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Assessment of Ecological Effects: For Sand Extraction from the Midshore Pakiri Embayment August 2020

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Cover Illustration: Sand dredge in operation off Pakiri beach (November 2019)

CONTENTS

1. INTRODUCTION

In 2006, McCallum Brothers Limited® (MBL) was granted the Coastal Permits (ARC28165, ARC28172, ARC28173 & ARC28174), under which they are permitted to remove up to 76,000 m^3/year of sand from the nearshore area between the 5 m and 10 m water depths located between the Auckland/Northland regional boundary and the Poutawa Stream as shown in Figure 1.1. This extraction regime was consented by the Environment Court in May 2006 for a 14-year period, expiring on the 6th September 2020. McCallum Brothers Limited (MBL) lodged an application to renew extraction with the existing inshore area in late February 2020 (Council References: BUN60352951, CST60352952 and DIS60347549).

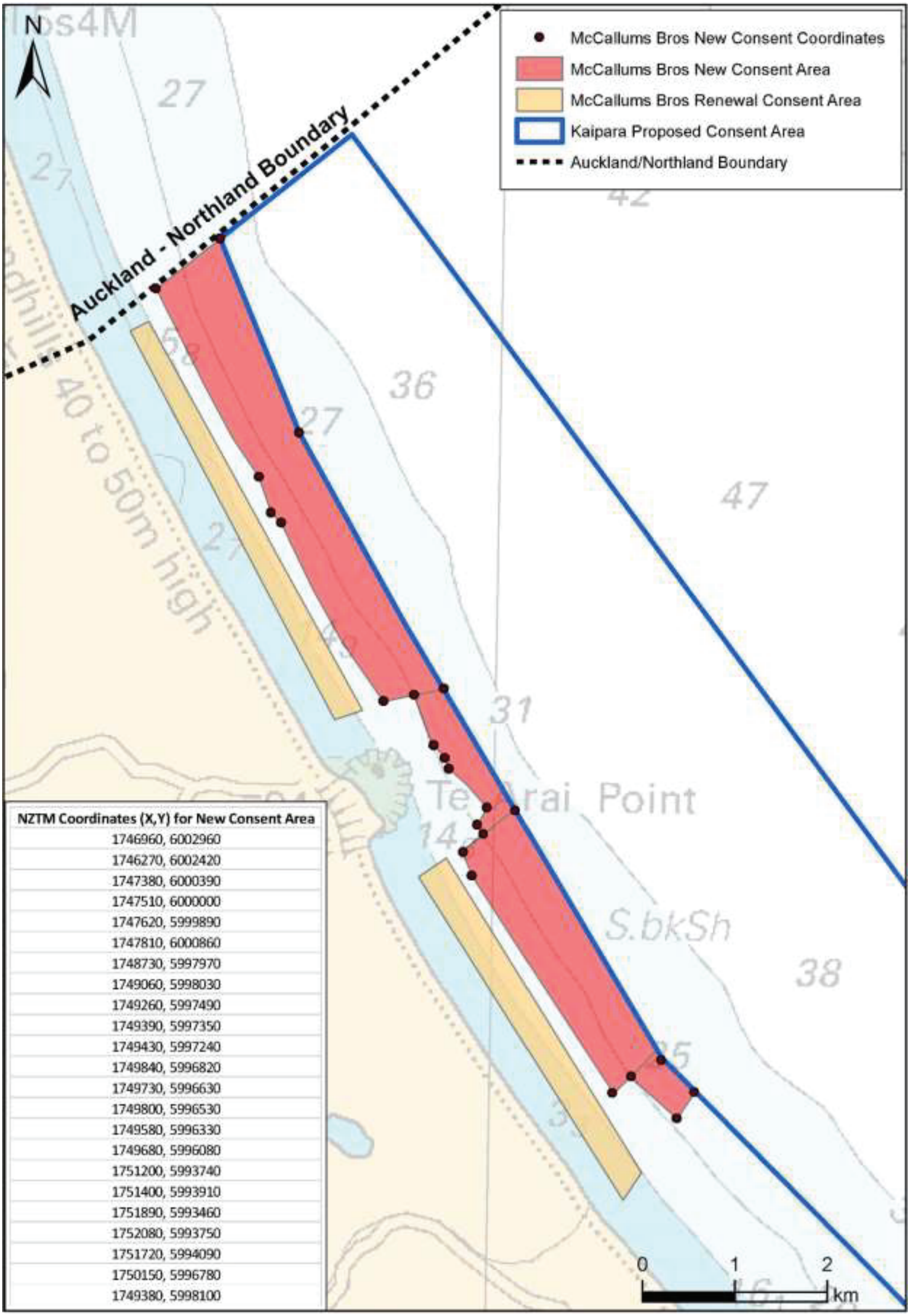
However, MBL has reviewed its sand extraction operation at Pakiri and considers that a relocation will improve some operational aspects of the extraction process and reduce potential opposition to the extraction from residents, beach users and some environmental groups. MBL proposes to move to an extraction area further offshore to between the 15 and 25 m chart datum depth contours (Proposed Midshore McCallums area) over the same length of Pakiri and Te Arai beaches as shown in Figure 1.1. The offshore boundary of the proposed mid-shore MBL area will be concurrent with the inshore boundary of the proposed Kaipara Excavators Limited (KEL) Offshore area.

It is recognised that considerable additional technical information will be required to support this application, and that final decisions on the granting of these consents may not be made until after the expiry of the current consents. Therefore, due to the economic significance of the resource for Auckland, MBL has applied for the renewal of the existing inshore extraction consents prior to their expiry in September of 2020. This then allows for their continuation under s124 of the Resource Management Act (RMA) 1991. Concurrently, MBL will apply for consent to relocate the area of extraction to the 15 to 25 m water depth area, with the aim of relinquishing the inshore consent should the mid-shore consent be granted.

A comparison of the benthic biota data from with the existing extraction areas against an adjacent control area has been provided in Bioresearches (2019a), to describe any effects related to the recent level of sand extraction. To provide comparative benthic biota and sediment particle size data, sampling was conducted seawards of the current consented area out to the 25 m contour, with reference to determining any pattern in the distribution of biota or changes in seabed sediments. The samples in the proposed consent area (mid-shore) were collected using an MBL vessel in 2019, in accordance with a sampling plan devised by MBL and Dr Roger Grace.

In order to provide clarity, the different consent areas were named as follows:

- MBL “Current Consent Area” or “Inshore” (~5 to 10 m deep)
- MBL “Proposed Consent Area” or “Mid-shore” (~15 to 25 m deep)
- KEL “Offshore” area (~25 to 40 m deep)
- The “Inshore Between” area, between “Inshore” and “Mid-shore” (~12 to 16 m deep)



NZTM Coordinates (X,Y) for New Consent Area
1746960, 6002960
1746270, 6002420
1747380, 6000390
1747510, 6000000
1747620, 5999890
1747810, 6000860
1748730, 5997970
1749060, 5998030
1749260, 5997490
1749390, 5997350
1749430, 5997240
1749840, 5996820
1749730, 5996630
1749800, 5996530
1749580, 5996330
1749680, 5996080
1751200, 5993740
1751400, 5993910
1751890, 5993460
1752080, 5993750
1751720, 5994090
1750150, 5996780
1749380, 5998100

Figure 1.1 Existing MBL Inshore and KEL Offshore Sand Extraction Areas and the proposed New Midshore Sand Extraction Area at Pakiri Beach.

1.1 Previous Surveys

In parallel to sand extraction along the shore of the Pakiri – Mangawhai Embayment, biological and physical surveys in the bay have been conducted since the late 80s to determine the sedimentation process along the shore, and the degree of impact from sand extraction on the dynamics of the bay's ecosystem. Hilton's thesis published in 1990 (Hilton, 1990) presented the results of macrobenthos surveys carried out in 1986 and 1987 along transects perpendicular to the beach to ~5 km offshore (> 40 m deep). Hilton described associations of species along a depth gradient. Within shallow waters to 10 m deep, the wheel shell (*Zethalia zelandica)* and the sand dollar (*Fellaster zelandiae)* dominated the macrobenthos. The gastropods *Cominella adspersa* and *Amalda australis*, and the heart urchin (*Echinocardium cordatum)* were also present in lower densities. These species were also part of the mid-shore assemblage (10 to 25 m deep) with clams such as *Tawera spissa* and *Myadora striata*. Offshore in deeper waters, other clams were common, such as the purple cockle *Purpurocardia purpurata*, the scallop *Pecten novaezelandiae,* and the clam *Corbula zelandica*. Only the macrobenthos was investigated in Hilton's study, as his ultimate purpose was to estimate the biogenic sand production, for which the source is mostly from the decomposition of molluscs.

Dr Grace undertook biological investigations in 1990 and 2005 in the inshore extraction area (Grace, 1991; Grace, 2005). Benthic fauna has been noted as extremely sparse as the environment is naturally harsh. Species such as the wheel shell, scale worms *(Sigalion)*, mantis shrimp *(Pterygosquilla armata)*, and large pink siphon worm (*Sipunculus maoricus)* showed a consistent occurrence and association with the dominant sand dollar*.* A small number of surf clams *(Dosinia anus & Dosinia subrosea)* were also found in the samples. The 1990 study noted that wheel shells were at lower densities than that of the Hilton (1990) study. In 2005, Dr Grace's investigations found no wheel shell or surf clam. However, there was the presence of stink worms and paddle crab (Grace, 2005). The main changes that were identified between the 1990 and 2005 studies was the decrease in species diversity and decrease in abundance in some species. Dr Grace attributed these changes to natural variations in recruitment of biota and the naturally harsh environment, and not to sand extraction. There was also a note that variation in sampling technique could lead to biota differences.

In 2003 and 2006, baseline physical and biological studies of the benthos in offshore waters (>25 m deep) were carried out. Extraction of offshore sand started in 2003 by Kaipara Excavators Ltd in Area 1 south of Te Arai Point, an area (Area 2) to the north of Te Arai Point was surveyed in 2006 (ASR, 2006). Subsequent surveys of Area 1 and a control area south of Area 1 were carried out in 2011 and 2017 to assess potential effects of sand mining on the benthos (Bioresearches 2011, 2019b). Offshore benthic fauna since 2003 showed a dominance in numbers of amphipods and polychaetes. *Corbula zelandica* and *Purpurocardia purpurata* were the most abundant bivalves in 2003, but their abundance decreased over the years. Scallops were present in surveys in patchy aggregations. Horse mussel (*Atrina zelandica*) beds recorded in the 2003 ASR survey have disappeared. According to comments by Dr Roger Grace a series of large storms lifted the horse mussel beds through wave activity and deposited them on the shore, the beds have not recovered from this natural damage. In 1992 Beca Carter Hollings and Ferner noted "Large numbers of horse mussels (*Atrina zelandica*) wash ashore in storms from time to time. Their sizes suggest that heavy settlements occur in intermittent years, individuals growing rapidly and the population tending to consist of similar sized individuals....". The above observation was noted as consistent with the views expressed by Dr Bob Creese in the NIWA sand study (Healy, *et al.* 1996), that in his experience, colonies of horse mussels seem to be transient.

A decline in water clarity has also been linked in Ellis *et al*. 2002 as a likely factor for declining horse mussel beds in estuarine environments However, the water quality report (Kubale, 2020) shows the levels of suspended solids in water from the normal operation of the William Fraser and earlier dredging operations (1.5-4.5 mg/L) would not be sufficient to cause a decline in horse mussels, which experimental studies showed occurred and suspended solids concentrations greater than 80 mg/L. The benthic community in the control area adjacent to the south of the sand-extracted area did not show significant differences with that of the Area 1, indicating a negligible effect of offshore sand mining on benthic communities (Bioresearches 2019b).

1.2 Dredging Activities and the Potential Effects

All extraction activities in the Proposed Consent area will be conducted by a Trailing Suction dredge. Trailing suction dredgers operate by sucking material from the seabed as a sand slurry using a trailing suction head fitted to pipes that trail over the bed as the ship sails over the extraction area. The sand pumps lift the extracted sand slurry through the pipework to pass through sand screens to be deposited in the onboard hopper. A key component of the activity is that once the dredge vessel is fully loaded, it returns directly by sea to the MBL depot at the Ports of Auckland for unloading, hence there are no local onshore components to the extraction operation.

A schematic diagram of a trailing suction hopper dredge is presented in Figure 1.2, note the vessel is not an MBL vessel.

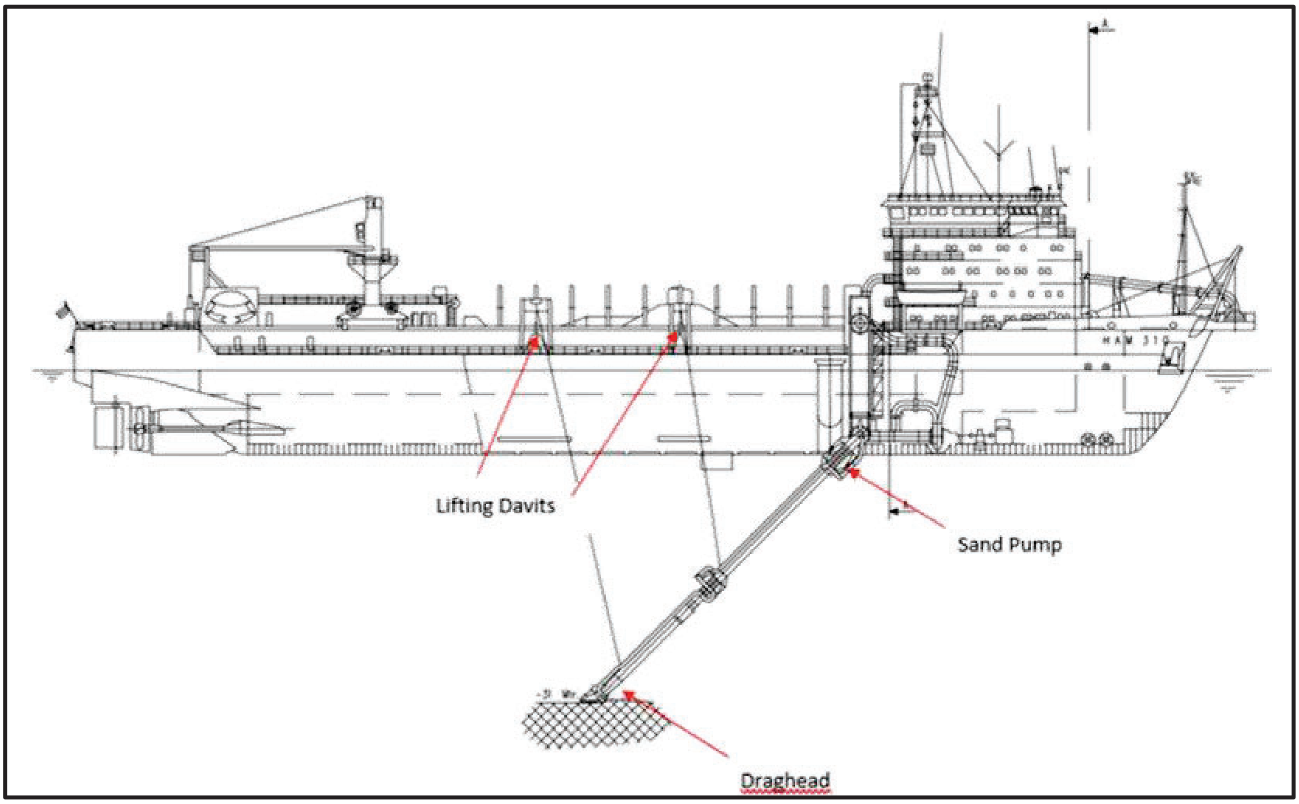


Figure 1.2 Schematic Diagram of Trailing Suction hopper Dredge (note not an actual MBL vessel)

In late 2019, MBL took possession of a new sand extraction vessel the William Fraser (see Cover Photo) to replace the ageing Coastal Carrier (1968). The William Fraser has been specifically built for trailing suction dredging of sand and has a number of new technologies that provide improvements in the operation of the vessel whilst minimising other impacts on the surrounding environment. The William Fraser is larger than the Coastal Carrier with improved pumping and screening technology.

There are some key operational changes between the William Fraser and the Coastal Carrier:

- The increased speed of the vessel when extracting; between 1.5 to 2.5 knots *vs* the Coastal Carrier at 1 – 1.5 knots. This is mainly due to the size of the vessel and the type of drag-head used,
- Wider dredge head (1.5 m *vs* 1.2 m) and larger hopper (900 m^3 *vs* 460 m^3), meaning fewer dredging trips to obtain the same consent volume,
- The increased speed of the vessel and wider dredge head has resulted in a wider shallower dredge path profile (1.6 m x 100 mm *vs* 1.2 m x 150 mm),
- The screening technology on the William Fraser is significantly improved from the Coastal Carrier resulting in significant improvements in the efficiency of sand retention, resulting in lower water quality effects and less over dredging.
- The addition of moon pools to discharge water below the keel, rather than via flume pipes and over the side of the vessel. This introduces the overspill and oversize material under the vessel rather than at the surface, reducing the effects of turbidity on the receiving environment.

The dredge head used by the William Fraser is shown in operation on the seabed in Figure 1.3, with the resulting dredge path profile.

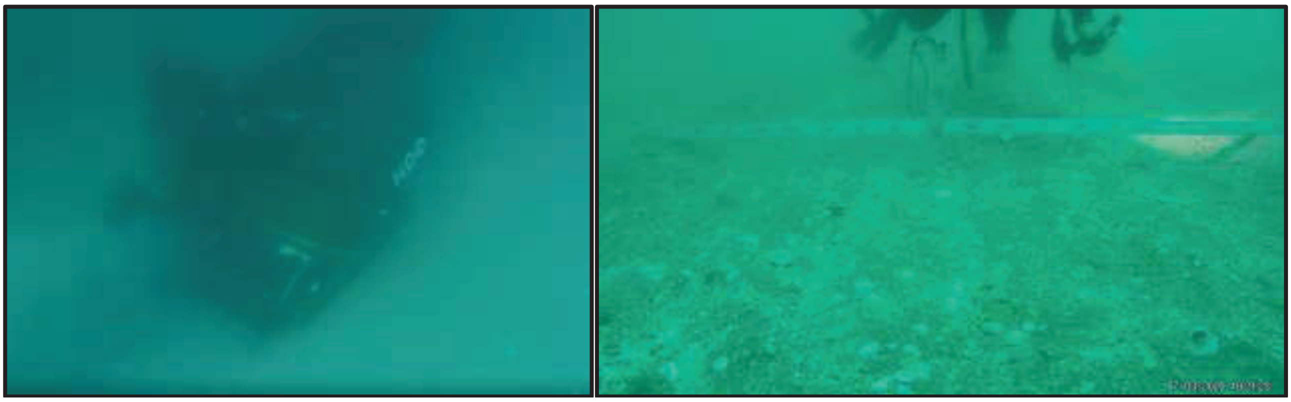


Figure 1.3 William Fraser dredge head and seabed dredge profile at Pakiri.

The effects of sand extraction occur in two general categories: seabed disturbance and water quality.

The effects to the seabed (and biota) occur in two ways:

1. **Removal of seabed and disturbance of the seabed substrate.** The magnitude and frequency of occurrence at any one location will influence the level of effects to biota. The William Fraser drag head is 1.5 m wide. Seabed investigations by MBL, showed the dredge path was 1.6 m wide and ranged in depth of 80 mm to 120 mm below the sediment surface. More frequent disturbances by dredging will likely result in greater observed effects to the biota population. Excessive dredging could potentially result in increased seabed depth, which has the potential to influence biota community composition. Shallower layers of dredging are likely to recover quicker than deeper layers of dredging.
2. **Damage to biota by passage through the dredge and screening**. Larger fragile biota are more likely to be adversely affected by passage through the dredge and screening equipment than robust biota. Smaller, less robust biota can potentially be damaged by impact with hard surfaces on passage through the dredge, pump, pipes and screen. The level of damage will vary among species and sizes, from minor scratches and chips to mortal cracks and dismemberment.

The effects to water quality are by discharge to the ocean from the dredge vessel and occur in two ways:

1. **Discharge of by-wash containing oversized material that is too large to pass through the sand screens to the hopper.** For safety reasons sampling was not undertaken at the discharge moon pool. Once discharged the concentration quickly reduces back to ambient conditions in both depth and distance from the discharge point, this is further defined in Kubale (2020).
2. **Discharge over the weir boards as the hopper fills with sand.** Water sampling of the weir board discharges indicated Total Suspended Solids (TSS) values of 450 to 1240 mg/L, to form part of the overall plume with the by-wash discharge as noted above. All discharge going over weir boards passes into moon pools that discharge at keel level on the vessel.

The effects of sand extraction dredging are summarised in Figure 1.4.

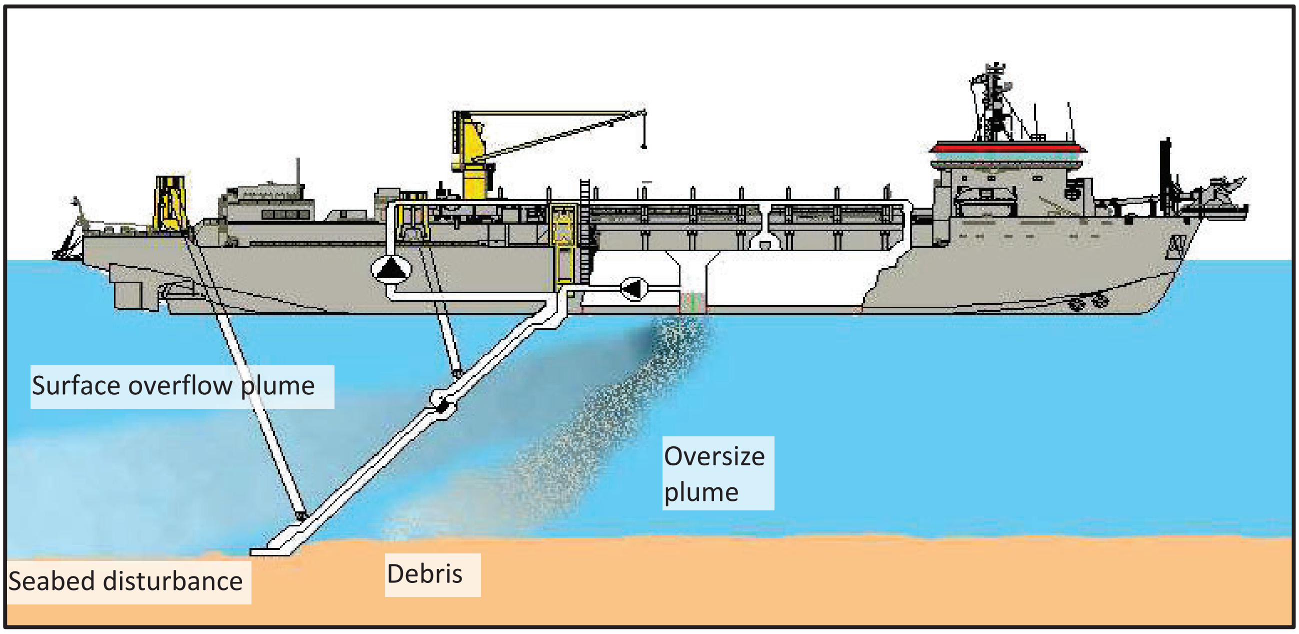


Figure 1.4 Summary of the effects of sand dredging (note not an actual MBL vessel)

2. METHODS

MBL in combination with Dr Grace devised the sampling methodologies as outlined below, to assess the nearshore benthic ecology in the Pakiri – Mangawhai embayment potentially affected by the proposed relocation of the sand extraction from the inshore extraction areas (Figure 1.1) operated by MBL to the proposed mid-shore area defined in Figure 1.1. The sampling was largely conducted by MBL using their own vessel but with Dr Mathew Jones present to ensure the methodology was followed.

Potential effects on birds and marine mammals or on marine water quality are not part of this assessment.

2.1 Seabed Sampling

2.1.1 Surficial Sediment Particle Size

Changes in the particle size composition of the seabed has the potential to influence benthic biota community composition. Samples were collected to determine the variation in sediment particle size in the proposed mid-shore sand extraction area, and therefore potential influences on the benthic biota communities. A total of 118 box dredge samples were collected in early 2019, numbers of samples were distributed as shown in Table 2.1. Each sampling site is shown in Figure 2.2 and the GPS locations are listed in Appendix 1.

Table 2.1 Numbers of samples in areas[1]

	Northern	Te Arai Point	Southern	Control
Offshore	15	4	10	2
Proposed Midshore Area	10	3	11	14
Inshore-Between area	4		5	1
Inshore Consent Area	10		10	10

A 1 kg subsample of the sediment was retained from that passing through a 3.15 mm sieve from the 118 box dredge samples collected for benthic fauna (see 2.2 Benthic Fauna Sampling), for the sediment size analysis. The sand was dried and processed to the concrete industry standard - NZS 3111: 1986 Methods of Test for Water and Aggregate for Concrete by MBL, which results in percentage composition based on the weight of particles passing a series of screen sizes. The NZS 3111 method uses different sieve sizes to samples normally processed for environmental samples and excludes large particles, but the results are still comparable across sites and provide indications of habitat variability.

Where possible, the raw particle size data has been grouped into the following standard size fractions.

Class	Gravel	Sand	Silt and Clay
Particle Size (mm)	> 2.00	2.00 – 0.063	< 0.063

According to the methodology defined in Folk (1980), the sediments were assigned a description based on the principle particle size fraction with modifiers based on the next important particle sizes. These descriptions are given as letter codes. For example,

- A sample which consisted of mostly sand with a significant proportion of silt and clay would be described as muddy sand. This would be denoted **mS**.

[1] Note: The Table consent area colour highlights are derived from Figure 1.1 and colour theme is continued through the document

- If the sample had a gravel component, it would be described as slightly gravelly muddy sand. This would be denoted **(g)mS**.

The descriptions of the sediments are based on criteria illustrated in Figure 2.1.

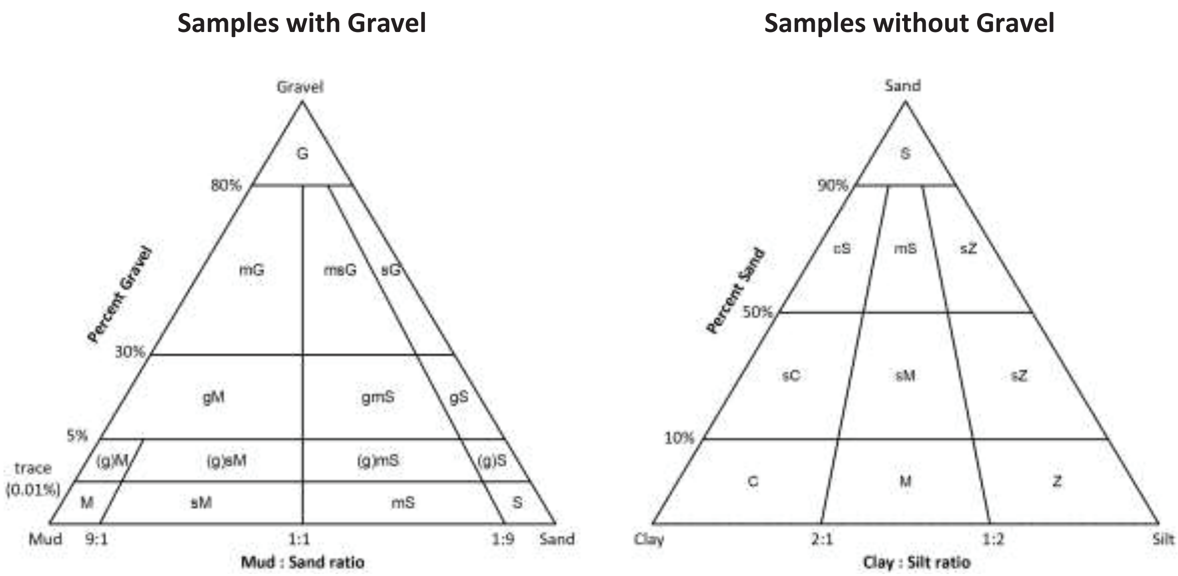


Figure 2.1 Sediment Particle Size Description. *(C=clay, M=mud, Z=silt, S=sand, G=gravel)*

2.1.2 Seabed Photographs

Seabed photographs were taken at approximately 1 m depth intervals aligned along four transects from 5 m to 30 m depth through the existing inshore and proposed mid-shore sand extraction areas. At each site, a single drop camera photograph of 1 m² of seabed was recorded with a compass reference. The camera was set to record images at 2-second intervals with the clearest image selected per site. Both the southern extraction area off Pakiri Beach and northern extraction area off Te Arai beach were surveyed by two photographic transects each that cover the inshore, the mid-shore and the offshore areas. Photographic sample locations are shown in Figure 2.3. GPS coordinates, water depth and time were recorded at each site (Table A3.5). Details of the substrate and presence of any conspicuous species were recorded.

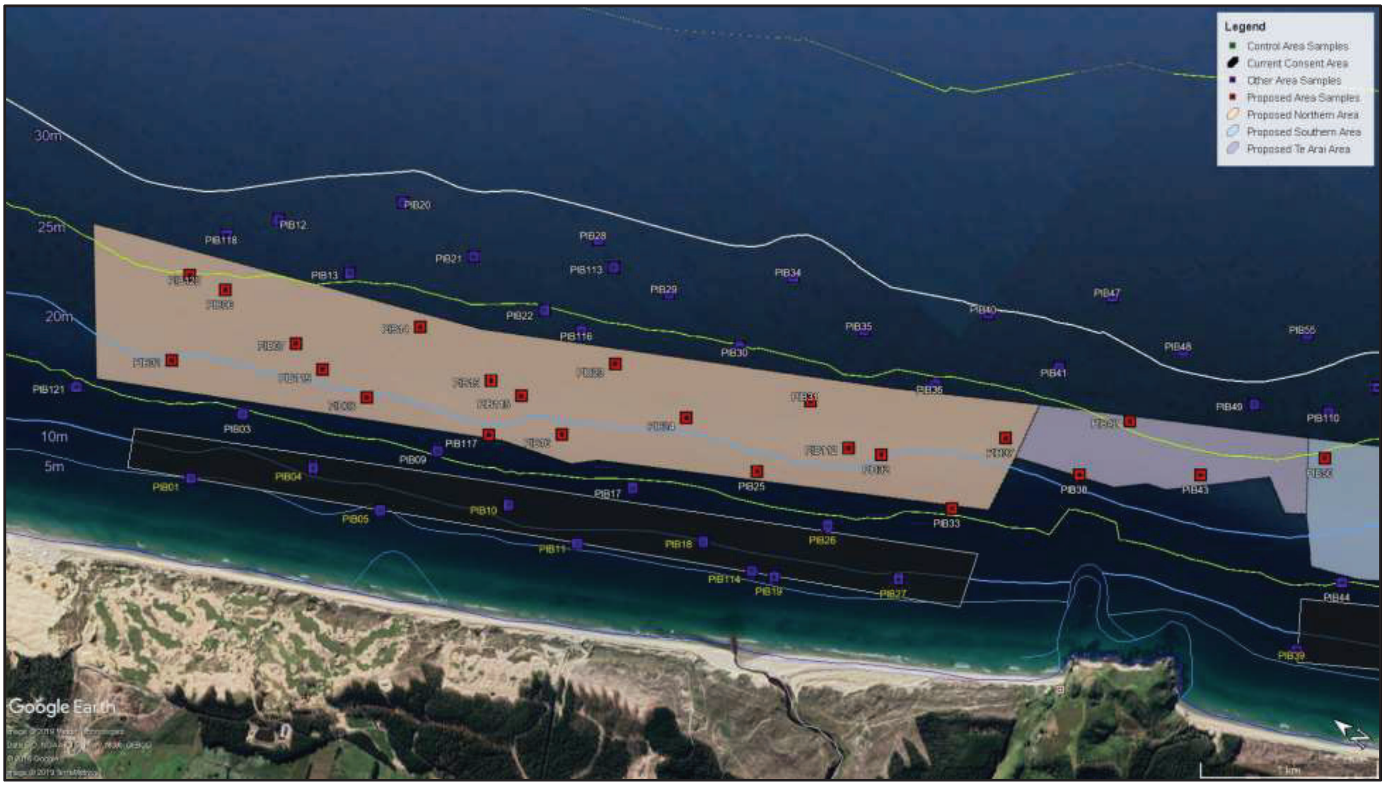


Figure 2.2 Location of benthic box dredge samples, 2019. North

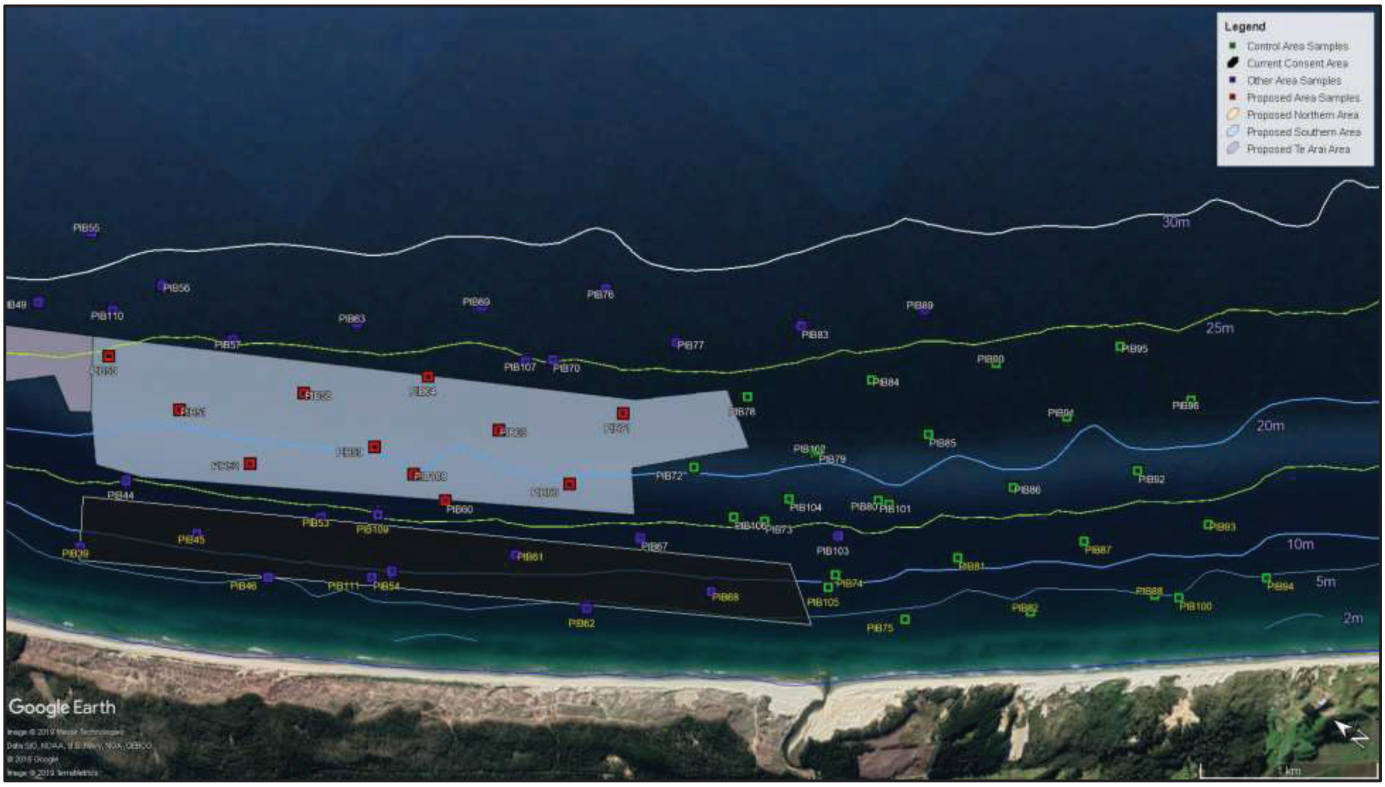


Figure 2.2 Location of benthic box dredge samples, 2019. South

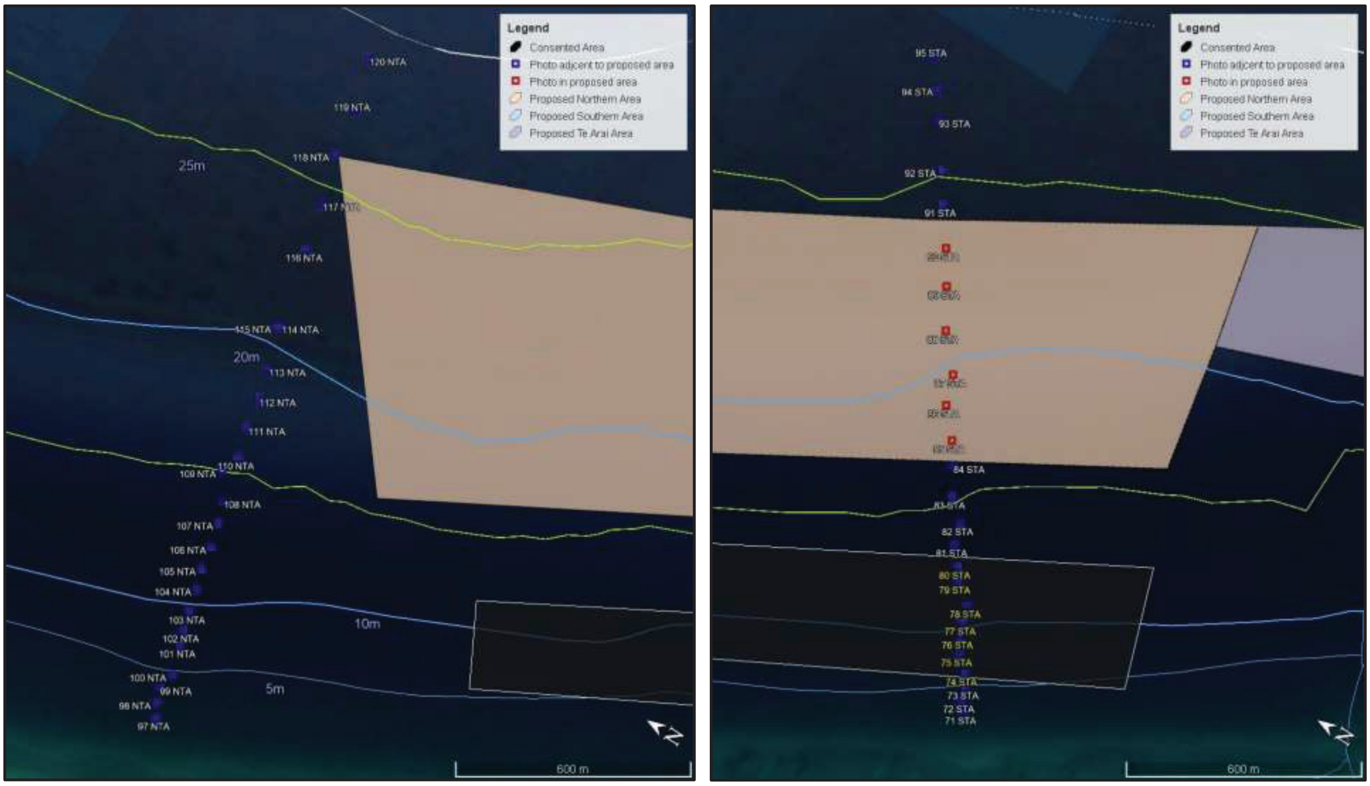


Figure 2.3 Location of seabed photographic samples, 2019. North (Te Arai Beach)

