showed that wind speed has a significant effect on the amount of dispersion, evaporation and mechanical weathering experienced by the oil. Accordingly, while the stronger wind conditions may lead to shorter beaching times, it may be the more moderate winds that result in the highest volumes of oil reaching the shore.

Analysis of the trajectory database showed that some 92.4 – 97.8% of oil spill events are predicted to result in a beaching outcome of some sort. The spring season was shown to have the highest probability of beaching (97.8%) while autumn has the lowest (92.4%). The minimum time between an oil spill and beaching varies throughout the seasons; from 12.5 hours in summer to 16.6 hours in spring and autumn.

A series of coastal beaching probability maps were produced, and maps of beaching probabilities are provided for each season. The region of the Taranaki coast most likely to be affected from an oil spill is located in the STB in the vicinity of the Rangitikei River Mouth (refer to Appendices 4.8 – 4.11).

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124 MetOcean Solutions Limited. *"Oil Spill Trajectory Modelling. TTR mining barge, New Zealand. Prepared for Trans-Tasman Resources."* January 2014.

The worst-case outcome of an accidental release of 100 metric tonnes of 380 HFO was also investigated. The release date in the 11-year trajectory database that produces the maximum beaching outcome was identified, and the coastal impacts associated with that scenario were quantified. The area with the highest impact is in the STB near Whanganui, where oil concentrations of 4.79 $m^3$ per kilometre of coastline were predicted.

#### **4.16.3.3** Considerations of Effects and Mitigation

MetOcean (2014) concluded that potential oil spill effects would be of moderate – significant environmental risk primarily as a consequence of the potential dispersion characteristics of HFO, and the ecological sensitivity of the nearfield ecotype which is identified as the Traps (more than 20 km distant, and submerged) and the coastal areas of the STB.

As the likelihood of unplanned oil spills can only be minimised through effective management and operational controls, TTR has committed to preparing a comprehensive Spill Contingency Management Plan that will be prepared as required by, and in consultation with, MNZ.

It is considered that such an approach is consistent with industry best practice and will address the risks of unplanned oil spills and associated mitigation measures necessary to reduce the oil spill ecological risk levels to as low as reasonably practicable. The provision of this plan has been provided for in the proposed consent conditions in Attachment 1 of this IA.

### 4.16.4 Jack – Up Development Impacts

OCEL Consultants NZ Limited ("**OCEL**"), provided an analysis of the geotechnical implications of the de-ored sediments produced as a result of the project for any future deployment and founding of mobile jack-up drill rig platforms used in the oil and gas industry (OCEL (2015)).[125]

OCEL, in conjunction with NZ Diving and Salvage Limited, has undertaken five geotechnical investigations using OCEL designed and diver operated subsea geotechnical drilling rigs for jack-up rig deployment off the West Coast of the North Island of New Zealand.

#### **4.16.4.1** Summary of Effects

For the purposes of the analysis, the de-ored sediments are a fine, non-cohesive, relatively high specific gravity sand material deposited in loose condition on the seabed in previously worked seabed areas. Prior to the project being undertaken, the substrate has been identified as very dense sand by OCEL and NZ Diving and Salvage Limited during their field investigations.

Prior to the deployment of any mobile jack-up drilling rig at an offshore location, a seabed geotechnical investigation is required and an evaluation made of the footing / spudcan penetration at the location.

The geotechnical investigation will typically establish the soil strength parameter for the seabed strata to allow a prediction of the extent to which the jack-up spudcans will penetrate into the seabed and identify any potential for a 'punch through' type bearing capacity failure that could jeopardise the safety of the rig.

125 OCEL, 2015. *"Implications of Loose Tailing Seabed Material on Future Jack-Up Deployment in the South Taranaki Bight"*.

The principle concern with regard to these set ups is related to the presence of soft or loose layers and the bearing pressure bulb developed by the spudcan load. The presence of soft or loose bearing layers on the seabed is less of a concern as the weight of the jack-up will typically force the spudcans well into, or through, the soft top layers until these layers become compressed or a harder substrate is reached.

The bearing loads exerted by jack-up rigs are in the order of 400 kPa, and as a consequence the spudcans will penetrate into the seabed in conditions other than very dense or high bearing capacity seabed conditions which are relatively rare. In loose or soft conditions the penetration can be several metres. The calculated penetration for spudcans into the loose seabed was estimated at 6 m.

Therefore, it is considered that the presence of the de-ored sediments will have no influence on the design of the foundations for any fixed platform structures in the future that may be located within the project area. These structures would be expected to have pile foundations extending deep into the seabed, therefore the nature of the shallow seabed layer is close to insignificant in terms of jack-up foundations.

OCEL (2015) states that irrespective of whether the seabed consists of loose, re-deposited de-ored sediments over previously worked areas or untouched seabed, a geotechnical investigation is required at the site prior to jack-up deployment and this consists of at least one borehole. If a jack-up rig was deployed within the project area following the completion of the project operations, the geotechnical investigation would identify the nature of the seabed, including any de-ored sediments, prior to deployment. Consolidation, enhanced by the high specific gravity of the de-ored sediments, and some seabed densification due to wave action will have occurred altering the properties from when the de-ored sediments were first deposited.

The presence of the de-ored sediments, and their potentially loose nature does not have any significant implications for any future deployment and founding of mobile jack-up drill rig platforms on the seabed. The spudcans will sink further into the seabed than for the untouched seabed case, therefore, they attain the ultimate bearing load capacity resistance required, but this is not of significance given that jack-ups are set up to recover spudcans no matter their depth into the seabed.