Boffa Miskell

Kaiwharawhara Wellington Ferry Terminal

Assessment of Effects on Benthic Marine Ecology
Prepared for KiwiRail

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Executive Summary

This report assesses the potential adverse effects on benthic marine ecology from construction and operation from the redevelopment of the existing Interislander ferry terminal at Kaiwharawhara, Wellington.

Existing marine ecology data from sites adjacent to the Project were sourced from the Ministry for Primary Industries, CentrePort, Greater Wellington Regional Council, Maritime New Zealand and scientific literature.

Field surveys were focussed on the key areas where reclamation and occupation of the coastal marine area were proposed. Intertidal and subtidal surveys were undertaken by a dive team, collecting samples and data for benthic community composition, sediment contaminants, sediment grain size, redox depth, epifauna and macroalgae.

In New Zealand, no regional or national guidelines or criteria for the assessment of marine ecological values have been developed to date.[1] Nevertheless, in the absence of such guidelines, Boffa Miskell have adopted the EIANZ guidelines (Roper-Lindsay et al., 2018) approach and adapted it to assess marine ecological value using a suite of factors relating to abundance, diversity and benthic invertebrate species richness, sediment grain size composition, and sediment contaminant concentrations. Threat status of benthic invertebrate species present is also considered (Freeman et al., 2014). This approach has been used and accepted in previous Board of Inquiry and Environment Court consenting processes for major infrastructure projects[2].

The order of priority for ecological impact management we have applied to this assessment has followed the effects management hierarchy as described in Roper-Lindsay et al. (2018) and Maseyk et al. (2018).

The construction methodology, construction noise assessment and coastal processes assessment in particular, informed this assessment.

Along Transect 1 (T1) through the proposed reclamation at Kaiwharawhara Point, the 20m station had the highest abundance of animals and its infauna composition differed significantly from both the 40m and the 60m station. A number of taxa abundant at the 20m station were absent at the 40m one. These included the bivalve *Corbula zelandica,* unidentified amphipods, the polychaetes *Barantolla lepte* and *Notomastus zeylanicus*, and the crab *Petrolisthes novaezelandiae*. Other taxa were present at the 40m station but not at the 20m one, including the ostracods *Diasterope grisea* and *Scleroconcha* sp., and the bivalve *Theora lubrica.* Similarly, several taxa abundant at the 20m station were absent or scarcely abundant at the 60m site. These included a range of polychaetes (*Prionospio multicristata*, *Barantolla lepte*, *Notomastus zeylanicus*, and *Armandia maculate*) the bivalves *Corbula zelandica* and *Arthritica bifurca*, and the crab *Petrolisthes*

[1] Dr De Luca is currently leading a team of marine ecologists who are drafting revisions to the EIANZ guidelines to include marine ecology.

[2] Transmission Gully Motorway, Mckays to Peka Peka Expressway, East West Link Auckland, Puhoi to Warkworth motorway.

novaezelandiae. Ostracods (primarily *Scleroconcha* sp.) were the only group more abundant at 60m than at 20m.

Along Transect 2 (T2) also through the proposed reclamation at Kaiwharawhara Point, the 20m station had the highest abundance of animals and its infauna composition differed significantly from the 60m station. Similar to transect 1, there was a range of taxa abundant at the 20m station, but absent at the 60m one. This included the polychaete *Prionospio multicristata*, the bivalve *Arthritica bifurca*, cumaceans, the ostracod *Parasterope quadrata* and *Rutiderma* sp., and the urchin *Echinocardium cordatum*. The polychaete *Cossura consimilis* and the ophiuroid stars were among the few taxa present at 60m but not at 20m distance from MHWS along transect 2.

Transects 3, 4 and 5 (T3-T5) were located within the new wharf area to assess occupation of the coastal marine area.

No *Threatened* or *At Risk* benthic invertebrates were detected at any site surveyed. The *At Risk* macroalgae *Macrocystis pyrifera* (sparse abundance, and low stature) was detected in the 0-5m contour from State Highway 1 at the Kaiwharawhara reclamation.

With respect to the assessment of effects, the transects can be separately valued as per their overall ecological value, with T1 and T2 (intertidal, 20m) adjacent to Kaiwharawhara having high ecological values, T1 40m and 60m subtidal, T2 40m and 60m subtidal having moderate values, T3 having low ecological values, and T4 and T5 having moderate ecological values.

Table 1: Summary of habitat characteristics based on ecological values in Table 1 by survey transect (refer to Figure 2 for transect locations)

Marine characteristic	Intertidal T1 and T2 20m	Subtidal T1 (40-60m)	Subtidal T2 (40-60m)	Subtidal T3	Subtidal T4	Subtidal T5
Benthic invertebrate abundance	High	Moderate	Moderate	Low	Moderate to High	Moderate to High
Number of benthic species	High	Low to Moderate	Low to Moderate	Low	Low to Moderate	Low to Moderate
Shannon-Wiener Diversity	High	Moderate	Moderate	Moderate	Moderate	Moderate
Macroalgae	High	Moderate	Moderate	Low	Low	Low
Invasive species	High	Low	Low	Low	Low	Low
Sediment contaminants	Moderate	Low	Low	Low	Low	Low
Sediment grain size	High	Low	Low	Low	Low	Low
Estuarine/Coastal edge vegetation	Low	Low	Low	Low	Low	Low

Marine characteristic	Intertidal T1 and T2 20m	Subtidal T1 (40-60m)	Subtidal T2 (40-60m)	Subtidal T3	Subtidal T4	Subtidal T5
Habitat modification	Low	Low	Low	Low	Low	Low
Overall Ecological Value	**High**	**Low to Moderate**	**Low to Moderate**	**Low**	**Moderate**	**Moderate**

Having stepped the ecological effects of the Project through the effects management hierarchy in relation to first avoiding, remedying and mitigating as much as possible, the current assessment identified one category of residual effect (permanent marine habitat (reclamation and occupation) loss at the scale of the Project footprint) that, because of its absolute (loss of habitat) and permanent nature, cannot be adequately addressed through mitigation. As such, this residual effect must be addressed through the application of the subsequent steps in the effects management hierarchy offsetting or compensation.

Offsetting measures proposed (in consultation with stakeholders, iwi and GWRC) include saltmarsh restoration in Kaiwharawhara Estuary, establishment of cobble beach on true left of Kaiwharawhara Estuary (and removal of construction rubble and debris), establishment of Living Seawalls, artificial tidal rock pools, and pile sleeves.

Effects on the sparse number of juvenile *Macrocystis pyrifera* located between 0-5m from MHWS adjacent to SH1 will be avoided by transplanting the plants out of the reclamation area along SH1 where *M. pyrifera* currently occurs.

Compensation was the last option for the loss of benthic habitat through occupation. Through discussions with GWRC, NIWA, iwi and KiwiRail a compensation package to support research and restoration of *M. pyrifera* has been developed.

Ongoing discussions are being held with the “I love Rimurimu Trust”, local NIWA marine scientists, iwi and GWRC to ensure that there is research, restoration and monitoring focus on the threatened species *M. pyrifera* (giant kelp) which was significantly more abundant in Wellington Harbour in previous decades. Restoration of this species would be of significant benefit to the marine ecological values at the Project site and wider Wellington Harbour.

KiwiRail has agreed to adopt our recommendations, including measures to avoid, remedy / minimise, mitigate, and offset / compensate for effects on ecological values. Our recommended measures are reflected in the proposed conditions of consents.

CONTENTS

Appendices

1 Introduction

Boffa Miskell has been engaged by KiwiRail Holdings Limited (KiwiRail) to provide an assessment of effects on benthic marine ecology associated with the redevelopment of the existing Interislander ferry terminal (Existing Terminal) at Kaiwharawhara, Wellington (the Project). This report provides an assessment of the likely effects on benthic marine ecology associated with the Project, piling and construction of the new elements required for the terminal and associated infrastructure.

1.1 Background

The Existing Terminal is located at Kaiwharawhara within the Wellington Harbour (Figure 1). The Existing Terminal operates from land owned by KiwiRail, CentrePort Limited (CentrePort) and Waka Kotahi New Zealand Transport Agency (Waka Kotahi). KiwiRail’s Interislander ferry service is an extension of State Highway 1 (SH1) and the main trunk railway line, linking road and rail networks between New Zealand North and South Islands. In the 2020 financial year, more than 710,000 passengers and 243,000 cars were carried across Te Moana-o-Raukawa, Cook Strait on the Interislander ferries, despite the COVID-19 lockdowns.

KiwiRail is replacing its three current ferries with two new, larger, rail enabled ferries which will enter service from mid-2025. The new ferries will enable KiwiRail to keep up with growing demand and replace its current fleet that are reaching the end of their economic and serviceable lives. As a result, the terminals at Waitohi Picton and Kaiwharawhara Wellington will need to be redeveloped to accommodate these new larger ferries and the associated increase in rail, freight, vehicle and passenger volumes. The Interisland Resilient Connection (iReX) Programme has been established to deliver the new ferries and terminals.

The redeveloped ferry terminals will be purpose-built to enable KiwiRail to take advantage of the functionalities and features of the new ferries and to deliver whole of life outcomes for KiwiRail including future-proofing the ability to meet the operational and health and safety needs of the new ferries and their replacements over the life of the terminals.

The Project (also referred to as the Single User Terminal (SUT) development) is the first stage of a multistage programme to develop a Multi User Ferry Precinct (MUFP) at Kaiwharawhara which would see StraitNZ Bluebridge relocate to the Kaiwharawhara site. A masterplan for the MUFP is currently being developed by the Future Ports Forum. This report assesses the potential adverse effects on benthic marine ecology from construction and operation from the Project.

Figure 1: Existing Terminal and site features

1.2 Purpose and structure of this report

The purpose of this document is to present the assessment of ecological effects on benthic marine ecology.

This report begins with a description of the Project (Section 2) and the methods used to collect ecological information and undertake the ecological assessment (Section 3). Section 4 outlines the proposed construction methodology. Section 5 summarises the background coastal processes information for the Project site and Section 6 summarises the effects of the proposal on those coastal processes. A description of the existing marine information is provided (Section 7) based on the desktop and field data collected; that information is then used to assign marine ecological values at the site (Section 8). Assessments of the construction and operational effects on marine ecology are presented in Sections 9 and 10 respectively. Section 11 outlines the process taken for this assessment to adhere to the effects management hierarchy, and the recommendations for addressing residual effects of the Project.

Where stated, this assessment has relied on the reports from other technical experts for this Project relating to coastal processes, contamination, freshwater and terrestrial ecology, coastal avifauna, erosion and sediment control and construction methodology.

2 Project Description

The Project involves the redevelopment of the Existing Terminal at Kaiwharawhara, Wellington. The Existing Terminal is located on land owned by KiwiRail, CentrePort and Waka Kotahi and is required to be redeveloped prior to the arrival of the first new ferry in mid-2025.

2.1 Wellington Terminal redevelopment details

The following information is based on a concept design for the Project and is subject to change. While the design is subject to change to an extent, the critical elements (on which this assessment is based) are not subject to change.

Development within / spanning the coastal marine area (CMA) is proposed to include:

a) A new wharf for the Interislander berth. The wharf will be approximately 250m in overall length and approximately 14m in width. The wharf form consists of substantial dolphin type structures with lighter weight access 'bridges' between the dolphins. There are six dolphins with reinforced concrete caps and these have 30 x 1.8m diameter reinforced concrete piles between them. The access bridges are prestressed concrete and supported on 16 x 0.9m diameter concrete filled steel tube piles.

b) A ~90m long reinforced concrete seawall that will be located between the linkspan / wharf and the terminal building, which is positioned along the edge of the existing reclamation low water mark. This will have a 1.2m thick by 40m deep diaphragm wall with 10m return legs tied back to a row of 27 x 1.5m diameter piles, positioned ~35m behind the wall.