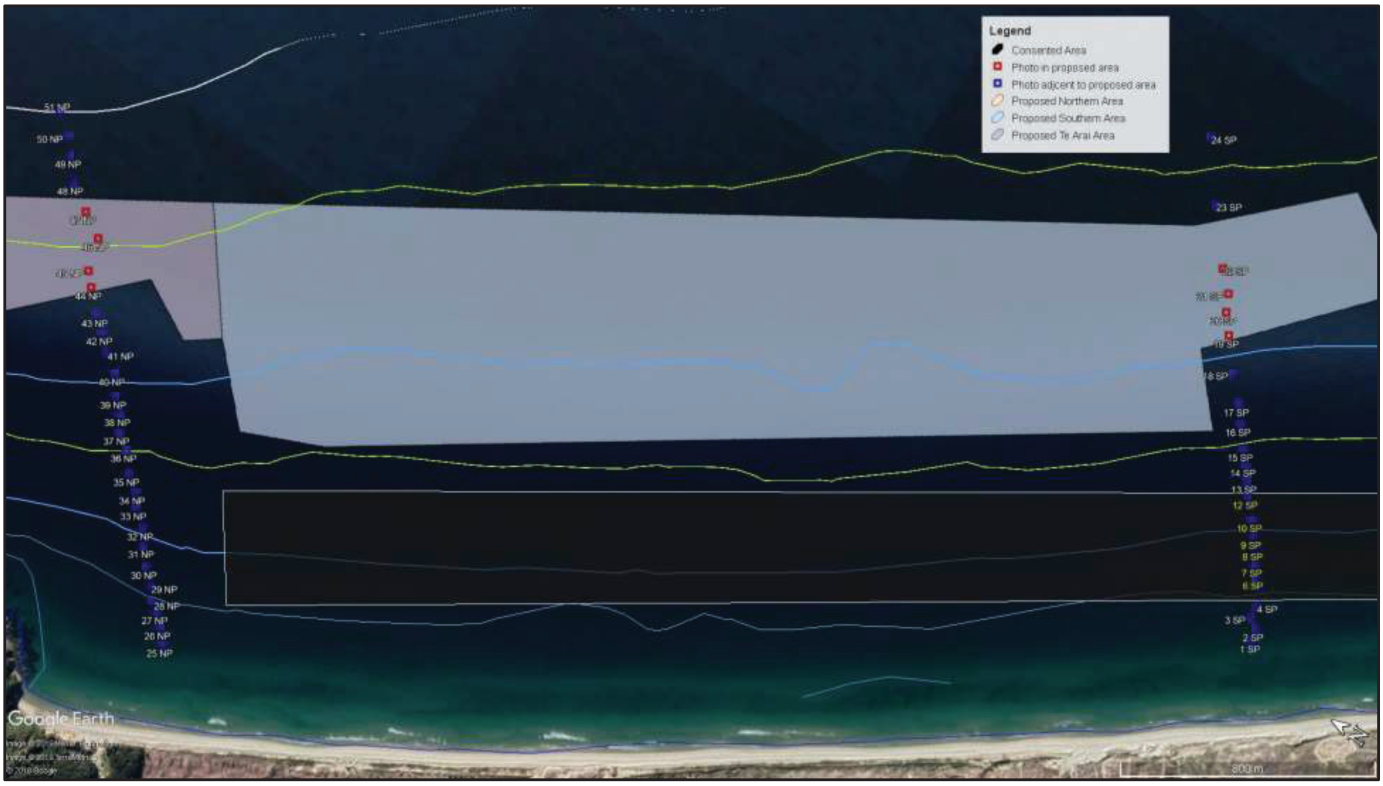


Figure 2.3 Location of seabed photographic samples, 2019. South (Pakiri Beach)

2.2 Benthic Fauna Sampling

2.2.1 Infauna (box dredges)

The potential effects of sand extraction on the relative abundance and diversity of benthic communities in the proposed mid-shore area (proposed new consent area) and adjacent seabed were assessed. A total of 118 box dredge samples were collected in early 2019, numbers of samples were distributed as shown in Table 2.1. Each sampling site is shown in Figure 2.2 and the GPS locations are listed in Appendix 1.

The samples were collected with a box dredge sampler, with a sample width of 180 mm, and a bite depth of about 75 mm, producing sample volumes of up to 4.5 L. The dredge was lowered to the seabed, towed to full and bought to surface for processing. If the sample volume was less than 3.75 L, the sample was discarded and repeated. Diver observation of the box dredge in operation (Figure 2.4) determined that the drag length to fill the box was in the order of 0.9 m.

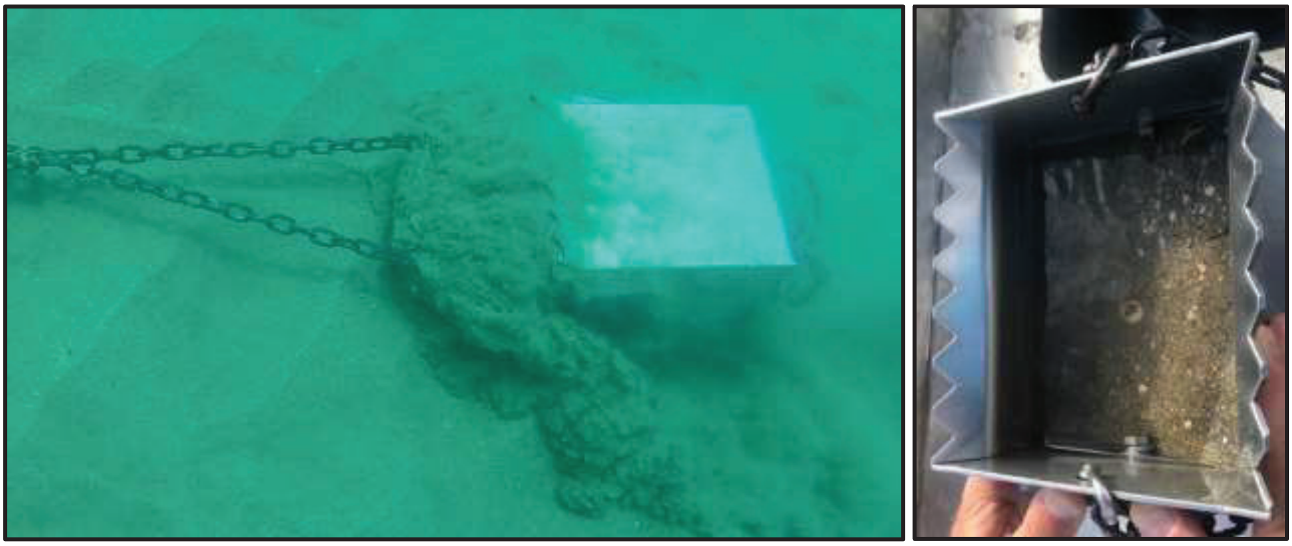


Figure 2.4 Box dredge in operation and full retrieved sample

Sieving large volumes of sandy material through 1 mm mesh sieves is time-consuming and produces large numbers of biota to identify and count, for little gain in understanding. Increasing the mesh size reduces the sample processing time and number of biota, but at the expense of not retaining some of the smaller species. Therefore, a combined approach has been adopted. A 200 mL subsample was taken from each sample and the material was screened over a 1 mm mesh screen and all material retained was transferred to a zip lock plastic bag, labelled and preserved in methylated spirits prior to later identification. The remainder of the box dredge sample was screened over a 3.15 mm mesh screen and all material retained was transferred to a zip lock plastic bag, labelled and preserved in methylated spirits prior to later identification. In both samples all animals were identified to the lowest possible taxonomic level and counted by Dr M. Jones.

The differences in abundance and diversity measures between areas alongshore (North, Te Arai, South and Control) were statistically compared within each consent area by ANOVA, when data satisfied the assumptions of normality and equal variance, but were compared by the non-parametric equivalent Kruskall-Wallis when otherwise, using Sigmaplot 11.0. The comparison of diversity measures does not describe any changes in composition of benthic biota communities. A multivariate approach is required to test differences in species assemblages between the sample area groupings. Multivariate tests were conducted with the software PRIMER-E (version 7.0.13, Quest Research Ltd).

To assess community differences between the sample grouping areas, the multivariate procedure "data transform – Bray-Curtis – nMDS – ANOSIM – SIMPER" has become the accepted statistical methodology (Clarke *et al.*, 2014). The data transformation down-weights the importance of abundant species such as the wheel shell and gives more influence of the rare taxa. Bray-Curtis (B-C) similarity matrices were created on 4^{th} root transformed data (both 1 mm screened, and 3.15 mm screened). Non-metric multidimensional scaling (nMDS) was used to visualise the degree of similarity among samples of different areas on a two-dimensional plot. One-way analysis of similarities ANOSIM (maximum permutations = 999) were performed on the B-C similarity matrices to test the null hypothesis "no difference between the areas". A test statistic R is calculated and is constrained between the values −1 to 1. Values close to zero mean no difference between areas. The ANOSIM test is the multivariate analogue of the univariate ANOVA test. If a global statistical significance is determined at the 0.05 level, then pairwise comparisons between each group should be completed. ANOSIM determines which groups are different from each other, but not what is responsible for the difference. In the case of significant differences between groups, a one-way similarity percentage analysis SIMPER is needed to determine the taxa responsible for the differences between the groups.

2.2.2 Epibenthic Macrofauna (dredge tows)

Larger epibenthic macrofauna can occur at low densities and are not adequately sampled by the small box dredge tow samples or seabed photographs. Thus approximately 300 m long dredge tows, using a 650 mm wide dredge fitted with a 15 mm square mesh bag, were conducted approximately along the 5, 10, 15, 20 and 25 m bathymetric contours. Three tows in the northern and southern extraction areas were conducted at each depth contour plus one tow at each contour in the control area to the south. The locations of each tow, including the start location, are shown in Figure 2.6, and the GPS locations are listed in Appendix 1. All species captured during each tow were removed and immediately sorted, photographed, identified, measured and then returned to the sea alive. The multivariate statistical procedures were used to test for differences in epifauna between consent areas and alongshore areas within the Mid-shore zone.

2.3 Macrofauna Survivorship

The aim of the survivorship sampling was to determine to what extent, if any, the larger macrofauna such as shellfish, starfish and urchins were damaged by passage through the dredge system. With the changes in dredging vessel from Coastal Carrier to William Fraser sampling undertaken using the Coastal Carrier as part of the inshore consent renewal studies was repeated with the William Fraser to assess any differences between the vessels. The sampling method borrows from the experience reported in Grace, 2016. However rather than using the sampling method to survey benthic biota present on the seabed, it has been used to collect a sample of larger macrofauna with which to assess the biota for damage as a result of the activity of dredging. Sampling locations are limited to those areas currently consented for sand extraction (MBL Inshore and KEL Offshore), and no sample from the proposed mid-shore sand extraction area could be collected.

Five replicate samples were collected on the 28th of February 2020, with the sand extraction dredge William Fraser operating along the offshore edge of the Inshore consent area, in similar locations to those collected in May 2019 (Bioresearches 2019a). Another set of five replicate samples were collected the same day along the inshore edge of the KEL Offshore sand extraction area. Sample sites are shown in Figure 2.7 and GPS points presented in Table A1.3 of Appendix 1.

The sand extraction intake pump was run at a normal stable operating speed as per standard extraction. Sampling from water level below the discharge point, would best capture all the potential effects to macrofauna of passing through the dredge during normal operation. Due the design of the William Fraser this is not possible:

- The lower end of the full overflow pipe discharges into a "well" and out under the hull.
- The volume of water being discharged under normal operating conditions makes sampling at the end of the pipe unsafe.
- Sampling at the water surface in the "well" is not accessible.

Therefore, sampling methods differed from that used in the Inshore consent renewal study. A 1 m wide box net (Figure 2.5) with a 9 mm square mesh, was inserted flush with the top of the 2.5 mm screen, for approximately 5 to 10 seconds, in order to collect sufficient sample. The material collected on each net was retrieved, photographed, and all live macrofauna were collected, bagged with site labels and chilled prior to damage assessment on shore. Each sample was sorted by species and level of damage, the size of individuals was recorded or estimated depending on damage. Each individual was assigned a damage level following criterion based on Moschino *et al.,* 2003. Three damage states were assessed:

- "no damage" for intact fauna,
- "sub-lethal" for fauna with a small level of damage (shells with small chips),
- "lethal" for fauna with broken shells or parts of their body missing.

Individuals classified as having "no" and "sub-lethal" damage were defined as having survived passage through the dredge. Individuals classified as suffering "lethal" damage were either already dead or were unlikely to survive.

Figure 2.5 Sand and water pumped into the sieving system where sampling occurred (Left); and mesh basket used for sampling (right)

2.4 Literature Review on Fish

Fish occurrence in the bay was not studied directly, and information provided in that report was sourced from anecdotal observations recorded during previous surveys conducted by Grace (2005), and Bioresearches (2019b). This is presented in the Discussion section.

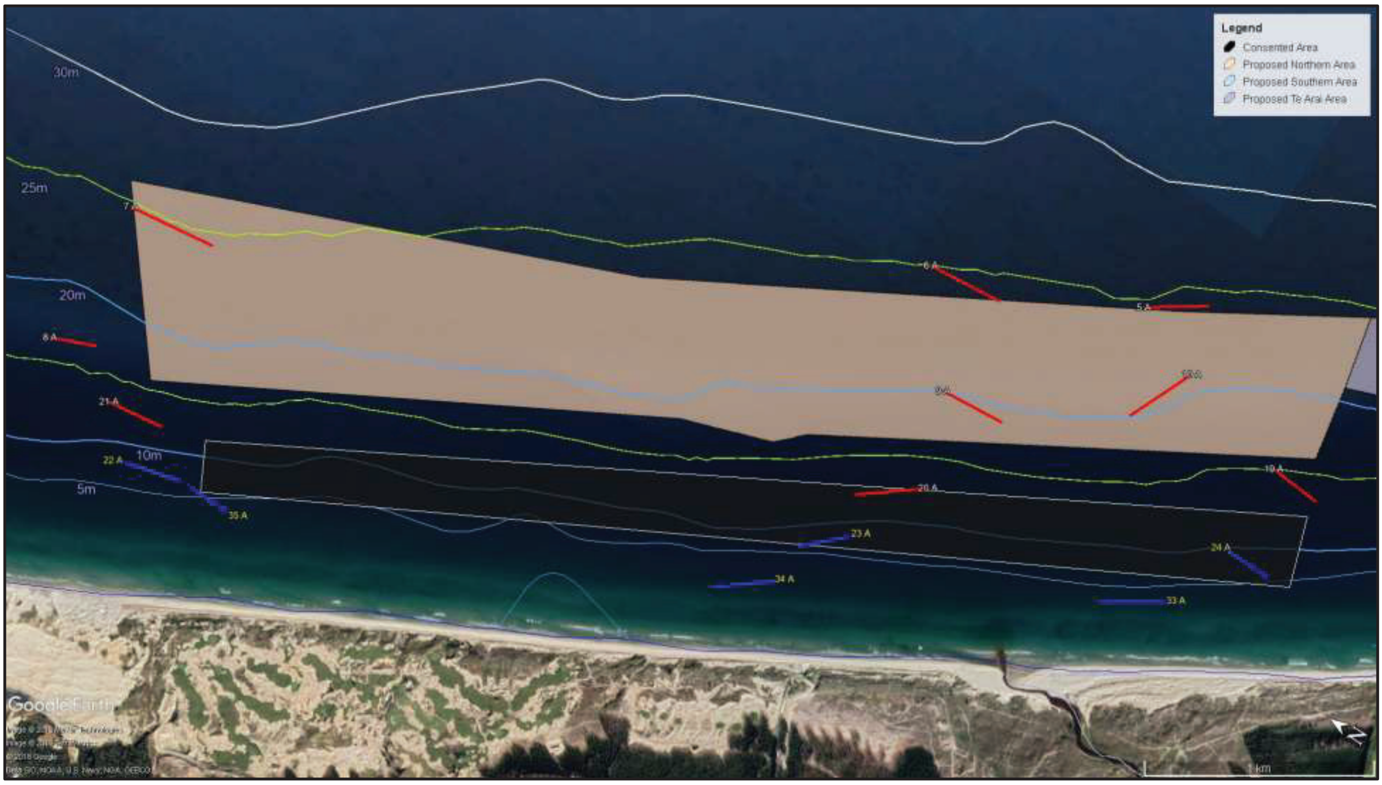


Figure 2.6 Location of epibenthic macrofauna dredge tows, 2019. North

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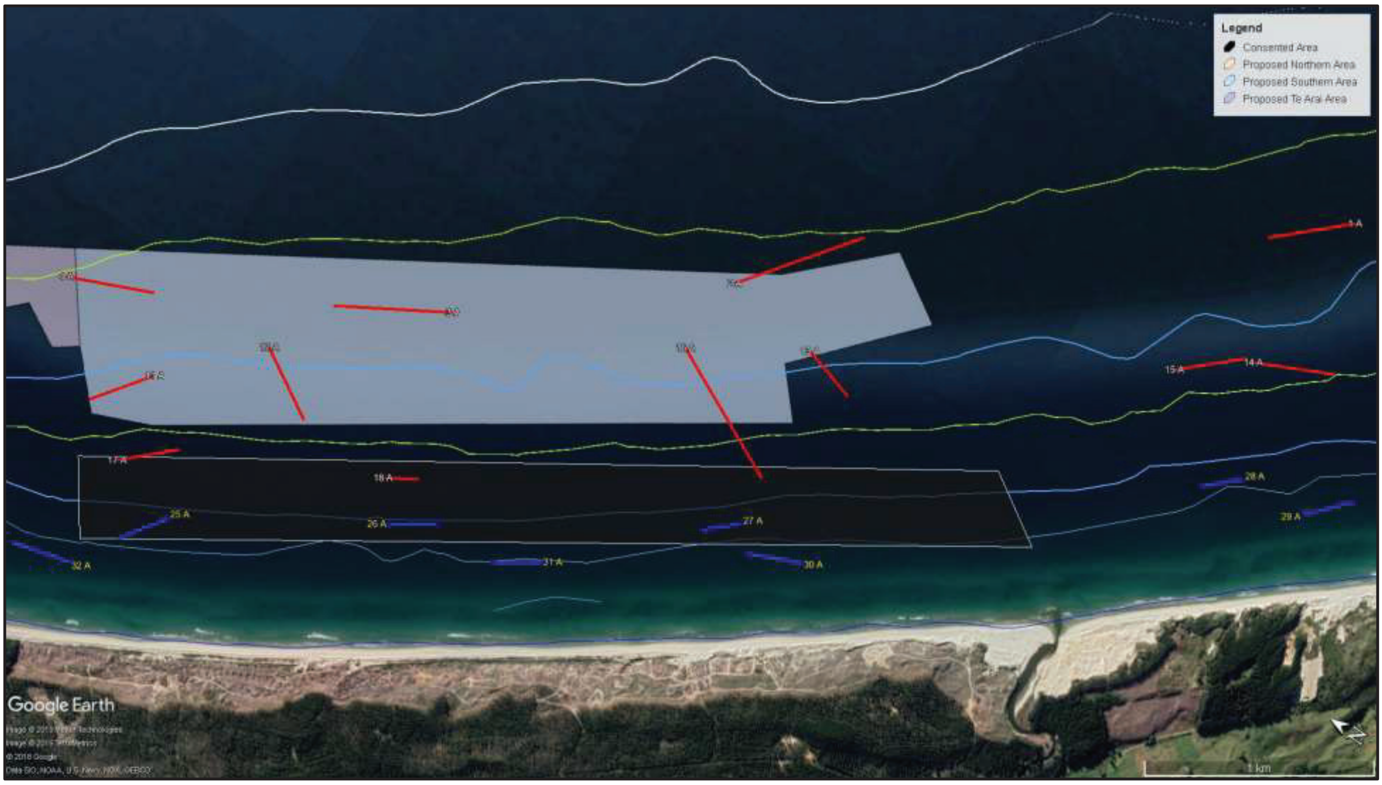

Figure 2.6 Location of epibenthic macrofauna dredge tows, 2019. South

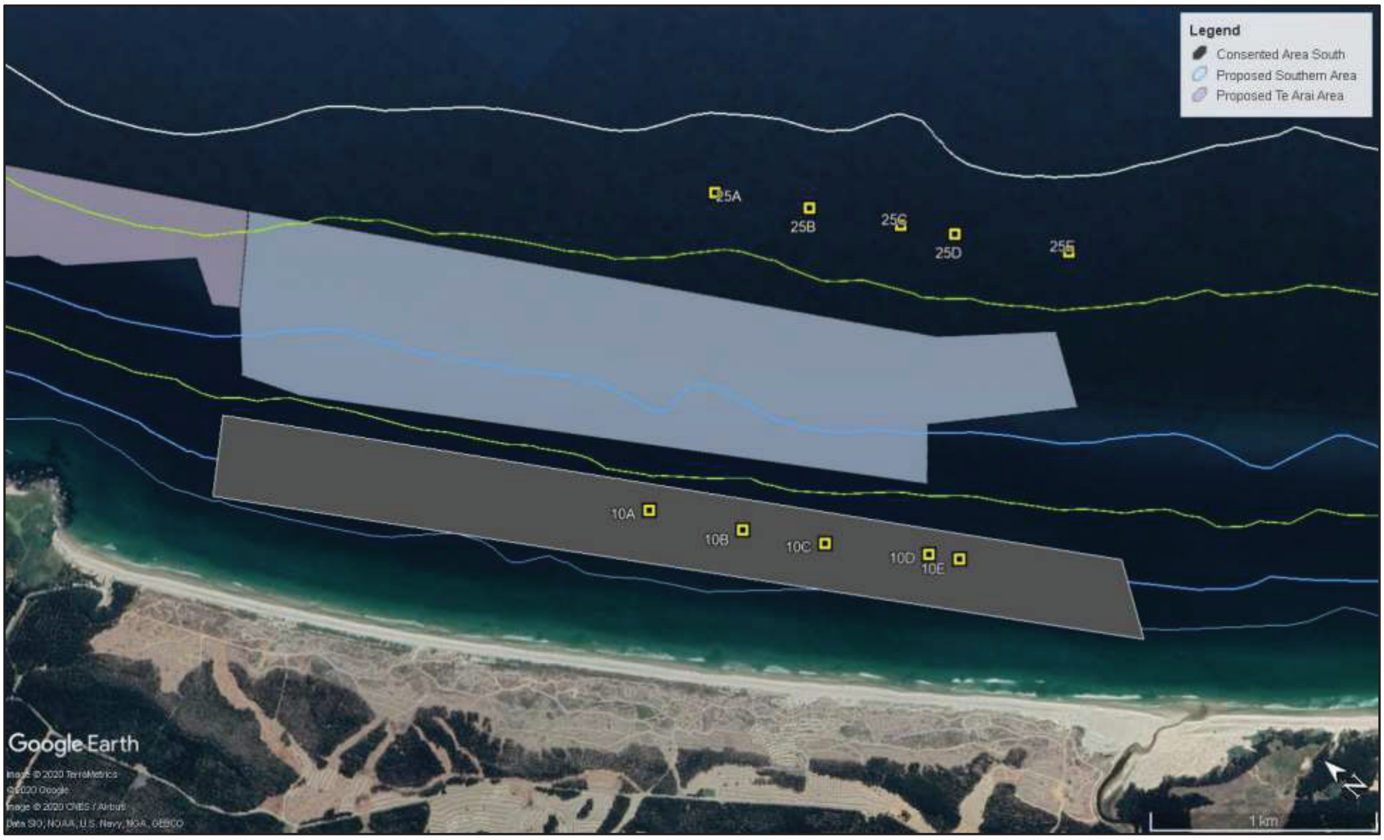

Figure 2.7 Location of Macrofauna Survivorship sample collection, 2020

2.5 Ecological Impact Assessment Methodology

In its simplest form, the Ecological Impact Assessment framework needs to include the following:

- Describe and assign value to ecological features and components potentially impacted
- Describe and determine the magnitude of effects
- Combine value and magnitude to assess the level of effect

Guidelines for undertaking the Ecological Impact Assessments have been published by the Environment Institute of Australia and New Zealand (EIANZ, 2018). These guidelines have been designed specifically for terrestrial and freshwater habitats. There are no standard guidelines on how to assess the ecological value of marine habitats. Therefore, the following outlines how ecological values, magnitudes of effect and level of effects have been determined.

Ecological values of sites, species, habitats, communities or ecosystems are ranked from "very high" to "negligible". Full listing of the factors considered behind any rankings is provided in Table 2.2, but generally consider the four factors.

- representativeness,
- rarity/distinctiveness,
- diversity and pattern, and
- ecological context.

Like Ecological values the magnitude of effect has been ranked from "very high" to "negligible". The criteria for determining the magnitude of the effect to the marine environment are given in Table 2.3.

The level of effect was determined through combining the value of the ecological feature, and the rating for the magnitude of effect (Table 2.4). The cells in bold red italics in Table 2.4 represent a 'significant' effect. Ecological values are presented in section 5 of the report. The assessment of effects is presented in section 6.

Table 2.2 Method for assigning ecological values.

Ecological Value	Characteristics and Determining Factors
Very High	• Benthic invertebrate community typically has very high diversity, species richness and abundance. • Nationally Threatened species present either permanently or seasonally. • Likely to be nationally important and recognised as such. • Surface sediment oxygenated. • Contaminant concentrations in surface sediment at background concentrations. • Invasive, opportunistic or disturbance tolerant species absent. • Habitat unmodified, pristine.
High	• Benthic invertebrate community typically has high diversity, species richness and abundance. • At Risk – Declining species present either permanently or seasonally. • Marine sediments typically comprise <50% silt and clay particle sizes. • Surface sediment oxygenated. • Contaminant concentrations in surface sediment rarely exceed low effects threshold concentrations. • Invasive, opportunistic or disturbance tolerant species largely absent. • Habitat largely unmodified

Ecological Value	Characteristics and Determining Factors
Medium	• Benthic invertebrate community typically has moderate species richness, diversity and abundance. • At Risk – Relict, Naturally Uncommon, Recovering species present either permanently or seasonally; and or Locally uncommon or distinctive species present. • Benthic invertebrate community has both (organic enrichment and mud) tolerant and sensitive taxa present. • Marine sediments typically comprise less than 50-70% silt and clay particle sizes. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below ISQG-high or ARC-red effects threshold concentrations. • Few invasive, opportunistic or disturbance tolerant species present. • Habitat modification limited.
Low	• Benthic invertebrate community degraded with low species richness, diversity and abundance. • Nationally and locally common indigenous species. • Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with few/no sensitive taxa present. • Marine sediments dominated by silt and clay particle sizes. • Surface sediment predominantly anoxic (lacking oxygen). • Elevated contaminant concentrations in surface sediment, above ISQG-high or ARC-red effects threshold concentrations. • Invasive, opportunistic or disturbance tolerant species dominant. • Habitat highly modified.
Negligible	• Benthic invertebrate community highly degraded with very low species richness, diversity and abundance. • Invasive, opportunistic or disturbance tolerant species dominant. Exotic species including pests, species having recreational value. • High contaminant concentrations in surface sediment, above ISQG-high or ARC-red effects threshold concentrations. • Habitat entirely artificial.

Table 2.3 Criteria for describing the magnitude of effects

Magnitude	Description
Very High	Total loss of, or a very major alteration to, key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost form the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature.
High	Major loss of major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature.
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature.
Minor	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances and patterns; AND/OR Having minor effect on the known population or range of the element/feature.
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature.

Table 2.4 Criteria for describing the level of effects

		Ecological Value				
		Very High	**High**	**Moderate**	**Low**	**Negligible**
Magnitude of Effect	**Very High**	***Very High***	***Very High***	***High***	***Moderate***	Minor
	High	***Very High***	***Very High***	***Moderate***	Minor	Negligible
	Moderate	***High***	***High***	***Moderate***	Minor	Negligible
	Minor	***Moderate***	Minor	Minor	Negligible	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible	Negligible
	Positive	Net Gain	Net Gain	Net Gain	Net Gain	Net Gain

3. RESULTS

3.1 Seabed Characteristics

3.1.1 Surficial Sediment Particle Size

The raw particle size data for each of the 118 sites sampled are presented in Table A2.4 of Appendix 2. The concrete method rather than the environmental method was used so that the data generated can be used to demonstrate suitability of the product to the industry requirements. With few exceptions, sediment in and adjacent to the proposed consented sand extraction areas were described as Sand (S), those that differed were described as slightly gravelly Sand ((g)S).

When the proximity to shore was considered, the consent areas show differing patterns of particle size distribution. The Mid-shore area consisted of approximately 26 to 40 % of fine sand (Figure 3.1). This was much less than the reported 58 to 59 % of fine sand in the Inshore area (current consent). The general pattern is that the proportion of larger sized sediment particles increased with greater depth (i.e. medium sand of 21 to 30 % in Inshore, compared with 48 to 66 % in Midshore, and 50 to 74 % in Offshore). This pattern was also seen in the Control area.

Particle composition showed some difference alongshore with more fine sand in the Midshore Southern area (40 %) than in the Midshore Northern area (26 %) (Figure 3.1).

Figure 3.1 Sediment particle size composition, in consent areas and alongshore within the Midshore area.

3.1.2 Seabed Photographs

Seabed photographs from each of the photographic sites sampled in March 2019 are presented in Figure A3.8.1 and Figure A3.8.2 in Appendix 3. The GPS locations and depths of each photographic site together with comments on sediment composition, topography and biota are presented in Table A3.5 in Appendix 3.

The descriptive nature of the photographic data (Table A3.5) precludes statistical analysis. In general, the seabed micro topography and condition shows a pattern that varies with increased depth and distance from shore, of:

- fine sand with irregular small or no ripples inshore of the Inshore consent areas,
- increasing sand size with shell debris and ripple size with depth, across the Inshore consent area,
- larger ripples but low or flat shape in areas deeper than the Inshore area.

No significant difference in surface biota was detected between consent areas (depth factor), and between North and South.

3.2 Benthic Fauna

3.2.1 Infauna

The raw benthic infauna data from each screen size are presented in Appendix 4. From all 118 stations sampled, the combined 1 mm and 3.15 mm screen data showed a total of 181 identified species/taxa and a total of 3683 individuals were counted.

Within the proposed new sand extraction area and control sites (Midshore), 150 species/taxa were identified and a total of 1440 individuals were counted from the combined screens. A total of 73 species/taxa were identified in the 1 mm screen samples (320 individuals counted) and 132 species/taxa were identified in the 3.15 mm screen samples (1120 individuals counted). Of the 150 species/taxa identified, 18 were only recorded in the 1 mm screen samples and 77 only in the 3.15 mm screen samples, with the remaining 55 common to both screens.

The abundance and diversity measures (species richness and the Shannon index) were calculated for each station and screen size and are summarised in Table 3.1. The statistical test results are presented in Appendix 6. All tests showed no statistical difference between the areas alongshore.

Statistical differences were detected between the current consent area and the “Inshore between” for the 1 mm screen abundance and both diversity measures, and between the Offshore and “Inshore between” areas for the 1 mm screen abundances. No other statistically significant differences were detected (Appendix 6).

The benthic biota data sets for both screens contain species/taxa, where only one individual was recorded from a single sample site. This has an adverse effect on the multivariate statistical analysis; thus, the data sets were reduced to taxa with 2 or greater individuals present. Those taxa excluded were then combined to higher taxa grouping and re-included in the data set providing more than 2 individuals were present. This data reduction resulted in data sets of 73 taxa from the 1 mm screen samples and 115 taxa from the 3.15 mm screen samples. Multivariate tests are presented in Appendix 6.

The sample data were grouped according to alongshore areas (North, Te Arai, South, and Control), and consent areas, which were divided into current Inshore consent area (approx. 5 – 10 m depth), “inshore-between” area (approx. 10 – 15 m depth), proposed Midshore consent area (approx. 15 – 25 m depth), and Offshore area (approx. 25 – 30 m depth).

Table 3.1 Summary of Benthic Biota Population Statistics by offshore and alongshore areas for each Screen Size

Alongshore	Current Consent (Inshore)								In between consent areas	
	Northern		Southern		Control		All			
1 mm Screen	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Number of Species / taxa	**3.10**	3.03	**3.20**	3.65	**4.00**	3.43	**3.43**	3.29	**6.50**	2.55
Number of Individuals	**6.60**	6.02	**4.80**	6.07	**6.40**	7.23	**5.93**	6.29	**10.30**	3.83
Shannon-Weiner Diversity Index	**0.753**	0.891	**0.748**	0.904	**1.030**	0.803	**0.844**	0.847	**1.653**	0.446
3 mm Screen	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Number of Species / taxa	**7.00**	3.40	**10.30**	11.13	**6.90**	4.86	**8.07**	7.21	**12.00**	10.21
Number of Individuals	**20.50**	13.22	**50.90**	74.49	**13.70**	10.86	**28.37**	45.64	**30.30**	34.10
Shannon-Weiner Diversity Index	**1.522**	0.760	**1.572**	1.009	**1.447**	0.712	**1.514**	0.809	**1.886**	0.664

Alongshore	Proposed New Consent Area (Midshore)										Offshore of Proposed area	
	Northern		Te Arai		Southern		Control		All			
1 mm Screen	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Number of Species / taxa	**4.00**	2.13	**3.67**	3.21	**5.27**	3.00	**6.36**	3.67	**4.98**	3.02	**3.74**	2.56
Number of Individuals	**5.21**	2.88	**4.33**	3.79	**7.64**	5.77	**8.86**	5.05	**6.81**	4.60	**5.39**	4.33
Shannon-Weiner Diversity Index	**1.157**	0.610	**1.089**	0.956	**1.466**	0.464	**1.561**	0.695	**1.345**	0.636	**1.033**	0.687
3 mm Screen	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Number of Species / taxa	**8.58**	7.31	**9.67**	1.15	**13.55**	12.65	**8.64**	7.43	**9.83**	8.70	**8.65**	5.31
Number of Individuals	**16.32**	18.19	**18.00**	2.65	**35.27**	51.02	**26.29**	32.93	**23.83**	32.57	**20.68**	15.26
Shannon-Weiner Diversity Index	**1.604**	0.785	**2.060**	0.182	**1.996**	0.800	**1.481**	0.704	**1.688**	0.755	**1.619**	0.680

3.2.1.1 Comparison between Consent areas

For each screen data set, benthic assemblages were compared between consent areas (Inshore, Inshore Between, Midshore, Offshore) to assess whether the Midshore area (proposed consent area) had different characteristics compared to adjacent areas.

The nMDS plot on the 3.15 mm similarity matrix (see Method section 2.2.1) showed distinctive groupings with the consent areas and therefore water depth (Figure 3.2). Midshore samples overlapped with the Offshore samples suggesting similar communities while there was a clear distinction with the Inshore samples. The ANOSIM test confirmed these observations (Table A6.31; Global R = 0.317, Global P = 0.001), and further pairwise tests showed a stronger dissimilarity between Midshore and Inshore samples (R_{Mid-In} = 0.451) than between Midshore and Offshore samples ($R_{Mid-Off}$ = 0.192). A SIMPER test (Table A6.32) revealed that dissimilarities were driven by the wheel shell (*Zethalia*), the sand dollar *Fellaster*, the lancelet *Epigonichthys hectori*, and the clams (*Myadora* and *Dosinia*), which were more abundant in the Inshore samples. The taxa characteristics of the Midshore samples were the polychaetes (Maldanidae), the speckled whelk *Cominella quoyana* and the amphipods Phoxocephalidae. These taxa were also dominant in the Offshore samples. The particularity of the Offshore samples compared to Midshore was the presence of the Turritellid *Striacolpus pagoda*.

With the 1 mm screen method, species communities showed weak differences compared to the 3.15 mm screen method (Table A6.33; ANOSIM, Global R = 0.092, Global P = 0.008). Pairwise tests revealed a significant variation only between Inshore and Midshore samples (R_{Mid-In} = 0.204, P_{Mid-In} = 0.003) and between Inshore and Offshore samples (R_{Mid-In} = 0.200, P_{Mid-In} = 0.001). The nMDS plot showed the high overlap between area groupings (Figure 3.3).

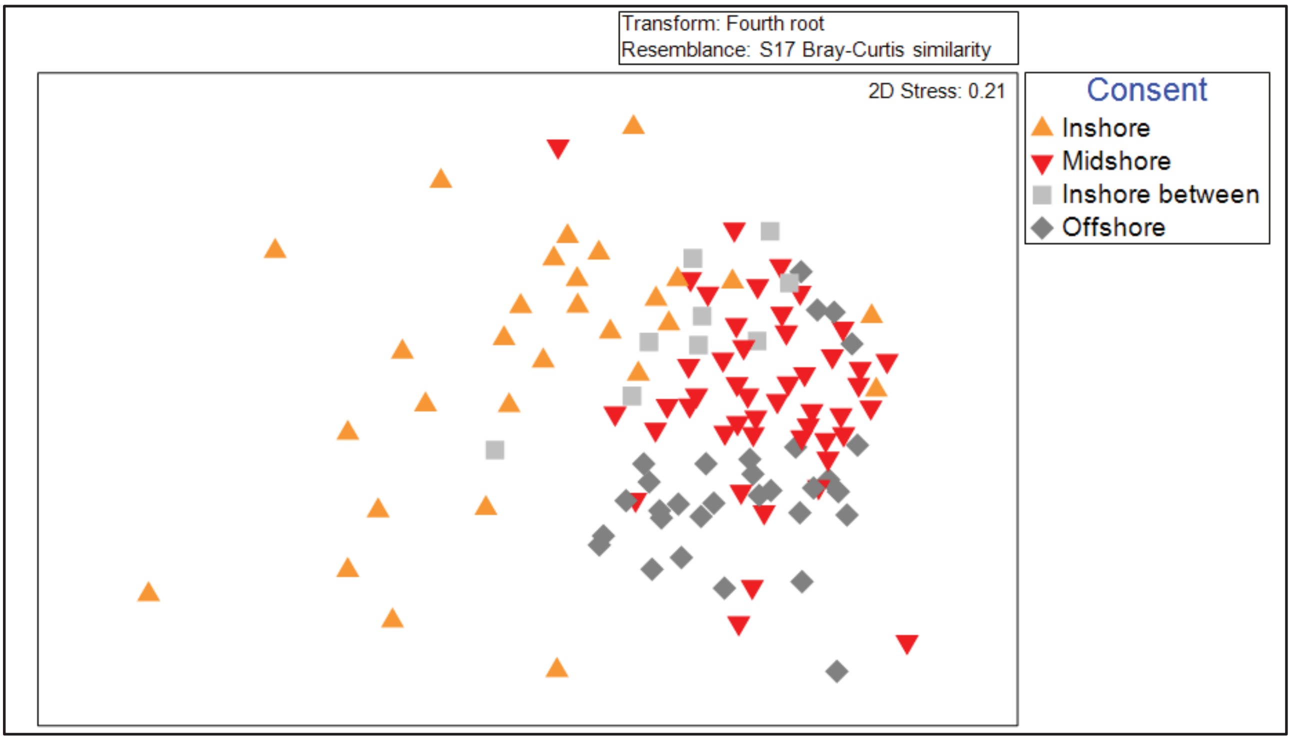

Figure 3.2 Non Metric multidimensional scaling (nMDS) of samples (3.15 mm screen) of benthic infauna classified by consent area.

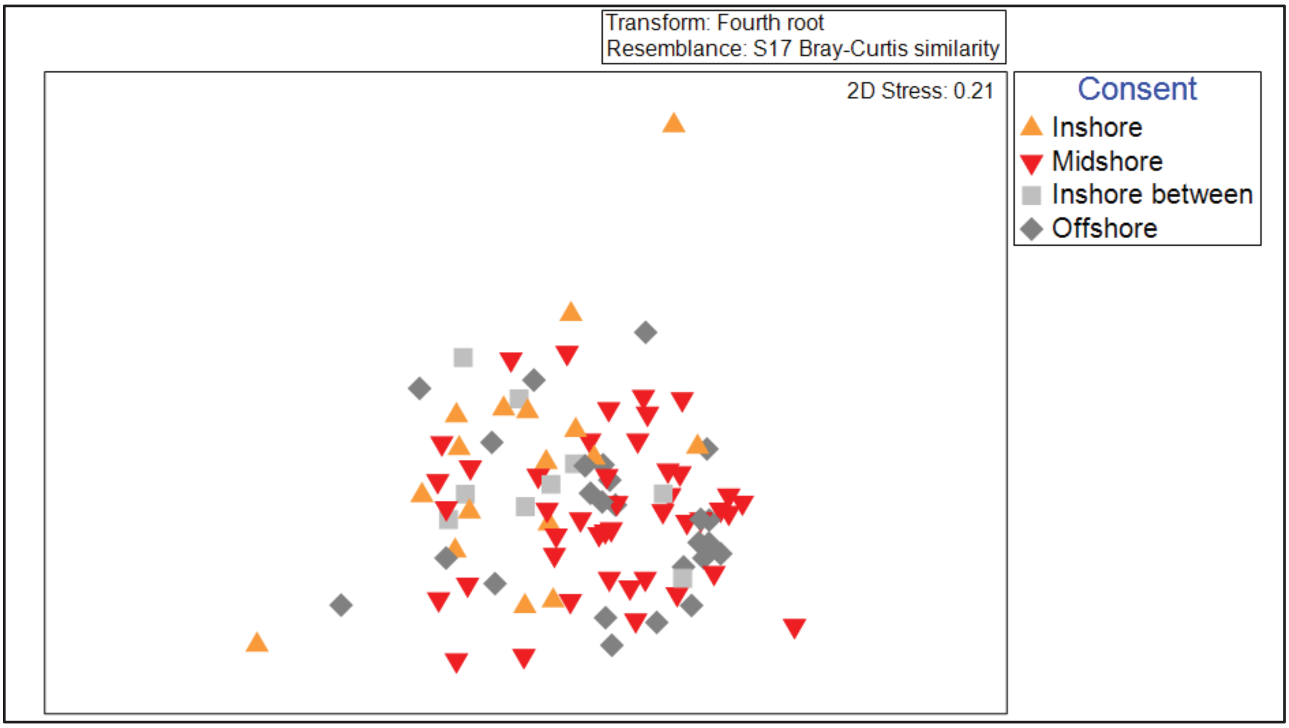

Figure 3.3 Non Metric multidimensional scaling (nMDS) of samples (1 mm screen) of benthic infauna classified by consent area.

3.2.1.2 Comparison between alongshore areas

The nMDS on the 3.15 mm screen Midshore data (Figure 3.4) or the 1 mm data (Figure 3.5) showed a high overlap between each alongshore area suggesting no difference in species communities North-South. The ANOSIM statistical tests for the two screening methods (Table A6.35 and Table A6.36) gave global Rs close to zero ($R_{3.15} = 0.059$, $R_1 = -0.006$) and P values > 0.05 ($P_{3.15} = 0.098$, $P_1 = 0.54$), meaning there was no statistical difference between the North, South, Te Arai and Control area within the proposed new consent midshore zone.

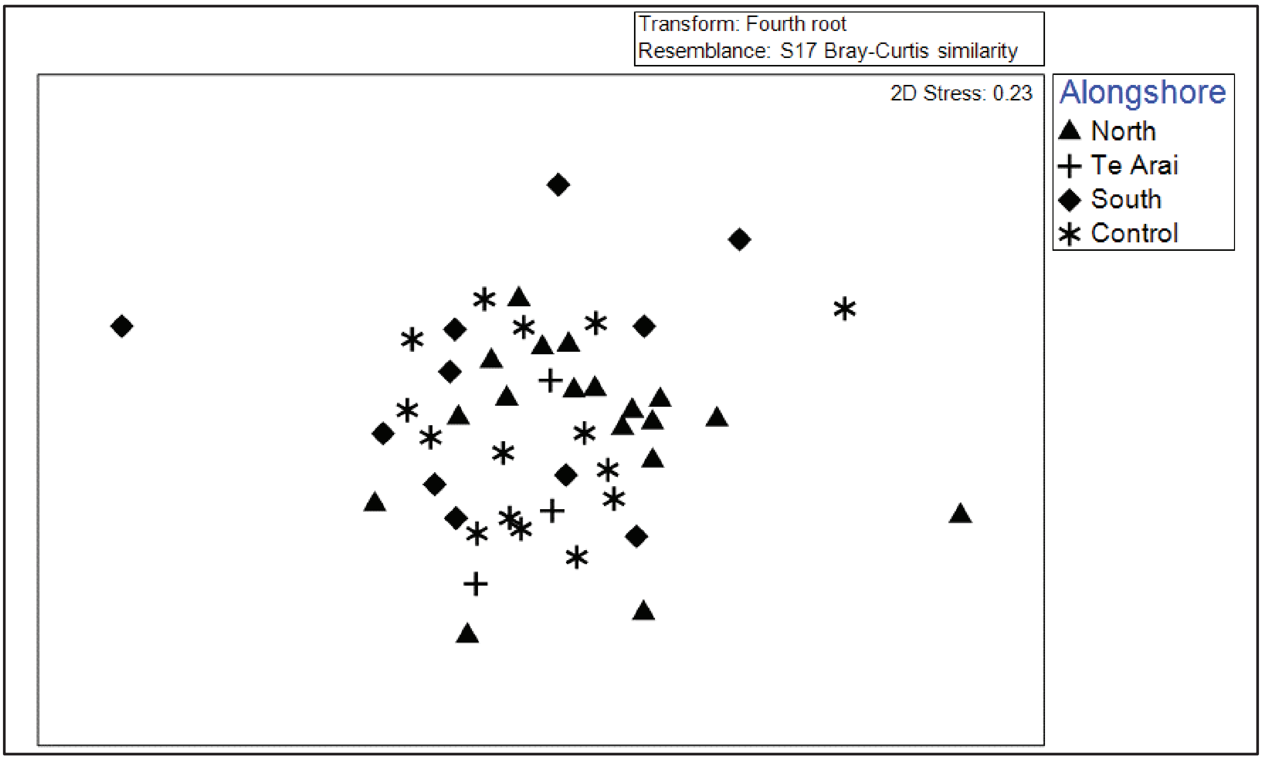

Figure 3.4 Non Metric multidimensional scaling (nMDS) of Midshore samples (3.15 mm screen) of benthic fauna classified by alongshore area.

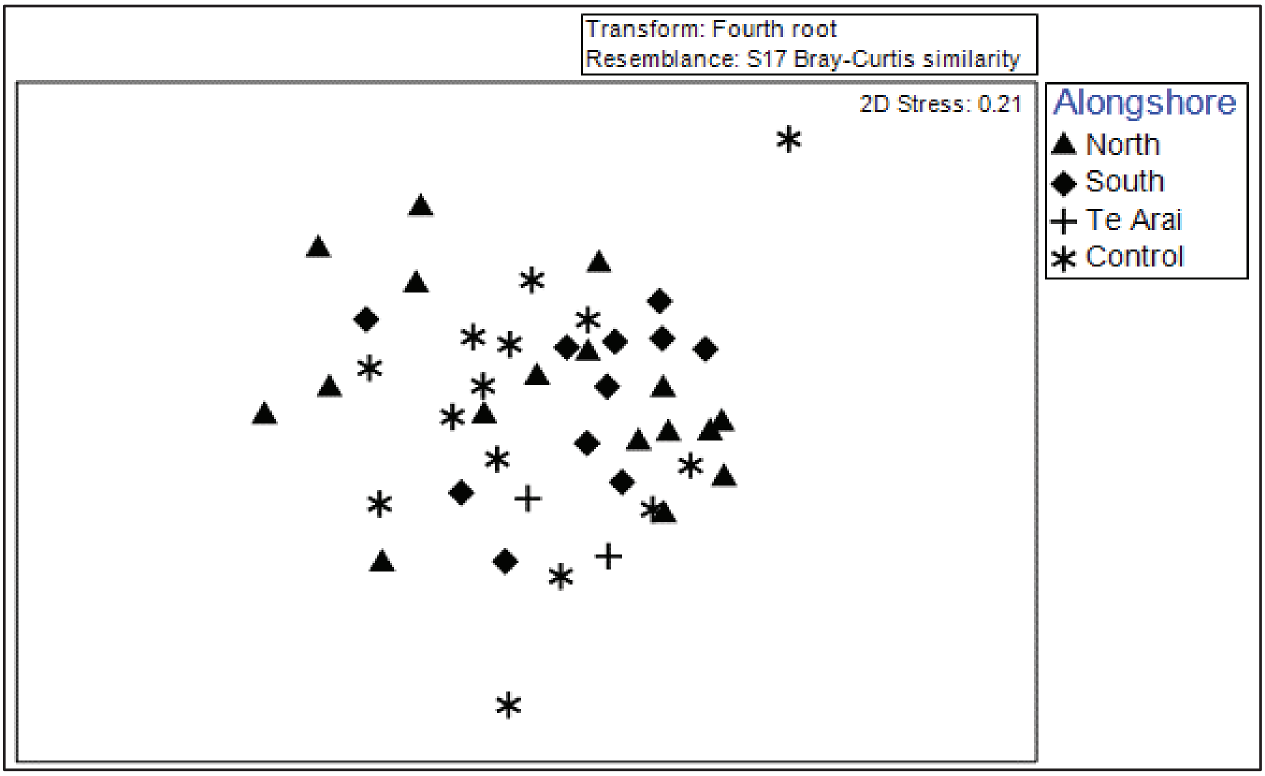

Figure 3.5 Non Metric multidimensional scaling (nMDS) of Midshore samples (1 mm screen) of benthic fauna classified by alongshore area.

3.2.2 Epibenthic macrofauna

The detailed dredge tow data, including sizes of shellfish and densities per 100 m^2, are presented in Table A4.14 in Appendix 4. The samples were photographed, identified and measured on capture and released alive, thus some small taxa such as polychaetes were not identified to the species level. Three tows did not contain any specimens (# 9, 19 and 24).

A total of 42 different taxa were identified over 32 tows (13 Inshore and 19 Midshore). Seven taxa were found only in the Inshore samples, leaving 35 taxa in the Midshore samples. The species and densities within each alongshore area in the Midshore zone are presented in Table 3.2. High densities of epi-macrobenthos (> 10/100 m²) consisted of the Hermit crab *Paguristes*, the speckled whelk *Cominella adspersa* and the starfish *Astropecten*. The sand dollar *Fellaster* was found in high density but only in the Inshore samples (Table A4.14).

Table 3.2 Densities (/100 m²) of species collected with the dredged tows in the Midshore zone.

	Control			Northern							Southern								
Tow #	1	14	15	5	6	7	8	10	20	21	2	3	4	11	12	13	16	17	18
Amalda (B.) australis		0.4								0.6				0.5					
Astropecten polyacanthus		0.4	1.0	0.5					0.5					4.1	0.4		0.5	1.7	1.0
Atrina zelandica						0.5									0.4		0.2		
Austrofusus glans		0.4								0.6									
Zeatrophon mortenseni											0.3								
Bryozoa											0.5					0.6			
Cominella adspersa		0.4	1.5	0.4			0.8		0.5	0.6		0.8	0.3	0.5		0.6	0.9	3.4	2.9
Cominella quoyana																0.6			
Dosinia subrosea															0.4				
Eunicida		0.4																	
Gari convexa								0.3											
Lamellaria ?ophione	0.5																		
Liocarcinus corrugatus		0.4					0.8									0.6			
Luidia maculata														0.5					
Maldanidae			1.0									0.5	0.4	0.5	0.4	0.6	0.9		
Myadora striata		0.4																0.6	1.0
Nemertea		0.4	0.5																
Notomithrax minor				0.3												0.6			
Ophiuroidea																			
Ostrea chilensis					0.5														
Ovalipes catharus															0.4				
Paguristes setosus		3.0	1.0		0.4	1.9	0.8	1.0		8.9	3.7	1.2	5.1	11.2	3.1	3.6	0.9	7.3	3.9
Pecten novaezelandiae		0.4		0.5	2.2	2.4													
Philine sp.																0.6			
Pilumnus novaezelandiae							1.5												
Polychaeta					0.8		0.8							0.5					
Porifera	0.3						0.8					0.4			0.4	0.6			
Purpurocardia purpurata													0.4						
Ranella australasia						0.5													
Red encrusting sponge					0.5														
Rhyssoplax canaliculata						0.4													
Scalpomactra scalpellum														0.5					
Selenaria concinna					0.3							0.3							
Struthiolaria papulosa														0.5	0.9		0.2		
Tawera spissa																	0.2		
Terebellidae														0.5					

3.2.2.1 Comparison between MBL Consent areas

Multivariate statistics show there was an apparent differentiation in epibenthic macrofauna between the current consent area (Inshore) and the Midshore area (nMDS plot, Figure 3.6), this was confirmed by an ANOSIM statistical test (Table A7.37; $R = 0.366$, $P = 0.001$). *Fellaster*, *Dosinia* and *Ovalipes* were only present in Inshore samples, while the scallop *Pecten* was only found in the Midshore area. The taxa Maldanidae, *Cominella, Paguristes*, and *Astropecten* were present in both current Inshore and proposed Midshore consent areas, but their densities were higher in the deeper Midshore zone, driving the differences between the two areas (SIMPER test in Table A7.38).

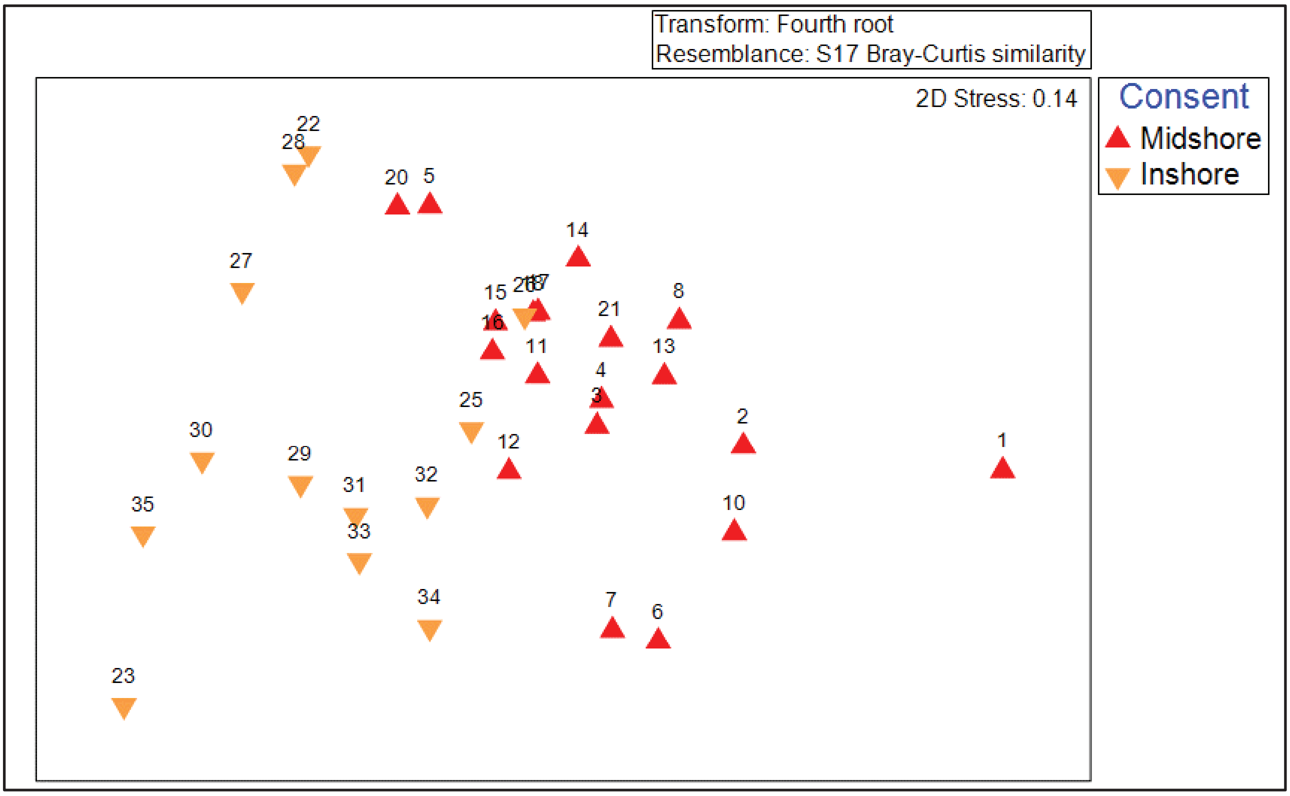

Figure 3.6 Non Metric multidimensional scaling (nMDS) of epibenthic macrofauna classified by consent area. The numbers represent the tow codes.

3.2.2.2 Comparison between alongshore areas

As with infauna samples, variation in epibenthic macrofauna was weaker alongshore (nMDS plot in Figure 3.7; ANOSIM in Table A7.39, Global R = 0.123, P = 0.047). Tow samples in the Control area showed a high dispersion in the nMDS plot. Dissimilarities between samples were mostly between the Northern and Southern regions with scallops only in the North. The Southern region showed higher densities by at least 2-fold of Hermit's crabs, *Cominella* and *Astropecten* than that in the North (Table A7.40).

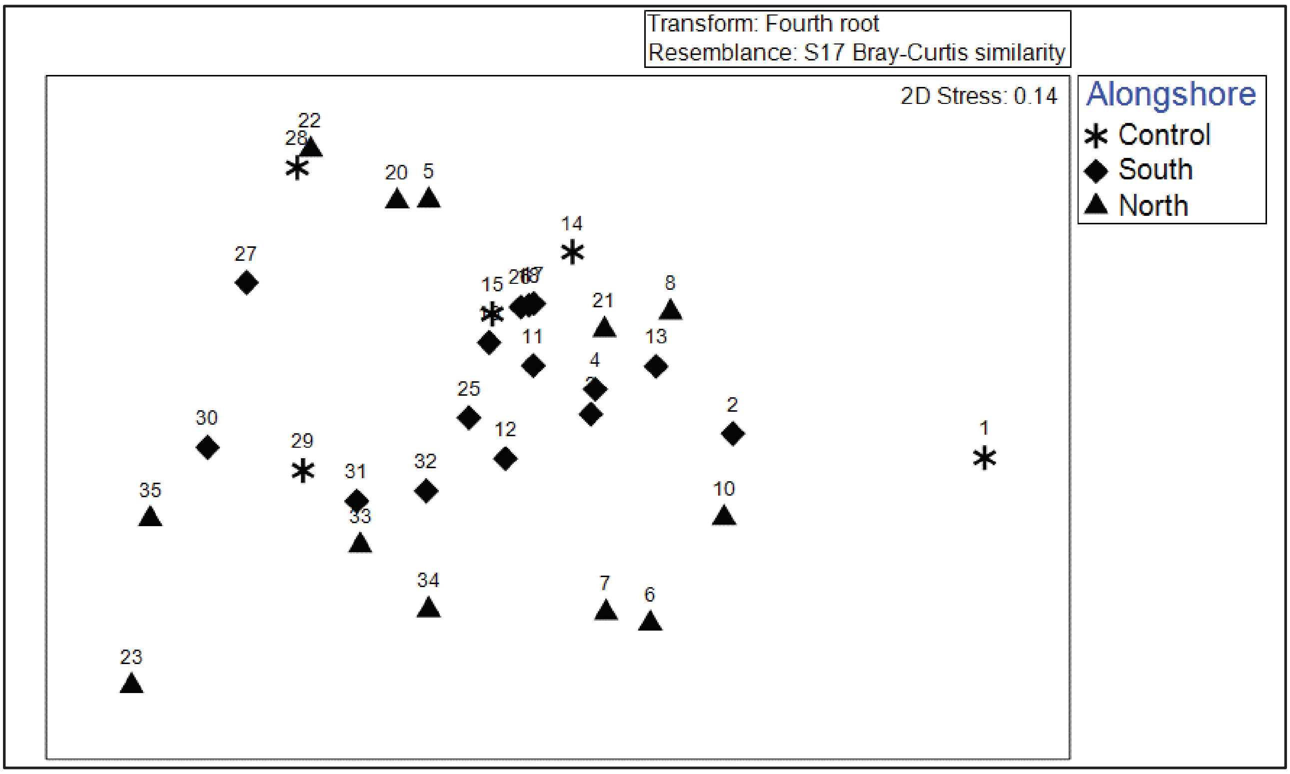

Figure 3.7 Non Metric multidimensional scaling (nMDS) of epibenthic macrofauna classified by alongshore area. The numbers represent the tow codes.

3.3 Macrofauna Survivorship

The macrofauna collected from the screening deck on the William Fraser were sorted by species and by state of damage (none, sub lethal and lethal), counted (Table A5.15), measured (Table A5.16 and Table A5.17) and photographed (Table A5.18).

3.3.1 Numbers of Individuals

The five samples collected at a 10 m bathymetry contained approximately 10 times more individuals than that found at a 25 m bathymetry (1369 individuals at 10 m, Table 3.3; 261 individuals at 25 m, Table 3.4), but the biodiversity was poor at 10 m compared to the fauna pumped at 25 m. This is reflective of the different communities living at these two depths, rather than any dredge related effects. The most common taxum represented in the dredge discharge at both bathymetries was the surf clam *Dosinia* sp. (31% at 10 m; 20% at 25 m). *Myadora striata*, represented more than half of the fauna in the 10 m samples. The other taxa found were gastropods, a few crabs and shrimps, annelids, fish and echinoderms (the last four taxa in the 25 m only).

With both sets of bathymetry data combined, 93% of individuals recorded no damage or had survivable damage (Table 3.5). When the numbers of individuals were divided by taxonomic group, differences were notable with the gastropods suffering no lethal damage. The bulk of Bivalves and Crustaceans found in the samples survived the dredging process with little or no damage (more than 90%).

Table 3.3 Total Numbers of Individuals per State of Damage found in 10 m bathymetry samples

Taxonomy	Species	Intact	Sub Lethal	Lethal	Total	%
Gastropod	*Amalda australis*	6			**6**	**0**
	Cominella adspersa	8	1		**9**	**1**
	Sigapatella sp.	4			**4**	**0**
Bivalve	*Bassina yatei*	2			**2**	**0**
	Dosinia sp.	333	10	87	**430**	**31**
	Gari lineolata	1		2	**3**	**0**
	Myadora striata	817	31	12	**860**	**63**
	Scalpomactra scalpellum	1			**1**	**0**
	Tawera spissa	22		1	**23**	**2**
Crustacean	Crabs	6			**6**	**0**
	Pagurus	17	2		**19**	**1**
Annelid	Annelids	2	1	3	**6**	**0**
	Total Damage	**1219**	**45**	**105**	**1369**	
	%	**89**	**3**	**8**		

Table 3.4 Total Numbers of Individuals per State of Damage found in 25 m bathymetry samples

Taxonomy	Species	Intact	Sub Lethal	Lethal	Total	%
Gastropod	*Amalda australis*	1	0	0	**1**	**0**
	Austrofusus glans	2	0	0	**2**	**1**
	Cominella adspersa	1	0	0	**1**	**0**
	Cominella quoyana	69	0	0	**69**	**26**
	Sigapatella sp.	24	0	0	**24**	**9**
	Stiracolpus pagoda	2	0	0	**2**	**1**
	Struthiolaria papulosa	1	0	0	**1**	**0**
	Struthiolaria vermis	1	0	0	**1**	**0**
	Xenophalium sp.	1	0	0	**1**	**0**
Bivalve	*Divalucina cumingi*	1	0	0	**1**	**0**
	Dosinia sp.	50	0	1	**51**	**20**
	Gari lineolata	3	0	4	**7**	**3**
	Myadora striata	2	0	0	**2**	**1**
	Notocallista multistriata	11	0	0	**11**	**4**
	Nucula sp.	2	0	0	**2**	**1**
	Pecten novaezelandiae	1	0	0	**1**	**0**
	Pratulum pulchellum	12	0	1	**13**	**5**
	Scalpomactra scalpellum	2	0	0	**2**	**1**
	Semele sp.	0	0	3	**3**	**1**
	Tawera spissa	1	0	0	**1**	**0**
	Purpurocardia purpurata	21	0	0	**21**	**8**
Crustacean	Barnacle	1	0	0	**1**	**0**
	Crabs	9	6	0	**15**	**6**
	Mantis shrimp	3	0	2	**5**	**2**
	Pagurus	3	2	0	**5**	**2**
Echinoderm	Starfish	4	1	0	**5**	**2**
Annelid	Annelids	1	3	3	**7**	**3**
Fish	*Muraenichthys beviceps*	1	0	0	**1**	**0**
	Synodus sp.	2	0	0	**2**	**1**
Lancelot	*Branchiostoma*	3	0	0	**3**	**1**
	Total Damage	**235**	**12**	**14**	**261**	
	%	**90**	**5**	**5**		

Table 3.5 Total Numbers of Individuals per State of Damage

	No Damage	Sub Lethal	Lethal	Total
Total Number of Individuals	1453	57	4	**1629**
% Total	90	3	7	
Bivalves	1281	41	111	**1433**
% Bivalves	89	3	8	
Gastropods	120	1	0	**121**
% Gastropods	99	1	0	
Crustaceans	39	10	2	**51**
% Crustaceans	76	20	4	

3.3.2 Size of Individuals

The average length and ranges of measured individuals are reported in Table A5.16 and Table A5.17. *Dosinia sp.* and *Myadora striata* were the only taxa collected in enough numbers to be informative of the damage caused by the dredging system relative to size (Figure 3.8, Figure 3.9). The data were not sufficient to determine any differences in damage effects associated with depth.

The undamaged clams ranged in size from 6 to 31 mm for *Dosinia*, and 10 to 26 mm for *Myadora*. The majority of clams in an undamaged state were less than 20 mm in size. The majority of larger *Dosinia* clams showed signs of chips or were fractured. This differential survivorship with size was not detected for *Myadora* because there were very few *Myadora* clams larger than 20 mm.

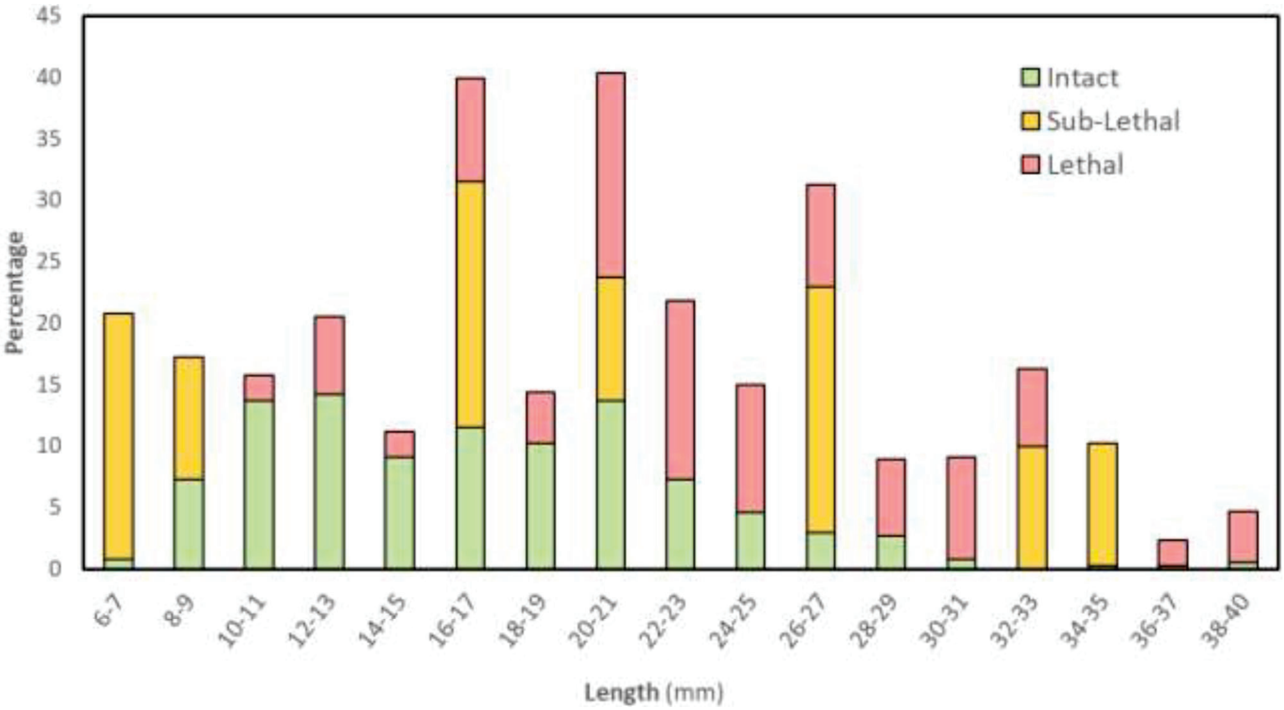

Figure 3.8 Length distribution (mm) of Dosinia sp. by state of damage.