- Construction of a new seawall at the ship berth supported by a rock revetment in front of the seawall of approximately 2,200 m² which is comprised of a double layer of armour rock (D50 = 0.85 m, W50 = 1,000kg), a double layer of underlayer rock (D50 = 0.35 m, W50 = 70kg) and geotextile fabric (Texcel 1200R or similar).

c) Scour protection will be placed in front of the seawall, upgrading the existing adjacent revetment to withstand propeller flows.

d) A piled concrete 'nesting' structure will support the linkspan towers and marine fenders that will absorb berthing loads as the ship berths, protect the linkspan from impact and hold the ship in position during loading / unloading. The nesting structure comprises a 2.4m thick reinforced concrete deck supported on 23 x 1.8m diameter reinforced concrete piles approximately 40m long. The two halves of the nesting structure are tied together by 2 x 1.2m diameter horizontal steel tube struts.

e) A two level linkspan, with a lower deck for rail and vehicle use and an upper deck for vehicle use, and an approach ramp bridge connecting from two approach ramp embankments, providing access to the upper linkspan deck from the road marshalling yards.

f) The linkspan is an articulated ramp / bridge connection between the land and the ship which allows for vehicle and rail loading and unloading. The linkspan decks are structural steel, supported by steel frame towers which also house hydraulic systems that adjust the level of the decks.

g) The upper level linkspan approach embankments are on mechanically stabilised earth (MSE) with segmental block faced vertical end and side walls and some vegetated side slopes. The MSE walls bear directly on stone column ground improvements.

h) The upper level linkspan approach bridges use precast concrete beams and are founded on shallow footings on top of the stone column ground improvements.

i) A piled groyne to the north-east of the wharf. There will be approximately 21 x 1.05m of diameter steel / concrete piles which will be ~25m in length. The total groyne length is currently ~35m long (with 10 m of this length within the existing seawall) and occupies around 22m^2 of the seabed, the length and exact location of which will be confirmed following additional modelling. The purpose of the groyne structure is to deflect / avert prop wash away from the Kaiwharawhara Stream estuary / delta.

j) A full upgrade / replacement of the existing rock revetment protecting the existing KiwiRail marshalling is scoped. This means that with existing crest levels as low as 1.5 m RL, there is 0.5 m freeboard during 100-year ARI storms, which will reduce to 0m freeboard between 50 and 100 years possibly due to rising sea levels. Note that during present-day extreme storms, some wave run-up and overtopping already reaches the seaward edge of the marshalling yard. Therefore, only limited re-shaping to tie into the proposed seawall (see point c) will be incorporated to the SUT above mean high water springs (MHWS).

k) A reclamation and rock revetment to the northeast of Kaiwharawhara Point to enable the construction of a rail marshalling yard. Construction of the reclamation will require removal of an existing beach and rock revetment.

- There will be approximately 35,000m^3 of reclamation material placed.
- The reclamation plan surface area will be approximately 3,200 m^2, with the reclamation fill comprised of AP150 (with minimal cohesive fines), which is uncompacted below water level (0.5 m RL) and compacted above water level.
- The total plan footprint at seabed level (including the slope face and revetment) is approximately 5,300 m^2.
- The edge of the reclamation will be protected with up to approximately 6,000 m^3 of rock, comprised of a double layer of armour rock (D50 = 0.85 m, W50 = 1T) and a double layer of underlayer rock (D50 = 0.35 m, W50 = 70kg) with a geotextile fabric (i.e., Texcel 1200R or similar) underneath.

l) A proposed realignment and naturalisation of the eastern bank of the Kaiwharawhara estuary mouth and south-western edge of Kaiwharawhara Point. The realignment is a proposed effects mitigation and is intended to provide more space for the Kaiwharawhara Stream entrance/ delta and enhance and naturalise the high tide beach and coastal edge along parts of Kaiwharawhara Point. The placement of additional gravels along the upper beach is intended to provide protection in the short to medium-term for the land area behind (edge of the private vehicle (PV) marshalling area) using a softer design approach.

m) An elevated passenger walkway from the terminal building along the wharf to the middle of the ship. The walkway will rise approximately 2.6m in height from the level 3 terminal building to deck 8 on the ship. The walkway structure comprises a steel truss with architectural cladding and fitout and spans 40-50m. The walkway is supported from the wharf over most of its length with reinforced concrete column piers. The truss is articulated at each pier support to accommodate large seismic displacements. A steel lifting tower and hydraulically controlled end span provide for connection to the ferry at the seaward end of the walkway.

The development on land is proposed to include:

n) Ground improvements across the area under the terminal building, and ramps behind the diaphragm seawall. This will include ~2,500 x 20m of deep stone columns to mitigate seismic liquefaction of the underlying granular soils and to reduce seismic induced lateral ground displacement. This stone column material will be imported granular fill no in-situ material and will be removed to construct the stone columns. A compacted working platform using reworked in situ material is proposed currently, if required. Otherwise, construction will commence from the existing grade.

o) New rail yard, on existing land and on new reclamation, which will connect to the existing rail network and the linkspan. The rail yard will consist of 14 turnouts, ~1,820m of new 50kg/m ballasted track, 160m of embedded rail concrete slab track and 1 concrete buffer stop. There will be subsoil drainage constructed for the rail yard which will outfall at a number of locations across the site. There will be approximately 18,000m^3 of cut to waste (or to reclamation) and 1,500m^3 of imported structural fill required to construct the yard formation.

p) A commercial vehicle (CV) and PV road marshalling yard. These will be located at the existing marshalling yard location. The CV marshalling allows for 30 drop trailer parks, 15 tug parks and 850m of CV lanes. The PV marshalling allows for 1,045m of 3.5m wide lanes and 978m of 2.6m wide lanes.

r) The two existing Kaiwharawhara Stream bridges (rail and single lane road) will be kept. The northern rail deck will support the re-aligned rail alignment. The road bridge will provide to and from access for PVs onto Kaiwharawhara Point. The existing bridges will be resurfaced, and vehicle edge barriers upgraded. If pedestrian access is also required over Kaiwharawhara Stream, additional precast concrete beams similar to those existing can be placed next to the existing deck on the downstream side to provide width for a footpath. No works will be required in the bed of Kaiwharawhara Stream.

s) Road access to the ferry terminal will continue to be provided off Aotea Quay. Public road realignments or alterations are still to be confirmed, nothing is currently proposed.

t) The marshalling areas will have soft landscaped elements comprised of tree planting, garden beds and lawn spaces, landscaping and urban enhancements.

u) The terminal building will be a predominantly two-level building with a vertical circulation and a ground floor footprint of 1,600m^2. A portion of the building will be four levels high to enable foot passengers to access the elevated pedestrian walkway at the correct height. The building structural system is expected to comprise a steel frame braced by walls and / or diagonal bracing and founded on a raft foundation slab on top of ground improvements to address seismic ground displacement and fault rupture risk.

v) Service connections will include power supply, wastewater connection and water supply from ship to public network, fuel supply connection from ship and communications and security throughout the site.

w) The existing stormwater network will be enhanced and expanded to accommodate new areas of runoff as well as treatment of stormwater prior to discharge into the Wellington Harbour via existing, modified and new outlets.

3 Methods

3.1 Desktop investigation

Existing marine ecology data from sites adjacent to the Project were sourced from the Ministry for Primary Industries (MPI), CentrePort, Greater Wellington Regional Council (GWRC), Maritime New Zealand (MNZ) and scientific literature.

3.2 Field surveys

3.2.1 Intertidal Marine

The survey points 20m from approximate MHWS at transects 1 and 2 (adjacent to Kaiwharawhara reclamation) are likely within the intertidal zone, whereas all other sampling points are subtidal, being below the -5m contour (Figure 2). However, all survey sites were surveyed by the subtidal dive team using the same methods and all data (including two intertidal sites T1 20m and T2 20m) are reported under subtidal marine below.

3.2.2 Subtidal Marine

The sub-contracted dive team sampled a number of sites for Boffa Miskell Limited for benthic invertebrates, surface sediment contaminants and surface sediment grain size (Figure 2 Transect 1 three sites, Transect 2 three sites, Transect 3 three sites, transect 4 five sites, transect 5 three sites).

3.2.2.1 Benthic invertebrates

At each survey site, three 13cm diameter and 15cm depth soft sediment core samples were collected, sieved through 0.5mm mesh and the retained material preserved in >70% ethanol. Samples were transported to a taxonomy laboratory for identification of invertebrates and enumeration.

3.2.2.2 Sediment contaminants

At each survey site, a composite surface sediment sample was collected, held on ice, and transported to Hill Laboratories for analysis of heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and tributyl-tin (TBT).

3.2.2.3 Sediment grain size

A composite surface sediment sample at each site was collected for sediment grain size analysis, held on ice and transported to the University of Waikato where they were analysed using laser particle analysis.

3.2.2.4 Redox depth, epifauna and macrofauna

The subtidal dive team tried to survey redox depth and epifauna and macrofauna present. However, the very limited visibility did not allow quantitative measures (see section 7.2.2).

3.2.2.5 Macroalgae assessment

Peer review comments led us to undertake an assessment of macroalgae species adjacent to the coastal edge of the proposed reclamation. The dive team who undertook the surveys on 14/07/21 did not identify the presence of macroalgae in their assessment.

However, a site visit on 22/02/2022 revealed the presence of some sparse individual plants of *Macrocystis pyrifera* (threat status At Risk – declining) (Nelson et al., 2019) which updated our assessment of ecological values at the proposed reclamation site.

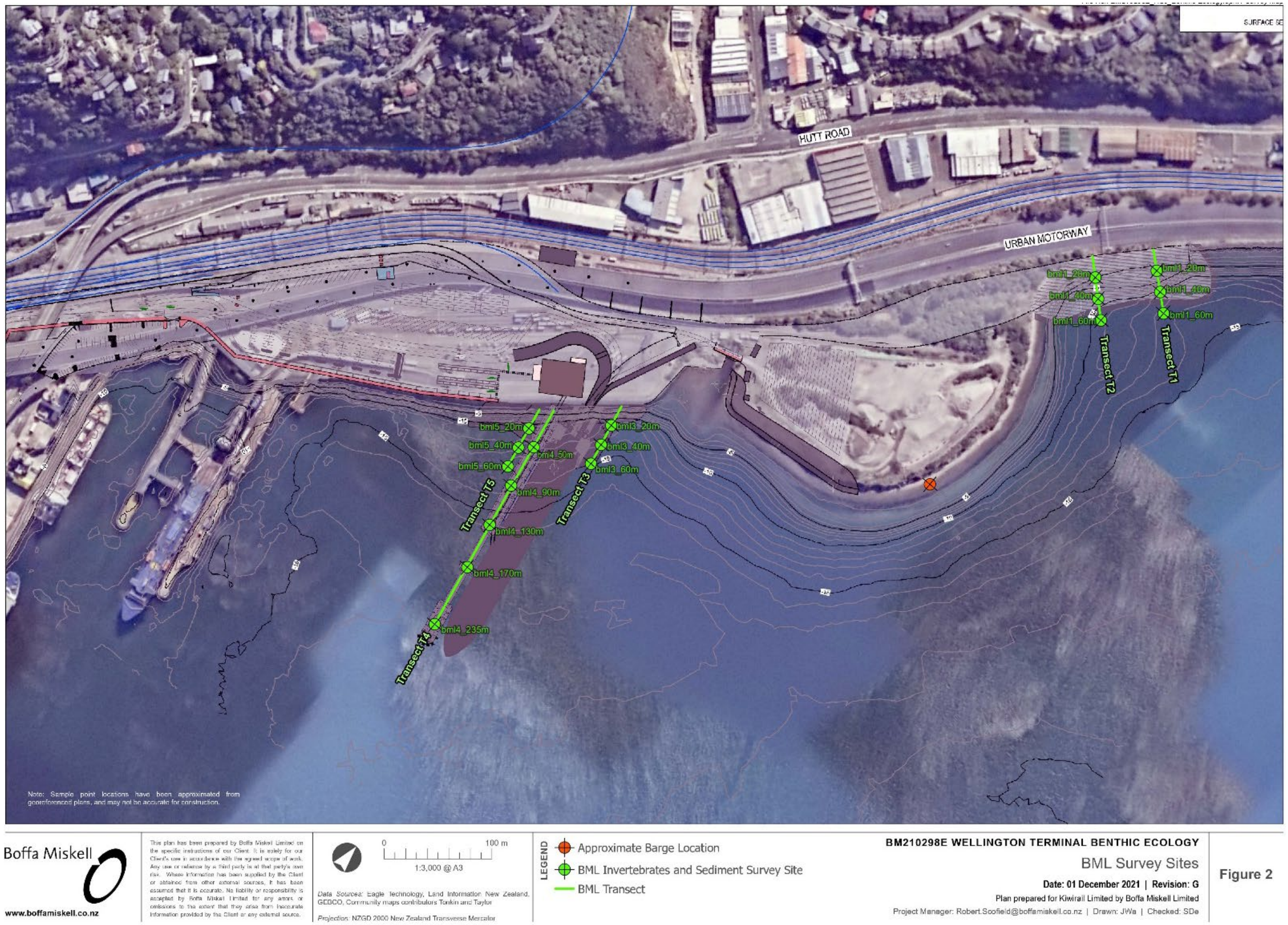


Figure 2: Sites sampled by the subtidal dive team for BML

3.3 Ecological assessment

The approach used to undertake this assessment is in line with the EIANZ guidelines for undertaking ecological impact assessments (Roper-Lindsay et al., 2018), whereby ecological values (Table 1) are assigned and the magnitude of effects identified (Table 2) in order to determine the overall level of effect of the proposal (Table 3).

However, in New Zealand, no regional or national guidelines or criteria for the assessment of marine ecological values have been developed to date.[3] Nevertheless, in the absence of such guidelines, we have adopted the EIANZ guidelines (Roper-Lindsay et al., 2018) approach to assess marine ecological value using a suite of factors relating to abundance, diversity and benthic invertebrate species richness, sediment grain size composition, and sediment contaminant concentrations. Threat status of benthic invertebrate species present is also considered (Freeman et al., 2014). This approach has been used and accepted in previous Board of Inquiry and Environment Court consenting processes for major infrastructure projects[4].

We note that this assessment has been undertaken at the scale of the Project footprint and wider Wellington Harbour with respect to cumulative effects.

We have described marine ecological values in this report as ranging from Very Low to Very High; Table 1 lists the characteristics we have used to guide our assessment of the ecological values of parts of the marine environment within the Project area. Due to the lack of marine assessment criteria and guidelines in New Zealand, our assessment of low, moderate and high benthic invertebrate species richness and diversity is based on our expert judgement and experience. However, the principles and approach to assessing the level of effect are directly applicable to marine environments.

According to Roper-Lindsay et al. (2018), the overall level of effect can then be used to guide the extent and nature of the ecological management response required (including the need for biodiversity offsetting):

- Very High adverse effects require a net biodiversity gain.[5]
- High and Moderate adverse effects require no net loss of biodiversity values.
- Low and Very Low effects should not normally be a concern. If effects are assessed taking impact management developed during project shaping into consideration, then it is essential that prescribed impact management is carried out to ensure Low or Very Low effects.

[3] Dr De Luca is currently leading a team of marine ecologists who are drafting revisions to the EIANZ guidelines to include marine ecology.

[4] Transmission Gully, Mckays to Peka Peka, East West Link, Puhoi to Warkworth,

[5] Though when ecological compensation is required because biodiversity offsetting is not possible, the principles of no-net-loss or net-gain do not apply (Maseyk et al., 2018).

Table 2: Characteristics of marine ecological values to guide assessment

Marine Ecological Value	Characteristics
VERY LOW	• Benthic invertebrate community degraded with very low species richness, diversity and abundance for the habitat type. • Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with no sensitive taxa present. • Marine sediments dominated by silt and clay grain sizes (>85%). • Surface sediment anoxic (lacking oxygen). • Elevated contaminant concentrations in surface sediment, above Australia and New Zealand Guidelines (ANZG, 2018) Default Guideline Values (DGV) effects threshold concentrations. • Invasive, opportunistic and disturbance tolerant species highly dominant. • Native estuarine vegetation absent. Habitat extremely modified.
LOW	• Benthic invertebrate community degraded with low species richness, diversity and abundance for the habitat type. • 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 grain sizes (>70%). • Surface sediment predominantly anoxic (lacking oxygen). • Elevated contaminant concentrations in surface sediment, above ANZG DGV effects threshold concentrations. • Invasive, opportunistic and/or disturbance-tolerant species dominant. • Estuarine vegetation dominated by exotic species. Habitat highly modified.
MODERATE	• Benthic invertebrate community typically has moderate species richness, diversity and abundance for the habitat type. • 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 grain sizes. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below ANZG DGV effects threshold concentrations. • Few invasive opportunistic and/or disturbance tolerant species present. • Estuarine vegetation a mixture of native and exotic species. Habitat modification limited.
HIGH	• Benthic invertebrate community typically has high diversity, species richness and abundance for the habitat type. • Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud. • Marine sediments typically comprise <50% silt and clay grain sizes. • Surface sediment oxygenated. • Contaminant concentrations in surface sediment significantly below ANZG DGV effects threshold concentrations. • Invasive opportunistic and/or disturbance tolerant species largely absent. • Estuarine vegetation dominated by native species. Habitat largely unmodified.

VERY HIGH	• Benthic invertebrate community typically has very high diversity, species richness and abundance for the habitat type. • Benthic invertebrate community contains dominated taxa that are sensitive to organic enrichment and mud. • Marine sediments typically comprise <25% smaller grain sizes. • Surface sediment oxygenated with no anoxic sediment present. • Contaminant concentrations in surface sediment significantly below ANZG DGV effects threshold concentrations. • Invasive opportunistic and disturbance tolerant species absent. • Native estuarine vegetation sequences intact and provides significant habitat for native fauna. Habitat unmodified.

Table 3: Criteria for describing magnitude of effect (EIANZ 2018)

MAGNITUDE	DESCRIPTION
Very High	Total loss of, or very major alteration, to key elements/ features of the baseline conditions such that the post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss[6] of a very high proportion of the known population or range of the element / feature.
High	Major loss or 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[6] 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 post-development character, composition and/or attributes will be partially changed; AND/OR Loss[6] of a moderate proportion of the known population or range of the element / feature.
Low	Minor shift away from 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/patterns; AND/OR Having a minor effect on the known population or range of the element / feature.
Negligible	Very slight change from existing baseline condition. Change barely distinguishable, approximating to the "no change" situation; AND/OR Having a negligible effect on the known population or range of the element / feature.

Table 4: Matrix to determine overall level of effect (EIANZ 2018)

LEVEL OF EFFECT		ECOLOGICAL AND / OR CONSERVATION VALUE				
		Very High	**High**	**Moderate**	**Low**	**Negligible**
MAGNITUDE	**Very High**	Very High	Very High	High	Moderate	Low
	High	Very High	Very High	Moderate	Low	Very Low
	Moderate	High	High	Moderate	Low	Very Low
	Low	Moderate	Low	Low	Very Low	Very Low
	Negligible	Low	Very Low	Very Low	Very Low	Very Low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

[6] In the context of mobile fauna, the term "loss" can include displacement from an area.

3.4 Effects management hierarchy

The order of priority for ecological impact management we have applied to this assessment is outlined in Table 4 and Figure 3. This process has followed the effects management hierarchy as described in Roper-Lindsay et al. (2018) and Maseyk et al. (2018).

Table 5: Effects management hierarchy and terminology (Maseyk et al., 2018)

EFFECTS MANAGEMENT HIERARCHY	DEFINITION
1) Avoidance	To modify a project proposal to prevent any environmental damage or loss of an ecological or environmental feature or function.
2) Remediation	To reverse or stop any environmental damage.
3) Mitigation	To alleviate, or to abate, or to moderate the severity of something (environmental damage), and typically occurs at the point of impact.
4) Biodiversity offset	A measurable conservation outcome resulting from actions designed to compensate for residual, adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied. The goal of a biodiversity offset is to achieve no-net-loss, and preferably a net-gain, of indigenous biodiversity values. Biodiversity offsetting includes: • **Like-for-like offset -** The residual effect is offset to a no-net-loss or net-gain level by exchanging the same type of biodiversity in accordance with all of the offset principles. • **Trading-up offset -** An out-of-kind exchange of biodiversity that demonstrably exchanges biodiversity of a lesser conservation value for biodiversity of greater conservation value. Meets key offset principles except equivalence of type but is considered to overall deliver an equivalent or improved outcome, because the biodiversity gained is considered to be of greater conservation importance than the biodiversity lost. No standard metrics are currently available to evaluate the exchange so trading up involves an element of subjectivity and societal preference.
5) Environmental compensation	Non-quantified biodiversity benefits are offered to compensate for biodiversity losses. The compensation actions may benefit different biodiversity to that lost (out-of-kind compensation), including biodiversity of lesser conservation concern than that lost. Compensation is not quantified or balanced with losses and may involve subjective decision-making subject to socio-political influences.

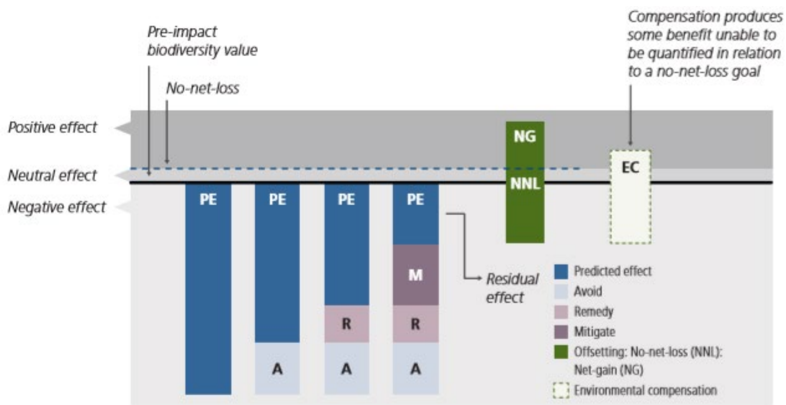


Figure 3: Conceptual illustration of effects management hierarchy progressing from avoidance to environmental compensation (Figure 2 from Maseyk et al. (2018))

4 Construction Methodology

The Existing Terminal will remain operational during the construction of the new infrastructure, which will require careful planning and will influence the construction/operational sequencing and methodology. The following is a high-level overview of the likely construction methodology.

4.1 Kaiwharawhara Point reclamation

It is expected that the reclamation for the rail marshalling yard north-east of Kaiwharawhara Point will be constructed by either pushing end-tipped fill out from the shore up to design levels and then armouring the front face of this material or constructing an armoured face from barge and filling behind this to form the reclamation area. The existing rock revetment along SH1 will be removed for reuse elsewhere where possible. A new rock revetment will be constructed along the seaward edge of the reclamation to protect the reclamation from coastal erosion. Existing beach material may be relocated to the Kaiwharawhara Estuary mouth or to other enhancement purposes.

- The area of reclamation is estimated to be 3,200m^2;
- Clean no fines AP150 screened rock for all fill below the MHWS level;
- Clean GAP 65 material (also no fines) above the MHWS level;
- A floating silt curtain will surround the reclamation area to further control the discharge of fine sediment.

The rail yard will be constructed by building a granular subgrade across the site and installing drainage, signalling and other services. Formation will be placed then track and turnouts will be installed and connected before ballast is placed on top. Once the new rail yard is operational the existing rail yard (track and ballast) will be removed and pavement constructed in its place.

There are two existing Wellington Water stormwater outfalls on Kaiwharawhara Point that will require extension due to conflict with the rail yard footprint.

4.2 New wharf

The wharf will be a concrete structure supported on piles. The piles and deck will be constructed by marine and/or land-based plant from a temporary wharf structure, with piles excavated deep into the Wellington alluvium material underlying the seabed[7]. The temporary structure will extend the length of the new wharf for the 1-1.5 year construction programme. It is proposed that the temporary piles (likely 900mm diameter) will be installed to enable construction of the permanent piles. Temporary piles are likely to occupy approximately 29m^2.