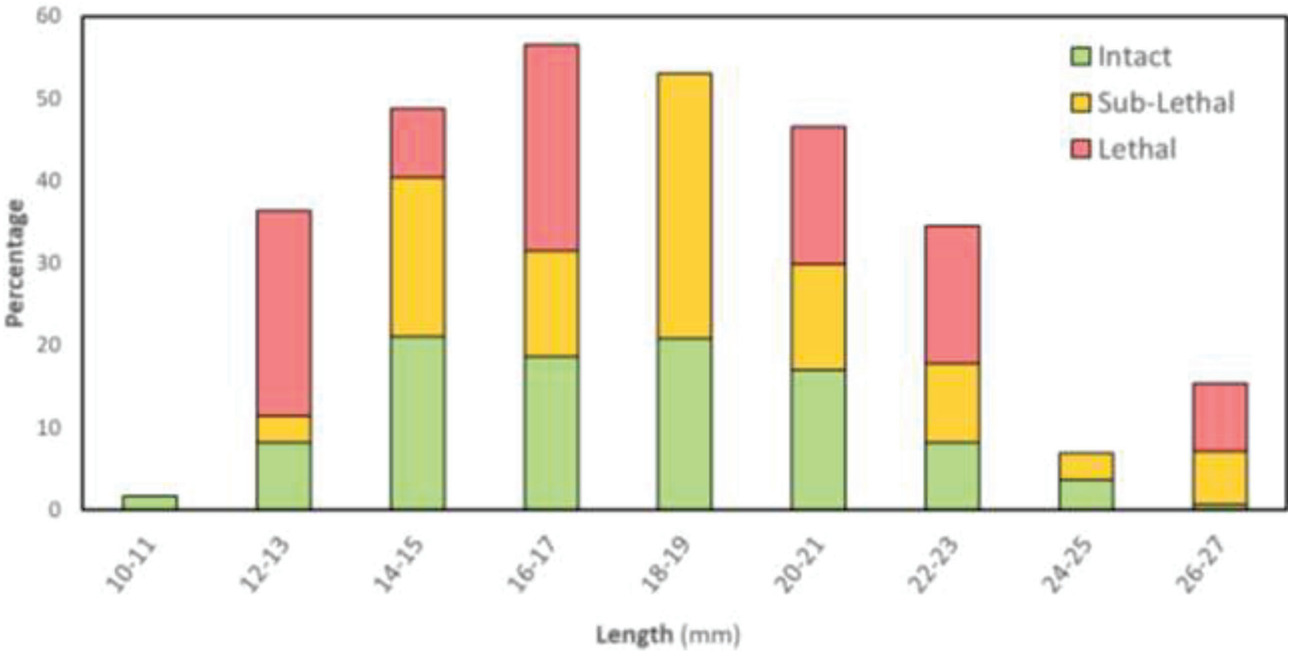

Figure 3.9 Length distribution (mm) of Myadora striata by state of damage.

4. DISCUSSION

4.1 Seabed Characteristics

4.1.1 Surficial Sediment Particle Size

None of the samples recorded the presence of gravel sized particles or silt and clay sized particles, this is due to the sampling methodology, which focused on processing benthic fauna. Pre-sieving the sample through a 3.15 mm sieve, removed the gravel sized particles from the sediment tested. Silt and clay sized particles are also likely to have been removed from the tested sample in the pre-sieving process by washing through and out.

For the sediment tested the size of sediment particles varied with the depth, with larger particles in deeper waters. This gradient in sediment particle size across the shore from 5 to 30 m depth, was seen in areas which have had sand extraction Inshore (Northern and Southern), but also in the Control zone where no sand extraction has occurred. This suggests that sand extraction is not likely to alter the sediment particle size composition. The sediments in the proposed Midshore sand extraction area were largely (59 %) of medium sand size (0.3 – 0.6 mm diameter) with a further average 31 % made up of fine sand (0.15 – 0.3 mm diameter). The remaining 10 % was distributed relatively evenly either larger or smaller.

The differences alongshore within the proposed Midshore area were relatively minor with less medium sand in the Southern area (47 %) compared to the Northern area (66 %) and more fine sand in the Southern area (40 %) compared with the Northern area (26 %), meaning the total of medium and fine sand ranged from 92 % in the Northern area to 87 % in the Southern area.

4.1.2 Seabed Photographs

Based on the photographic evidence collected in the Midshore areas, the seabed is relatively homogeneous in appearance, with some minor suggestion of more shell present in the deeper areas.

4.2 Benthic Fauna

4.2.1 Methodology Differences

Both screening methods (1 mm and 3.15 mm) using the box dredge are complementary to each other by representing different communities in the benthos. Indeed, amphipods, isopods and several polychaete species were only present when the 1 mm sieve was used. The dredge tow, by contrast, is a technique limited to collecting large individuals such as molluscs, crabs and echinoderms. For instance, the scallop *Pecten*, the starfish *Astropecten*, and the swimming crab *Ovalipes*, were only recorded with the dredge tow. This highlights the necessity to use a range of methods to quantify species presence/absence and abundance when surveying soft sediment habitats. The 3.15 mm mesh size was chosen as this was the mesh size use on the sand extraction vessel Coastal Carrier at the time of the sampling in early 2019. Thus, those biota larger than 3.15 mm would pass through the oversize discharge and be returned to the sea. Post sampling the sand extraction vessel has changed to the William Fraser which uses a 2.5 mm mesh, those biota larger than 3.15 mm will still be returned to the sea.

4.2.2 Midshore Benthic Community

Within the proposed Midshore consent area the combined infuana samples showed the biota was numerically dominated by the polychaete worms Maldanidae and Capitellidae, hermit crabs, Phoxocephalidae amphipods, the bivalves *Nucula* and *Myadora*, the gastropods *Striacolpus* and *Cominella*, foraminifera, and the Lancelet *Epigonichthys hectori*. The community is comprised of 30 species of polychaetes, 10 species of amphipods 10 species of decapods, with 16 additional crustacea, 22 gastropods, 27 bivalves, 7 echinoderms, 4 sponges and 12 other species form a range of taxa groupings, to make a total diversity of 139 species or taxa.

4.2.3 Differences in Benthic Communities Alongshore

Alongshore, the benthic infauna was similar within the box dredge samples for both screening methods. Differences were found between the Northern and the Southern areas only when the dredge tow was used. Scallops were only found in the Northern Midshore area while Hermit's crabs, starfish, and *Cominella* were more abundant in the Southern Midshore area.

4.2.4 Differences in Benthic Communities Between Consent Areas (depth)

Benthic infauna in the Midshore area had a different assemblage of species than that found in the Inshore and Offshore areas. This was observed in both screening methods and for dredge tows. Differences were however weaker with the 1 mm screening method, suggesting differences were mostly driven by large taxa.

Considering all methods, Midshore samples were characterised by higher densities of Maldanidae, the whelk *Cominella*, scallops and starfish. These taxa were also present in the Offshore area but in lower densities. The Inshore area consisted of taxa specific to shallow depths such as sand dollars, the Wheel shell *Zethalia*, the lancelet, and clams *Myadora* and *Dosinia*. This inshore assemblage is consistent with previous reports from Hilton (1990) and Grace (1991), and the effects of sand extraction on the current Inshore consent area were discussed in Bioresearches, 2019a.

4.3 Macrofauna Survivorship

Ninety three percent of benthic macrofauna individuals sampled, were deemed to have survived the pumping and screen system on the William Fraser. A similar study was carried out with the previous vessel, the Coastal Carrier, in which the bivalves suffered more damage, with an estimated survivorship of fifty five percent (Bioresearches, 2019a). The improved survivorship of macrofauna could be the result of the shallower profile of the William Fraser's drag head on the seabed, which does not extract the larger biota, buried deeper in the sand and / or an increase in the size of the pump. As part of monitoring studies in the Kaipara harbour Grace (Grace, 2016) found that an increase in the pump size resulted in greater survivorship of shellfish entrained. Additionally, many larger burrowing worms and crustaceans were found to not be entrained during the extraction process. It is likely with their burrows being deeper than the deepest extraction depth of 120 mm, they somehow manage to remain in – situ, thus they survive the passage of the dredge.

Figure 4.1 Seabed immediately post dredging showing worms and stomatopods still present in the dredge path.

As with the earlier study there were differences between the taxa groupings of gastropods, bivalves and crustaceans. It is hypothesised gastropods have harder more robust shells in a structurally stronger shape, than the thinner more fragile shelled bivalves in a weaker flat plane, resulting in the fewer occurrences of damage in gastropods. Similarly, more fragile macrofauna such as crustaceans and annelids are likely to suffer more damage than more robust biota such as molluscs as they lack the protection of the shells. However, even fragile taxa were found to pass through the new dredge of the William Fraser with mostly no damage detected. It is unknown whether all the biota passing through the screening deck were recovered. It is possible that some biota may have been completely disassembled beyond recognition, or into fragments too small to be retained and thus excluded from the assessment, however there was no evidence of this occurring.

When the sizes of biota were cross referenced with damage the data showed, large bivalves seem to be more susceptible to damage when extracted than smaller bivalves. For the *Dosinia* clam, individuals larger than 20 mm suffered more damage than the smaller individuals. These results are consistent with the previous survivorship study on the Coastal Carrier. In the present study, only two bivalve taxa could be tested for differences of survivorship with size, as the other taxa were not found in enough numbers.

Individuals classified as having “no” and “sub-lethal” damage were defined as having survived passage through the dredge. There is still a possibility that they could suffer predation by fish on their descent to the seabed and prior to their reburial in the seabed sediments. The new pump system in the William Fraser is likely to reduce the risk of predation as the waste material is rejected under the boat, and not on the side as for the Coastal Carrier.

Only larger macrofauna greater than about 10 mm were able to be assessed for damage and survivorship. The survivability of the much smaller infaunal species retained on the 3.15 mm biota sieves as discussed in section 4.2, were not able to be assessed. However, it is hypothesised that an unknown proportion of this biota will have survived passage through the dredge and screening. The biota is small and in part fragile, so there is greater threat of opportune predation on its return passage to the seabed.

4.4 Fish Review

Very few surveys of fish community composition have been undertaken in the region of the sand extraction areas. Snapper (*Pagrus auratus*), Red gurnard (*Chelidonichthys kumu*) and blue cod (*Parapercis colias*) are known to be present further offshore (Bioresearches, 2019b) and are likely to occur in the sand extraction area. Grace (2005) reported the presence of sole (*Peltorhamphus novaezeelandiae*) and sand divers (*Tewara* *cranwellae*) in samples passing through the dredge. The 2020 survivorship study reported the presence of two small benthic fish species, a lizard fish (*Synodus* sp.) and a snake eel (*Muraenichthys* sp.) in the Offshore consent area. Pelagic species such as Kahawai (*Arripis trutta*), kingfish (*Seriola ialandi*), trevally (*Pseudocaranx dentex*), skipjack tuna (*Katsuwonus pelamis*) as well as other bottom feeding species such as John dory (*Zeus faber*), red gurnard (*Chelidonichthys kumu*) and tarakihi (*Nemadactylus macropterus*) are either known from fish reported catch, or expected to be present all or at some of the time in the sand extraction area at varying abundances. A school of kingfish were recorded offshore at a depth of 27 m along the line of the south Pakiri beach photographic transect. A number of species of sharks are also expected to be present in the sand extraction area at times throughout the year. Bronze whaler (*Carcharhinus brachyurus*) are one such species that can be found from the surf zone to slightly beyond the continental shelf in the open ocean, diving to depths of 100 m or more. This species commonly enters very shallow habitats, including bays, shoals, and harbours, and also inhabits rocky areas such as Te Arai point (Duffy & Gordon, 2003).

Most fished coastal marine teleost finfish have life histories that can be divided up into spawning/reproduction, eggs and larval periods, a juvenile phase, and an adult phase, when reproductive maturity is reached. Many fish species spend their juvenile life stage in more sheltered estuarine habitats meaning juvenile fish are not abundant in the sand extraction area.
Pelagic and midwater living fish species will not be directly affected by the dredging activity in terms of physical impacts. There is potential for impacts from:

- underwater noise, this is covered in the underwater noise report by Pine (2020),
- water quality, this is discussed in Kubale (2020),
- loss or changes in food sources.

In general, neither the underwater noise created or the effect to water quality are large enough to have more than behavioural changes, resulting in avoidance of the very short-term local effects of the extraction activity. Some fish species may even benefit in the form of food, from the discharge of oversized material from the dredge vessel.

The survivorship studies have shown that some fish species living or sheltering within the seabed sediments can be entrained in the extraction process. However, recent studies with the William Fraser have shown that these species have the ability to potentially survive passage through the dredge and screening process.

4.5 General Implications of Findings

Depth has been found to be a strong factor influencing the composition and abundance of benthic communities in the Mangawhai-Pakiri embayment. Inshore (5 – 10 m) areas are dominated by biota capable of surviving in the high energy highly mobile seabed environment, while midshore (15 - 25 m) areas are a little more stable on the sea bed but still suffer the effects in extreme events or are influenced by seasonal changes. The deeper water Offshore (> 25 m) areas are most stable and have more fragile species. The species diversity is higher in the proposed Midshore area relative to the Inshore or Offshore areas, while the relative abundance was highest in the Inshore area and showed no difference between the Midshore and Offshore areas.

The data from the Inshore area shows that patterns in benthic composition and particle sizes are similar in alongshore areas (North, South and Control). This suggests that sand extraction has had little effect on the benthos in the Inshore environment. The commonality in benthic composition between the Inshore and Midshore areas suggests a similar lack of effects would be likely in the proposed Midshore area.

The disturbance and removal of sand by dredging of any kind results in the loss of benthic habitat along with infaunal and epifaunal organisms. The depth of the dredge profile has a significant influence on how the benthic community is impacted. Empirically, different biota from different functional groups have different preferences and abilities to live at different depths within the sediments. Predatory species (*Cominella*) or surface deposit feeders live on the surface of the sediment as they need to move around to find food, some have the ability to bury themselves just below the sediment surface and some live at varying depths in burrows they create. While other biota such as filter feeders permanently live on the sediment surface or buried within the sediment at varying depths, sending up siphon tubes to suck water and food to them. The depths within the sediment at which they live is dependent on the length of siphon they possess. Polychaete worms and crustacea have similar functional groupings with a range of within-sediment living depths.

Dernie *et al* (2003) reported that sediment disturbances to deeper depths (20 cm) took longer to recover than areas of shallower (10 cm) sediment disturbance. Therefore, a shallow disturbance dredge profile, will not only affect fewer species, but likely result in faster recovery times from the disturbance.

The benthic community in the sand extraction area is seasonally subjected to the settlement of juvenile biota from planktonic larvae and constantly subjected to the migration of biota from adjacent habitats. The initial step towards recovery of local bottom topography and benthos occurs through slumping and slope re-equilibration of the sides of the dredge depressions (Cooper, *et al*. 2007). Lateral migration of juvenile and adult benthic organisms into the dredged depression may help accelerate recolonization (Brooks, *et al*. 2004, 2006). The majority of benthic biological recovery occurs through subsequent larval settlement and interactive community development, analogous to recovery from other mass perturbations of seafloor sediments and benthos at these depths where sand extraction occurs.

5. ECOLOGICAL VALUES

5.1 Benthic Habitat and Fauna

The proposed Midshore consent area has an assemblage of species similar to the Offshore area, but at different densities. Scallops represent the only taxa with moderate ecological and high commercial value but were found in low numbers.

No invasive species were recorded as present. Based on the sparse populations of biota of nationally and locally common species, with no "At Risk" species, the benthic biota faunal community is ascribed a classification of low to moderate ecological value. The low ecological value is due to low abundance of nationally and locally common species, while the diversity of 150 taxa and lack of invasive species suggests an ecological value of moderate.

5.2 Fish

Fish are more mobile than the benthic biota therefore a wider area was considered. The fish identified as present within the Pakiri embayment were all typical of the region. These include a number of economically important species such as Snapper, Red gurnard, Blue cod, Kahawai, Kingfish, Trevally, John Dory and Tarakihi. None of these species are likely to be directly killed or negatively impacted by the sand extraction process. Many of these species can be found around the dredge while it is in operation and are clearly taking advantage of the opportunity for an easy meal. Therefore, the dredge has a potentially positive effect on fish present in the area providing easier access to food. Based on the sparse populations of fish of nationally and locally common species, the fish community is ascribed a classification of low ecological value.

5.3 Summary of Ecological Values

The sand extraction area represents habitat typical of the wider outer Hauraki Gulf and north eastern New Zealand. That is, dynamic, mobile sediments supporting common, opportunistic benthic fauna; and a fish community containing common nearshore species. Less common fish species may pass through the area. However, they are considered to be vagrant and therefore not part of the fish community.

Table 5.1 provides a summary of ecological values for the marine environment using the criteria described in Table 2.2. The values of Birds and Marine Mammals are covered by separate reports (Thompson, 2020, Clement and Johnston, 2020).

Table 5.1 Summary of ecological values within the sand extraction area and surrounding areas

Component	Value	Comments
Benthic Fauna	Low – Moderate	Species adapted to the high energy environment. Benthic fauna was sparse but moderately diverse. Benthic community has an ecological function as a food resource for the fish community.
Benthic Habitat	Low	Benthic habitat dominated by mobile substrates typical of the shallow outer Hauraki Gulf area as well as wider north east coast of North Island. The habitat does not provide protection for sensitive life stages.
Fish	Low	Species that frequent the area are locally common, present within the Hauraki Gulf area. Most species widely distributed around New Zealand.

6. ASSESSMENT OF EFFECTS OF SAND EXTRACTION ON BIOTA

Sand has been extracted from the Mangawhai-Pakiri embayment since post World War 2 to supply the Northland-Auckland region with a high-quality product that requires minimum processing for use in the concrete industry. The quantities recovered have varied over the years based on demand and consenting constraints. The majority of sand has been extracted from the shallow nearshore environment but sand from water depths of deeper than 25 m has been extracted since 2003.

The comments presented below are based on data obtained as part of monitoring of the current Inshore consent area (Bioresearches, 2019a), the Offshore consent area (Bioresearches, 2019b) and proposed new Midshore consent area (this report), and from background information available. The assessment of effects includes:

- changes to benthic biota
- changes to the fish community

Effects to marine mammals and birds are addressed in separate reports (Clement and Johnston, 2020, Thompson, 2020).

6.1 Benthic Biota and Macrobenthic Epifauna

6.1.1 Community structure and habitat

Estimates of the time taken for a benthic community to recover from a disturbance event of the scale of sand dredging is between 6 months to several years (Michel *et al.* 2013). This is based on international monitoring studies and defines recovery to be the benthic community returning to a similar composition and abundance. Many studies did not extend until complete recovery was achieved. The complexity of some habitats and changes in the benthic environment resulting from dredging can result in total recovery not occurring for many years. The longer recovery time periods have been linked to coarser sediment particle sizes. Post dredging changes in sediment characteristics can result in benthic communities recovering with different compositions and abundance.

Seasonal timing will also influence the speed of recovery. Initially recovery will be by survival and migration from adjacent habitats, which will occur almost immediately. On a longer time frame, recovery will be by reproductive settlement which will be seasonal and vary from species to species.

The degree of impact on the composition and abundance of the benthic communities caused by the dredge operation will to some extent determine the recovery time. Incomplete removal of biota will potentially result in shorter recovery times. The dredge head currently used by the William Fraser has been shown to extract a shallow layer of sand to a depth of between 80 – 120 mm below the seabed. Observations by divers immediately post dredging have shown large worms, clams and some crustacea being retained in the sediment after passage of the dredge. The abundance of smaller molluscs and other biota remaining within the seabed after the passage of the William Fraser dredge head has yet to be assessed. Divers have recorded Stomatopods surviving the passage of the dredge and resuming feeding and other activities less than 5 minutes after dredging, and predatory gastropods moving into the dredge footprint in search of prey (Figure 6.1).

Figure 6.1 Survival and migration biota in the dredge path at Pakiri, August 2020 MBL.

The shallow disturbance dredge profile not only affects fewer species, but has been shown to result in faster recovery times from the disturbance. Dernie *et al* (2003) reported that sediment disturbances to deeper depths (200 mm) took longer to recover than areas of shallower (100 mm) sediment disturbance. Dernie *et al* showed recovery occurred after 64 days when shallow disturbance occurred, compared with more than 107 days when deeper disturbance occurred.

Therefore, it is predicted that the shallow sand layer extracted by the William Fraser's dredge head will result in a short recovery time of less than 1 year. The dredging practices previously used in both the Inshore and Offshore consented areas, where a deeper sand layer was extracted, did not result in significant differences in the composition and abundance of benthic communities in dredged areas as opposed to the non-dredged control areas.

The Pakiri Mangawhai embayment is considered a dynamic environment with currents and sea swells influencing the movement of the seabed surface (e.g. large ripples of sand visible on seabed photographs). Considering the naturally dynamic environment in the Bay and the shallow (< 120 mm) layer of sand extracted during dredging it is not expected to alter the benthic community over and above what is experienced naturally in extreme events. Therefore the magnitude of effects is expected to be minor on the benthic community.

6.1.2 Benthic Fauna Survival

Macrofauna survivorship studies showed that the macrofauna passing through the dredge and screening deck suffers some damage but the majority (93%) survive and are returned to the seabed. This will further decrease the recovery time of the benthic community.

The data showed bivalves are more likely to suffer some shell damage and potential mortality than gastropods. Gastropods are generally more robust and compact than bivalves and suffered no lethal damage by the passage through the dredge of the William Fraser. More fragile species such as echinoderms and polychaete worms are likely to be more affected than robust species such as molluscs. Crustaceans, which consisted mostly of small crabs, showed a high survival rate of 96%, this is largely due to many of the crabs being hermit crabs living inside robust gastropod shells.

The upgrading of the dredging vessel in late 2019 to the William Fraser has resulted in significantly lower mortality rates of the macrofauna passing through the dredge. The mortality rate of bivalves with the Coastal Carrier was estimated at 45%, while this study on the William Fraser estimated only an 8% mortality rate.

The surviving benthic fauna passing through the dredge, screens and discharged through moon pools below the William Fraser, are likely to suffer predation by fish during their descent to the seabed. However, the large volume discharged means a significant proportion will reach the seabed intact. The change in discharge to under the vessel via moon pools means predation by birds is limited and much less than previously occurred from the Coastal Carrier which discharged over the side of the vessel.

Considering the lower mortality, greater volume and sub-surface discharge, the dredging is expected to have effects of a minor magnitude on macrofauna survival.

6.1.3 Suspended Sediment and Turbidity

The sediment quality has been assessed in Gibbs and Kubale (2019) and shown to be devoid of contaminants. Therefore, there is no source of chemical contamination in or near the sand extraction area. Thus, the composition of the seabed sediments will not result in the release of contaminants causing adverse effects if disturbed.

Water clarity is important for the healthy functioning of marine ecosystems. Increased suspended solid loads that reduce water clarity, through increased turbidity, can affect the amount of photosynthesis (primary production) of aquatic plants, which in turn means less food for filter feeders. Reduced water clarity can also affect the feeding efficiency of visual predators like fish and sea birds.

Water quality testing of the discharges from the William Fraser and the ambient conditions at the extraction site were conducted and reported by Kubale (2020). To define ambient background natural water quality Kubale used both water quality monitoring data collected for a short period adjacent to the extraction area and from regular repeated long-term council monitoring sites nearby. The water quality monitoring at the dredge area was generally lower in concentration than the Goat Island monitoring site for turbidity and suspended solids, while other physical parameters were similar, which was as expected. Background turbidity at the dredge area ranged from 0.14 to 3.11 NTU, averaging 0.31 NTU in May - July 2019. Similarly background suspended solids at the extraction site ranged from 0.47 to 10.46 mg/l, averaging 1.04 mg/l.

During sand extraction operations, the seabed sediment is sucked up through the dredge head, extraction pipe and discharged into an 8 m² screening tray. The water and sediment pass over and through two screens; a coarse 35 mm screen and a fine 2.5 mm screen. The coarse shell and other material not passing through the fine screen is then discharged through a pipe which discharges into a moon pool and out under the vessel. The sand passing through the 2.5 mm screen is then discharged into the hopper. Water discharged into the hopper overflows weir boards which discharge into several moon pools and out under the vessel. The oversize discharge contains both shell and sand, and the weir board hopper overflows contain very small amounts of silt and clay sized sediments. The plume created behind the vessel is approximately as wide as the vessel with very little lateral spread visually obvious.

In December 2019 during routine sand extraction operations the turbidity and suspended solids were assessed in the discharge plume created behind the William Fraser. The results showed minor elevations in turbidity (1 – 2 NTU) values and suspended solids (3.5 – 8 mg/l) concentrations in the surface water at the point of discharge that rapidly decline back to ambient ranges of 0.13 - 0.14 NTU and 2.4 - 2.9 mg/l by a distance of 250 m behind the dredge. The increases in turbidity and suspended solids concentrations recorded immediately behind the William Fraser, are within the range of natural variation recorded as part of the background water quality studies. The suspended solids concentrations and turbidity values found within the plume beyond 250 m from the William Fraser were within ranges recorded in the nearby unaffected coastal marine environment. Under the test operating speed of 2.5 knots this equates to the very weak plume being present at any one location for no more than 3 minutes 15 seconds in any one area on a day. The initial aim was to operate the William Fraser at 1.5 knots as had been possible with the Coastal Carrier, however course maintenance problems due to the low speed were initially encountered, therefore, the operating speed was increased to 2.5 knots. Since the water quality tests were conducted the crew have managed to operate the vessel at speeds between 1.5 – 2.5 knots. The variance is typically based on weather conditions on the day of extraction.

Biota in and on the seabed areas adjacent to the dredge path could suffer temporary minor smothering from the settlement of oversized material discharges, however the level of discharge is not expected to result in complete coverage of the seabed with burial of biota, just light partial covering.

The magnitude of effects of sediment discharges on water quality are expected to be negligible, in regard to the absence of contaminants in the sediments and the limited time period of the plume. Similarly, the effects on the benthic biota are expected to be negligible.

6.2 Fish

No direct assessment has been made of the fish population prior to and following sand dredging, or in comparison between areas dredged and not dredged. The assessment of effects on fish is based on literature information.

Fish will potentially be affected by a number of factors related to the operation of the sand dredge. These include:

- Underwater noise
- entrainment
- suspended sediment; and
- food source reduction.

6.2.1 Effects of Underwater Noise

An underwater noise assessment was undertaken by Styles Group in 2020 (Pine, 2020). The main noise sources associated with the activity will be the drag head making contact with the seafloor, the water jetting and the movement of the sand slurry up the pipe to the hopper. The assessment was based on the loudest operational stage (active dredging), using measured noise level data of the William Fraser. The data revealed a typical soundscape for an open coastal area, with sounds from fish, marine mammals, snapping shrimp, vessels, dredging and weather (wind and waves) generating daily sound pressure levels between 96 and 111 dB re 1 µPa. The average source level of the William Fraser was approximately 168 dB re 1 µPa @ 1m.

Predicted noise emissions from the William Fraser were evaluated in terms of critical distances for which injury or behavioural changes occur:

- permanent threshold shifts (PTS), where hearing sensitivities do not return to normal following noise exposure,
- temporary threshold shifts (TTS), whereby hearing sensitivities do return to pre-exposure thresholds after a period of time following noise exposure,
- risk of behavioural effects, as a percentage over range,
- auditory masking, whereby noise interferes with a biologically-important signal that marine fauna rely on.

The assessment considers the dredging noise effects on invertebrates, fish and marine mammals. However, given the physical properties of the dredging noise in this case and differing hearing mechanisms between the different groups of animals, the potential noise effects on invertebrates and fishes were directly measured. Therefore, the effects modelling was undertaken specifically for marine mammals, with effects on fishes and invertebrates being assumed less than those for the marine mammals.

Audibility of the dredging noise from the William Fraser for marine mammals is calculated to be within 5.6 km, beyond which, acoustic disturbance is theoretically not possible. While the underwater noise produced by the William Fraser under normal operation in the southern end of the extraction area may be faintly heard by marine mammals and fish within the Cape Rodney-Okakari Point Marine Reserve, the sound levels are not expected to result in any adverse injury or behavioural effects within the marine reserve.

Injury (PTS) from the sand extraction activities using the William Fraser is not expected to occur at any stage of the dredging within the Extraction Area, for any species. Temporary threshold shifts are also not expected to occur for any species beyond 1 m from the pump of the William Fraser while extraction is taking place.

Based on the measured ambient sound levels and published hearing thresholds there is a risk of auditory masking and behavioural effects in marine mammals and fish occurring at a limited range from the William Fraser. However, the risks to fish are substantially smaller than for marine mammals. It has been calculated that there is a 50% probability of a low behavioural response in delphinids within 28 m compared to 0 m for a moderate response. Response distances for fish are expected to be less.

Thus, the magnitude of effects of noise on fish are expected to be negligible.

6.2.2 Effects of Entrainment

It is not expected that fish will be entrained in the dredge as the water flow will be targeted at sucking sediment up from the seabed. Fish are highly mobile and it is expected that the majority of fish species present will be able to avoid the drag head and avoid entrainment due to the slow speed (1.5 – 2.5 knots) the sand dredge moves over the seabed. Fish species that are slow moving, have behaviours that limit escape or avoidance, or live within the sediment, may be entrained. Both sand divers and sole have been reported in samples passing through the dredge in the current Inshore consent area (Bioresearches 2019a). Opal fish and short finned worm eels have been recorded further north and offshore (Bioresearches, 2016). In this survivorship study conducted on the fringes of the proposed Midshore consent area, two species of benthic fish, lizardfish and snake eel, were recorded as surviving passage through the dredge and screening deck and returned to sea via the moon pool discharge.

The magnitude of effects of entrainment on fish are expected to be negligible.

6.2.3 Effects of Suspended Sediment

Recent studies have identified that increased suspended solids in the water column are detrimental to juvenile snapper health in estuarine environments (Lowe, 2013). While the research was aimed at the effects of increased terrestrial sediment inputs, the discharge of fine marine sediments from the sand barge could have similar effects. However, the percentage of fine sediments in the seabed of the sand extraction area is, and has been, low, ranging from 0 – 3 percent. The water quality data suggests that the suspended solids and turbidity effects of discharges are within the natural variation ranges for the proposed Midshore consent area. This means the amount of fine sediment discharged from the sand dredge that remains suspended for any significant length of time, will be small and very unlikely to adversely affect fish. The frequency of dredging events is likely to be greater than that of natural events producing similar suspended solids concentrations, however it is not considered significant due to its limited area.

The magnitude of effects of suspended sediment on fish is expected to be negligible.

6.2.4 Effects of Food Source Reduction

Benthic biota forms the basis of many fish diets. A reduction in benthic biota abundance or a change in composition as a result of sand dredging could potentially impact bottom feeding fish species. The comparison of benthic biota collected in the current Inshore sand extraction area and an adjacent control area did not suggest a decrease in abundance or a change in species composition (Bioresearches 2019a). A similar level of effect is expected to occur in the proposed Midshore consent area, therefore fish are not expected to be adversely affected through loss of prey. It has also been noted that the discharge of oversized material from the sand dredge, includes damaged and undamaged biota which acts as a food source and attracts fish.

The changes in water quality are insufficient in concentration, geographic scale, duration and frequency to measurably affect the production of phytoplankton, which generally forms the base of the food chain, supporting zooplankton, benthic biota and thus fish.

The magnitude of effects of food reduction for fish is expected to be negligible.

6.3 Summary of the Magnitude of Effects

Table 6.1 summarises the magnitude of potential effects associated with sand extraction in the proposed Midshore consent area.

6.4 Level of Ecological Effects

Table 6.2 presents the overall assessment of the potential level of ecological effects, based on the matrix shown in Table 2.4. The level of ecological effects are determined by combining the ecological values presented in Table 5.1 and the magnitude of potential ecological effects presented in Table 6.1.

Overall, we estimated a less than minor level of effects due to the operation of the sand dredge on benthic fauna and fish. Dredging is considered to have a minor level of effects on the benthic community structure. Dredging is considered to have a minor level of effects on the survival of macro fauna (including crustaceans and bivalves) other than gastropods passing through the dredge, gastropods showed 100% survival, thus the level of effects is considered negligible.

Table 6.1 Magnitude of potential ecological effects from sand extraction

Biota	Effect	Magnitude of Effect	Comments
Benthic fauna	Community structure	Minor	The area of disturbed sediment is shallow with fauna small in size. It is expected to be recolonised quickly from adjacent areas. Long term changes in community composition are not expected to be directly attributable to sand extraction, rather, result from natural dynamics of the bay.
	Survival	Minor	Mortality of macrofauna due to passage through the dredge is estimated to be low. Predation of fauna after being discharged from the boat is expected but the amount unknown.
	Turbidity	Negligible	The increases in turbidity and suspended solids concentrations recorded immediately behind the William Fraser, are within the range of natural variation recorded as part of the background water quality studies. Biota in and on the seabed areas adjacent to the dredge path could suffer temporary minor partial smothering from the settlement of oversized material discharges.
Fish	Underwater Noise	Negligible	The underwater noise created will not cause injury but may cause behavioural effects when in very close proximity to the pump.
	Entrainment	Negligible	Only a few benthic fishes were found to pass through the dredge, and they were all undamaged.
	Suspended sediment	Negligible	The water quality data suggests that the suspended solids and turbidity effects of discharges are within the natural variation ranges for the proposed Midshore consent area.
	Food reduction	Negligible	Composition and abundance of benthic biota is not expected to change, therefore no shortage of food is expected due to sand dredging. Potentially dredging could have a positive effect on predatory fish species such as snapper by providing a food source.

Table 6.2 Level of ecological effects incorporating the ecology values (in Table 5.1) and magnitude of effects (in Table 6.1) for the project.

Biota	Ecological value	Effects	Magnitude of effects	Level of effects
Benthic fauna	Low-Moderate	Community structure	Minor	Minor
		Survival	Minor	Minor
		Turbidity	Negligible	Negligible
Fish	Low	Noise	Negligible	Negligible
		Entrainment	Negligible	Negligible
		Suspended sediment	Negligible	Negligible
		Food reduction	Negligible	Negligible

The consent application is for a rolling annual average rate of 125,000 m^3/year over any consecutive 5 year period, with a maximum rate of 150,000 m^3 over any consecutive 12-month period. Further the temporal distribution of the extraction volume will be limited to a maximum of 15,000 m^3 over any consecutive 30 day period, with the dredging spatially balanced over the entire dredging area.

Current dredging operations are reporting the 900 m^3 hopper is filled with sand in 3-4 hours of dredging, with an average dredging track length of approximately 12 km, based on the dredge profile 1.6 m wide and 0.1 m deep this would equate to a sand extraction efficiency by volume of 47%. Based on this the annual volume limits will limit the number of dredging trips per year to an average of less than 139 trips, effecting approximately 2.67 km^2 of the 6.6 km^2. MBL have stated they plan to distribute the dredging spatially evenly within and between management cells. Therefore, theoretically up to 40% of the seabed included in the application will be dredged in any one year, and any particular area of seabed should not be dredged in theory more than once in any 30 month period.

Thus seabed biota will have approximately 30 months to recolonise the dredged area either from lateral migration or from reproductive settlement. Given recolonization is predicted to occur over a 12 month period, a 30 month recovery period is expected to result in no detectable ecological differences in composition and abundance above or below natural variation. If further increases in the efficiency of sand retention in the barge or slightly greater dredge profile depths can be achieved, then a smaller area would need to be dredged to obtain the same volume of sand. This would also have the added benefit of increasing the period between re-dredging allowing for greater recovery. However this should be tempered with the reality that deeper dredging profile depths have been shown in the literature to increase the time needed for recovery.

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8. APPENDICES

Appendix 1 Sampling Area Geographical Positions

Table A1.1 Benthic Biota and Sediment particle size Sampling coordinates in the Consented and Proposed Sand Extraction Areas, Control Areas and Adjacent Areas, 2019 (WGS 84 datum)

Area		Site	World Geodetic System 1984		Depth
Offshore	Longshore		Latitude	Longitude	m
Current	Northern	PIB01	-36.11882	174.62399	4.9
		PIB05	-36.12737	174.62977	5.8
		PIB11	-36.13625	174.63578	10.1
		PIB19	-36.14514	174.64179	7.9
		PIB114	-36.14407	174.64122	9.1
		PIB27	-36.15017	174.64649	4.5
		PIB04	-36.12337	174.62927	8.5
		PIB10	-36.13230	174.63501	15.9
		PIB18	-36.14124	174.64075	11.0
		PIB26	-36.14567	174.64640	13.1
	Southern	PIB39	-36.16827	174.65844	2.7
		PIB46	-36.17667	174.66429	7.7
		PIB54	-36.18141	174.66939	18.7
		PIB111	-36.18078	174.66830	11.8
		PIB62	-36.19034	174.67514	4.8
		PIB68	-36.19477	174.68079	5.8
		PIB45	-36.17247	174.66364	7.0
		PIB53	-36.17690	174.66929	21.1
		PIB109	-36.17907	174.67165	17.2
		PIB61	-36.18584	174.67504	9.7
	Control	PIB75	-36.20336	174.68695	6.7
		PIB82	-36.20813	174.69220	6.2
		PIB88	-36.21256	174.69786	5.5
		PIB100	-36.21360	174.69867	5.7
		PIB94	-36.21646	174.70305	10.7
		PIB74	-36.19920	174.68645	15.0
		PIB105	-36.19930	174.68555	12.2
		PIB81	-36.20353	174.69204	11.2
		PIB87	-36.20805	174.69776	11.0
		PIB93	-36.21248	174.70342	17.5
Inshore Between	Northern	PIB121	-36.11138	174.62407	17.4
		PIB03	-36.11886	174.62917	12.5
		PIB09	-36.12780	174.63491	17.2
		PIB17	-36.13673	174.64066	14.7
	Southern	PIB44	-36.16797	174.66354	9.6
		PIB67	-36.19026	174.68070	11.3
		PIB73	-36.19469	174.68635	22.6
		PIB106	-36.19333	174.68533	20.0
		PIB72	-36.19019	174.68625	23.8
	Control	PIB103	-36.19808	174.68847	18.1
Proposed (midshore)	Northern	PIB02	-36.11435	174.62908	19.4
		PIB08	-36.12329	174.63482	22.8
		PIB119	-36.12065	174.63448	21.8
		PIB07	-36.11878	174.63473	29.6
		PIB06	-36.11428	174.63463	27.4
		PIB120	-36.11240	174.63398	26.2
		PIB117	-36.12933	174.63770	17.2
		PIB16	-36.13223	174.64056	27.7
		PIB115	-36.12940	174.64090	23.0
		PIB15	-36.12772	174.64047	24.1
		PIB14	-36.12321	174.64038	24.9
		PIB25	-36.14116	174.64631	16.2
		PIB24	-36.13666	174.64621	19.8
		PIB23	-36.13215	174.64612	24.7
		PIB33	-36.15010	174.65205	16.1
		PIB112	-36.14408	174.65102	20.5
		PIB32	-36.14559	174.65196	23.2
		PIB31	-36.14109	174.65186	24.4
		PIB37	-36.15002	174.65761	19.2
	Te Arai Point	PIB38	-36.15412	174.65866	18.6
		PIB43	-36.15896	174.66335	20.0
		PIB42	-36.15445	174.66326	21.0
Proposed (midshore)	Southern	PIB52	-36.17240	174.66920	21.8
		PIB51	-36.16789	174.66910	24.0
		PIB50	-36.16338	174.66900	29.8
		PIB60	-36.18133	174.67494	20.5
		PIB108	-36.17923	174.67502	20.8
		PIB59	-36.17682	174.67485	22.8
		PIB58	-36.17232	174.67475	24.1
		PIB66	-36.18576	174.68060	15.3
		PIB65	-36.18125	174.68050	23.7
		PIB64	-36.17675	174.68041	25.4
		PIB71	-36.18568	174.68616	24.6
	Control	PIB104	-36.19497	174.68838	20.4
		PIB80	-36.19912	174.69201	22.8
		PIB101	-36.19857	174.69178	20.5
		PIB79	-36.19461	174.69191	24.2
		PIB102	-36.19457	174.69167	22.5
		PIB78	-36.19011	174.69181	27.1
		PIB86	-36.20355	174.69766	15.5
		PIB85	-36.19851	174.69699	24.5
		PIB84	-36.19454	174.69747	25.2
		PIB92	-36.20797	174.70332	20.5
		PIB91	-36.20347	174.70322	22.9
		PIB90	-36.19896	174.70312	25.7
		PIB96	-36.20789	174.70888	25.0
		PIB95	-36.20339	174.70878	20.0
Offshore	Northern	PIB118	-36.11260	174.63740	28.1
		PIB13	-36.11871	174.64028	25.2
		PIB12	-36.11420	174.64019	30.1
		PIB22	-36.12764	174.64602	26.1
		PIB116	-36.12977	174.64643	20.4
		PIB21	-36.12314	174.64593	26.5
		PIB20	-36.11863	174.64584	27.2
		PIB30	-36.13658	174.65177	25.6
		PIB29	-36.13207	174.65167	30.0
		PIB28	-36.12757	174.65158	30.8
		PIB113	-36.12907	174.65082	29.5
		PIB36	-36.14552	174.65751	25.0
		PIB35	-36.14101	174.65742	26.2
		PIB34	-36.13650	174.65732	27.9
		PIB40	-36.14544	174.66307	27.5
	Te Arai Point	PIB41	-36.14994	174.66316	21.9
		PIB49	-36.15888	174.66891	30.0
		PIB48	-36.15437	174.66881	30.6
		PIB47	-36.14987	174.66872	30.7
	Southern	PIB110	-36.16210	174.67140	29.8
		PIB57	-36.16781	174.67466	25.8
		PIB56	-36.16331	174.67456	33.2
		PIB55	-36.15880	174.67447	33.9
		PIB63	-36.17224	174.68031	26.3
		PIB70	-36.18117	174.68606	28.5
		PIB107	-36.18017	174.68492	25.8
		PIB69	-36.17667	174.68596	30.1
		PIB77	-36.18560	174.69172	28.0
		PIB76	-36.18110	174.69162	29.3
	Control	PIB83	-36.19003	174.69737	26.4
		PIB89	-36.19446	174.70303	27.5

Table A1.2 Dredge tow sampling coordinates in the Consented and Proposed Sand Extraction Areas and Control Areas, 2019 (WGS 84 datum)

Area		Site	Date	Depth	World Geodetic System 1984				Distance
					Beginning		End		
Consent	Alongshore			(m)	Latitude	Longitude	Latitude	Longitude	(m)
Current	Northern	35	31-Jan-19	5	-36.11767	174.62208	-36.11555	174.62205	**235**
		34	15-Apr-19	5	-36.13685	174.63420	-36.13467	174.63202	**311**
		33	15-Apr-19	5	-36.15007	174.64383	-36.14755	174.64177	**336**
		22	31-Jan-19	10	-36.11272	174.62122	-36.11515	174.62205	**280**
		23	31-Jan-19	10	-36.13835	174.63808	-36.13657	174.63595	**275**
		24	31-Jan-19	10	-36.15038	174.64718	-36.15248	174.64718	**233**
	Southern	32	15-Apr-19	5	-36.16922	174.65668	-36.16652	174.65580	**310**
		31	15-Apr-19	5	-36.18452	174.66947	-36.18245	174.66780	**274**
		30	15-Apr-19	5	-36.19305	174.67640	-36.19060	174.67510	**296**
		25	31-Jan-19	10	-36.17133	174.66140	-36.16993	174.65892	**272**
		26	14-Feb-19	10	-36.17795	174.66632	-36.18002	174.66807	**278**
		27	14-Feb-19	10	-36.19013	174.67655	-36.18863	174.67482	**228**
	Control	29	15-Apr-19	5	-36.20757	174.69118	-36.20920	174.69345	**273**
		28	14-Feb-19	10	-36.20552	174.69183	-36.20387	174.68990	**252**
Proposed (midshore)	Northern	21	31-Jan-19	15	-36.11107	174.62325	-36.11337	174.62368	**258**
		20	31-Jan-19	15	-36.13952	174.64165	-36.13730	174.63952	**312**
		19	31-Jan-19	15	-36.15025	174.65165	-36.15243	174.65153	**242**
		8	31-Jan-19	20	-36.10777	174.62433	-36.10948	174.62522	**206**
		9	31-Jan-19	20	-36.13788	174.64595	-36.14048	174.64630	**290**
		10	31-Jan-19	20	-36.14563	174.65332	-36.14448	174.65002	**323**
		7	31-Jan-19	25	-36.10762	174.63173	-36.11105	174.63233	**384**
		6	31-Jan-19	25	-36.13482	174.65068	-36.13777	174.65110	**330**
		5	31-Jan-19	25	-36.14255	174.65465	-36.14467	174.65652	**289**
	Southern	17	14-Feb-19	15	-36.16820	174.66203	-36.16995	174.66410	**269**
		18	31-Jan-19	15	-36.17715	174.66837	-36.17842	174.66933	**165**
		16	14-Feb-19	15	-36.18417	174.68168	-36.18945	174.67845	**654**
		11	31-Jan-19	20	-36.16758	174.66635	-36.16600	174.66367	**298**
		12	14-Feb-19	20	-36.17073	174.67060	-36.17343	174.66855	**352**
		13	14-Feb-19	20	-36.18833	174.68490	-36.19045	174.68412	**245**
		4	31-Jan-19	25	-36.16258	174.66798	-36.16580	174.66965	**388**
		3	14-Feb-19	25	-36.17593	174.67693	-36.17193	174.67395	**519**
		2	14-Feb-19	25	-36.18437	174.68555	-36.18760	174.69087	**598**
	Control	15	14-Feb-19	15	-36.20050	174.69385	-36.20260	174.69630	**321**
		14	14-Feb-19	20	-36.20285	174.69633	-36.20577	174.69797	**356**
		1	14-Feb-19	25	-36.20318	174.70460	-36.20072	174.70167	**379**

Table A1.3 Macrofauna Survivorship 2020 sampling coordinates (WGS 84 datum)

Depth	Site	World Geodetic System 1984	
		Latitude	Longitude
10 m	10A	-36.18183	174.68667
	10B	-36.18511	174.67389
	10C	-36.18789	174.67611
	10D	-36.19124	174.67917
	10E	-36.19227	174.68000

Depth	Site	World Geodetic System 1984	
		Latitude	Longitude
25 m	25A	-36.17539	174.68528
	25B	-36.17859	174.68778
	25C	-36.18173	174.69028
	25D	-36.18356	174.69167
	25E	-36.18739	174.69472

Appendix 2 Surficial Sediment Particle Size

Table A2.4 Summary Sediment Particle Size Data 2019 (Percentage by Weight)

Area	Site	Depth (m)	% of particles in each size class (mm)									Fineness Modulus	Characterization
			Gravel		Very Coarse sand	Coarse sand	Medium sand		Fine sand	Very fine sand	Silt and Clay		
			>4.75	4.75 - 2.36	2.36 - 1.18	1.18 - 0.6	0.6 - 0.43	0.43 - 0.3	0.3 - 0.15	0.15 - 0.08	<0.075		
Control area	BD75	6.7			2	5	7	14	59	13		1.26	S
	BD82	6.2			3	9	8	20	54	6		1.51	S
	BD88	5.5			2	1	2	10	71	14		1.07	S
	BD100	5.7			2	5	7	16	60	10		1.27	S
	BD94	10.7			1	1	4	22	59	13		1.15	S
	BD74	15.0			2	6	23	33	32	4		1.54	S
	BD105	12.2			1	1	4	10	66	18		1.01	S
	BD81	11.2			2	2	2	13	62	19		1.07	S
	BD87	11.0				1	1	7	80	11		0.98	S
	BD93	17.5				2	11	35	48	4		1.36	S
	BD104	20.4				4	23	43	28	2		1.55	S
	BD80	22.8				1	4	25	61	9		1.19	S
	BD101	20.5			2	10	22	24	36	6		1.58	S
	BD86	15.5				2	4	18	64	12		1.13	S
	BD92	20.5			1		6	32	55	6		1.30	S
	BD79	24.2				1	7	37	49	6		1.34	S
	BD102	22.5			1	11	32	37	18	1		1.75	S
	BD85	24.5			1	1	7	30	54	7		1.32	S
	BD91	22.9				1	8	45	42	4		1.45	S
	BD96	25.0			1	4	27	43	24	1		1.57	S
	BD78	27.1				1	9	38	46	6		1.35	S
	BD84	25.2			1	9	24	45	20	1		1.73	S
	BD90	25.7			1	5	21	44	27	2		1.62	S
	BD95	20.0			1	1	9	40	45	4		1.42	S
	BD103	18.1				5	21	34	36	4		1.45	S
	BD83	26.4			1	5	16	39	36	3		1.54	S
	BD89	27.5		1	18	26	23	21	10	1		2.74	(g)S
Inshore		**10.2**			**1.5**	**3.3**	**6.9**	**18.0**	**59.1**	**11.2**		**1.22**	**S**
Inshore between		**18.1**				**5**	**21**	**34**	**36**	**4**		**1.45**	**S**
Midshore		**22.6**			**0.6**	**3.6**	**14.5**	**35.8**	**40.6**	**4.8**		**1.45**	**S**
Offshore		**26.9**		**0.5**	**9.5**	**15.5**	**19.5**	**30.0**	**23.0**	**2.0**		**2.14**	**(g)S**
Northern area	BD1	4.9				1	2	7	77	13		0.98	S
	BD5	5.8			8	21	10	10	43	8		1.99	S
	BD11	10.1			2	1	4	10	63	20		1.01	S
	BD19	7.9			5	10	16	20	42	7		1.64	S
	BD114	9.1			2	3	5	17	59	14		1.20	S
	BD27	4.5			1	1	3	7	73	15		1.00	S
	BD4	8.5			4	6	6	18	55	11		1.40	S
	BD10	15.9				1	9	47	38	5		1.44	S
	BD18	11.0			1	1	2	10	69	17		0.98	S
	BD26	13.1			1		3	8	70	18		0.95	S
	BD25	16.2				1	2	11	66	20		0.94	S
	BD33	16.1				1	2	16	71	10		1.08	S
	BD2	19.4				1	23	48	25	3		1.48	S
	BD8	22.8			1	5	49	32	12	1		1.49	S
	BD117	17.2				1	3	25	61	10		1.17	S
	BD16	27.7				2	36	45	16	1		1.51	S
	BD24	19.8					3	19	67	11		1.10	S
	BD32	23.2			1	7	32	44	15	1		1.68	S
	BD112	20.5				9	36	38	16	1		1.65	S
	BD7	29.6			1	14	53	22	9	1		1.66	S
	BD119	21.8				2	40	42	15	1		1.46	S
	BD15	24.1				4	42	39	14	1		1.49	S
	BD115	23.0				5	39	42	13	1		1.57	S
	BD23	24.7				6	43	37	13	1		1.54	S
	BD31	24.4			1	4	31	42	21	1		1.56	S
	BD37	19.2			1	3	25	46	24	1		1.58	S
	BD6	27.4			1	7	48	32	11	1		1.56	S
	BD14	24.9				4	46	36	13	1		1.46	S
	BD120	26.2			1	4	46	34	14	1		1.47	S
	BD121	17.4					8	30	52	10		1.21	S
	BD3	12.5				1	2	10	69	18		0.95	S
	BD9	17.2				1	29	54	15	1		1.56	S
	BD17	14.7				1	2	12	70	15		1.01	S
	BD22	26.1			1	10	47	31	10	1		1.64	S
	BD116	20.4				1	31	50	17	1		1.53	S
	BD30	25.6			2	13	43	32	9	1		1.78	S
	BD36	25.0			1	4	27	46	20	2		1.59	S

Area	Site	Depth (m)	% of particles in each size class (mm): Gravel		Very Coarse sand	Coarse sand	Medium sand		Fine sand	Very fine sand	Silt and Clay	Fineness Modulus	Characterization
			>4.75	4.75 - 2.36	2.36 - 1.18	1.18 - 0.6	0.6 - 0.43	0.43 - 0.3	0.3 - 0.15	0.15 - 0.08	<0.075		
	BD118	28.1			1	12	47	30	9	1		1.69	S
	BD13	25.2			1	7	49	31	11	1		1.54	S
	BD21	26.5			2	12	44	30	11	1		1.72	S
	BD29	30.0			3	15	48	22	10	2		1.77	S
	BD35	26.2			1	7	45	35	11	1		1.58	S
	BD12	30.1			1	9	46	30	13	1		1.60	S
	BD20	27.2			1	11	42	33	12	1		1.69	S
	BD28	30.8			6	21	49	17	6	1		2.04	S
	BD113	29.5			2	13	46	26	11	2		1.72	S
	BD34	27.9			2	14	45	27	11	1		1.75	S
	BD40	27.5			2	12	41	30	13	2		1.71	S
Inshore		**9.1**			**2.4**	**4.5**	**6.0**	**15.4**	**58.9**	**12.8**		**1.26**	**S**
Inshore between		**15.5**				**0.7**	**10.3**	**26.5**	**51.5**	**11.0**		**1.18**	**S**
Midshore		**22.5**			**0.4**	**4.2**	**31.5**	**34.2**	**26.1**	**3.6**		**1.44**	**S**
Offshore		**27.1**			**1.7**	**10.7**	**43.3**	**31.3**	**11.6**	**1.3**		**1.69**	**S**
Te Arai Point	BD38	18.6				0	7	38	50	5		1.34	S
	BD43	20.0				1	11	49	36	3		1.48	S
	BD42	21.0				3	36	45	15	1		1.55	S
	BD49	30.0			13	22	27	27	10	1		2.43	S
	BD41	21.9				4	41	38	16	1		1.51	S
	BD48	30.6		1	14	25	29	23	8			2.58	(g)S
	BD47	30.7			9	20	34	23	13	1		2.19	S
Midshore		**19.9**				**1.3**	**18.0**	**44.0**	**33.7**	**3.0**		**1.46**	**S**
Offshore		**28.3**		**0.3**	**9.0**	**17.8**	**32.8**	**27.8**	**11.8**	**0.8**		**2.18**	**(g)S**
Southern area	BD39	2.7				1	3	25	67	4		1.23	S
	BD46	7.7			2	5	7	23	55	8		1.37	S
	BD54	18.7				1	2	23	64	10		1.16	S
	BD111	11.8			2	2	3	12	64	17		1.09	S
	BD62	4.8				1	4	19	68	8		1.15	S
	BD68	5.8			1	2	7	22	58	10		1.21	S
	BD45	7.0			3	12	15	21	43	6		1.65	S
	BD53	21.1				3	19	47	29	2		1.55	S
	BD109	17.2			1		6	25	59	9		1.21	S
	BD61	9.7			1	1	2	9	69	18		0.98	S
	BD52	21.8				1	4	23	63	9		1.17	S
	BD60	20.5				2	11	48	36	3		1.50	S
	BD66	15.3				1	2	12	71	14		1.01	S
	BD108	20.8			2	6	34	38	19	1		1.63	S
	BD51	24.0				1	2	22	64	11		1.13	S
	BD59	22.8				1	13	51	33	2		1.53	S
	BD65	23.7				1	2	15	67	15		1.03	S
	BD50	28.9		1	21	33	22	17	5	1		3.05	(g)S
	BD58	24.1			1	7	27	44	20	1		1.66	S
	BD64	25.4				3	23	48	24	2		1.55	S
	BD71	24.6				3	19	41	35	2		1.49	S
	BD67	11.3			1	1	1	11	70	16		1.00	S
	BD44	9.6				1	1	9	74	15		0.97	S
	BD73	22.6				1	4	20	64	11		1.12	S
	BD106	20.0			1	1	3	14	69	12		1.08	S
	BD72	23.8				2	18	42	35	3		1.46	S
	BD110	29.8			13	28	34	18	6	1		2.53	S
	BD57	25.8			1	3	27	48	19	2		1.60	S
	BD63	26.3			1	4	31	45	17	2		1.59	S
	BD70	28.5			5	11	29	33	20	2		1.85	S
	BD107	25.8			1	12	29	37	20	1		1.74	S
	BD77	28.0			5	18	26	32	17	2		2.03	S
	BD56	33.2		1	19	18	30	22	9	1		2.57	(g)S
	BD69	30.1			4	9	33	33	19	2		1.75	S
	BD76	29.3			6	11	32	32	18	1		1.89	S
	BD55	33.9		1	13	17	33	24	11	1		2.31	(g)S
Inshore		**10.7**			**1.0**	**2.8**	**6.8**	**22.6**	**57.6**	**9.2**		**1.26**	**S**
Inshore between		**17.5**			**0.4**	**1.2**	**5.4**	**19.2**	**62.4**	**11.4**		**1.13**	**S**
Midshore		**22.9**		**0.1**	**2.2**	**5.4**	**14.5**	**32.6**	**39.7**	**5.5**		**1.52**	**(g)S**
Offshore		**29.1**		**0.2**	**6.8**	**13.1**	**30.4**	**32.4**	**15.6**	**1.5**		**1.99**	**(g)S**

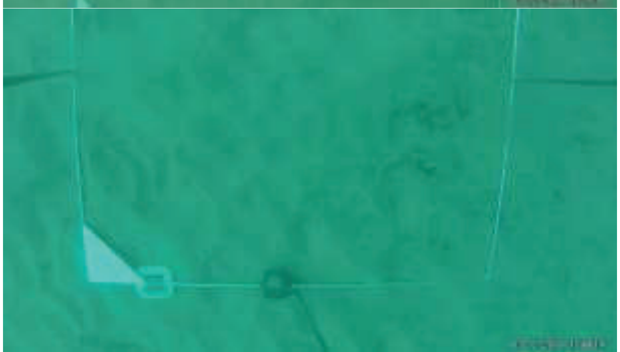
Appendix 3 Seabed Photographs

Northern Boundary Te Arai Beach

97 NTA 5.3m

98 NTA 6.2m

99 NTA 7.0m



100 NTA 8.0m

101 NTA 9.0m

Southern Boundary Te Arai Beach

71 STA 5.0m

72 STA 6.1m

73 STA 7.2m

74 STA 7.8m

75 STA 9.1m

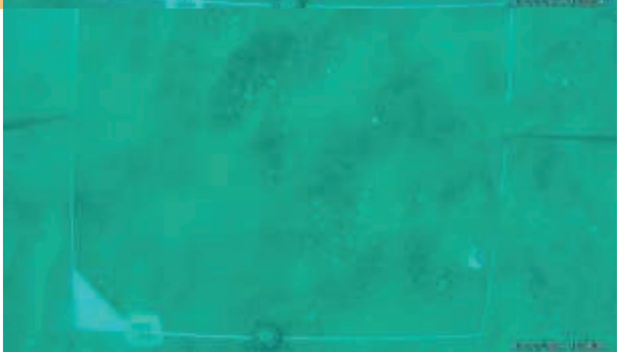
Northern Boundary Te Arai Beach

102 NTA 10.2m

103 NTA 10.9m

104 NTA 12.2m

105 NTA 13.0m



106 NTA 14.1m

Southern Boundary Te Arai Beach

76 STA 10.1m

77 STA 10.9m

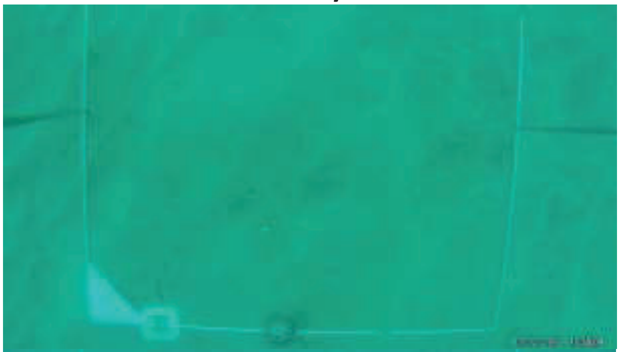
78 STA 12.0m

79 STA 12.9m

80 STA 14.0m

Northern Boundary Te Arai Beach

107 NTA 15.3.m



108 NTA 16.2m

109 NTA 17.3m

110 NTA 18.0m

111 NTA 18.9m

Southern Boundary Te Arai Beach

81 STA 14.9m

82 STA 15.8m

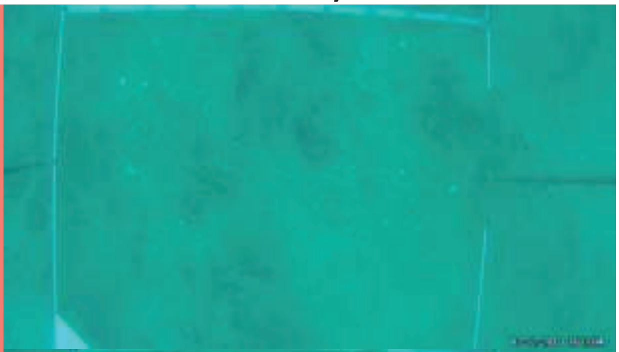
83 STA 17.0m

84 STA 18.1m

85 STA 18.9m

Northern Boundary Te Arai Beach

112 NTA 20.1m



113 NTA 21.1m

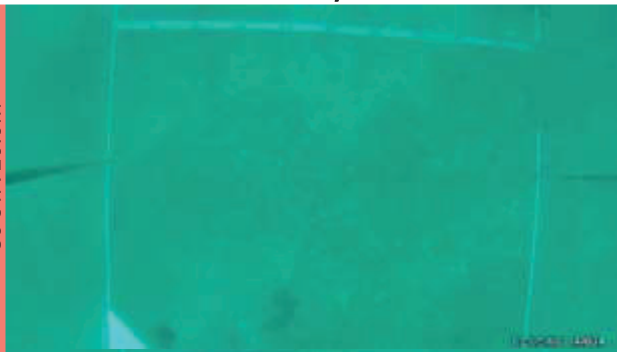
114 NTA 22.0m

115 NTA 22.7m

116 NTA 24.0m

Southern Boundary Te Arai Beach

86 STA 20.0m



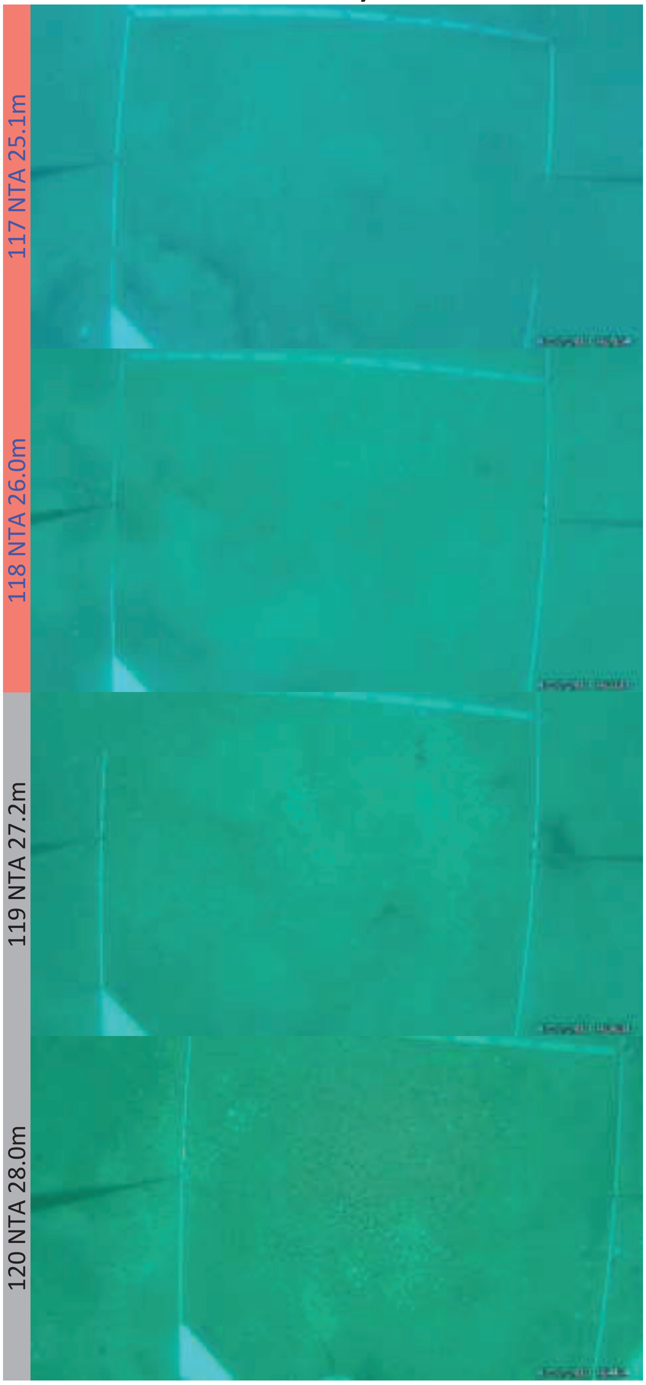
87 STA 20.9m

88 STA 22.0m

89 STA 22.9m

90 STA 24.0m

Northern Boundary Te Arai Beach



Inshore	Midshore	Offshore
Inshore	Midshore	Offshore

Photos are colour-coded according to the consent areas. The blue text represent areas not dredged or not in the proposed dredging but with similar depths to the consent areas.

Southern Boundary Te Arai Beach

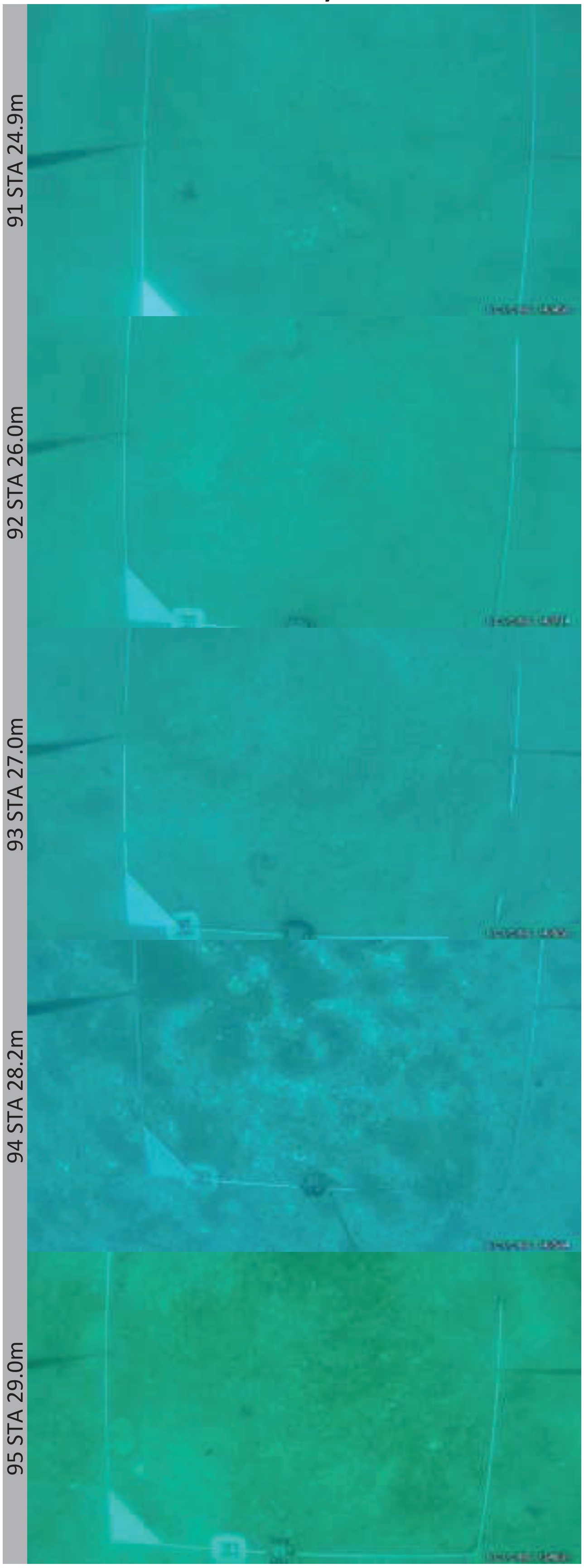
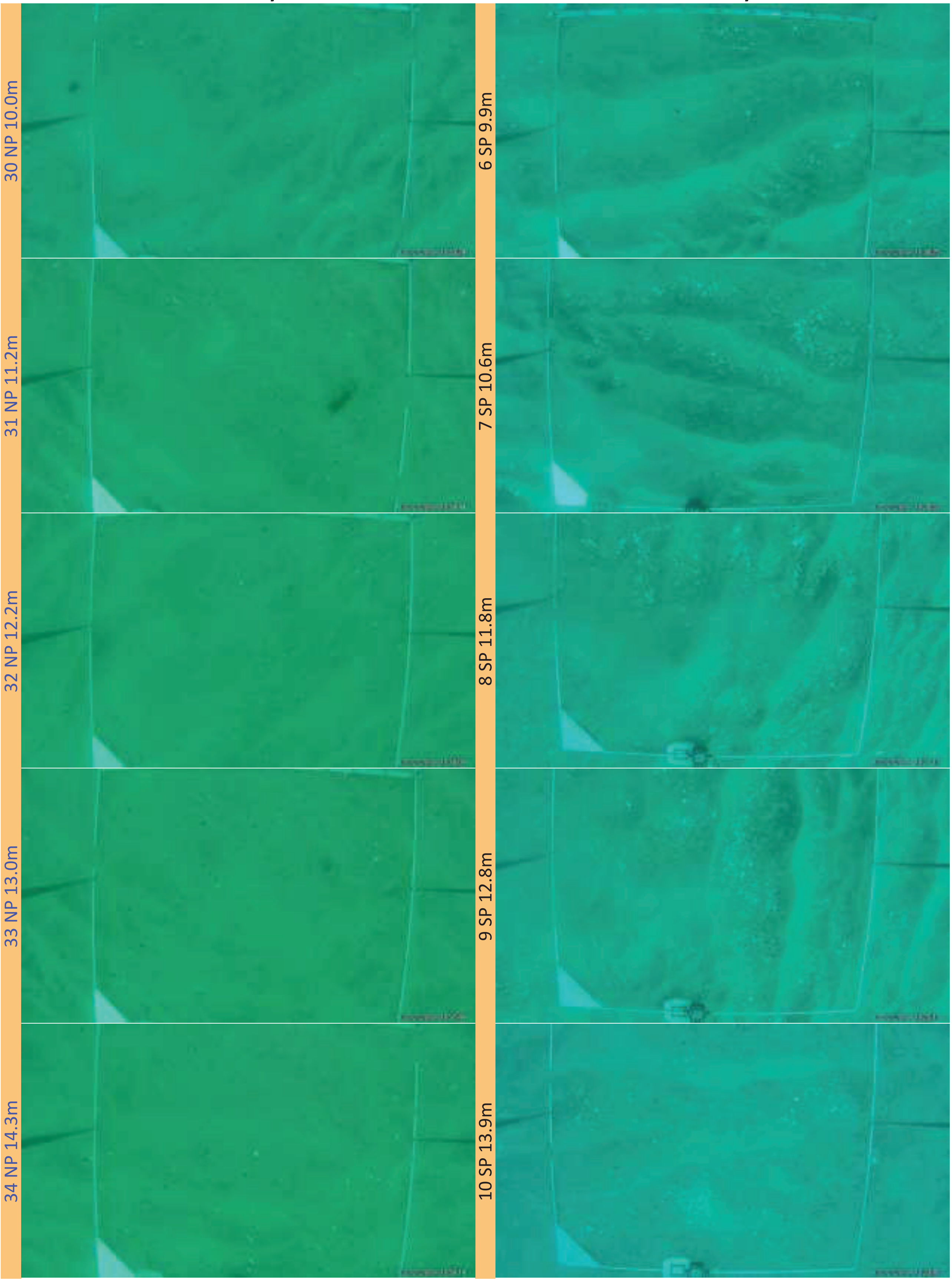


Figure A3.8.1 Drop Camera images from Northern Area Te Arai Beach, March 2019.