Construction of the new wharf will involve the location of 16 piles (0.9m diameter). The total area of permanent occupation relating to the new wharf structure is 15 m^2.

The deck consists of both precast and in-situ reinforced concrete. With the main structure complete, wharf furniture (fenders, bollards, ladders etc.) will be installed. The new wharf will take approximately 18 months to construct.

[7] Piles will be driven by a piling rig using a vibration and/or impact hammer from marine-based and/or land-based plant.

4.3 Linkspan and nesting structure

The primary two-level linkspan will be either a piled fixed structure or a floating structure held in place with guide piles. The piles and deck will be constructed by marine and/or land-based plant from a temporary wharf structure with piles excavated deep into the Wellington alluvium material underlying the seabed.

Cast in-situ concrete deck will be constructed then prefabricated steel towers and bridge spans will be installed with accompanying hydraulics, mechanical, electrical and control systems. Finally, linkspan furniture (fenders, bollards, ladders etc.) will be installed.

4.4 Coastal protection structures

The seawall will be constructed behind the wharf and primary linkspan. The seawall will be of the diaphragm wall type, with 1.2m thick walls to 40m below ground. The wall will be anchored with tiebacks to a row of 1.5m diameter anchor piles within the reclamation. Reinforced concrete facing panels are provided to the harbour side, to provide wave/scour protection. The existing rock revetment landward of the seawall will be removed for reuse elsewhere where possible. Seaward of the seawall, the slope will be cut and/or filled to the design profile and large rock will be placed to protect the seawall from ship wash scour and coastal erosion and provide additional stability to the seawall.

Large rock scour protection will be installed on the seabed in front of the seawall revetment, beneath the primary linkspan and inner section of the wharf to protect those structures, and the revetment toe, from ship wash scour. Dredging and/or trimming/levelling of the seabed may be required to enable this where scour rock layers may impede into the required draft depth. Dredging for the berth pocket is unlikely required due to sufficient existing depth.

The groyne will be a piled structure. Piles will be driven by a piling rig using a vibration and/or impact hammer from a marine-based and/or land-based plant, with the concrete capping beam being precast or cast in situ. The groyne will occupy 22m^2.

The gravel beach extending east around Kaiwharawhara Point to the edge of the PV Marshalling area will likely be constructed by end tipping gravel material from Kaiwharawhara Point with a digger distributing the gravels across the beach. Occupation above MHWS is estimated to be 600m^2, with 1,400m^2 occupied below MHWS.

5 Coastal processes summary

The following is taken from the Coastal Process Assessment for the Project to provide context to the marine environment.

5.1 Background information

The Project site is in Wellington Harbour at Kaiwharawhara. Wellington Harbour is located at the southern point of the North Island and has an area of around 85km^2 and a maximum width of 11km. The harbour mouth is approximately 1,800m wide and open south to Cook Strait. The harbour mouth is approximately 15m deep while the central harbour has an approximate depth of 20m. Kaiwharawhara is located 5.5km from the Wellington Harbour entrance and is offset by 90 degrees once past Miramar Peninsular (Coastal Processes Assessment).

The coastal environment at Kaiwharawhara has been heavily modified for Port activity, with reclamation, wharfs, and rock armouring along the coastline (Coastal Processes Assessment).

Sediment is supplied to the CMA from Kaiwharawhara Stream, where a delta has formed at the stream mouth following reclamation. The stream mouth, at the shallow section of the delta, is a dynamic coastal feature at the Project site, with the channel migrating and periodic bar and spit formation occurring over recent decades. Between the stream channel and the reclaimed marshalling area (to the west), the delta has filled with sediment and occasionally forms a spit that extends to the east across the stream channel. A combination of coastal processes and river processes influence the stream delta formation and dynamics (Coastal Processes Assessment).

Sediment delivery to the coast is likely during high discharge events that can transport gravels, silts and sand downstream. The material is then reshaped by local wave action during storm events, with the Project site exposed to wind generated waves from the south and east. During calm weather and ambient environmental conditions, the main processes including the shoreline are tidal water exchange, which is not expected to generate currents that can mobilise sediment, and wake and wash generated by vessels (Coastal Processes Assessment).

Proximity to the existing Interislander ferry wharf means that the point and delta are already exposed to passing and turning vessels. However, it is unlikely that prop wash exerts an influence on the delta currently. Wakes from arriving and passing vessels is likely and may exert some influence at the delta and neighbouring unprotected shorelines (Coastal Processes Assessment)[8].

Section 3.2 of the Coastal Processes Assessment provides information on the topography and bathymetry for the project areas, including the reclaimed area of Kaiwharawhara Point (completed in 1960s) and the outlet of the Kaiwharawhara Stream. Section 3.6 of the Coastal Processes Assessment details the tidal currents in the Wellington Harbour, noting a generally clockwise pattern in the flood tide phase and anti-clockwise pattern during the ebb tide phase.

A summary of the CMA reclamation and occupation is presented in Table 5 and descriptions of the main design features are included below.

Table 6: Summary of design features that occupy the CMA and seabed[9]

Design feature	Reclamation area[1] (m^2)	Seabed area[2] (m^2)	Overwater area[3] (m^2)
~90 m long vertical seawall behind new wharf	0	300	0
Reclamation fill behind seawall	20	20	0
Submerged rock revetment	0	0*	0
Existing revetment upgrade	0*	0*	0
Toe/Scour protection for existing revetment	0	520	0
New scour protection	0	2,700	0
Kaiwharawhara Point cobble beach	0	2,100	0
Back shunt reclamation	3,200	5,300	0
Kaiwharawhara estuary naturalisation	0	415	0
North Beach	0	0	0
Timber groyne at Kaiwharawhara delta (No. 75 dia. 0.3 m, 28 m long)	0	14	0
25 m long piled groyne wall to protect delta from prop. Wash (No. 21 dia. 1.05 m)	0	22	0
Access bridge piles (No. 16 dia. 0.9 m)	0	14	0
Dolphin piles (No. 30 dia. 1.8 m)	0	54	0

[8] Executive summary, page 6 within Coastal Processes Assessment Report

[9] Table ES.0.01 within the Coastal Processes Assessment Report.

Nesting structure piles (No. 23 dia. 1.8 m)	0	41	0
Wharf deck (260m x up to 14m)	0	0	3,640
Linkspan deck	0	0	730

[1]Defined by the change in area at MHWS associated with new land

[2]Defined by occupation within the CMA at the bed level (excluding existing structure footprints; excluding new reclamation area)

[3]Area of structures that are over the CMA that can cast a shadow over the sea surface

*Within existing structure footprint

Sections 2.1.1 to 2.1.11 of the Coastal Processes Assessment provides a useful summary of the main project construction areas.

5.1.1 New wharf

The wharf will be approximately 250m in overall length and approximately 14m in width. The wharf form consists of substantial dolphin type structures with lighter weight access 'bridges' between the dolphins. Structures within the CMA and penetrating through the seabed are:

- 6 No. dolphins with reinforced concrete caps each formed from 5 No 1.8 diameter reinforced concrete piles. In total, the 30 piles will occupy 54m^2 of the CMA.
- 16 No. 0.9m diameter concrete filled steel tube piles in total supporting the access bridge that will occupy 15m^2 of the CMA.

5.1.2 New seawall with fill reclamation

A new vertical seawall will be constructed at the seaward edge of the wharf and terminal. The seawall will be approximately 90m alongshore and 1.2m wide (across shore) and will occupy an area of 300m^2 in the CMA, with the entire footprint within the CMA.

In some locations the seawall is offset from the existing land and a total reclamation fill area of 20m^2 within the CMA is needed.

5.1.3 Submerged rock revetment

The seawall will be supported by a new submerged rock revetment that extends a length of 120m. The total footprint of the rock revetment will be approximately 2,200m^2 as the structure extends from a crest level of -2.5m to at a slope of 1(V):2(H) m to the existing bed level (approx. -10 m RL).

5.1.4 Existing rock revetment upgrade

An upgrade to an existing revetment is proposed for a 120m section (alongshore). This will include placement of additional rock layers over the existing revetment down to around low tide level. This is expected to increase the MHWS area by 86m^2.

5.1.5 Scour protection

A scour protection rock layer will be placed at the toe of the revetment. This will be a 1.5m thick layer of rock on the seabed that extends seaward for 30-40m, occupying a total area of 2,700m^2.

Scour protection will also be placed along a 30m length of existing rock recruitment in a seabed area of 520m². This layer will be a 1.5m thick placement of armour rock that extends seaward from the toe to upgrade existing adjacent revetment to withstand propeller flows.

5.1.6 Piled concrete nesting structure

A piled concrete 'nesting' structure will support the linkspan towers and marine fenders that will absorb berthing loads as the ship berths, protect the linkspan from impact and hold the ferry in position during loading/ unloading. The nesting structure comprises a 2.4m thick reinforced concrete deck supported on 23 x 1.8m diameter reinforced concrete piles approximately 40m long. The piles will occupy a CMA area of approximately 41m^2.

5.1.7 Piled groyne

A piled groyne to the northeast of the wharf has been designed to deflect prop wash away from the Kaiwharawhara Stream estuary/ delta. The groyne will be formed from 1.05m diameter steel/concrete piles with a narrow gap between them. There will be a reinforced concrete cap beam (1.5m x 1.5m) on top of the piles. The total groyne length will be around 35m long, with 10m of this being within the existing seawall. It will occupy a total seabed area of 22m^2. It will be situated approximately midway between the berth and the delta.

5.1.8 Kaiwharawhara Point reclamation and protection

A reclamation and rock revetment to the northeast of Kaiwharawhara Point will enable the construction of a rail marshalling yard. Construction of the reclamation will require removal of an existing beach and the rock revetment.

- There will be approximately 35,000m^3 of reclamation material placed. The proposal has material cut from site and from piling being re-used as reclamation as available;
- The reclamation plan surface area increases the area of the MHWS contour by approximately 3,200 m^2;
- The reclamation fill comprised of AP150 (with minimal cohesive fines), which is uncompacted below water level (0.5 m RL) and compacted above water level;
- The total plan occupation of the seabed (including the slope face and revetment) is approximately 5,300 m^2 ; and
- The edge of the reclamation will be protected with up to approximately 6,000m^3 of rock, comprised of a double layer of armour rock (D50 = 0.85m, W50 = 1T) and a double layer of underlayer rock (D50 = 0.35m, W50 = 70kg) with a geotextile fabric (i.e. Texcel 1200R or similar) underneath.

5.1.9 Kaiwharawhara Stream restoration and naturalisation

Restoration and naturalisation of the eastern bank of the Kaiwharawhara estuary mouth and south-western edge of Kaiwharawhara Point is proposed. The restoration will initially cover an area of 415m² to be planted with native saltmarsh/estuarine species. Monitoring of sediment accumulation within the estuary will be conducted and further areas of saltmarsh/estuarine vegetation may be included if habitat conditions are suitable.

The concept design for naturalising Kaiwharawhara estuary (section11.1.7) includes the following design features:

- planting of saltmarsh vegetation around the landward edge on the true right bank of the stream mouth/estuary;
- timber piled walls on the seaward edge of the true right stream mouth/estuary bank to buffer waves.

6 Summary of Assessment of Effects on Coastal Processes

A summary of the potential coastal processes effects is provided in Table 4.5 of the Coastal Processes Assessment. The following sections (6.1 to 6.6) are summarised from the Coastal Processes Assessment (Section 4.2).

6.1 Earthworks and land clearance

Potential effects on the CMA would be associated with uncontrolled release of fine sediments, and any associated contaminants, into Kaiwharawhara Stream or the CMA from overland flow and rainfall events. Any fines released into the CMA would be expected to result in local and temporal discolouration of the water column until the fines settle to the seabed. Sands and gravels would settle in close to the coastal edge, and this would occur rapidly over periods of minutes to hours. Finer silts would settle more slowly over a period of hours.