Northern Boundary Pakiri Beach		Southern Boundary Pakiri Beach	
25 NP 5.1m		1 SP 5.1m	
26 NP 6.1m		2 SP 5.9m	
27 NP 7.3m		3 SP 6.9m	
28 NP 8.2m		4 SP 8.0m	
29 NP 9.0m		5 SP 9.0m	

Northern Boundary Pakiri Beach | Southern Boundary Pakiri Beach



Northern Boundary Pakiri Beach

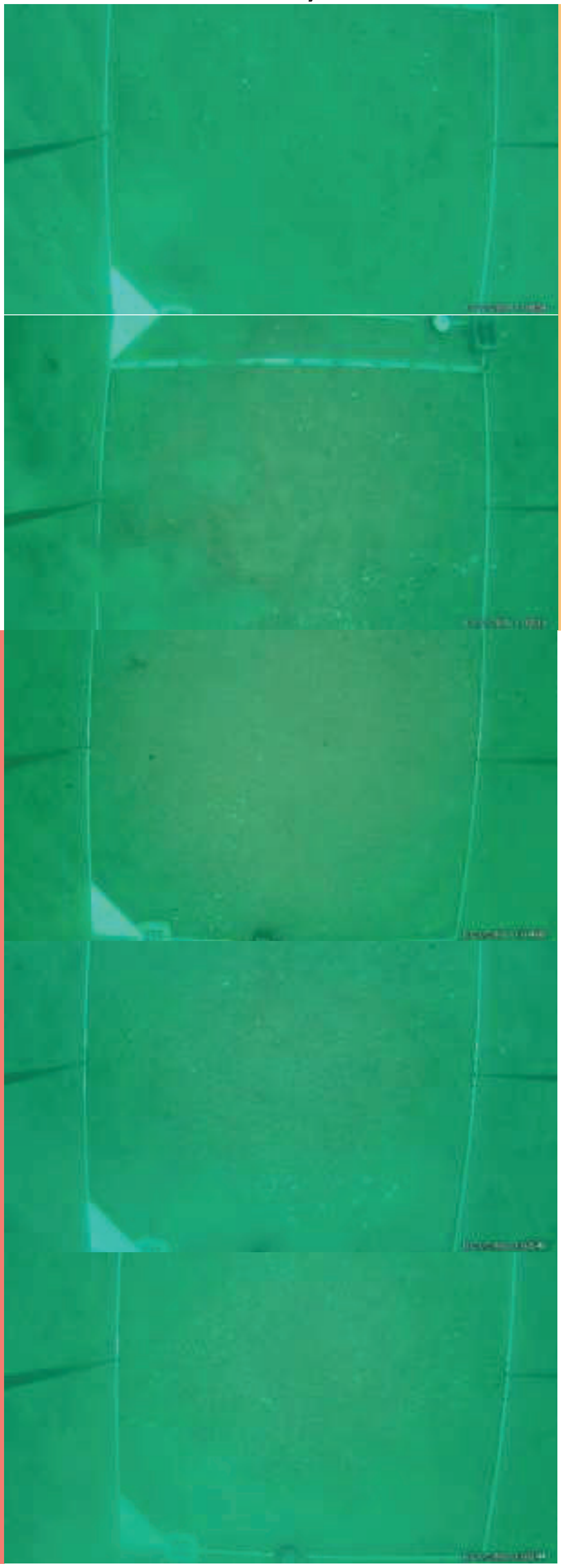
35 NP 15.0m

36 NP 16.2m

37 NP 17.1m

38 NP 18.0m

39 NP 19.3m



Southern Boundary Pakiri Beach

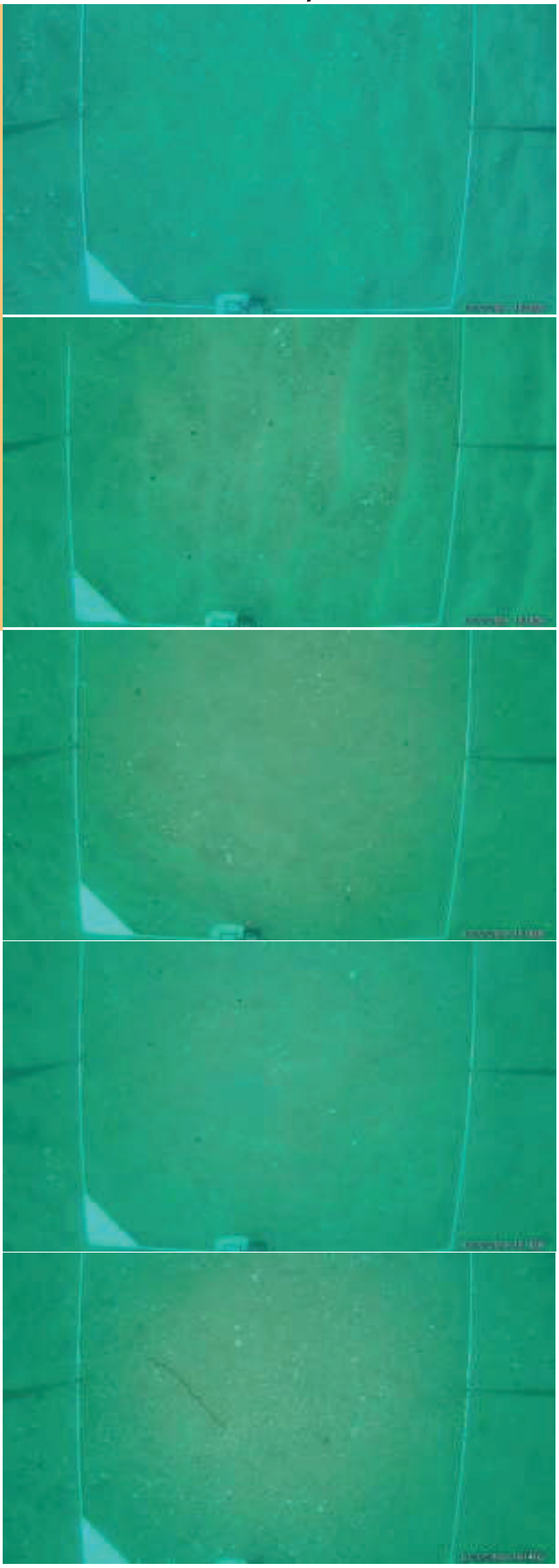
11 SP 15.0m

12 SP 15.9m

13 SP 17.0m

14 SP 18.1m

15 SP 18.9m



Northern Boundary Pakiri Beach

40 NP 20.1m

41 NP 21.0m

42 NP 22.1m

43 NP 23.2m

44 NP 24.0m

Southern Boundary Pakiri Beach

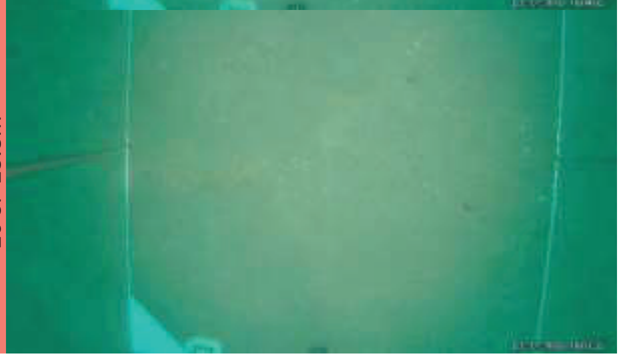
16 SP 20.1m

17 SP 21.1m

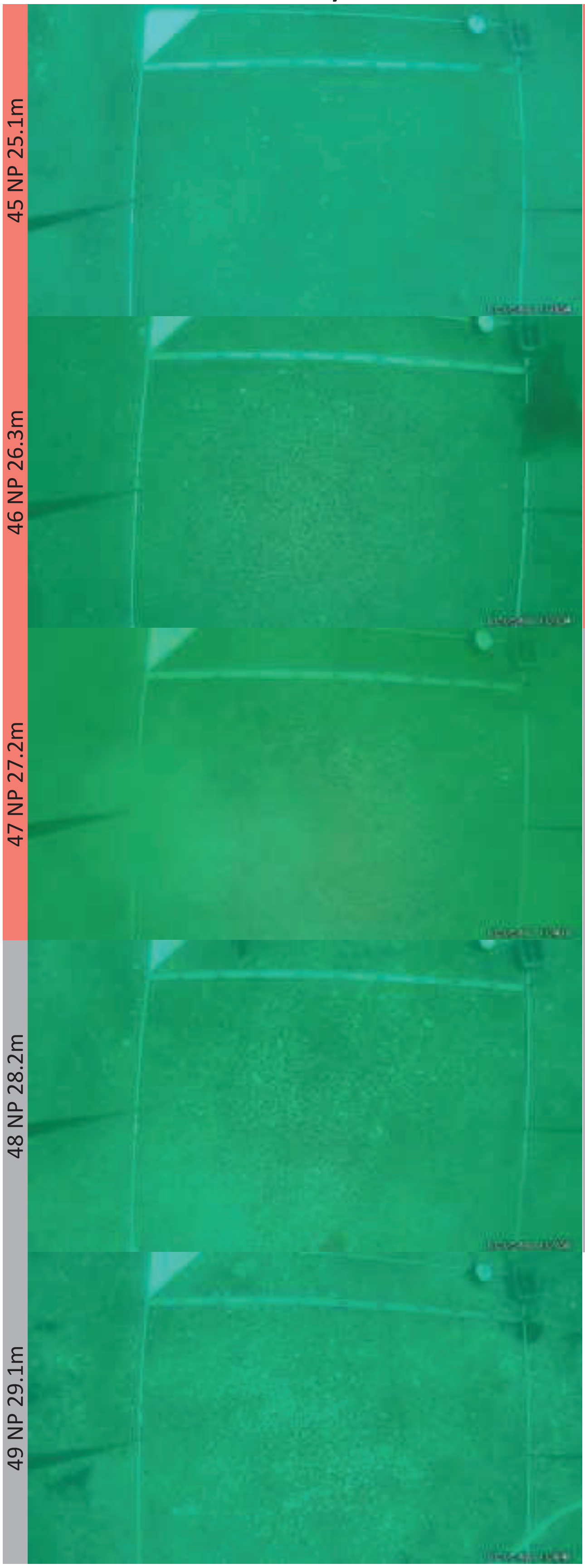
18 SP 22.0m

19 SP 23.0m

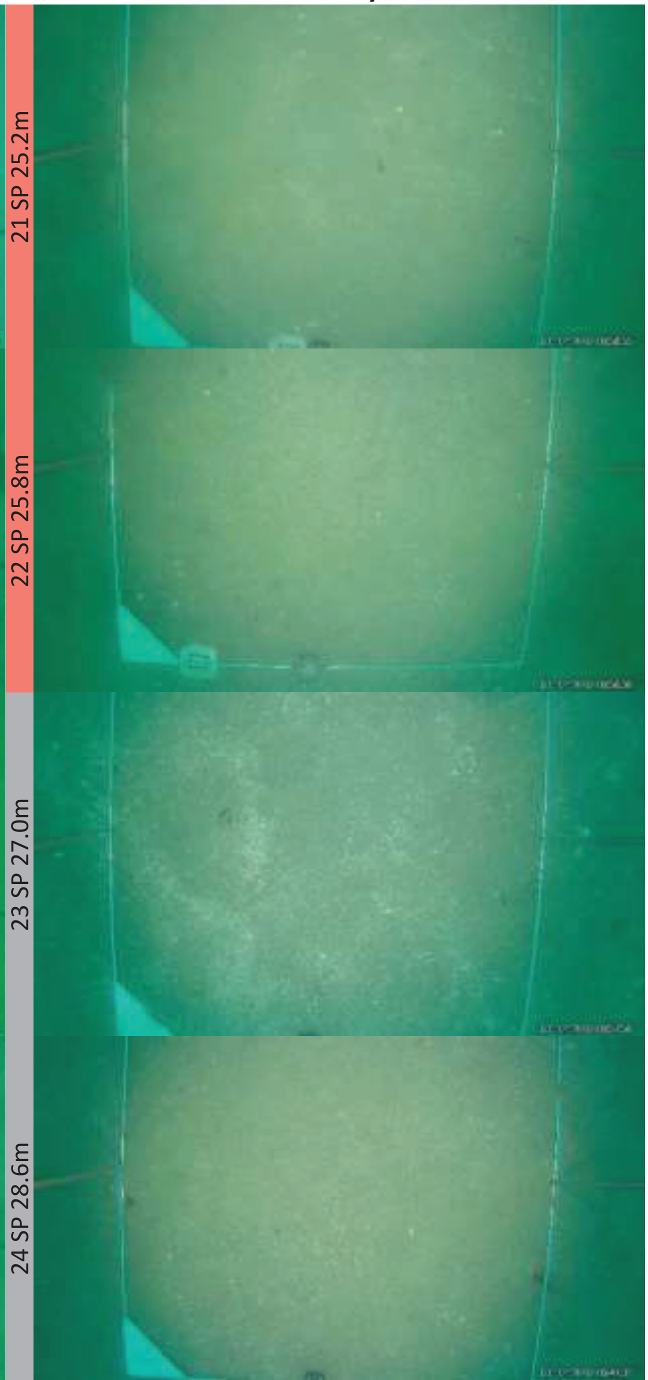
20 SP 23.8m



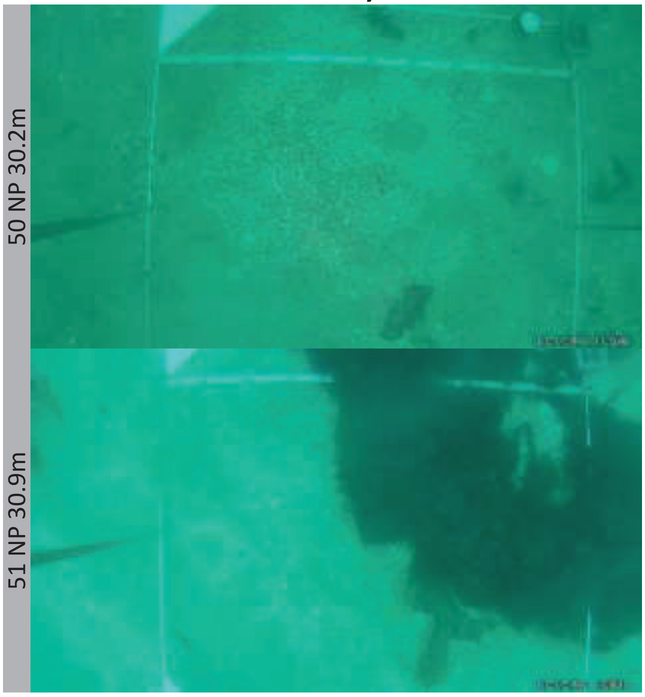
Northern Boundary Pakiri Beach



Southern Boundary Pakiri Beach



Northern Boundary Pakiri Beach



Southern Boundary Pakiri Beach

Inshore	Midshore	Offshore
Inshore	Midshore	Offshore

Photos are colour-coded according to the consent areas.
The blue text represent areas not dredged or not in the proposed dredging but with similar depths to the consent areas.

Figure A3.8.2 Drop Camera images from Southern area Pakiri Beach, March 2019.

Table A3.5 Seabed photography summary descriptions, 2019. (colour-codes correspond to the colours used in Figures A3.1 and A3.2)

Photo ID	World Geodetic System 1984		Depth	Date	Comments		
	Latitude	Longitude	(m)		Substrate	Ripples	Biota
Northern Boundary Te Arai Beach							
97 NTA 5.3	-36.11035	174.61655	5.3	12 Mar 19	sand 100%	irregular small	
98 NTA 6.2	-36.11017	174.61690	6.2	12 Mar 19	sand 100%	irregular small	
99 NTA 7.0	-36.11005	174.61730	7.0	12 Mar 19	sand 100%	irregular small	
100 NTA 8.0	-36.11012	174.61780	8.0	12 Mar 19	Sand 85%, Shell debris 5%, rock 10%	medium	
101 NTA 9.0	-36.10990	174.61863	9.0	12 Mar 19	sand 100%	medium irregular	
102 NTA 10.2	-36.10978	174.61905	10.2	12 Mar 19	sand 100%	medium irregular	
103 NTA 10.9	-36.10967	174.61958	10.9	12 Mar 19	sand 90%, shell debris 10%	medium	burrows
104 NTA 12.2	-36.10953	174.62023	12.2	12 Mar 19	sand 98%, shell debris 2%	medium	burrows
105 NTA 13.0	-36.10937	174.62078	13.0	12 Mar 19	sand 95%, shell debris 5%	medium	burrows
106 NTA 14.1	-36.10930	174.62145	14.1	12 Mar 19	sand 95%, shell debris 5%	medium	burrows
107 NTA 15.3	-36.10913	174.62213	15.3	12 Mar 19	sand 100%	medium flat	burrows
108 NTA 16.2	-36.10897	174.62272	16.2	12 Mar 19	sand 100%	medium flat	
109 NTA 17.3	-36.10855	174.62342	17.3	12 Mar 19	sand 100%	medium flat	burrows
110 NTA 18.0	-36.10870	174.62400	18.0	12 Mar 19	sand 100%	medium flat	burrows
111 NTA 18.9	-36.10853	174.62483	18.9	12 Mar 19	sand 98%, shell debris 2%	none	burrows
112 NTA 20.1	-36.10838	174.62568	20.1	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
113 NTA 21.1	-36.10820	174.62655	21.1	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
114 NTA 22.0	-36.10792	174.62777	22.0	12 Mar 19	sand 98%, shell debris 2%	large flat	
115 NTA 22.7	-36.10782	174.62770	22.7	12 Mar 19	sand 98%, shell debris 2%	large flat	red sea weed
116 NTA 24.0	-36.10743	174.63000	24.0	12 Mar 19	sand 98%, shell debris 2%	large flat	
117 NTA 25.1	-36.10718	174.63132	25.1	12 Mar 19	sand 98%, shell debris 2%	large flat	
118 NTA 26.0	-36.10680	174.63268	26.0	12 Mar 19	sand 100%	large flat	
119 NTA 27.2	-36.10663	174.63403	27.2	12 Mar 19	sand 95%, shell debris 5%	large flat	
120 NTA 28.0	-36.10628	174.63548	28.0	12 Mar 19	sand 98%, shell debris 2%	large flat	
Southern Boundary Te Arai Beach							
71 STA 5.0	-36.15068	174.64438	5.0	12 Mar 19	sand 98%, shell debris 2%	irregular	
72 STA 6.1	-36.15050	174.64463	6.1	12 Mar 19	sand 100%	irregular	
73 STA 7.2	-36.15042	174.64502	7.2	12 Mar 19	sand 100%	irregular medium	
74 STA 7.8	-36.15022	174.64532	7.8	12 Mar 19	sand 98%, shell debris 2%	irregular medium	
75 STA 9.1	-36.14988	174.64570	9.1	12 Mar 19	sand 98%, shell debris 2%	irregular medium	
76 STA 10.1	-36.14968	174.64613	10.1	12 Mar 19	sand 95%, shell debris 5%	irregular medium flat	
77 STA 10.9	-36.14957	174.64650	10.9	12 Mar 19	sand 98%, shell debris 2%	irregular medium flat	burrows
78 STA 12.0	-36.14945	174.64698	12.0	12 Mar 19	sand 98%, shell debris 2%	irregular medium flat	burrows
79 STA 12.9	-36.14895	174.64740	12.9	12 Mar 19	sand 100%	large flat	burrows
80 STA 14.0	-36.14877	174.64775	14.0	12 Mar 19	sand 98%, shell debris 2%	irregular small flat	burrows large
81 STA 14.9	-36.14843	174.64823	14.9	12 Mar 19	sand 100%	none	burrows
82 STA 15.8	-36.14828	174.64883	15.8	12 Mar 19	sand 100%	none	burrows
83 STA 17.0	-36.14780	174.64933	17.0	12 Mar 19	sand 100%	none	weed
84 STA 18.1	-36.14745	174.65007	18.1	12 Mar 19	sand 100%	none	
85 STA 18.9	-36.14710	174.65067	18.9	12 Mar 19	sand 100%	none	

Photo ID	World Geodetic System 1984		Depth	Date	Comments		
	Latitude	Longitude	(m)		Substrate	Ripples	Biota
86 STA 20.0	-36.14655	174.65142	20.0	12 Mar 19	sand 100%	large flat	
87 STA 20.9	-36.14630	174.65225	20.9	12 Mar 19	sand 100%	large flat	
88 STA 22.0	-36.14562	174.65318	22.0	12 Mar 19	sand 100%	large flat	
89 STA 22.9	-36.14508	174.65425	22.9	12 Mar 19	sand 100%	large flat	
90 STA 24.0	-36.14460	174.65515	24.0	12 Mar 19	sand 100%	large flat	burrows
91 STA 24.9	-36.14400	174.65615	24.9	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
92 STA 26.0	-36.14355	174.65693	26.0	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
93 STA 27.0	-36.14288	174.65807	27.0	12 Mar 19	sand 95%, shell debris 5%	large flat	scallop
94 STA 28.2	-36.14248	174.65882	28.2	12 Mar 19	sand 75%, shell debris 25%	none	
95 STA 29.0	-36.14198	174.65953	29.0	12 Mar 19	sand 95%, shell debris 5%	none	burrows
Northern Boundary Pakiri Beach							
25 NP 5.1	-36.16768	174.65537	5.1	12 Mar 19	sand 100%	irregular small	
26 NP 6.1	-36.16737	174.65583	6.1	12 Mar 19	sand 100%	small aligned	
27 NP 7.3	-36.16707	174.65623	7.3	12 Mar 19	sand 100%	medium aligned	
28 NP 8.2	-36.16685	174.65642	8.2	12 Mar 19	sand 100%	medium irregular	
29 NP 9.0	-36.16653	174.65685	9.0	12 Mar 19	sand 100%	medium irregular	burrows
30 NP 10.0	-36.16612	174.65735	10.0	12 Mar 19	sand 98%, shell debris 2%	large with small sub-ripples	burrows
31 NP 11.2	-36.16573	174.65792	11.2	12 Mar 19	sand 98%, shell debris 2%	large flat	
32 NP 12.2	-36.16543	174.65842	12.2	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
33 NP 13.0	-36.16497	174.65888	13.0	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows large
34 NP 14.3	-36.16470	174.65932	14.3	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
35 NP 15.0	-36.16428	174.65975	15.0	12 Mar 19	sand 98%, shell debris 2%	large flat	burrows
36 NP 16.2	-36.16385	174.66040	16.2	12 Mar 19	sand 95%, shell debris 5%	none	burrows
37 NP 17.1	-36.16342	174.66077	17.1	12 Mar 19	sand 98%, shell debris 2%	none	burrows
38 NP 18.0	-36.16315	174.66133	18.0	12 Mar 19	sand 98%, shell debris 2%	none	burrows
39 NP 19.3	-36.16278	174.66177	19.3	12 Mar 19	sand 98%, shell debris 2%	none	burrows
40 NP 20.1	-36.16240	174.66242	20.1	12 Mar 19	sand 100%	none	burrows
41 NP 21.0	-36.16193	174.66287	21.0	12 Mar 19	sand 98%, shell debris 2%	none	burrows
42 NP 22.1	-36.16148	174.66338	22.1	12 Mar 19	sand 98%, shell debris 2%	large flat	
43 NP 23.2	-36.16110	174.66382	23.2	12 Mar 19	sand 95%, shell debris 5%	none	weed
44 NP 24.0	-36.16053	174.66450	24.0	12 Mar 19	sand 95%, shell debris 5%	large flat	burrows, weed
45 NP 25.1	-36.16022	174.66493	25.1	12 Mar 19	sand 95%, shell debris 5%	none	
46 NP 26.3	-36.15995	174.66607	26.3	12 Mar 19	sand 98%, shell debris 2%	none	burrows, weed
47 NP 27.2	-36.15925	174.66662	27.2	12 Mar 19	sand 100%	large flat	
48 NP 28.2	-36.15850	174.66723	28.2	12 Mar 19	sand 95%, shell debris 5%	large flat	burrows
49 NP 29.1	-36.15803	174.66798	29.1	12 Mar 19	sand 90%, shell debris 10%	large flat	weed
50 NP 30.2	-36.15768	174.66850	30.2	12 Mar 19	sand 80%, shell debris 20%	large flat	weed
51 NP 30.9	-36.15708	174.66910	30.9	12 Mar 19	sand 80%, shell debris 20%	large flat	weed
Southern Boundary Pakiri Beach							
1 SP 5.1	-36.19347	174.67617	5.1	12 Mar 19	sand 100%	irregular small	burrows
2 SP 5.9	-36.19337	174.67657	5.9	12 Mar 19	sand 100%	small aligned	
3 SP 6.9	-36.19307	174.67682	6.9	12 Mar 19	sand 98%, shell debris 2%	medium aligned	burrows
4 SP 8.0	-36.19305	174.67725	8.0	12 Mar 19	sand 95%, shell debris 5%	medium aligned	burrows

Photo ID	World Geodetic System 1984		Depth (m)	Date	Comments		
	Latitude	Longitude			Substrate	Ripples	Biota
5 SP 9.0	-36.19278	174.67790	9.0	12 Mar 19	sand 90%, shell debris 10%	medium aligned	
6 SP 9.9	-36.19257	174.67808	9.9	12 Mar 19	sand 95%, shell debris 5%	large with small sub-ripples	
7 SP 10.6	-36.19235	174.67843	10.6	12 Mar 19	sand 95%, shell debris 5%	large	
8 SP 11.8	-36.19212	174.67893	11.8	12 Mar 19	sand 90%, shell debris 10%	medium aligned	burrows
9 SP 12.8	-36.19190	174.67923	12.8	12 Mar 19	sand 90%, shell debris 10%	large aligned	burrows
10 SP 13.9	-36.19160	174.67970	13.9	12 Mar 19	sand 95%, shell debris 5%	large smooth	burrows common, C. adspersa
11 SP 15.0	-36.19132	174.68003	15.0	12 Mar 19	sand 95%, shell debris 5%	medium flat	burrows
12 SP 15.9	-36.19115	174.68030	15.9	12 Mar 19	sand 95%, shell debris 5%	medium flat	burrows large
13 SP 17.0	-36.19088	174.68073	17.0	12 Mar 19	sand 98%, shell debris 2%	none	burrows large
14 SP 18.1	-36.19060	174.68120	18.1	12 Mar 19	sand 98%, shell debris 2%	none	burrows large
15 SP 18.9	-36.19030	174.68160	18.9	12 Mar 19	sand 95%, shell debris 5%	none	burrows
16 SP 20.1	-36.18987	174.68230	20.1	12 Mar 19	sand 95%, shell debris 5%	none	burrows
17 SP 21.1	-36.18952	174.68285	21.1	12 Mar 19	sand 98%, shell debris 2%	medium flat	
18 SP 22.0	-36.18893	174.68365	22.0	12 Mar 19	sand 95%, shell debris 5%	large flat	burrows
19 SP 23.0	-36.18823	174.68467	23.0	12 Mar 19	sand 98%, shell debris 2%	large flat	
20 SP 23.8	-36.18782	174.68530	23.8	12 Mar 19	sand 100%	none	
21 SP 25.2	-36.18758	174.68588	25.2	12 Mar 19	sand 100%	none	
22 SP 25.8	-36.18707	174.68652	25.8	12 Mar 19	sand 100%	large flat	
23 SP 27.0	-36.18593	174.68827	27.0	12 Mar 19	sand 95%, shell debris 5%	none	
24 SP 28.6	-36.18478	174.69015	28.6	12 Mar 19	sand 98%, shell debris 2%	none	

Appendix 4 Benthic Fauna

Table A4.6 Benthic Infauna Retained in 1 mm screen samples from the currently consented sand extraction areas and control ("Inshore"), 2019 (Number per sample).

Taxa	Current Consent (inshore)																													
Area	North										South										Control									
Sample number	01	05	11	19	114	27	04	10	18	26	39	46	54	111	62	68	45	53	109	61	75	82	88	100	94	74	105	81	87	93
Depth (m)	5	6	10	8	9	5	9	16	11	13	3	8	19	12	5	6	7	21	17	10	7	6	6	6	11	15	12	11	11	18
Annelida																														
Polychaeta																														
Paraprionospio pinnata													1															7		
Cirratulidae								2																						
?Aglaophamus/Nephtys																											1			
Phyllodocidae																			1											
Magelona cf. *dakini*													2	1																
Capitellidae								1																						
Armandia cf. maculata			2										2					2	1									1		
Maldanidae										2								3	2							1		1		
?Aricidea sp.														1																
Scalibregmidae																												1		
Polychaeta undet.										2					1			1			1		1							
Nemertea																														
Nemertea														1													1			
Arthropoda																														
Malacostraca																														
Amphipoda																														
Gammaridea undet.											2		1					1					1			1				
Lysianassidae																		4												
Phoxocephalidae sp. 1			2				1		1					3				1					4		1			2		2
Phoxocephalidae sp. 2																													1	2
Phoxocephalidae sp. 3								1		1																		1		
Haustoriidae								2						1				2							1			3		1
Liljeborgiidae									1																		1			
Cumacea																														
Cyclaspis elegans								2		1																				
Cyclaspis cf. levis					1			1		1															1					
Decapoda																														
Paguridae																							1							
Isopoda																														
Sphaeromatidae sp. 1							3			2																				
Paranthura sp.									1																					
Cirolanidae sp. 1			1					1		1				1											1		3	1		
Cirolanidae sp. 2																							1							
Mysida																														
Tenagomysis spp.									1					1									1		1					
Mollusca																														
Gastropoda																														
Zethalia zelandica	6	2				20									2															
Antisolarium egenum																														1
Maoricolpus roseus																							1							
Epitonium jukesianum																									1					
Amalda depressa																											1			
Turbonillia sp.												1																		
Bivalvia																														
Nucula nitidula																		1								1	1			
Hiatula nitida																				1										
Tawera spissa																												1		
Myadora boltoni									1	1																				
Myadora striata																		1												
Echinodermata																														
Ophiuroidea																														
Amphiura aster														1															1	
Chordata																														
Leptocardii																														
Epigonichthys hectori										1			1	1				3					7					3		
Actinopterygii																														
Limnichthys polyactis			1																											
Number of Species / taxa	1	1	4	0	1	1	2	7	5	9	1	1	5	9	2	0	0	10	3	1	1	0	8	0	6	3	6	10	2	4
Number of Individuals	6	2	6	0	1	20	4	10	5	12	2	1	7	11	3	0	0	19	4	1	1	0	17	0	6	3	8	21	2	6
Shannon - Wiener Diversity Index	0.00	0.00	1.33	0.00	0.00	0.00	0.56	1.89	1.61	2.14	0.00	0.00	1.55	2.10	0.64	0.00	0.00	2.16	1.04	0.00	0.00	0.00	1.71	0.00	1.79	1.10	1.67	2.02	0.69	1.33

Table A4.7 Benthic Infauna Retained in 3.15 mm screen samples from the currently consented sand extraction areas and control ("Inshore"), 2019 (Number per sample).

Taxa	Current Consent (inshore)																													
Area	North										South										Control									
Sample number	1	5	11	19	114	27	4	10	18	26	39	46	111	54	62	68	45	53	109	61	75	82	88	100	94	105	74	81	87	93
Depth (m)	5	6	10	8	9	5	9	16	11	13	3	8	12	19	5	6	7	21	17	10	7	6	6	6	11	12	15	11	11	18
Annelida																														
Polychaeta																														
Hydroides sp.																	1			1										
?Prionospio sp.		1																												
Paraprionospio pinnata		1																			4									
Terebellidae																	4													
Ampharetidae					1												2			2							4			
Cirratulidae																	3													1
Eunicidae																				2										
Lumbrineries sp.																										1				
Onuphidae																					1									
Nephtyidae			1																											
?Aglaophamus/Nephtys															1														1	
Phyllodocidae																											1			
Polynoidae																								1						
Sigalionidae																				2					1					
Syllidae									1																					
Magelona cf. *dakini*						1																								
Capitellidae				1				3	1							1		1		1										
Armandia cf. maculata																						1								
Maldanidae			7	4	5			3	2	4		6	13		4	1	7	3		7	4			3	1		5		1	6
Polychaeta undet.				2				1	2							3	20			5						2				
Nemertea																														
Nemertea																				1						1				
Arthropoda																														
Neocopepoda																														
Calanoida																	2													
Cyclopoida																	3													

Taxa	Area: Current Consent (inshore)																													
	North										South										Control									
Sample number	1	5	11	19	114	27	4	10	18	26	39	46	111	54	62	68	45	53	109	61	75	82	88	100	94	105	74	81	87	93
Depth (m)	5	6	10	8	9	5	9	16	11	13	3	8	12	19	5	6	7	21	17	10	7	6	6	6	11	12	15	11	11	18
Malacostraca																														
Amphipoda																														
Gammaridea undet.																	5							1						
Gammaridea sp. 2																	2													
Gammaridea sp. 3																	22													
Gammaridea sp. 5						1																								
Phoxocephalidae sp. 1		3		3				1	3												1									
Phoxocephalidae sp. 3																											1			
Haustoriidae																					1									
Corophiidae																											1			
Cumacea																														
Cyclaspis cf. levis																	2													
Decapoda																														
Periclimenes yaldwyni																	1	1												
Pontophilus sp.																		1												
Liocarcinus corrugatus									1						1		1							1						
Ovalipes catharus																						1								
Ebalia laevis			2					1												1										
Anomura											1	1				1	3						1	1						
Paguridae			1					9	1								21	2		2	1	1					2			
Paguristes setosus																1										1				
Isopoda																														
Sphaeromatidae sp. 1						1											2													
Paranthura sp.					2				1						1		1													
Cirolanidae sp. 1		3				2	1														2									
Mysida																														
Tenagomysis spp.			1				1						1																	
Tenagomysis producta																					1									
Stomatopoda																														
Pariliacantha georgeorum						1											1		1											
Tanaidacea																														
Tanaidacea																											1			
Insecta																														
Coleoptera undet.																								1						
Mollusca																														
Polyplacophora																														
Leptochiton inquinatus																	5													
Gastropoda																														
Zethalia zelandica	30	42	1								204																			
Antisolarium egenum					1			2	2									1												
Maoricolpus roseus																				1		1								
Striacolpus pagoda					3			2												4										
Sigapatella tenuis				1	1			3		1		2					1	3		4				1						
Trichosirius inornatus																	1													
Tanea zelandica								1																						
Semicassis pyrum (juvenile)																													1	
Cominella adspersa																						1								
Cominella quoyana				2													1	2		1							1			
Austrofusus glans																		1												
Amalda australis														1																
Amalda depressa																												1		
Amalda novaezelandiae								1										2												
?Antiguraleus sp.																								2						
Euterebra tristis													1											1						
Pupa affinis												1			1			5												
Cylichna thetidis																	1													
Bivalvia																														
Nucula nitidula				2												5	9	3						1			1			
Glycymeris modesta					1																									
Purpurocardia purpurata																	1													
Athritica bifurcata								1								1														
Gari convexa																								1						
Gari lineolata												2						1												
Gari stangeri																	2													
Hiatula nitida	1					1																								
Zemysina globus																											1			
Bassinia yatei																								1						
Tawera spissa																	3			1						1				
Dosinia lambata												1																		
Dosinia maoriana				1																										
Dosinia subrosea						1										1			2				1	1		1				
Corbula zelandica																	10													
Myadora boltoni						1				3		4		1			1				2	1		1		2				
Myadora striata						1				4		3									4	1		1	1		2			
Myadora subrostrata																	6													
Echinodermata																														
Ophiuroidea																														
Amphiura aster											1						3			1								1		
Echinoidea																														
Fellaster zelandiae																												7		
Nematoda																														
Nematoda																	7													
Foraminifera																														
Foraminifera																				1	3									
Bryozoa																														
Selenaria concinna			4	4					1								1													
Bryozoa																	3													
Porifera																														
Beige finger sponge					1												7			1										
Cnidaria																														
Hydrozoa																														
Leptothecata																	1													
Chordata																														
Thaliacia																														
Salpida																							1							
Leptocardii																														
Epigonichthys hectori					1					4						1	8		1		13	10		2		9				
Actinopterygii																														
Limnichthys polyactis																				1										
Number of Species / taxa	2	5	7	9	9	9	2	12	10	5	3	8	3	2	5	9	38	13	3	19	12	8	3	16	3	8	11	3	3	2
Number of Individuals	31	50	17	20	16	10	2	28	15	16	206	20	15	2	8	15	174	26	4	39	37	17	3	20	3	18	20	9	3	7
Shannon - Wiener Diversity Index	0.14	0.64	1.62	2.07	1.98	2.16	0.69	2.17	2.21	1.53	0.06	1.88	0.49	0.69	1.39	1.95	3.13	2.41	1.04	2.68	2.10	1.48	1.10	2.69	1.10	1.64	2.18	0.68	1.10	0.41

Table A4.8 Benthic Infauna Retained in 1 mm screen samples from the proposed sand extraction areas ("Midshore"), 2019 (Number per sample).