Site development and earthworks on the existing land areas will need to follow best practise for identifying and managing areas of contamination and for limiting uncontrolled discharge to the CMA**.**

6.2 Kaiwharawhara Point reclamation

The construction scope from KiwiRail indicates the likely method (to be refined) is either:

- pushing end tip fill seaward from the shoreline until the design level is reached, then armouring the seaward face, or
- constructing an armoured face from a barge then filling in behind.

Construction of the reclamation could involve uncontrolled sediment discharge into the CMA. Sand and gravels will settle in close to the coastal edge with finer sediment held in suspension longer and discharged over a larger area. Any fines released into the CMA would be expected to result in local and temporal discolouration of the water column until the fine sediment settle to the seabed. Sands and gravels would settle in close to the coastal edge, and this would occur rapidly over periods of minutes to hours. Finer silts would settle more slowly over a period of hours and disperse further, depending on wind, tide and wave conditions (Coastal Processes Assessment, Section 4.3.1).

Best practice techniques, such as use of silt curtains and works being carried out in calm weather, will minimise the effects of sediment discharge.

6.3 Wharf and marine structures

The wharf structure will take approximately 1.5 years to construct, using a combination of land-based and marine-based plant. The construction includes piling, installation of temporary wharf structures for plant, and installation of the wharf deck and linkspan.

Installation of piles will create a local disturbance to the seabed through impact and vibration. This is likely to induce fine sediment into suspension, which will temporarily increase the suspended sediment concentration in the immediate area. Installation of a single pile is likely to have a negligible effect on coastal processes due to the seabed depth and cohesive silt material on the bed. However, the duration of works (1.5 years) and number of piles (including permanent piles and temporary piles for construction) means that this disturbance will span a temporal and spatial scale that will have a low (minor) effect.

Installation of a precast concrete deck will take place using land-based plant, or plant based on a floating or piled barge. The effect on coastal processes is considered low because any marine based plant will be temporary and the disturbance to the seabed will be localised.

6.4 Seawall

Construction of the seawall requires the existing coastal edge (rock revetment) to be excavated, with fill placed to reclaim a 1-2 m section between the current MHWS line and the concrete seawall. Excavation of the existing coastal protection will risk uncontrolled release of fine material into the CMA. This risk increases proportional to the length of time the edge is exposed and will be exacerbated during high tide and large wave activity.

Best practice procedures will be in place to limit discharge from land into the CMA during the excavation process and this would include the identification and removal of harmful contaminants existing site prior to excavation. Excavation of the existing coastal edge should be undertaken during calm weather conditions and the duration of time the face is left exposed should be minimised. A silt curtain around the perimeter of the works may be used to reduce the extent of fines from concrete cutting being released into this area.

Any fill that will be placed landward of the seawall will need to be placed in a controlled manner that does not result in uncontrolled release into the CMA. Construction of the seawall will require land-based plant that will first excavate the site before constructing the wall. Concrete guide walls will be constructed on either side of the wall extent and a temporary fill bund will be placed seaward of the crane platform to prevent the risk of concrete overflow to the CMA.

The construction effects of the excavation, fill and seawall instillation are centred around the uncontrolled release of fine sediment, contaminants, and land-based pollutants into the CMA. With best practice in place, discharges can be controlled so the effect on coastal processes is likely to be low.

6.5 Coastal edge protection

Installation of submerged rock armour for coastal protection and scour protection will likely require a combination of land-based and barge-based plant, with rock placed by long reach excavators. Works on the seabed will require the site to be shaped before placement, which will result in temporary suspension of fine sediment on the bed. Placement of a geotextile layer on the seabed as part of the design will help to reduce sediment suspension when placing filter rock and armour rock.

The effect of construction on coastal process is considered temporary and localised and is therefore low.

6.6 Propeller wash and sedimentation extent

Propeller wash velocity at the bed for the new vessel ranged between 0.28m/s (2% power) and 0.75m/s (40% power) at a depth of 16m, with the new vessel associated with slightly higher velocities than the existing Kaiarahi vessel because of the deeper draft and larger propeller. This is generally within the range of wave orbital velocities that are expected under comparable occurrences at the same depth.

The comparison of wave orbital velocities to propeller induced velocities is useful for gauging the potential impact of ship induced suspended sediment. The new vessel induced suspended sediment at the site is expected to be similar to the existing vessel induced suspended sediment with a slightly larger area of seabed affected within the near field zone and negligible effect beyond that zone.

7 Existing Marine Environment

7.1 Desktop assessment

7.1.1 MPI marine species data

MPI collect a range of marine organism data at a number of ports around New Zealand on an annual basis. We have obtained MPI data from the sites they routinely survey close to the Project area and display in Figure 4 below the non-indigenous and native species (having excluded indeterminate species) (https://www.marinebiosecurity.org.nz/search-for-species/). The nearest location of non-indigenous species has been detected 75 m to the north of the proposed wharf. The main non-indigenous species detected in 2019 and 2020 included the common and widespread invasive macroalgae *Undaria pinnatifida* (at a number of sites) and common gastropod *Theora lubrica*. These invasive species are common to the Project site in addition to a large number of Port Sites in New Zealand. Native species detected by MPI in the 2019 and 2020 surveys included the following common species (Table 6)[10].

Table 7: Native marine species detected by MPI in the Project area 2019-2020

Native marine species	Common name
Parapercis colias	Blue cod
Notolabrus celidotus	Spotty
Coscinasterias muricata	Eleven-armed sea star
Austrohelice crassa	Tunnelling mud crab
Hemiplax hirtipes	Stalk eyed mud crab
Petrolisthes elongatus	Half crab

[10] MPI data was kindly supplied by Abraham Growcott at MPI.

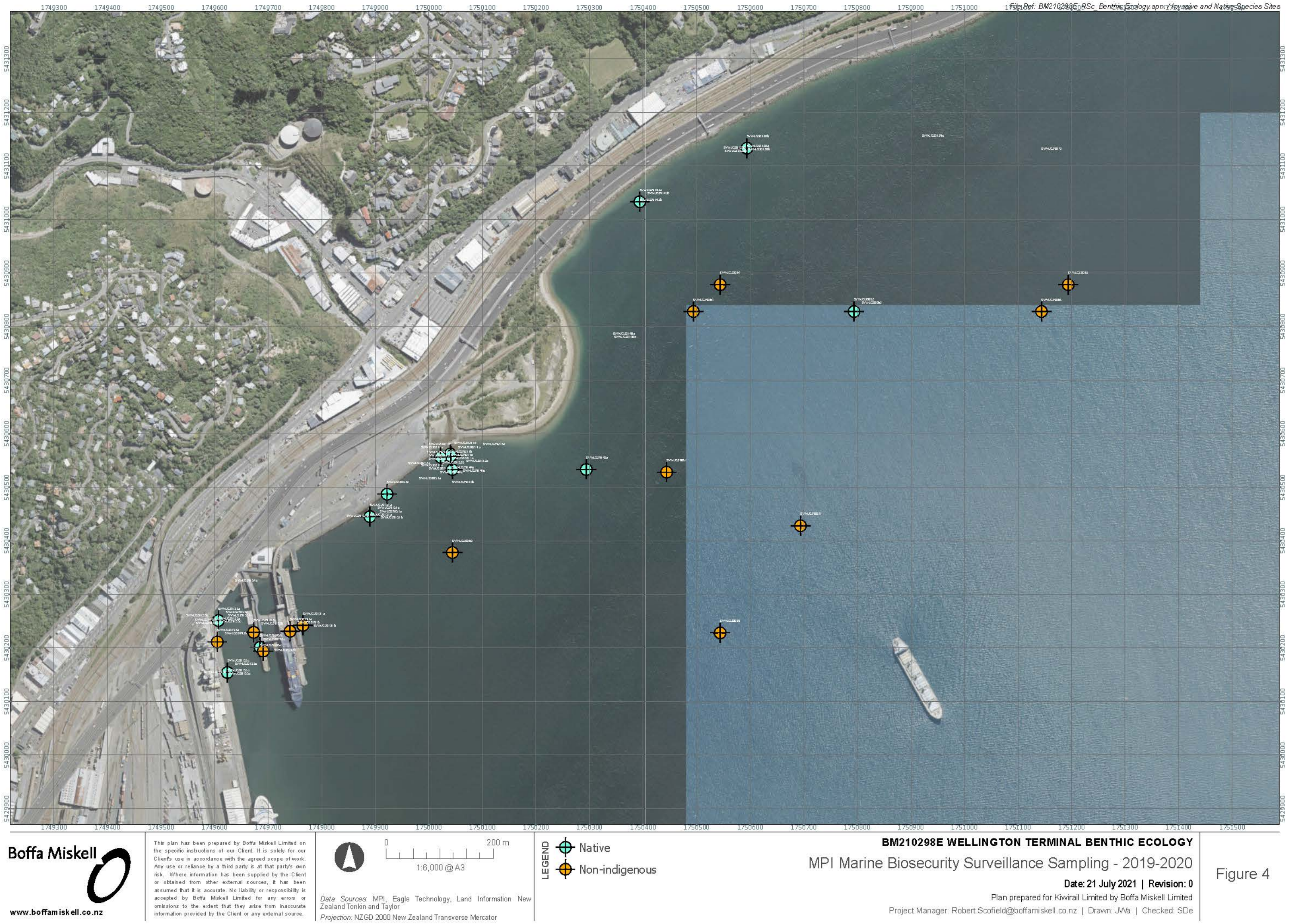


Figure 4: Non-indigenous and native marine species (MPI data)

7.1.2 2015 CentrePort data for Kaiwharawhara Point

Boffa Miskell Limited were contracted by CentrePort in 2015 to provide ecological advice on the location of previously proposed stormwater treatment devices as part of a proposed development. This proposed development, and the associated stormwater treatment devices were not pursued by CentrePort. The intertidal surveys (Figure 5) were focussed on the northern gravel beach and the Kaiwharawhara Estuary, as well as sediment samples around the intertidal area of Kaiwharawhara to better understand the extent of polycyclic aromatic hydrocarbon (PAH) contamination.

The intertidal walkover and subsequent sample collection in 2015 on the Kaiwharawhara reclamation revealed a community of relatively common rocky shore invertebrate and algal species inhabiting a hard shore comprising a mixture of more natural looking cobbles and stones and building debris, including bricks, earthen pipes, and concrete slabs (Table 7, Photograph 1). Our search in 2015 was not exhaustive, and it is likely that a greater diversity of organisms were present within the intertidal habitat.

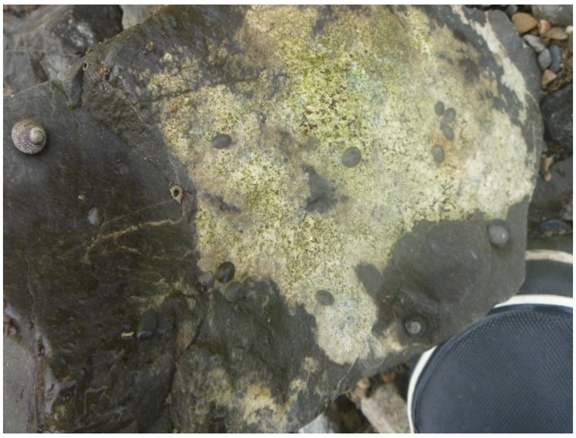
Photograph 1: Kaiwharawhara beach – northern end

Photograph 2: Northern end of Kaiwharawhara Point

Photograph 3: Kaiwharawhara Estuary

Photograph 4: Epifauna on concrete debris

Figure 5: 2015 Survey sites at Kaiwharawhara Point


Photograph 5: Epifauna on rock


Photograph 6: Epifauna on rock

Table 8: Intertidal and shallow subtidal rocky shore organisms detected around Kaiwharawhara Point

Scientific Name	Common Name
Invertebrates	
Austrolittorina unifasciata	Banded periwinkle
Chaemosipho columna	Column barnacle
Spirobranchus cariniferus	Tubeworm
Diloma aethiops	Top shell
Cominella virgata	Red mouthed whelk
Lunella smaragdus	Cats eye
Onichidella nigrans	-
Mytilus edulis	Blue mussel
Perna canaliculus	Green lipped mussel
Nerita melanotragus	-
Cellana dentriculata	-
Cellana ornata	Ornate limpet
Cellana radians	Radiate limpet
Sypharochiton pelliserpentis	Snakeskin chiton
Haustrum scobina	Oyster borer
Heterozius rotundifrons	Big handed crab
Petrolisthes elongatus	Porcelain crab / Half crab
Halicarcinus spp	
Patirella regularis	Common cushion star
-	Subtidal red anemone (undescribed)
Fish	
Fosterygion lapillum	Common or pebble triplefin
Algae	
Coralline algae	
Lithothamnion or *Lithophyllum* crust	Pink paint
Ulva laetevirens	Sea lettuce
Colpomenia peregrina	
Scytothamnus australis	
Gigartina circumcincta	
Ceramium rubrum	

In terms of the soft shore, a high abundance of organisms was detected within sediments from the Kaiwharawhara Estuary (approximately 70-140), whereas a significantly lower abundance was detected at sites within the gravel beach (<30) in 2015 (Figure 6).

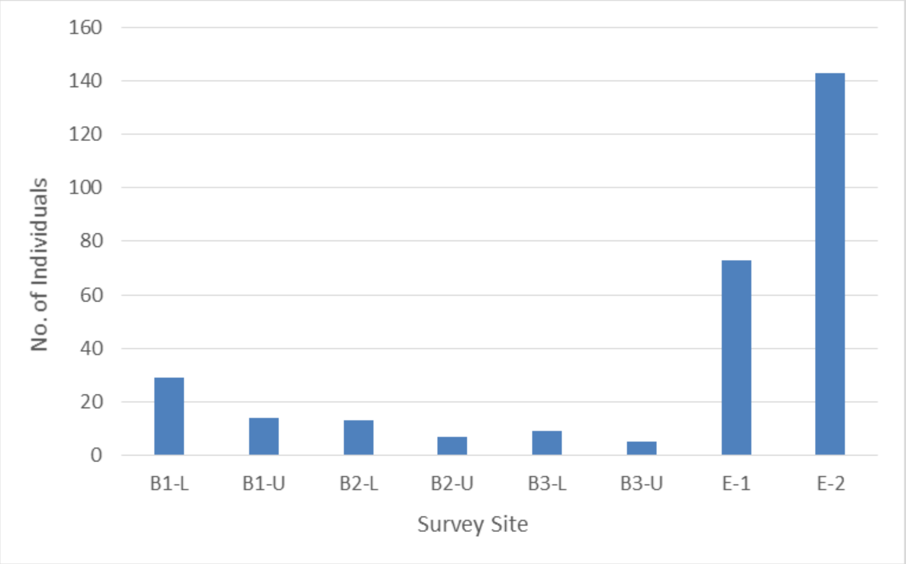


Figure 6: Abundance of benthic invertebrates in core samples (see Figure 5 for sampling locations)

With respect to the number of taxa site B1 lower on the shore had the highest number of species (8), whereas all other sites had between 3 and 5 (Figure 7).

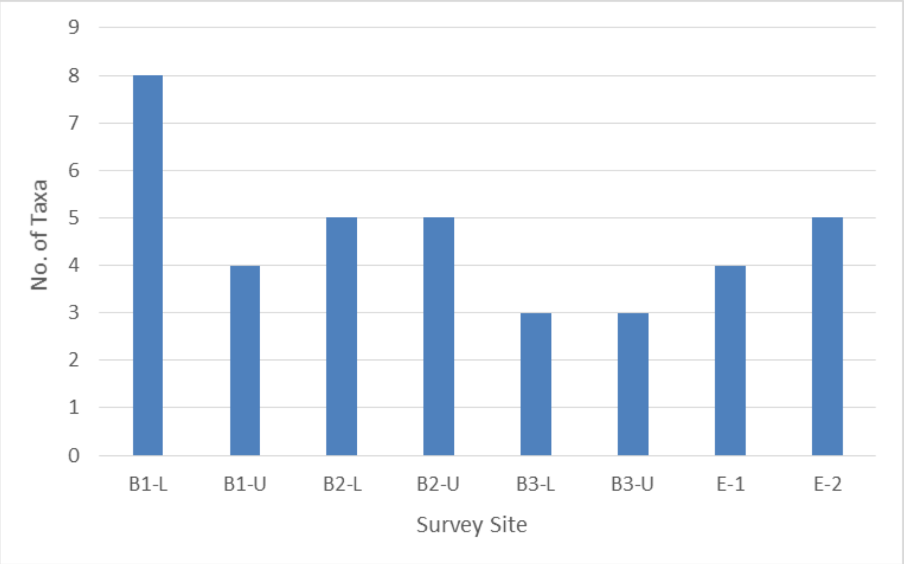


Figure 7: Number of taxa in core samples (see Figure 5 for sampling site locations).

The two estuary sites and B3 (lower) had low diversity, sites B3 (upper), B1 (upper) and B2 (lower) had low to moderate diversity and sites B2 (upper) and B1 (lower) had moderate to high diversity (Figure 8)[11].

[11] The Shannon-Wiener diversity index looks at the evenness of the distribution of abundance across the taxa, with a score of less than 1 typically indicating low diversity, a score of 1-1.5 indicating low to moderate diversity and a score of 1.5-2.0 indicating moderate to high diversity.

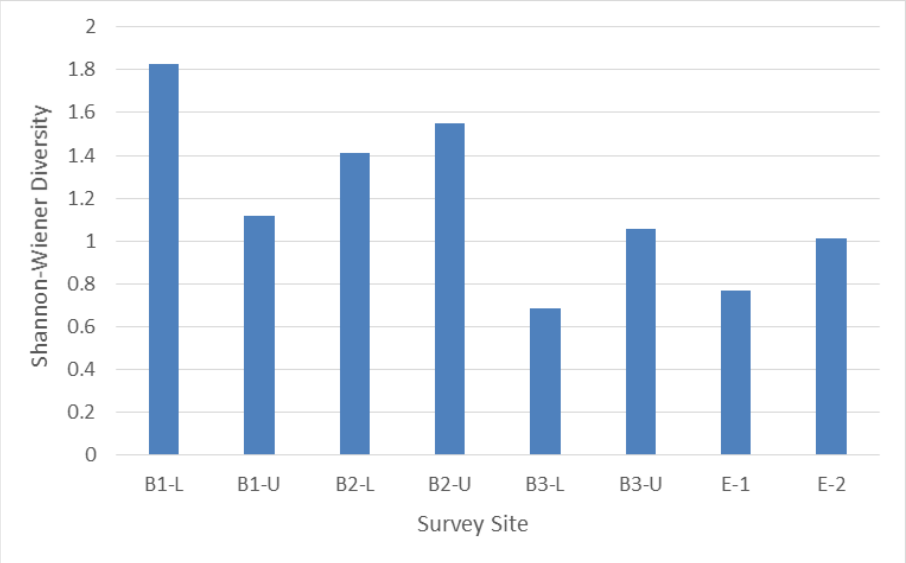


Figure 8: Shannon-Wiener Diversity Index calculated (see Figure 5 for sampling site locations)

B1 had a higher abundance of organisms that attach to rocks or shells compared to the other core samples and a low abundance of polychaete worms. The other gravel beach cores had a lower diversity of organisms and were mostly dominated by oligochaete and polychaete worms (many of which are known to be tolerant species). Estuarine samples had a high abundance of amphipods (which is typical of habitats with a strong freshwater influence) and Nereid polychaete worms (Figure 9).

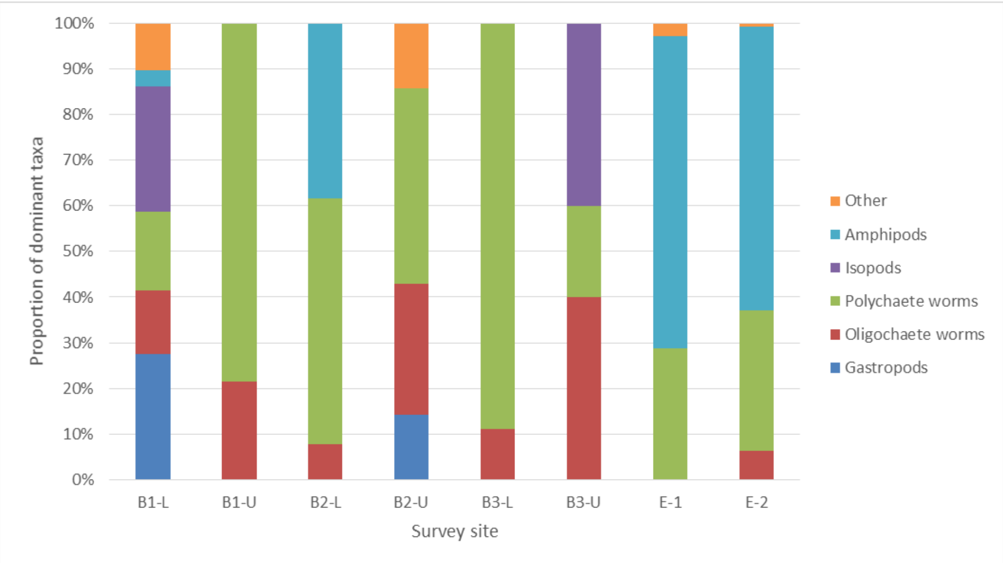


Figure 9: Proportion of dominant taxa groups within each core sample (see Figure 5 for sampling site locations)

Sediment grain size composition was dominated by gravels at most sites, including the Kaiwharawhara Estuary. Site B3, at the north-eastern end of the existing reclamation had the finest sediment but remained dominated by gravel and sands (Figure 10).

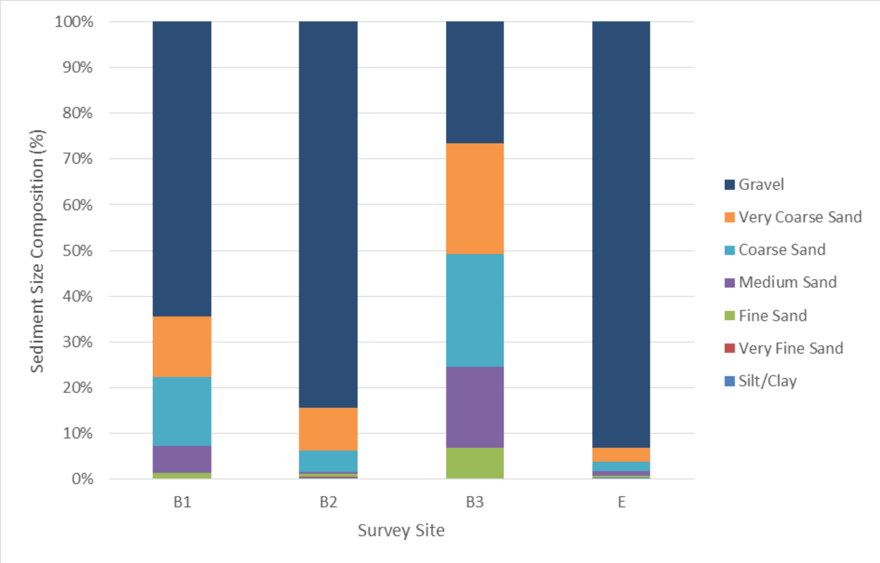


Figure 10: Proportion of sediment grain size within composite core samples (Figure 5 for site locations)

Analysis of stormwater contaminants in surface sediment revealed a low concentration of copper at all four sites, whereas lead and zinc were higher at the Kaiwharawhara Estuary (E) compared to the northern shore sites (B1-B3) (Table 8). The concentration of metals at all sites are below ANZG[12] DV. However, the concentration of zinc in surface sediment at the estuary is approaching the DV value. PAHs are below DGV[13] concentration at three sites (B1, B2 and E), whereas PAHs at B3 are above DGV concentration (Table 8).