Taxa	Proposed New Consent Area (midshore)																																
Area	Northern																			Te Arai Point			Southern										
Sample number	2	8	119	7	6	120	117	16	115	15	14	25	24	23	33	112	32	31	37	38	43	42	52	51	50	60	108	59	58	66	65	64	71
Depth (m)	19	23	22	30	27	26	17	28	23	24	25	16	20	25	16	21	23	24	19	19	20	21	22	24	30	21	21	23	24	15	24	25	25
Annelida																																	
Polychaeta																																	
?*Euchone* sp.																		1								1							
?*Prionospio* sp.													1																				
Spionidae																															1		
Ampharetidae																								1									
Cirratulidae																							3	1		1			2			1	
Eunicidae																															1		
Goniadidae																															1		
Nephtyidae											1																						
Phyllodocidae											1													1			1						
Polynoidae														1																			
Sigalionidae													1			1			1								1						
Capitellidae				1	2			1																									
Armandia cf. maculata	1						1						1																	1	1		
Maldanidae		1	3			1		1	2	1		4		1		2	1	1			1	3	2	1	2	4		4	2		1	1	1
?*Aricidea sp.*												1						1															
Polychaeta undet.			1															1							2						1	2	
Nemertea																																	
Nemertea	1																				1							1			1		
Arthropoda																																	
Malacostraca																																	
Amphipoda																																	
Gammaridea undet.															1																1		
Gammaridea sp. 2																		1															
Lysianassidae													1																				
Phoxocephalidae sp. 1	2		1				5							2	1												1		1	1		1	1
Phoxocephalidae sp. 2	1										1																	2				1	
Phoxocephalidae sp. 3																			2														
Haustoriidae							1					2																					
Liljeborgiidae												1										1					2						
Cumacea																																	
Cyclaspis elegans																			1														
Cyclaspis cf. levis											1			1															1	1			
Diastylopsis thileniusi							1																										
Cumacean undet.																					1												
Decapoda																																	
Callianassa sp.																					1												
Callianassidae												1																					
Anomura																									6								
Isopoda																																	
Sphaeromatidae sp. 1												1	1		5				1			1								1			
Cirolanidae sp. 1		1																															
Cirolanidae sp. 2																																	
Isopoda undet.																							1										
Mysida																																	
Tenagomysis spp.											1										1	1											
Ostracoda																																	
Leuroleberis zealandica	1																	1							1								
Myodocopida sp. 1						1																											
Mollusca																																	
Gastropoda																																	
Roseaplagis rufozona																									1								
Sigapatella tenuis																									1								
Mesoginella larochei										1																	1						
Amalda novaezelandiae										1																							
Bivalvia																																	
Nucula nitidula																									1		2						
Limatula maoria			1																														
Myllita vivens											1																						
Athritica bifurcata				3																													
Gari stangeri																									1								
Zemysina globus																										1							
Tawera spissa																									1								
Myadora striata															1																		
Myadora subrostrata							1																										
Echinodermata																																	
Holothuroidea																																	
?*Kolostoneura* sp.																					1												
Ophiuroidea																																	
Amphiura aster											1																						
Ophiozonoida picta																			1						1								
Echinoidea																																	
Apatopygus recens																			1														
Nematoda																																	
Nematoda																									3								
Bryozoa																																	
Selenaria concinna		1									1											1											
Bryozoa																									3								
Hemichordata																																	
Enteropneusta						1																											
Chordata																																	
Leptocardii																																	
Epigonichthys hectori			1									2	1				1	1					1		1	1							
Number of Species / taxa	5	3	5	2	1	3	5	2	1	3	8	7	6	4	4	2	2	7	6	0	6	5	4	4	13	5	6	3	4	4	8	5	2
Number of Individuals	6	3	7	4	2	3	9	2	2	3	8	12	6	5	8	3	2	7	7	0	6	7	7	4	24	8	8	7	6	4	8	6	2
Shannon - Wiener Diversity Index	1.56	1.10	1.48	0.56	0.00	1.10	1.30	0.69	0.00	1.10	2.08	1.79	1.79	1.33	1.07	0.64	0.69	1.95	1.75	0.00	1.79	1.48	1.28	1.39	2.34	1.39	1.73	0.96	1.33	1.39	2.08	1.56	0.69

Table A4.9 Benthic Infauna Retained in 3.15 mm screen samples from the proposed sand extraction areas ("Midshore"), 2019 (Number per sample).

Taxa / Sample number	2	8	119	7	6	120	117	16	115	15	14	25	24	23	33	112	32	31	37	38	43	42	52	51	50	60	108	59	58	66	65	64	71
Area	Proposed New Consent Area (midshore)																																
	Northern																			Te Arai Point			Southern										
Depth (m)	19	23	22	30	27	26	17	28	23	24	25	16	20	25	16	21	23	24	19	19	20	21	22	24	30	21	21	23	24	15	24	25	25
Annelida																																	
Polychaeta																																	
Hydroides sp.				1		2											1																14
Paraprionospio pinnata																		1															
Terebellidae		1											1					1				2			3	1							
Ampharetidae				1																									2				2
?*Lanice* sp.																											1						
Cirratulidae										1	1		4							1						1						1	
?*Lagis australis*																										2							
Eunicidae										1	1																	1					
Lumbrineris sp.			1																											1	1		
Onuphidae																										1							
?*Aglaophamus/Nephtys*	1																																
Neanthes cricognatha																																	1
Nereididae																1																	
Phyllodocidae																				1										1			
Polynoidae									1																								1
Sigalionidae	2									1			2				2						1				1			1			2
Magelona cf. *dakini*				1														1													1		1
Capitellidae							8																		2	2	1	2					8
Cossuridae																										2							1
Maldanidae	9	8	1		5	1	1	1		3	10	4	12				4		2		4				6		6	4	10	4	2		11
Travisia olens																																	3
Polychaeta undet.	1												1		1			8		7	1	1	1		6	1							5
Nemertea																																	
Nemertea			1			1					1						1									1							1
Arthropoda																																	
Malacostraca																																	
Amphipoda																																	
Gammaridea undet.																		1							1			1					1
Gammaridea sp. 2																									1				1				1
Gammaridea sp. 3																		4							1	3							1
Gammaridea sp. 5																									2								
Lysianassidae																											1						
Phoxocephalidae sp. 1	1				2	1					1																1	1			1		3
Liljeborgiidae											1							1								1				1			5
Cumacea																																	
Cyclaspis cf. *levis*															1															1			
Decapoda																																	
Ogyrides delli																			2														
Liocarcinus corrugatus				1																						1							2
Ovalipes catharus															1																		
Ebalia laevis										1							1	1															1
Notomithrax minor																		1															1
Anomura																	1							1									1
Paguridae	1			1									2	1				13					1		1					3			17
Paguristes setosus																		1															
Isopoda																																	
Sphaeromatidae sp. 1																		2															
Sphaeromatidae sp. 2																																	1
Paranthura sp.						1				1															1	1							
Cirolanidae sp. 1																															1		
Isopoda undet.																		1							1								
Mysida																																	
Tenagomysis spp.																							1										1
Stomatopoda																																	
Pariliacantha georgeorum															1																1		
Ostracoda																																	
Myodocopida sp. 1																	1																
Myodocopida sp. 2																		2															
Pycnogonida																																	
Pycnogonida																		1															
Insecta																																	
Coleoptera undet.		1																															
Mollusca																																	
Polyplacophora																																	
Ischnochiton maorianus																	1																1
Leptochiton inquinatus					1													10				1				3							3
Gastropoda																																	
Zethalia zelandica									4																							15	
Antisolarium egenum				1	4																1	2					1						
Roseaplagis rufozona																																	1
Solariella tryphenensis				1																													
Maoricolpus roseus																																	1
Striacolpus pagoda				4	1					9					1		1				1		1		2		2						1
Rissoina fictor																		1							2	1							2
Pisinna semisulcata																									1								
Sigapatella tenuis				2	1			1		1							1	1		3	2									2			
Trichosirius inornatus																											1						
Seila cf. *cincta*																		1															1
Epitonium jukesianum						1																											
Cominella quoyana		1		1	1													2			2		3		3		1		1				6
Austrofusus glans																	1																
Zemitrella aff. regis																																	1
Amalda australis	1													2																		1	
Amalda depressa															1																		
Amalda novaezelandiae					1																	1								1			
Antimelatoma buchanani maorum																	1																
Euterebra tristis							1																										
Cylichna thetidis																	1	1				1											

Taxa / Area	Proposed New Consent Area (midshore)																																
	Northern																			Te Arai Point			Southern										
Sample number	2	8	119	7	6	120	117	16	115	15	14	25	24	23	33	112	32	31	37	38	43	42	52	51	50	60	108	59	58	66	65	64	71
Depth (m)	19	23	22	30	27	26	17	28	23	24	25	16	20	25	16	21	23	24	19	19	20	21	22	24	30	21	21	23	24	15	24	25	25
Bivalvia																																	
Nucula nitidula		2			2												2	8		1		2			12	1							14
Glycymeris modesta	2										1																						
Talochlamys zelandiae				1																													
Limatula maoria																		1															
Pleuromeris latiuscula																									1								
Pleuromeris paucicostata																		1							1								3
Pleuromeris zelandica										1																							
Purpurocardia purpurata																		1							3								2
Myllita vivens										1																							
Scalpomactra scalpellum					1																												
Gari convexa																														1			
Gari stangeri																	1	3								1							1
Hiatula nitida																				1													
Zemysina zelandica																										1							
Zemysina globus																													1				
Notocallista multistriata																					1												
Tawera spissa																								1									
Dosinia lambata	1																																
Dosinia maoriana		1		1																	1												
Dosinia subrosea			1					1											1												1		
Corbula zelandica																	1	3															1
Myadora boltoni						1													4	4				11						1			
Myadora striata	1																			2				5						1	2		
Myadora subrostrata					1					1								2			1												
Hunkydora novozelandica																											1						
Bivalvia undet.										1																							
Echinodermata																																	
Holothuroidea																																	
Holothuroidea	1																																
Ophiuroidea																																	
Amphiura aster							1										1	1													1		
Ophiocentrus novaezelandiae																																	1
Ophiozonoida picta																																	2
Echinoidea																																	
Fellaster zelandiae									1																							3	
Nematoda																																	
Nematoda																															1		
Foraminifera																																	
Foraminifera																																	24
Bryozoa																																	
Selenaria concinna	1	1			1					1		1	2								2	5					2						
Bryozoa																																	12
Porifera																																	
Callyspongiidae																									1								
Beige finger sponge																	1	6							2								12
Orange sponge																																	1
Black sponge																																	1
Cnidaria																																	
Hydrozoa																																	
Leptothecata						1																				1							
Hemichordata																																	
Enteropneusta																					1												
Chordata																																	
Ascidiacea																																	
Stolidobranchia																										1							
Molgula sp.																		1															2
Leptocardii																																	
Epigonichthys hectori					1								1					2	3	1		1		1	3	1							6
Actinopterygii																																	
Limnichthys polyactis			1	2					1															1									
Number of Species / taxa	12	7	5	13	13	8	4	3	4	13	7	2	8	2	6	1	18	32	5	9	11	9	6	6	22	20	12	5	5	12	10	4	47
Number of Individuals	22	15	5	18	22	9	11	3	7	23	16	5	25	3	6	1	23	84	12	21	17	16	8	20	56	27	19	9	15	18	12	20	184
Shannon - Wiener Diversity Index	2.07	1.51	1.61	2.43	2.35	2.04	0.89	1.10	1.15	2.13	1.33	0.50	1.64	0.64	1.79	0.00	2.77	3.01	1.52	1.91	2.26	2.01	1.67	1.27	2.75	2.90	2.23	1.43	1.08	2.32	2.25	0.80	3.25

Table A4.10 Benthic Infauna Retained in 1 mm screen samples from Offshore and "Inshore Between" areas, 2019 (Number per sample).

Taxa / Area	Inshore Between									Offshore																												
	Northern				Southern					Northern															Te Arai Point				Southern									
Sample number	121	3	9	17	44	67	73	106	72	118	13	12	22	116	21	20	30	29	28	113	36	35	34	40	41	49	48	47	110	57	56	55	63	70	107	69	77	76
Depth (m)	17	13	17	15	10	11	23	20	24	28	25	30	26	20	27	27	26	30	31	30	25	26	28	28	22	30	31	31	30	26	33	34	26	29	26	30	28	29
Annelida																																						
Polychaeta																																						
Spionidae								1																	1													
Paraprionospio pinnata				1	1	3																																
Terebellidae																													1									1
Ampharetidae																										1	1											
Cirratulidae														1							1				2				1	1	1	1		1	1			
Eunicidae																			1										2									
Goniadidae						1																																
Nephtyidae						1																																
Sigalionidae																																			1			
Magelona cf. dakini																	1																					
Capitellidae												2															5						1			1		
Armandia cf. maculata	1			1																																		
Maldanidae	2		2			1			3	2	1			4	1				2	2	1	2	1	4	3	3	1			2	1	1		1	2			2
?Aricidea sp.				1			7	1									1																					
Polychaeta undet.								1																1		2		1	1	1								
Nemertea																																						
Nemertea																					1												1					
Arthropoda																																						
Malacostraca																																						
Amphipoda																																						
Gammaridea undet.																			1																			
Gammaridea sp. 2								1																														
Gammaridea sp. 3																											1		1									
Gammaridea sp. 4																														1								
Lysianassidae							2																										1					
Phoxocephalidae sp. 1	1	2	1	5	2	5	1	1						1	1	1	1			1			1	1									1					
Phoxocephalidae sp. 2					1																																	
Phoxocephalidae sp. 3	1							1																														
Haustoriidae		2	1	1	3	2		3															1															
Liljeborgiidae	2				1																					2			3					2				2
Cumacea																																						
Cyclaspis cf. levis		2																								1			2				1					
Cumacean undet.	1																																					

Taxa	Inshore Between									Offshore																												
Area	Northern				Southern					Northern															Te Arai Point				Southern									
Sample number	121	3	9	17	44	67	73	106	72	118	13	12	22	116	21	20	30	29	28	113	36	35	34	40	41	49	48	47	110	57	56	55	63	70	107	69	77	76
Depth (m)	17	13	17	15	10	11	23	20	24	28	25	30	26	20	27	27	26	30	31	30	25	26	28	28	22	30	31	31	30	26	33	34	26	29	26	30	28	29
Isopoda																																						
Sphaeromatidae sp. 1	2		1											3																								
Paranthura sp.																											1											1
Cirolanidae sp. 1	1					1												1																				
Leptostraca																																						
Nebalia sp.		1																																				
Ostracoda																																						
Leuroleberis zealandica						1																																
Myodocopida sp. 2				1										1																								
Mollusca																																						
Polyplacophora																																						
Leptochiton inquinatus																										2												
Gastropoda																																						
Antisolarium egenum																						1																
Striacolpus pagoda																																					1	
Rissoina fictor																													1									
Pisinna semisulcata																										1						1						
Sigapatella tenuis						1																																
Amalda novaezelandiae																																	1					
Neoguraleus murdochi																																						
Turbonillia sp.																																	1					
Pupa affinis							1																															
Bivalvia																																						
Nucula nitidula								1						2													1											
Glycymeris modesta														1				1																				
Pleuromeris paucicostata																																					1	
Athritica bifurcata																																	1					
Gari convexa														1																								
Zemysina globus																									1													
Myadora boltoni	1																																					
Myadora striata						1																																
Myadora subrostrata																											1											
Hunkydora novozelandica			1																																			
Echinodermata																																						
Ophiuroidea																																						
Amphiura aster																																					2	
Ophiozonoida picta																									1													
Foraminifera																																						
Foraminifera									1																				1									
Bryozoa																																						
Selenaria concinna									1																3													2
Porifera																																						
Beige finger sponge															1												2											
Chordata																																						
Leptocardii																																						
Epigonichthys hectori	1		1	5				1						2	4		1			1									3						1		2	
Number of Species / taxa	10	4	6	7	5	10	4	9	3	1	1	1	0	9	4	1	4	2	3	3	3	2	3	3	6	7	8	1	10	4	2	3	8	3	4	1	4	5
Number of Individuals	13	7	7	15	8	17	11	11	5	2	1	2	0	16	7	1	4	2	4	4	3	3	3	6	11	12	13	1	16	5	2	3	8	4	5	1	6	8
Shannon - Wiener Diversity Index	2.25	1.35	1.75	1.64	1.49	2.08	1.03	2.10	0.95	0.00	0.00	0.00	0.00	2.05	1.15	0.00	1.39	0.69	1.04	1.04	1.10	0.64	1.10	0.87	1.67	1.86	1.84	0.00	2.19	1.33	0.69	1.10	2.08	1.04	1.33	0.00	1.33	1.56

Table A4.11 Benthic Infauna Retained in 3.15 mm screen samples from Offshore and "Inshore Between" areas, 2019 (Number per sample).

Taxa	Inshore Between									Offshore																												
Area	Northern				Southern					Northern															Te Arai Point				Southern									
Sample number	121	3	9	17	44	67	106	73	72	118	13	12	116	22	21	20	30	29	113	28	36	35	34	40	41	49	48	47	110	57	56	55	63	107	70	69	77	76
Depth (m)	17	13	17	15	10	11	20	23	24	28	25	30	20	26	27	27	26	30	30	31	25	26	28	28	22	30	31	31	30	26	33	34	26	26	29	30	28	29
Annelida																																						
Polychaeta																																						
Hydroides sp.	1																																		1			
Paraprionospio pinnata				1																												1						
?Malacoceros																														3								
Terebellidae					8																					1				2					1			
Ampharetidae					1			1	7									2							7					5								
Cirratulidae					2		2																											1				
Lumbrineries sp.								1																														
Onuphidae									1																		1											
Goniadidae					1																																	
Goniada sp.																1																						
Nephtyidae								2			1						1																			1		
?Aglaophamus/Nephtys							1																											1				
Phyllodocidae													1	1	1								1			1							2	1				
Polynoidae										1																												
Sigalionidae					1		1						1	1			1			1	1	1								3							2	
Magelona cf. *dakini*				1																					1										1			
Capitellidae	1		1					1							1	2							1															
Armandia cf. *maculata*																																1						
Maldanidae	3	1			6	19	17	8	15	6	5	5	10	10	10	5	2	1			8	6	2			13	1	52	17	6		1	18	7			6	
Polychaeta undet.	2	1		1	11												3	1		2					1					1		1						
Nemertea																																						
Nemertea	1							1																				1						1				
Arthropoda																																						
Neocopepoda																																						
Cyclopoida					1																																	
Malacostraca																																						
Amphipoda																																						
Gammaridea undet.	1				1																				1							1						
Gammaridea sp. 2					4																																	
Gammaridea sp. 3					6																									1								
Lysianassidae																							1															
Phoxocephalidae sp. 1									1					1	1										1	1			1			2			1			
Phoxocephalidae sp. 2																																1						
Phoxocephalidae sp. 3																																1						
Haustoriidae																														1				1				
Ampelisca chiltoni	1																																					
Cumacea																																						
Cyclaspis cf. *levis*					1											1				1																		
Cyclaspis sp. 1																1																						
Diastylopsis thileniusi									1																													
Decapoda																																						
Liocarcinus corrugatus					1													1								1			1						1			
Ebalia laevis													1											2	1													
Anomura																											1											
Paguridae					7	1						1	1				1						1			1												
Paguristes setosus	1																										1											

Taxa / Area	Inshore Between									Offshore																												
	Northern				Southern					Northern															Te Arai Point				Southern									
Sample number	121	3	9	17	44	67	106	73	72	118	13	12	116	22	21	20	30	29	113	28	36	35	34	40	41	49	48	47	110	57	56	55	63	107	70	69	77	76
Depth (m)	17	13	17	15	10	11	20	23	24	28	25	30	20	26	27	27	26	30	30	31	25	26	28	28	22	30	31	31	30	26	33	34	26	26	29	30	28	29
Isopoda																																						
Sphaeromatidae sp. 1	1																																					
Paranthura sp.					2		1								1								1							2				2			1	
Cirolanidae sp. 1				1																												1						
Isopoda undet.																												1										
Mysida																																						
Tenagomysis spp.							1													2																		
Stomatopoda																																						
Pariliacantha georgeorum									1																													
Ostracoda																																						
Myodocopida sp. 2					1																																	
Myodocopida undet.					3																																	
Pycnogonida																																						
Pycnogonida						1																																
Mollusca																																						
Polyplacophora																																						
Leptochiton inquinatus	1				14																																	
Gastropoda																																						
Zethalia zelandica						2														1													1					
Antisolarium egenum	2																						1			2								2				
Roseaplagis rufozona																																					1	
Solariella tryphenensis																								1	1													
Striacolpus pagoda																		1						1	1	1								2				
Rissoina fictor					2																																	
Pisinna semisulcata					1																																	
Sigapatella tenuis	4				5		1			1							1									4				4								
Cominella adspersa											1			1								1										2						
Cominella quoyana					2				1			1			1	2						2				3			1				1	2	2		3	
Xymenella pusillus					1																																	
Alcithoe arabica (juvenile)																	1																					
Peculator hedleyi																									1													
Amalda australis		1		2																																		
Amalda novaezelandiae								1	2				1																		1			2				
Phenatoma zealandicum														1																								
Antimelatoma buchanani maorum																									2													
Euterebra tristis	1					1																																
Pupa affinis						3		1	5												1																	
Philine sp.						1																																
Cylichna thetidis																														1								
Bivalvia																																						
Nucula nitidula	7				2	1	4		2	2			5	4		1					1	1			1		2											
Glycymeris modesta			1														2								1									2				
Pleuromeris latiuscula					1																																	
Pleuromeris paucicostata					1																																	
Purpurocardia purpurata																														1								
Pratulum pulchellum																																		1				
Athritica bifurcata	1																																					
Scalpomactra scalpellum									1																													
Gari convexa														1																								
Gari stangeri					3						1			1											1													
Hiatula nitida		1															3																					
Zemysina globus	1										1			1			1									1												
Tawera spissa					2																																	
Dosinia maoriana																	1						1						1	1							1	
Dosinia subrosea	2					1										1				1	1					1												
Corbula zelandica					6																			6														
Myadora boltoni	5			1		2			1		3	1									1						6	1				9						
Myadora striata	1					2						1															3	1				6						
Myadora subrostrata			1		1										2			1					1						1									
Hunkydora novozelandica			1																											1								
Bivalvia undet.										1																				1								
Echinodermata																																						
Ophiuroidea																																						
Amphiura aster					1																														1			1
Amphiura amokurae					1																																	
Echinoidea																																						
Fellaster zelandiae																															2					1		1
Apatopygus recens																1																						
Nematoda																																						
Nematoda					9																																	
Foraminifera																																						
Foraminifera	1																													3								
Bryozoa																																						
Selenaria concinna					1	1				3					4	6	2	2				4	4	1	3	1			1				9	1	9			
Bryozoa	1																													2					1		1	
Porifera																																						
Beige finger sponge					3										1		1	1						1						2				2				
Black sponge																													1									
Cnidaria																																						
Anthozoa																																						
Actiniaria	1																																					
Chordata																																						
Leptocardii																																						
Epigonichthys hectori	5			1	4				1	1							1			1						1				1				1	2			
Actinopterygii																																						
Limnichthys polyactis				1																																		1
Number of Species / taxa	23	4	4	8	36	12	8	8	13	7	6	5	7	10	9	10	14	8	0	7	6	6	10	6	14	14	7	5	8	19	2	12	5	16	10	2	7	3
Number of Individuals	45	4	4	9	117	35	28	16	39	15	12	9	20	22	22	21	21	10	0	9	13	15	14	12	23	32	15	56	24	41	3	27	31	29	20	2	15	3
Shannon - Wiener Diversity Index	2.86	1.39	1.39	2.04	3.20	1.74	1.36	1.65	2.00	1.68	1.54	1.30	1.44	1.79	1.73	2.02	2.53	2.03	0.00	1.89	1.29	1.53	2.14	1.47	2.34	2.10	1.68	0.36	1.17	2.74	0.64	2.06	1.07	2.56	1.87	0.69	1.68	1.10

Table A4.12 Benthic Infauna Retained in 1 mm screen samples from the Control area south of the proposed sand extraction areas, 2019 (Number per sample).

Taxa — Area	Inshore Between	Proposed New Consent Area (midshore)														Offshore	
	Control	Control														Control	
Sample number	103	104	80	101	79	102	78	86	85	84	92	91	90	96	95	83	89
Depth (m)	18	20	23	21	24	23	27	16	25	25	21	23	26	25	20	26	28
Annelida																	
Polychaeta																	
Terebellidae						1											
Ampharetidae								1				1					
?*Lanice* sp.			2														
Cirratulidae		1			1									3			
Eunicidae					1		1										
Goniadidae																	1
Nephtyidae									1								
Nereididae			1						1								
Phyllodocidae												1					
Sigalionidae	1															1	
Capitellidae												1					3
Armandia cf. maculata							1		1						2		
Maldanidae		2	4	2	2	3	6	1	2	1		4			3	3	
?Aricidea sp.							1	2									
Polychaeta undet.						1								1			
Nemertea																	
Nemertea										1							
Arthropoda																	
Malacostraca																	
Amphipoda																	
Gammaridea undet.				1			1										
Gammaridea sp. 2								1									
Gammaridea sp. 5		1											1				
Lysianassidae																	
Phoxocephalidae sp. 1	1			1	1			2				1	1		1	1	
Phoxocephalidae sp. 2													4				
Haustoriidae			1				1	1	1						1		
Liljeborgiidae		1										2			1		
Cumacea																	
Cyclaspis elegans			1									1			1		
Cyclaspis cf. levis	1							1									
Cyclaspis sp. 1													1				
Cyclaspis sp. 2								1									
Diastylopsis thileniusi								1									
Decapoda																	
Paguridae																1	
Isopoda																	
Sphaeromatidae sp. 1	1		1	2				1									
Cirolanidae sp. 1					1	1											
Mysida																	
Tenagomysis spp.	2							1							1		
Stomatopoda																	
Pariliacantha georgeorum					1												
Ostracoda																	
Leuroleberis zealandica	1				1	1						1					
Mollusca																	
Gastropoda																	
Cominella quoyana		1				1											1
Mesoginella larochei													1				
Amalda depressa												1					
Neoguraleus murdochi								1									
Pupa affinis							1									1	
Cylichna thetidis					1												
Bivalvia																	
Nucula nitidula				2		1							1				
Tawera spissa	2																
Myadora boltoni								1									
Myadora subrostrata												1					
Hunkydora novozelandica																	1
Echinodermata																	
Ophiuroidea																	
Amphiura aster						1							2				
Bryozoa																	
Selenaria concinna													1				
Chordata																	
Leptocardii																	
Epigonichthys hectori							1	3				2					1
Number of Species / taxa	7	5	6	5	8	8	8	14	5	2	0	11	8	2	7	5	5
Number of Individuals	9	6	10	8	9	10	13	18	6	2	0	16	12	4	10	7	7
Shannon - Wiener Diversity Index	1.89	1.56	1.61	1.56	2.04	1.97	1.74	2.55	1.56	0.69	0.00	2.25	1.91	0.56	1.83	1.48	1.48

Table A4.13 Benthic Infauna Retained in 3.15 mm screen samples from the Control area south of the proposed sand extraction areas, 2019 (Number per sample).

Taxa	Inshore Between	Proposed New Consent Area (midshore)														Offshore	
Area	Control	Control														Control	
Sample number	103	104	101	80	102	79	78	86	85	84	92	91	90	96	95	83	89
Depth (m)	18	20	21	23	23	24	27	16	25	25	21	23	26	25	20	26	28
Annelida																	
Polychaeta																	
?*Euchone* sp.																3	
Hydroides sp.							1				1						
Spionidae				1													
Paraprionospio pinnata																1	
Terebellidae															1		
Terebellidae		1									2					1	
Ampharetidae		4				1										1	
?*Lanice* sp.						1											
Cirratulidae		1													1	1	1
Eunicidae		1															
Lumbrineries sp.										1				2			
Onuphidae						1											
Nephtyidae						1											
?*Aglaophamus/Nephtys*								1									1
Phyllodoce sp. (Purple)			1														
Phyllodocidae																1	
Polynoidae																2	1
Sigalionidae		1			2			1				1				1	
Pelogenia antipoda																	1
Syllidae																4	
Capitellidae											1					5	
Cossuridae																1	
Orbiniidae																1	
Maldanidae	3	3	24	8	4	12	6	10	4	24			7		30	3	26
Travisia olens														1		1	
Scalibregmidae				1													
Polychaeta undet.	1	8								3					1	4	
Nemertea																	
Nemertea	1			1												2	
Arthropoda																	
Malacostraca																	
Amphipoda																	
Gammaridea undet.		3															
Gammaridea sp. 2		14															
Gammaridea sp. 3		18															
?Calliopiidae				1													
Phoxocephalidae sp. 1								1	1	2						1	
Phoxocephalidae sp. 2								1									
Liljeborgiidae															1	1	
Ampelisca chiltoni																	2
Cumacea																	
Cyclaspis sp. 2		1															
Diastylopsis thileniusi															1		
Decapoda																	
Callianassidae								1									
Processa sp.				1													
Anomura		2			1												
Paguridae		12							2		1						
Isopoda																	
Paranthura sp.		2			1												
Cirolanidae sp. 1															1		
Mysida																	
Tenagomysis spp.							1	1									
Stomatopoda																	
Pariliacantha georgeorum								1									
Tanaidacea																	
Tanaidacea																1	
Ostracoda																	
Myodocopida undet.		5															
Mollusca																	
Polyplacophora																	
Leptochiton inquinatus		4															
Gastropoda																	
Antisolarium egenum		1															
Roseaplagis rufozona		1															
Maoricolpus roseus		2															
Striacolpus pagoda		1															
Pisinna semisulcata		1															
Sigapatella tenuis		1			2										1	2	
Cominella quoyana	1	12						1		1	1						
Xymenella pusillus		1															
Amalda australis														2			
Amalda novaezelandiae							2								1		
Pupa affinis						3											
Cylichna thetidis						1											
Bivalvia																	
Nucula nitidula		6			3	1		1								7	
Pleuromeris latiuscula		2															
Purpurocardia purpurata		1															
Scalpomactra scalpellum								1									
Gari convexa						1			1								
Gari stangeri		4															
Zemysina globus									1								
Tawera spissa											2						
Dosinia maoriana																1	
Dosinia subrosea			1														
Myadora boltoni					1					2				1			
Myadora striata				1				1									1
Myadora subrostrata														1			
Bivalvia undet.														1			
Echinodermata																	
Ophiuroidea																	
Amphiura aster		2								1		2	1	1	1		
Echinoidea																	
Fellaster zelandiae												1					
Nematoda																	
Nematoda		2														7	
Foraminifera																	
Foraminifera											2					14	
Bryozoa																	
Selenaria concinna		6					8										
Bryozoa											1						
Porifera																	
Beige finger sponge											1						

Taxa / Area	Inshore Between	Proposed New Consent Area (midshore)														Offshore	
	Control	Control														Control	
Sample number	103	104	101	80	102	79	78	86	85	84	92	91	90	96	95	83	89
Depth (m)	18	20	21	23	23	24	27	16	25	25	21	23	26	25	20	26	28
Cnidaria																	
Anthozoa																	
Actiniaria																1	
Chordata																	
Leptocardii																	
Epigonichthys hectori		12				1		1							1	5	
Number of Species / taxa	4	32	3	7	7	10	5	13	5	7	9	3	2	7	11	26	7
Number of Individuals	6	135	26	14	14	23	18	22	9	34	12	4	8	9	40	72	33
Shannon - Wiener Diversity Index	1.24	3.01	0.32	1.45	1.81	1.70	1.29	2.04	1.43	1.10	2.14	1.04	0.38	1.89	1.14	2.86	0.89

Table A4.14 Epibenthic Macrofauna Retrieved in Dredge Tows, 2019.