Table 9: Stormwater contaminant concentrations in surface sediment.

Contaminant (mg/kg dry weight)	B1	B2	B3	E	ANZG DGV	ANZG GV-High
Copper	14.8	12.7	12.6	16.2	65	270
Lead	25	16.6	21	32	50	220
Zinc	83	65	60	174	200	410
Total PAHs (normalised to 1% TOC)	8.73	0.21	16.39	0.42	10	50

The additional sediment samples (labelled as 'S' sites on Figure 5) that were collected from around the Kaiwharawhara reclamation in 2015 in order to better understand the spatial pattern of PAHs in intertidal sediment revealed elevated PAHs around the proposed stormwater discharge point. Site S1, S2 and S6 were found to have PAHs above DGV. Site 4 recorded PAHs of just below the DGV (Table 9).

Table 10: PAH concentration in surface sediment.

Contaminant (mg/kg dry weight)	Total PAHs (normalised to 1% TOC)
S1	11.88
S2	30.73
S3	0.66

[12] Australia and New Zealand Guidelines (2018)

[13] Default Guideline Value

S4	9.51
S5	1.61
S6	46.61

7.1.3 CentrePort data for dredging assessment (2016)

CentrePort undertook an assessment of a proposed dredging campaign related to the Wellington Harbour entrance shipping channel, Aotea Quay and around the Thorndon Container Wharf (TCW). Of the sites investigated for the technical reports for the dredging campaign the closest sites surveyed to this current KiwiRail Project is the TCW and Thorndon disposal site (TD) (Figure 11 and Figure 12).

The sediments around Thornton Container wharf and disposal area were known to be contaminated due to historic investigations[14]. Tri-butyl tin (TBT), Dichlorodiphenyltrichloroethane (DDT) and mercury were detected in sediment above the DGV values of the Australian and New Zealand Governments (2018) for marine sediments.

Grain size at the TCW site comprised silt, sand and gravel, whereas the disposal area of the TD consisted of silt and fine sand (ES.4 Executive Summary in Tonkin & Taylor (2016a)).

In the TCW dredge area, grain size varies with depth through layers of silt, sand, and gravel (D50 ranging from 5.8 to 945 μm). At the proposed TCW disposal area, the surface sediment is predominantly silt and fine sand, with little variability across the disposal area (D50 from 8.8 to 15 μm).

Tonkin + Taylor concluded that the TD site has the following contaminant profile:

- The total organic carbon content ranges from 1.7 to 1.8%.
- Lead and mercury exceeded the Interim Sediment Quality Guidelines low trigger (ISQG) (ANZECC, 2000). However, other metals were below the ISQG-low trigger value.
- PAHs were detected at all sampling locations. However, concentrations were below the ISQG-low trigger value.
- DDT and its breakdown products were detected at most (four out of six) of the locations tested. Despite the relatively high organic carbon content in the surface sediment at the disposal ground (1.7-1.8%) the normalised results and detection limits for dieldrin and endrin were higher at the TCW disposal area than the ISQG-low trigger value.
- TBT was detected at 4 of the 6 locations tested, at concentrations close to the laboratory detection limit.

Tonkin + Taylor (2016b) assessed soft sediment invertebrate assemblages at the TCW and TD sites. The main species by abundance detected included gastropods, opisthobranchia, bivalves (including non-indigenous species), polychaete worms, tanaid shrimp, isopods, amphipods, crabs, ostracods, bryozoans, brittle stars, sea cucumber and sea tulip (see Table 10 below and Appendix A.3. in Tonkin + Taylor (2016b)).

[14] ES.1 introduction of Executive Summary in Tonkin & Taylor (2016a)

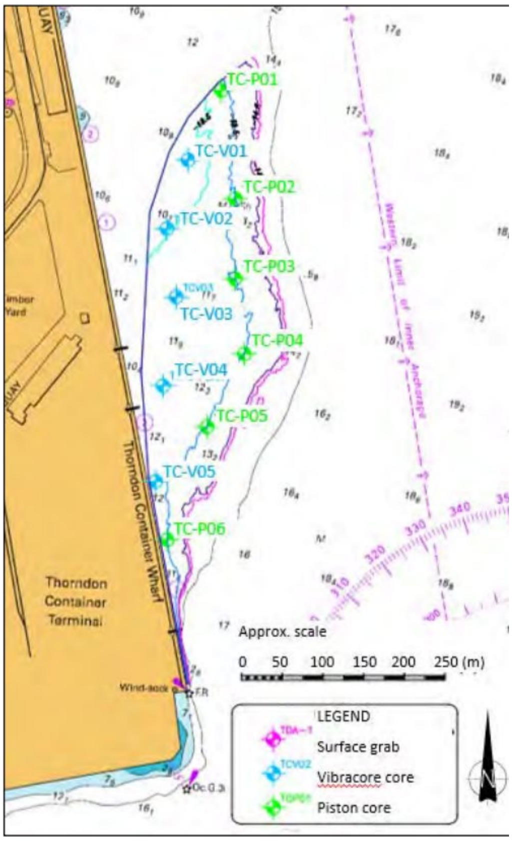


Figure 11: Location of CentrePort's dredging site at TCW (Figure 7.2 in Tonkin + Taylor (2016a))

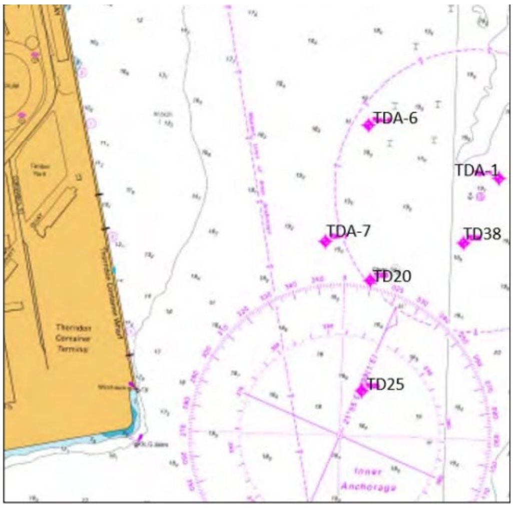


Figure 12: Dredge spoil location for CentrePort's dredging campaign from TCW (Figure 7.4 in Tonkin +Taylor (2016a))

Table 11: Most abundant species detected by Tonkin + Taylor (2016b) at Thorndon Container dredge sites

Species common name	Scientific name
Bivalve	*Ennucula strangei*
Bivalve	*Leptomya retiaria*
Morning star	*Tawera spissa*
Window shell	*Theora lubrica*[15]
Bivalve	*Varinucula gallinacea*
Polychaete worm	*Prionospio multicristata*
Polychaete worm	*Barantolla lepte*
Polychaete worm	*Heteromastius filiformus*
Bamboo worms	Maldanidae
Polychaete worm	Sigalionidae
Polychaete worm	*Sphaerosyllis* sp.
Polychaete worm	Glyceridae
Polychaete worm	Lumbrineridae
Polychaete worm	Cirratulidae
Polychaete worm	*Sternaspis scutata*
Polychaete worm	Terebellidae
Amphipod	Phoxocephalidae
Amphipod	Unidentified amphipod
Decapod	Unidentified crab larvae
Brittle star	Ophiurodea

Abundance of species at TCW site ranged between 7-104 per samples, whereas the disposal site Thorndon Disposal (TD) abundance varied between 4 and 27 per sample. The number of species was higher at TCW (5-29) compared to TD (3-15). Shannon-Wiener Diversity ranged between 1.55-2.66 whereas at TD ranged between 1.03 to 2.50. At both sites the Shannon Wiener Diversity Index reflected low to moderate diversity (1.0-2.0) to high diversity (<2.0)[16].

Tonkin + Taylor identified the majority of the benthic invertebrates at TCW and TD comprised species indifferent to disturbance and tolerant of disturbance, based on AMBI[17] scores. Some sites had between approximately 5-25% of species sensitive to disturbance, and approximately 75% of sites comprised some second-order opportunistic species but no first order species were detected (Tonkin + Taylor Ltd, 2016b, see graph on page 85 of Tonkin + Taylor report).

7.1.4 GWRC benthic invertebrate and sediment contaminant data

GWRC have four sites near to the Project area that they routinely sample for benthic invertebrates and sediment contaminants (sites AQ1, AQ2, WH3 and WH4; Figure 13) (Cummings et al., 2021). The contaminants surveyed include heavy metals, proportion of <63μm grain size (mud content), and total organic content.

[15] Non-indigenous

[16] We interpret a Shannon-Weiner index score of less than 1 as low diversity, 1-2 as moderate diversity, >2 as high diversity.

[1717] AZTI's Marine Biotic Index (AMBI) – invertebrate species are classified into five ecological groups based on their sensitivity to environmental stress, and relative abundance of species in each group (insert reference to Warwick et al 2010 in Zotero).

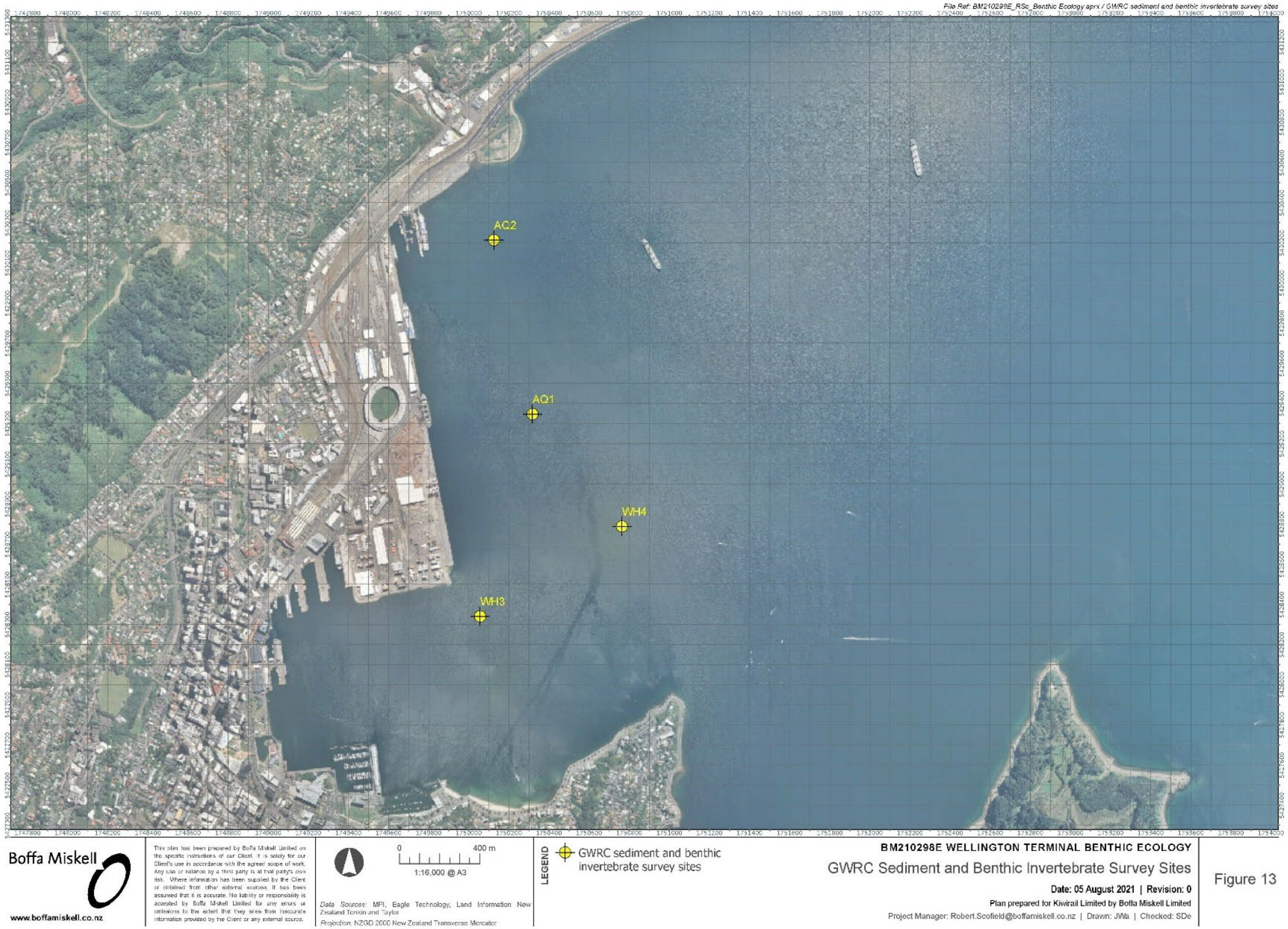


Figure 13: GWRC sediment and macroinvertebrate survey sites adjacent to the Project

GWRC surveys of benthic invertebrates comprised a suite of typical soft sediment organisms, dominated by bivalves, polychaete worms, cumacea, amphipods and ostracods (Figure 14). The introduced bivalve, *Theora lubrica,* was the most abundant species in the communities across all sites.