Areas		Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	Density n	Density /100m²	Comments	Photo
Current Consent (Inshore)	Northern	5 m	35	31 Jan 19	235	152.8	Paddle Crab	*Ovalipes catharus*	30	1	0.65		
							Sand Dollar	*Fellaster zelandiae*	60	1	0.65		
			34	15 Apr 19	311	202.2	Isopod (with Kelp)	*Euidotea peronii*		1	0.49	Kelp dweller	
							Amphipod (with kelp)	Gammaridea	5 to 10	5	2.47	Kelp dweller	
							Hermit Crab	Paguridae	15, 25	2	0.99		
							Cartwright Shell	*Dicathais orbita*	15	1	0.49		
							Sand Dollar	*Fellaster zelandiae*	35 to 70	19	9.40	Lots of Seaweed present	
			33	15 Apr 19	336	218.4	Paddle Crab	*Ovalipes catharus*	30	1	0.46		
							Hermit Crab	Paguridae	15	1	0.46		
							Dosinia	*Dosinia subrosea*	25	1	0.46	Lots of Shell Hash	
							Olive Shell	*Amalda (B.) australis*	30	1	0.46		
							Wheel shell	*Zethalia zelandica*	5 to 15	7	3.21		
							Sand Dollar	*Fellaster zelandiae*	50 to 60	8	3.66		

Areas		Depth (m)	Tow Number	Date	Distance (m)	Area m^2	Common Name	Scientific Name	Size mm	n	Density $/100m^2$	Comments	Photo
Current Consent (inshore)	Northern	10 m	22	31 Jan 19	280	182	Nemertean (black)	Nemertea	70	1	0.55		
							Spiny Starfish (arm)	*Astropecten polyacanthus*		1	0.55	Shell Hash	
			23	31 Jan 19	275	178.8	Paddle Crab	*Ovalipes catharus*	20	1	0.56		
							Limpet (on shell)	*Sigapatella tenuis*	5	1	0.56		
			24	31 Jan 19	233	151.5	Nothing in Tow						
Current Consent (inshore)	Southern	5 m	32	15 Apr 19	310	201.5	Bamboo Worm	*Maldanidae*	40	1	0.50		
							Isopod (with Kelp)	*Euidotea peronii*	25	1	0.50		
							Amphipod (with kelp)	Gammaridea	10	2	0.99		
							Hermit Crab	Paguridae	20, 20	2	0.99		
							Dosinia	*Dosinia subrosea*	20, 25	2	0.99		
							Olive Shell	*Amalda (B.) australis*	30	1	0.50		
							Speckled Whelk	*Cominella adspersa*	35, 45	2	0.99		
							Sand Dollar	*Fellaster zelandiae*	15	1	0.50		
							Brittle Star	Ophiuroidea	60	1	0.50		
							Ulva Branches			2	0.99	Seaweed	
			31	15 Apr 19	274	178.1	Polychaete Tube		70	1	0.56	Empty tube	
							Hermit Crab	Paguridae	10	1	0.56		
							Silky Dosinia	*Dosinia subrosea*	35, 45	2	1.12		
							Myadora	*Myadora striata*	35	1	0.56		
							Sand Dollar	*Fellaster zelandiae*	15	1	0.56		
							Brittle Star	Ophiuroidea	100	1	0.56		
			30	15 Apr 19	296	192.4	Dosinia	*Dosinia subrosea*	30, 30	2	1.04		

Areas	Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	n	Density /100m²	Comments	Photo
						Sand Dollar	*Fellaster zelandiae*	20, 20, 70, 70	4	2.08		
Current Consent (inshore) Southern	10 m	25	31 Jan 19	272	176.8	Bamboo Worm	Maldanidae	30, 60	1	0.57		
						Paddle Crab	*Ovalipes catharus*	20, 20, 30	3	1.70		
						Hermit Crab	Paguridae	10	1	0.57		
						Speckled Whelk	*Cominella adspersa*	30	1	0.57		
		26	14 Feb 19	278	180.7	Hermit Crab	Paguridae	30	6	3.32		
						Speckled Whelk	*Cominella adspersa*	30	1	0.55		
						Spiny Starfish	*Astropecten polyacanthus*	100 to 200	7	3.87		
		27	14 Feb 19	228	148.2	Spiny Starfish	*Astropecten polyacanthus*	10	1	0.67		
						Sand Dollar	*Fellaster zelandiae*	50	1	0.67		

Areas		Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	Density n	Density /100m²	Comments	Photo
Current Consent (inshore)	Control	5 m	29	15 Apr 19	273	177.5	Polychaete		30 to 65	2	1.13		
							Paddle Crab	*Ovalipes catharus*	15	1	0.56		
							Silky Dosinia	*Dosinia subrosea*	40	1	0.56		
							Myadora	*Myadora striata*	20	1	0.56		
							Speckled Whelk	*Cominella adspersa*	35	1	0.56		
							Sand Dollar	*Fellaster zelandiae*	15, 20, 20	3	1.69		
							Brittle Star - arms	Ophiuroidea	80	1	0.56		
		10 m	28	14 Feb 19	252	163.8	Spiny Starfish	*Astropecten polyacanthus*	130	1	0.61		
Proposed New Consent Area (midshore)	Northern	15 m	21	31 Jan 19	258	167.7	Hermit Crab	Paguridae	30,20	15	8.94		
							Olive Shell	*Amalda (B.) australis*	30	1	0.60		
							Polychaete Tube		40	1	0.60	Empty tube	
							Gastropod (Knobbed)	*Austrofusus glans*	30	1	0.60		
							Gastropod (Speckled)	*Cominella adspersa*	20	1	0.60		
			20	31 Jan 19	312	202.8	Spiny Starfish	*Astropecten polyacanthus*	40	1	0.49		
							Speckled Whelk	*Cominella adspersa*	15	1	0.49		
							Isopod (with Kelp)	Isopoda			0.00		
			19	31 Jan 19	242	157.3	Nothing Present						

Areas	Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	n	Density /100m²	Comments	Photo
Proposed New Consent Area (midshore) Northern	20 m	8	31 Jan 19	206	133.9	Sponge – massive brown/orange	Porifera	100	1	0.75		
						Paddle Crab	*Liocarcinus corrugatus*	20	1	0.75		
						Crab	*Pilumnus novaezelandiae*	5, 10	2	1.49		
						Hermit Crab	Paguridae		1	0.75		
						Speckled Whelk	*Cominella adspersa*	25	1	0.75		
						Polychaete	Polychaeta		1	0.75		
		9	31 Jan 19	290	188.5	Nothing Present						
		10	31 Jan 19	323	209.95	Hermit Crab	*Paguristes setosus*	20, 40	2	0.95		
Proposed New Consent Area Northern	25 m	7	31 Jan 19	384	249.6	Scallops	*Pecten novaezelandiae*	70, 70, 90, 90, 95, 95	6	2.40		
						Hermit Crab	Paguridae	10 to 50	13	5.21		
							Paguristes setosus	30	2	0.80		
						Speckled Whelk	*Cominella adspersa*	30	1	0.40		
						Sponge red	Porifera	50	1	0.40		
						Bamboo Worm	Maldanidae		1	0.40		
		6	31 Jan 19	330	214.5	Horse Mussel	*Atrina zelandica*	40	1	0.47		

Areas		Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	n	Density /100m²	Comments	Photo
							Sea Slug	*Lamellaria ?ophione*	10	1	0.47		
							Hermit Crab	Paguridae		1	0.47		
							Trumpet Shell	*Ranella australasia*	70	1	0.47		
							Scallops	*Pecten novaezealandiae*	70	1	0.47		
							Starfish	*Astropecten polyacanthus*	200	1	0.47		
							Sponge	Red encrusting sponge	140	1	0.47		
			5	31 Jan 19	289	187.9	Scallops	*Pecten novaezelandiae*	50, 60, 80, 90	4	2.13		
							Hermit Crab	Paguridae	10 to 50	5	2.66		
							Bamboo Worm	Maldanidae	50	1	0.53		
							Dredge Oyster	*Ostrea chilensis*		1	0.53		
Proposed New Consent Area (midshore)	Southern	15 m	17	14 Feb 19	269	174.9	Spiny Starfish	*Astropecten polyacanthus*	120	3	1.72		
							Hermit Crab	Paguridae	20 to 50	13	7.43		
							Speckled Whelk	*Cominella adspersa*	20 to 30	6	3.43		
							Myadora	*Myadora striata*	25	1	0.57		
			18	31 Jan 19	165	107.25	Spiny Starfish	*Astropecten polyacanthus*	130	1	0.93	Lot of shell Hash	
							Speckled Whelk	*Cominella adspersa*	25,40,40	3	2.80		
							Hermit Crab	Paguridae	5,30,50,60	4	3.73		
							Myadora	*Myadora striata*	20	1	0.93		
			16	14 Feb 19	654	425.1	Spiny Starfish	*Astropecten polyacanthus*	130, 120	2	0.47		
							Hermit Crab	Paguridae	10 to 35	4	0.94		
							Polychaete Tube	Maldanidae		2	0.47	Broken (Empty)	

Areas	Depth (m)	Tow Number	Date	Distance (m)	Area m^2	Common Name	Scientific Name	Size mm	n	Density /100m²	Comments	Photo
						Morning Star	*Tawera spissa*	25	1	0.24		
						Speckled Whelk	*Cominella adspersa*	30 to 45	4	0.94		
						Ostrich Foot Shell	*Struthiolaria papulosa*	60	1	0.24		
						Horse Mussel	*Atrina zelandica*	40	1	0.24		
						Bamboo Worm	Maldanidae	40, 60	2	0.47		
		11	31-Jan-19	298	193.7	Hermit Crab	Paguridae	5 to 50	22	11.36		
						Bamboo Worm	Maldanidae	30	1	0.52		
						Speckled Whelk	*Cominella adspersa*	40	1	0.52		
						Olive Shell	*Amalda (B.) australis*	20	1	0.52		
						Bivalve	*Scalpomactra scalpellum*	15	1	0.52		
						Spiny Starfish	*Astropecten polyacanthus*	100 - 150	8	4.13		
						Starfish	*Luidia maculata*	250	1	0.52		
						Ostrich Foot Shell	*Struthiolaria papulosa*	70	1	0.52		
						Tube Worms (clump)	Terebellidae	50	1	0.52		
						Polychaete	Polychaeta	100	1	0.52		
		12	14-Feb-19	352	228.8	Paddle Crab	*Ovalipes catharus*	30	1	0.44		
						Spiny Starfish	*Astropecten polyacanthus*	200	1	0.44		
						Ostrich Foot Shell	*Struthiolaria papulosa*	65, 45	2	0.87		
						Hermit Crab	Paguridae	25 - 40	6	2.62		
						Hermit Crab	*Paguristes setosus*	25	1	0.44		
						Silky Dosinia	*Dosinia subrosea*	25	1	0.44		
						Horse Mussel	*Atrina zelandica*	50	1	0.44		
						Polychaete		60	1	0.44	Empty tube	
						Red Sponge (on hermit crab)	Porifera	40	1	0.44		
						Bamboo Worm	Maldanidae	50	1	0.44		
		13	14-Feb-19	245	159.25	Hermit Crab	Paguridae	30 - 50	6	3.77		

Areas	Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	n	Density /100m²	Comments	Photo
						Polychaete Tube		50	5	3.14	Empty tube	
						Speckled whelk	*Cominella adspersa*	25	1	0.63		
						Small speckled whelk	*Cominella quoyana*	20	1	0.63		
						White shelled slug	*Philine* sp.	20	1	0.63		
						Notomithrax Crab	*Notomithrax minor*	20	1	0.63		
						Dwarf Paddle Crab	*Liocarcinus corrugatus*	20	1	0.63		
						Large beige sponge	Porifera	100	1	0.63		
						Bryozoan Colony (on driftwood)	Bryozoa	5	1	0.63		
						Bamboo Worm	Maldanidae	45	1	0.63		
		4	31-Jan-19	388	252.2	Speckled Whelk	*Cominella adspersa*	40	1	0.40		
						Hermit Crab	Paguridae	10	1	0.40		
						Cockle	*Purpurocardia purpurata*		1	0.40		
						Pink Chiton	*Rhyssoplax canaliculata*	10	1	0.40		
		3	14-Feb-19	519	337.35	Bryozoan Disc	*Selenaria concinna*	20	1	0.30		
						Speckled Whelk	*Cominella adspersa*	25	1	0.30		
						Polychaete Worm	Polychaeta	10	1	0.30		
						Hermit Crab	Paguridae	15	1	0.30		
						Sunset shell	*Gari convexa*	25	1	0.30		
						Polychaete Tube		80	1	0.30	Empty tube	
						Gastropod	*Zeatrophon mortenseni*	5	1	0.30		

Areas	Depth (m)	Tow Number	Date	Distance (m)	Area m²	Common Name	Scientific Name	Size mm	n	Density /100m²	Comments	Photo
						Orange Finger Sponge	Porifera	30	1	0.30		
		2	14-Feb-19	598	388.7	Notomithrax Crab	*Notomithrax minor*	15	1	0.26		
						Bryozoan Colony (Tree like)	Bryozoa	65	2	0.51		
						Bryozoan Disc	*Selenaria concinna*	5	1	0.26		
						Polychaete Worm		40	2	0.51		
Control		15	14-Feb-19	321	208.65	Spiny Starfish	*Astropecten polyacanthus*	130, 120	2	0.96		
						Bamboo Worm	Maldanidae	60	2	0.96	Shell Hash present	
						Black nemertean	Nemertea	20	1	0.48		
						Speckled Whelk	*Cominella adspersa*	30 to 35	3	1.44		
						Hermit Crab	Paguridae	30, 60	2	0.96		
		14	14-Feb-19	356	231.4	Hermit Crab	Paguridae	5 to 60	7	3.03		
						Scallops	*Pecten novaezealandiae*	110	1	0.43		
						Spiny Starfish	*Astropecten polyacanthus*	150	1	0.43		
						Olive Shell	*Amalda (B.) australis*	25	1	0.43		
						Dwarf Paddle Crab	*Liocarcinus corrugatus*	10	1	0.43		

Areas	Depth (m)	Tow Number	Date	Distance (m)	Area m^2	Common Name	Scientific Name	Size mm	Density n	Density /100m²	Comments	Photo
						Speckled Whelk	*Cominella adspersa*	30	1	0.43	Also eggs	
						Red Polychaete	Eunicida	70	1	0.43		
						Black nemertean	Nemertea	70	1	0.43		
						Knob Whelk	*Austrofusus glans*	35	1	0.43		
						Bivalve	*Myadora striata*	25	1	0.43		
		1	14-Feb-19	379	246.35	Hermit Crab	Paguridae	20 or less	4	1.62		
						Bamboo Worm	Maldanidae	30-60	5	2.03	Mostly empty tubes	
						Speckled Whelk	*Cominella adspersa*	30	1	0.41		

Appendix 5 Macrofauna Survivorship

Table A5.15 Numbers of live macrofauna passing through the dredge head (William Fraser) sorted by site and degree of damage, February 2020.

Depth	Site	Species	Damage		
			Intact	Sub Lethal	Lethal
10 m	10A	*Myadora striata*	74	8	1
		Dosinia sp.	32	3	7
		Tawera spissa	8		
		Cominella adspersa	1		
		Amalda australis	1		
		Sigapatella sp.	2		
		Crab	1		
		Pagurus	7		
	10B	*Myadora striata*	379	14	8
		Dosinia sp.	125	3	28
		Tawera spissa	11		1
		Scalpomactra scalpellum	1		
		Cominella adspersa	1	1	
		Sigapatella sp.	1		
		Crab	1		
		Pagurus	4		
		Annelids	2	1	
	10C	*Myadora striata*	118	4	2
		Dosinia sp.	62	2	13
		Bassina yatei	1		
		Cominella adspersa	1		
		Sigapatella sp.	1		
		Crab	2		
		Pagurus	2	2	
	10D	*Myadora striata*	105	3	
		Dosinia sp.	37		10
		Bassina yatei	1		
		Gari lineolata	1		1
		Cominella adspersa	2		
		Amalda australis	2		
		Pagurus	2		
		Annelids			3
	10E	*Myadora striata*	141	2	1
		Dosinia sp.	77	2	29
		Tawera spissa	3		
		Gari lineolata			1
		Cominella adspersa	3		
		Amalda australis	3		
		Crab	2		
		Pagurus	2		
25 m	25A	*Dosinia* sp.	10		
		Purpurocardia purpurata	2		
		Notocallista multistriata	8		
		Scalpomactra scalpellum	2		
		Pratulum pulchellum	6		
		Sigapatella sp.	7		
		Stiracolpus pagoda	2		
		Austrofusus glans	1		
		Cominella quoyana	19		
		Crabs		6	
		Starfish		1	
		Annelids		3	
25 m	25B	*Dosinia* sp.	11		
		Purpurocardia purpurata	6		
		Notocallista multistriata	1		
		Pratulum pulchellum	4		
		Gari lineolata	1		
		Pecten novaezelandiae	1		
		Sigapatella sp.	2		
		Cominella quoyana	11		
		Struthiolaria papulosa	1		
		Crabs	3		
		Pagurus	1		
		Mantis shrimp	1		
		Starfish	3		
		Annelid	1		
		Synodus sp.	1		
	25C	*Dosinia* sp.	12		1
		Purpurocardia purpurata	4		
		Notocallista multistriata	1		
		Pratulum pulchellum	2		
		Sigapatella sp.	1		
		Cominella quoyana	14		
		Xenophalium sp.	1		
		Amalda australis	1		
		Pagurus	1		
		Mantis shrimp			1
		Barnacle	1		
		Annelid			1
	25D	*Dosinia* sp.	10		
		Notocallista multistriata	1		
		Pratulum pulchellum			1
		Divalucina cumingi	1		
		Semele sp.			2
		Gari lineolata	2		4
		Nucula sp.	1		
		Austrofusus glans	1		
		Cominella adspersa	1		
		Cominella quoyana	15		
		Crab	1		
		Pagurus	1	1	
		Mantis shrimp	1		
		Starfish	1		1
		Annelids			2
	25E	*Dosinia* sp.	7		
		Myadora striata	2		
		Tawera spissa	1		
		Purpurocardia purpurata	9		
		Semele sp.			1
		Nucula sp.	1		
		Struthiolaria vermis	1		
		Cominella quoyana	10		
		Sigapatella sp.	14		
		Crab	5		
		Mantis shrimp	1		1
		Pagurus		1	
		Synodus sp.	1		
		Muraenichthys beviceps	1		
		Branchiostoma	3		

Table A5.16 Sizes of live macrofauna passing through the dredge head (William Fraser) at 10 m depth sorted by degree of damage, February 2020

Taxonomy	Species	Average size (mm)			Range (mm)		
		Damage			Damage		
		Intact	Sub Lethal	Lethal	Intact	Sub Lethal	Lethal
Gastropods	*Amalda australis*	20			[14-25]		
	Cominella adspersa	31	36		[23-39]	-	
Bivalves	*Bassina yatei*	18			[17-18]		
	Dosinia sp.	17	20	24	[6-40]	[6-34]	[10-38]
	Gari lineolata	19		18			
	Myadora striata	18	18	19	[10-33]	[13-26]	[12-26]
	Scalpomactra scalpellum	14					
	Tawera spissa	9			[6-17]		
Crustaceans	Crabs	17			[15-20]		

Table A5.17 Sizes of live macrofauna passing through the dredge head (William Fraser) at 25 m depth sorted by degree of damage, February 2020

Taxonomy	Species	Average size (mm)			Range (mm)		
		Damage			Damage		
		Intact	Sub Lethal	Lethal	Intact	Sub Lethal	Lethal
Gastropods	*Amalda australis*	26			-		
	Austrofusus glans	28			[20-35]		
	Cominella adspersa	17			-		
	Cominella quoyana	17			[13-19]		
	Stiracolpus pagoda	20			[16-24]		
	Struthiolaria papulosa	62			-		
	Struthiolaria vermis	48			-		
	Xenophalium sp.	33			-		
Bivalves	*Divalucina cumingi*	11			[10-19]		
	Dosinia sp.	16		14	[9-30]		-
	Gari lineolata	24		25	[15-30]		[20-28]
	Myadora striata	15			[14-15]		
	Notocallista multistriata	19			[17-22]		
	Nucula sp.	7			-		
	Pecten novaezelandiae	12					
	Pratulum pulchellum	15		17			-
	Scalpomactra scalpellum	19			[18-19]		
	Semele sp.			10			[10-12]
	Tawera spissa	15					
	Purpurocardia purpurata	21			[10-30]		
Crustaceans	Crabs	10	9		[6-16]	[6-15]	
	Mantis shrimp	29			[24-36]		
Echinoderm	Starfish	15	18	22	[14-22]		
Fish	*Muraenichthys beviceps*	268			-		
	Synodus sp.	39			[37-40]		
Lancelet	*Branchiostoma*	40			[27-50]		

Table A5.18 Photographic records of live macrofauna after passing through the dredge head sorted by site and degree of damage, February 2020.

Site	Intact	Sub Lethal Damage	Lethal Damage
10A			
10B			

<table>
<tr><th>Site</th><th>Intact</th><th>Sub Lethal Damage</th><th>Lethal Damage</th></tr>
<tr><td>10C</td><td>
</td><td></td><td>
</td></tr>
<tr><td>10D</td><td>
</td><td></td><td></td></tr>
</table>

Site	Intact	Sub Lethal Damage	Lethal Damage
10E			
25A			

Site	Intact	Sub Lethal Damage	Lethal Damage
25B			
25C			

Site	Intact	Sub Lethal Damage	Lethal Damage
25D			
25E			

Appendix 6 Statistical Results - Infauna

Univariate Statistics

Table A6.19 One Way Analysis of Variance of Number of Taxa from 1 mm Screen between Alongshore areas in the proposed Midshore consent

Dependent Variable: Number of Taxa
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Northern	48	0	3.000	1.500	5.000
Southern	36	0	4.000	2.500	5.500
Control	27	0	5.000	2.250	8.000
Te Arai	7	0	6.000	2.000	6.750

H = 5.864 with 3 degrees of freedom. (P = 0.118)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.118)

Table A6.20 One Way Analysis of Variance of Number of Individuals from 1 mm Screen between Alongshore areas in the proposed Midshore consent

Dependent Variable: Number of individuals
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Northern	48	0	4.000	2.000	7.000
Southern	36	0	6.000	3.000	8.000
Control	27	0	7.000	3.250	10.000
Te Arai	7	0	7.000	2.250	11.750

H = 3.710 with 3 degrees of freedom. (P = 0.295)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.295)

Table A6.21 One Way Analysis of Variance of Shannon – Weiner Diversity from 1 mm Screen between Alongshore areas in the proposed Midshore consent

Dependent Variable: Shannon-Weiner Diversity index
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Northern	48	0	1.099	0.281	1.585
Southern	36	0	1.331	0.822	1.647
Control	27	0	1.561	0.795	1.875
Te Arai	7	0	1.673	0.369	1.827

H = 5.867 with 3 degrees of freedom. (P = 0.118)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.118)

Table A6.22 One Way Analysis of Variance of Number of Taxa from 3.15 mm Screen between Alongshore areas in the proposed Midshore consent

Dependent Variable: Number of Taxa
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Northern	48	0	7.000	5.000	10.000
Southern	36	0	8.000	5.000	13.000
Control	27	0	7.000	3.000	10.750
Te Arai	7	0	9.000	7.500	13.250

H = 3.922 with 3 degrees of freedom. (P = 0.270)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.270)

Table A6.23 One Way Analysis of Variance of Number of Individuals from 3.15 mm Screen between Alongshore areas in the proposed Midshore consent

Dependent Variable: Number of individuals
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Northern	48	0	15.000	9.000	21.500
Southern	36	0	20.000	13.500	33.000
Control	27	0	17.000	8.250	25.250
Te Arai	7	0	21.000	16.250	29.750

H = 7.491 with 3 degrees of freedom. (P = 0.058)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.058)

Table A6.24 One Way Analysis of Variance of Shannon- Weiner Diversity from 3.15 mm Screen between Alongshore areas in the proposed Midshore consent

Dependent Variable: Shannon-Weiner Diversity index
Normality Test: Passed (P = 0.337)
Equal Variance Test: Passed (P = 0.394)

Group Name	N	Missing	Mean	Std Dev	SEM
Northern	48	0	1.620	0.694	0.100
Southern	36	0	1.756	0.832	0.139
Control	27	0	1.489	0.716	0.138
Te Arai	7	0	1.809	0.677	0.256

Source of Variation	DF	SS	MS	F	P
Between Groups	3	1.318	0.439	0.796	0.499
Residual	114	62.938	0.552		
Total	117	64.256			

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.499).

Table A6.25 One Way Analysis of Variance of Number of Taxa from 1 mm Screen between Consent areas

Dependent Variable: Number of Taxa
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Current	30	0	2.000	1.000	6.000
Between	10	0	6.500	4.000	9.000
Proposed	47	0	5.000	3.000	6.750
Offshore	31	0	3.000	2.000	5.000

H = 12.722 with 3 degrees of freedom. (P = 0.005)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.005)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
Between vs Current	37.383	2.993	Yes
Between vs Offshore	31.903	2.564	No
Between vs Proposed	17.862	1.499	Do Not Test
Proposed vs Current	19.522	2.442	No
Proposed vs Offshore	14.042	1.774	Do Not Test
Offshore vs Current	5.480	0.626	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table A6.26 One Way Analysis of Variance of Number of Individuals from 1 mm Screen between Consent areas

Dependent Variable: Number of individuals
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Current	30	0	4.000	1.000	8.000
Between	10	0	10.000	7.000	13.000
Proposed	47	0	6.000	3.250	8.000
Offshore	31	0	4.000	2.000	7.000

H = 12.486 with 3 degrees of freedom. (P = 0.006)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.006)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
Between vs Current	39.483	3.161	Yes
Between vs Offshore	38.026	3.057	Yes
Between vs Proposed	25.789	2.165	No
Proposed vs Current	13.694	1.713	No
Proposed vs Offshore	12.236	1.546	Do Not Test
Offshore vs Current	1.458	0.166	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table A6.27 One Way Analysis of Variance of Shannon- Weiner Diversity from 1 mm Screen between Consent areas

Dependent Variable: Shannon-Weiner Diversity index
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Current	30	0	0.665	0.000	1.667
Between	10	0	1.691	1.352	2.084
Proposed	47	0	1.475	0.985	1.792
Offshore	31	0	1.099	0.651	1.475

H = 12.067 with 3 degrees of freedom. (P = 0.007)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.007)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
Between vs Current	35.083	2.809	Yes
Between vs Offshore	29.832	2.398	No
Between vs Proposed	15.172	1.274	Do Not Test
Proposed vs Current	19.911	2.491	No
Proposed vs Offshore	14.660	1.852	Do Not Test
Offshore vs Current	5.251	0.599	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Table A6.28 One Way Analysis of Variance of Number of Taxa from 3.15 mm Screen between Consent areas

Dependent Variable: Number of Taxa
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Current	30	0	7.500	3.000	10.000
Between	10	0	8.000	4.000	13.000
Proposed	47	0	7.000	5.000	12.000
Offshore	31	0	7.000	6.000	10.000

H = 2.117 with 3 degrees of freedom. (P = 0.548)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.548)

Table A6.29 One Way Analysis of Variance of Number of Individuals from 3.15 mm Screen between Consent areas

Dependent Variable: Number of individuals
Normality Test: Failed (P < 0.050)

Kruskal-Wallis One Way Analysis of Variance on Ranks

Group	N	Missing	Median	25%	75%
Current	30	0	16.500	8.000	26.000
Between	10	0	22.000	6.000	39.000
Proposed	47	0	16.000	9.000	22.750
Offshore	31	0	20.000	12.000	26.250

H = 0.767 with 3 degrees of freedom. (P = 0.857)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.857)

Table A6.30 One Way Analysis of Variance of Shannon- Weiner Diversity from 3.15 mm Screen between Consent areas

Dependent Variable: Shannon-Weiner Diversity index
Normality Test: Passed (P = 0.713)
Equal Variance Test: Passed (P = 0.456)

Group Name	N	Missing	Mean	Std Dev	SEM
Current	30	0	1.514	0.809	0.148
Between	10	0	1.886	0.664	0.210
Proposed	47	0	1.688	0.755	0.110
Offshore	31	0	1.619	0.680	0.122

Source of Variation	DF	SS	MS	F	P
Between Groups	3	1.208	0.403	0.728	0.537
Residual	114	63.048	0.553		
Total	117	64.256			

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.537).

Multivariate Statistics

Table A6.31 ANOSIM - Analysis of Similarities by Consent Areas, 3.15 mm Screen

Consent levels
Inshore
Midshore
Inshore between
Offshore

Tests for differences between unordered Consent groups
Global Test Sample statistic (R): 0.317
Significance level of sample statistic: **0.1%**
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level (%)
Inshore, Midshore	0.451	**0.1**
Inshore, Inshore between	-0.028	64
Inshore, Offshore	0.44	**0.1**
Midshore, Inshore between	0.132	10.9
Midshore, Offshore	0.192	**0.1**
Inshore between, Offshore	0.413	**0.1**

Table A6.32 SIMPER - Similarity Percentages - species contributions by consent areas, 3.15 mm Screen

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Group Inshore Average similarity: 11.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Fellaster zelandiae	0.28	1.64	0.23	14.59	14.59
Myadora boltoni	0.43	1.45	0.35	12.84	27.43
Epigonichthys hectori	0.39	1.23	0.30	10.89	38.32
Zethalia zelandica	0.45	1.15	0.18	10.19	48.51
Dosinia subrosea	0.25	0.85	0.22	7.51	56.01
Maldanidae	0.29	0.79	0.22	7.04	63.05
Amphiura aster	0.21	0.73	0.19	6.50	69.56
Myadora striata	0.30	0.62	0.23	5.48	75.04

Group Midshore Average similarity: 24.77

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Maldanidae	1.51	15.53	1.69	62.70	62.70
Cominella quoyana	0.36	1.16	0.33	4.69	67.38
Selenaria concinna	0.38	1.11	0.28	4.48	71.86

Group Offshore Average similarity: 23.83

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Maldanidae	1.16	5.82	0.94	24.44	24.44
Selenaria concinna	0.63	2.14	0.54	8.97	33.41
Striacolpus pagoda	0.56	1.52	0.50	6.37	39.79
Epigonichthys hectori	0.58	1.18	0.50	4.94	44.72
Cominella quoyana	0.56	1.15	0.45	4.84	49.56
Sigapatella tenuis	0.52	1.11	0.46	4.65	54.22
Paranthura sp.	0.42	0.94	0.38	3.95	58.17
Phoxocephalidae sp. 1	0.39	0.90	0.34	3.76	61.93
Porifera	0.46	0.81	0.37	3.40	65.33
Nucula nitidula	0.54	0.77	0.38	3.22	68.54
Antisolarium egenum	0.36	0.74	0.31	3.10	71.65

Groups Inshore & Midshore Average dissimilarity = 90.62
(only more than 2% of dissimilarities is displayed)

	Group					
	Inshore	Midshore				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Maldanidae	0.29	1.51	10.21	1.51	11.26	11.26
Zethalia zelandica	0.45	0.04	3.83	0.47	4.23	15.49
Myadora boltoni	0.43	0.23	3.61	0.76	3.98	19.47
Epigonichthys hectori	0.39	0.19	3.11	0.72	3.43	22.91
Selenaria concinna	0.00	0.38	2.85	0.58	3.14	26.05
Nucula nitidula	0.13	0.39	2.84	0.71	3.13	29.18
Fellaster zelandiae	0.28	0.00	2.71	0.51	2.99	32.17
Cominella quoyana	0.03	0.36	2.64	0.66	2.91	35.09
Myadora striata	0.30	0.18	2.59	0.67	2.85	37.94
Dosinia subrosea	0.25	0.11	2.44	0.58	2.69	40.63
Phoxocephalidae 1	0.16	0.24	2.35	0.61	2.59	43.22
Amphiura aster	0.21	0.11	2.26	0.54	2.49	45.71
Sigalionidae	0.07	0.27	2.23	0.60	2.46	48.18
Paguridae	0.07	0.32	2.16	0.60	2.39	50.56

Groups Midshore & Offshore Average dissimilarity = 79.47
(only more than 2% of dissimilarities is displayed)

	Group					
	Midshore	Offshore				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Maldanidae	1.51	1.16	3.57	0.92	4.50	4.50
Selenaria concinna	0.38	0.63	3.29	0.94	4.14	8.63
Cominella quoyana	0.36	0.56	2.58	0.90	3.25	11.88
Striacolpus pagoda	0.07	0.56	2.55	0.85	3.21	15.10
Nucula nitidula	0.39	0.54	2.54	0.89	3.20	18.29
Sigapatella tenuis	0.26	0.52	2.36	0.88	2.97	21.26
Epigonichthys hectori	0.19	0.58	2.27	0.92	2.86	24.12
Phoxocephalidae 1	0.24	0.39	2.22	0.77	2.80	26.92
Paguridae	0.32	0.47	2.21	0.85	2.79	29.70
Sigalionidae	0.27	0.39	2.02	0.78	2.54	32.24

Table A6.33 ANOSIM - Analysis of Similarities by Consent Areas, 1 mm Screen

Consent levels
Inshore
Midshore
Inshore between
Offshore

Tests for differences between unordered Consent groups
Global Test Sample statistic (R): 0.092
Significance level of sample statistic**: 0.8%**
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 7

Pairwise Tests

Groups	R Statistic	Significance Level %
Midshore, Inshore between	0.05	29
Midshore, Inshore	0.204	**0.3**
Midshore, Offshore	0.003	42.3
Inshore between, Inshore	-0.042	70.4
Inshore between, Offshore	0.066	20.3
Inshore, Offshore	0.2	**0.1**

Table A6.34 SIMPER - Similarity Percentages - species contributions by consent areas, 1 mm Screen

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Group Inshore Average similarity: 18.79

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Phoxocephalidae 1	0.65	5.91	0.65	31.44	31.44
Gammaridea	0.36	2.29	0.32	12.16	43.60
Epigonichthys hectori	0.50	2.00	0.42	10.66	54.26
Cirolanidae	0.35	1.69	0.34	8.97	63.23
Haustoriidae	0.41	1.63	0.35	8.68	71.91

Group Midshore Average similarity: 21.91

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Maldanidae	0.88	13.85	0.95	63.20	63.20
Phoxocephalidae 1	0.37	2.05	0.33	9.36	72.56

Group Offshore Average similarity: 22.79

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Maldanidae	0.84	15.04	0.88	66.00	66.00
Phoxocephalidae 1	0.41	3.00	0.40	13.18	79.18

Groups Midshore & Inshore Average dissimilarity = 84.46
(only more than 2% of dissimilarities is displayed)

	Group					
	Midshore	Inshore				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Maldanidae	0.88	0.33	8.11	1.08	9.60	9.60
Phoxocephalidae 1	0.37	0.65	6.15	0.96	7.28	16.88
Epigonichthys hectori	0.27	0.50	4.74	0.88	5.61	22.49
Gammaridea	0.07	0.36	4.29	0.62	5.08	27.57
Haustoriidae	0.16	0.41	3.98	0.79	4.71	32.28
Cyclaspis	0.25	0.28	3.68	0.73	4.36	36.64
Sphaeromatidae	0.22	0.22	3.68	0.59	4.36	41.00
Armandia maculata	0.21	0.27	3.61	0.66	4.28	45.28
Cirolanidae 1	0.10	0.35	3.61	0.72	4.28	49.55
Cirratulidae	0.18	0.13	2.80	0.48	3.31	52.87
Nucula nitidula	0.09	0.25	2.70	0.57	3.20	56.07
Phoxocephalidae 2	0.13	0.13	2.60	0.47	3.08	59.15
Tenagomysis sp.	0.14	0.18	2.47	0.57	2.92	62.07
Phoxocephalidae 3	0.03	0.24	2.02	0.55	2.39	64.46

Groups Midshore & Offshore Average dissimilarity = 77.76
(only more than 2% of dissimilarities is displayed)

	Group					
	Midshore	Offshore				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Maldanidae	0.88	0.84	6.10	0.96	7.84	7.84
Phoxocephalidae1	0.37	0.41	5.58	0.86	7.17	15.01
Cirratulidae	0.18	0.29	4.67	0.65	6.01	21.03
Epigonichthys hectori	0.27	0.31	4.50	0.74	5.78	26.81
Cyclaspis	0.25	0.08	2.79	0.60	3.59	30.39
Liljeborgiidae	0.12	0.19	2.66	0.53	3.43	33.82
Sphaeromatidae	0.22	0.05	2.38	0.51	3.06	36.88
Armandia maculata	0.21	0.00	2.17	0.48	2.80	39.68
Haustoriidae	0.16	0.08	2.05	0.48	2.64	42.32
Selenaria concinna	0.11	0.10	2.02	0.44	2.59	44.91

Table A6.35 ANOSIM - Analysis of Similarities by alongshore areas, 3.15 mm Screen

Alongshore levels within Midshore samples
North
Te Arai
South
Control

Tests for differences between unordered Alongshore groups
Global Test Sample statistic (R): 0.059
Significance level of sample statistic: 9.8%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 97

Table A6.36 ANOSIM - Analysis of Similarities by alongshore areas, 1 mm Screen

Alongshore levels
North
Te Arai
South
Control

Tests for differences between unordered Alongshore groups
Global Test
Sample statistic (R): -0.006
Significance level of sample statistic: 54%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 539

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Appendix 7 Statistical Results - Epibenthic macrofauna

Multivariate analysis

Table A7.37 ANOSIM - Analysis of Similarities by Consent Areas, tow

Consent levels
Midshore
Inshore

Tests for differences between unordered Consent groups
Global Test Sample statistic (R): 0.366
Significance level of sample statistic: **0.1%**
Number of permutations: 999 (Random sample from 347373600)
Number of permuted statistics greater than or equal to R: 0

Table A7.38 SIMPER - Similarity Percentages - species contributions by Consent Areas, tow

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Group Midshore Average similarity: 30.89

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Paguristes setosus	1.08	14.91	1.32	48.26	48.26
Cominella adspersa	0.65	7.72	0.85	24.98	73.24

Group Inshore Average similarity: 23.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Fellaster zelandiae	0.69	8.37	0.66	35.88	35.88
Astropecten polyacanthus	0.31	3.66	0.27	15.67	51.56
Paguristes setosus	0.45	3.31	0.47	14.17	65.73
Ovalipes catharus	0.35	3.13	0.35	13.42	79.14

Groups Midshore & Inshore Average dissimilarity = 83.01
(only more than 2% of dissimilarities is displayed)

	Group					
	Midshore	Inshore				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Paguristes setosus	1.08	0.45	10.53	1.17	12.68	12.68
Fellaster zelandiae	0.00	0.69	8.13	1.04	9.80	22.48
Cominella adspersa	0.65	0.28	7.43	1.06	8.95	31.43
Astropecten polyacanthus	0.46	0.31	6.72	0.90	8.09	39.52
Ovalipes catharus	0.04	0.35	4.67	0.71	5.63	45.14
Maldanidae	0.32	0.13	4.05	0.77	4.87	50.02
Dosinia subrosea	0.04	0.36	4.04	0.72	4.87	54.89
Porifera	0.22	0.00	2.77	0.53	3.34	58.22
Pecten novaezelandiae	0.22	0.00	2.61	0.48	3.14	61.36
Myadora striata	0.14	0.13	2.56	0.56	3.08	64.45
Amalda (B.) australis	0.13	0.13	2.13	0.56	2.56	67.01
Polychaeta	0.14	0.08	2.01	0.50	2.42	69.43

Table A7.39 ANOSIM - Analysis of Similarities by Alongshore Areas, tow

Alongshore levels
Control
South
North

Tests for differences between unordered Alongshore groups
Global Test Sample statistic (R): 0.123
Significance level of sample statistic: **4.7%**
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 46

Pairwise Tests

Groups	R Statistic	Significance Level %
Control, South	0.216	7.4
Control, North	-0.077	72.1
South, North	0.146	**2.1**

Table A7.40 SIMPER - Similarity Percentages - species contributions by Alongshore Areas, tow

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Group North Average similarity: 13.98

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Paguristes setosus	0.62	6.18	0.64	44.19	44.19
Cominella adspersa	0.29	2.11	0.30	15.10	59.29
Astropecten polyacanthus	0.21	1.78	0.21	12.70	71.99

Group South Average similarity: 33.84

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Paguristes setosus	1.11	15.58	1.43	46.05	46.05
Cominella adspersa	0.65	6.83	0.82	20.20	66.25
Astropecten polyacanthus	0.50	3.68	0.47	10.86	77.11

Groups South & North Average dissimilarity = 78.87
(only more than 2% of dissimilarities is displayed)

	Group					
	South	North				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Paguristes setosus	1.11	0.62	9.72	1.16	12.32	12.32
Cominella adspersa	0.65	0.29	6.95	1.09	8.81	21.13
Astropecten polyacanthus	0.50	0.21	6.52	0.92	8.26	29.39
Fellaster zelandiae	0.25	0.34	5.99	0.74	7.59	36.98
Maldanidae	0.46	0.00	4.95	0.97	6.28	43.26
Ovalipes catharus	0.13	0.22	3.92	0.62	4.97	48.23
Dosinia subrosea	0.26	0.07	3.55	0.58	4.50	52.74
Pecten novaezelandiae	0.00	0.27	3.00	0.55	3.80	56.54
Myadora striata	0.18	0.00	2.27	0.48	2.88	59.42
Porifera	0.17	0.08	2.22	0.56	2.82	62.24
Amalda (B.) australis	0.11	0.14	2.10	0.56	2.67	64.90