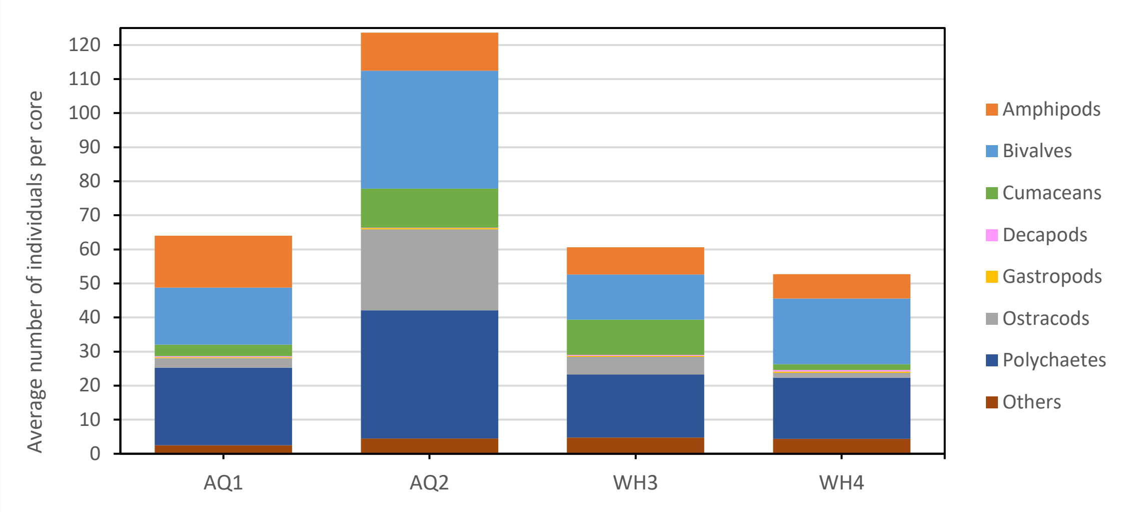
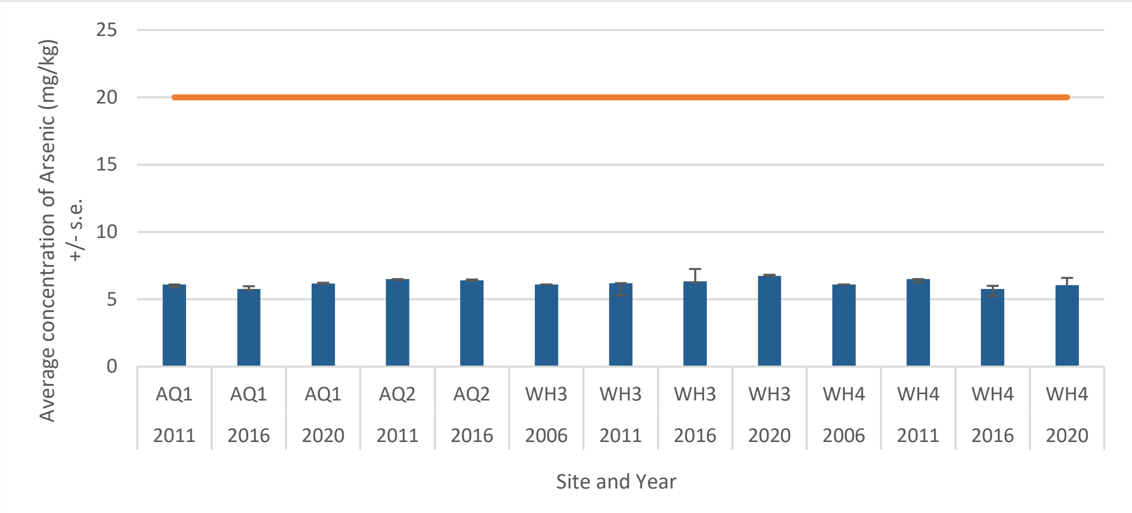


Figure 14: GWRC benthic invertebrate taxa groups from 2020 data (refer to Figure 13 for sample locations)

The concentrations of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni) and zinc (Zn) have been relatively consistent over past years[18] and below DGV values for most contaminants (refer to Figure 15 to Figure 22). The average concentration of lead was above DGV at all sites excluding AQ1 in 2011 and 2020 and WH4 in 2020. The average concentration of mercury was significantly above the DGV value at all sites and years (most likely source is atmospheric deposition from fossil fuel burning) (Figure 20). The average concentration of nickel, whilst below DGV, is close to the effect threshold of 21 mg/kg.



[18] Not all sites were sampled for each contaminant every year.

Figure 15: Average concentration of arsenic in sediment (refer to Figure 13 for sample locations). DGV value is 20 mg/kg.

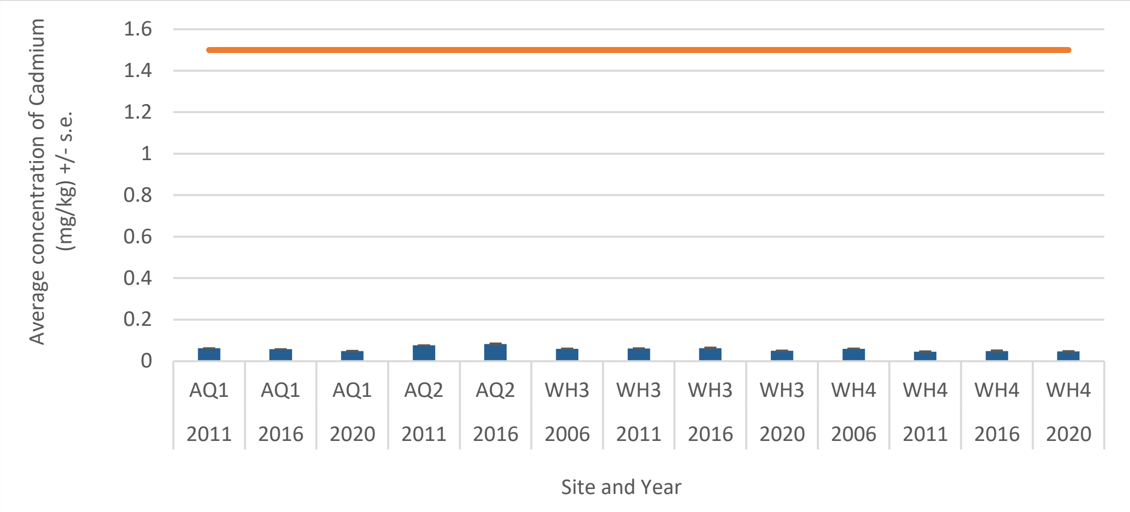


Figure 16: Average concentration of cadmium in sediment (refer to Figure 13 for sample locations). DGV value is 1.5 mg/kg.

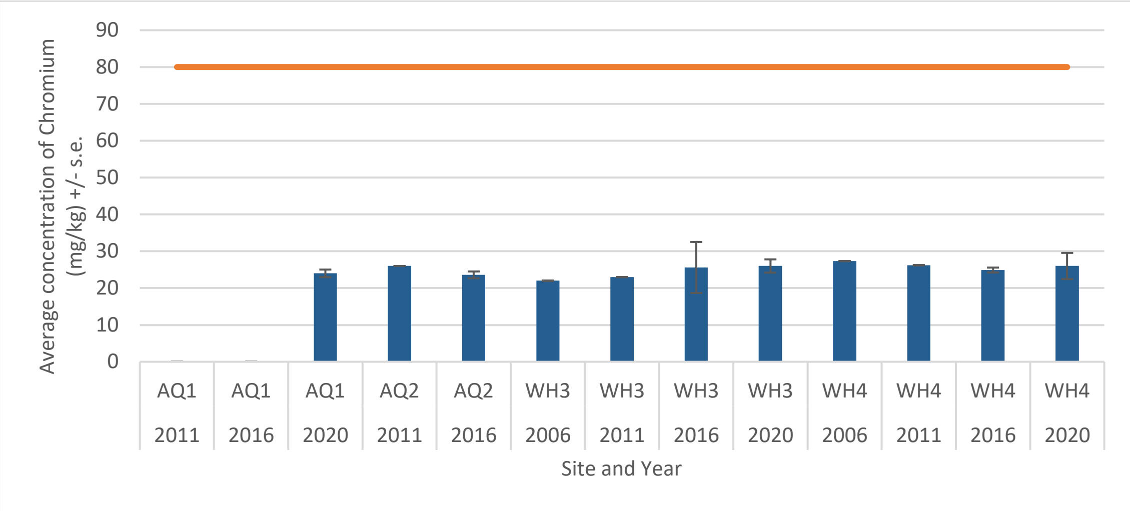


Figure 17: Average concentration of chromium in sediment (refer to Figure 13 for sample locations). DGV value is 80 mg/kg.

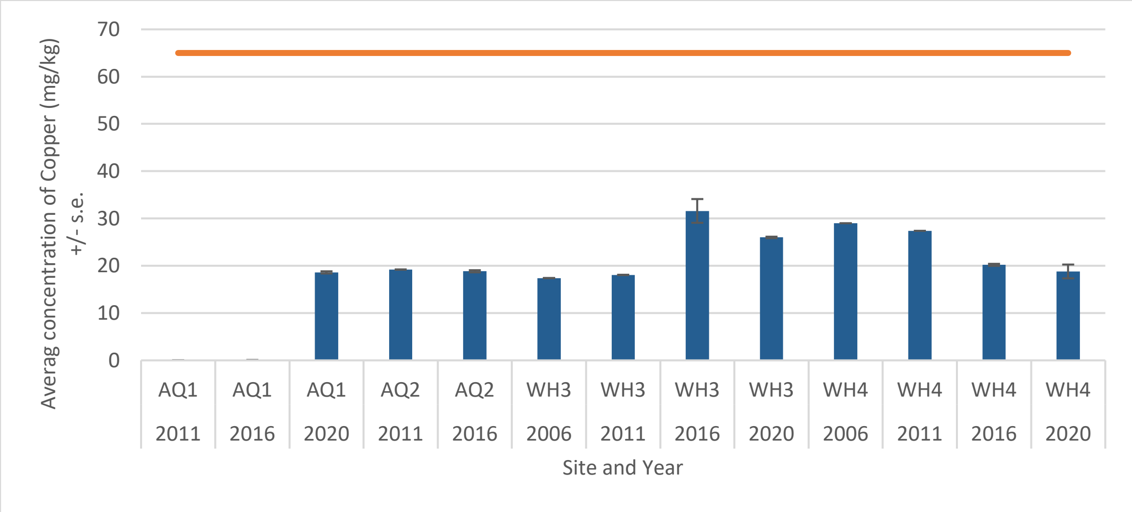


Figure 18: Average concentration of copper in sediment (refer to Figure 13 for sample locations). DGV value is 65 mg/kg.

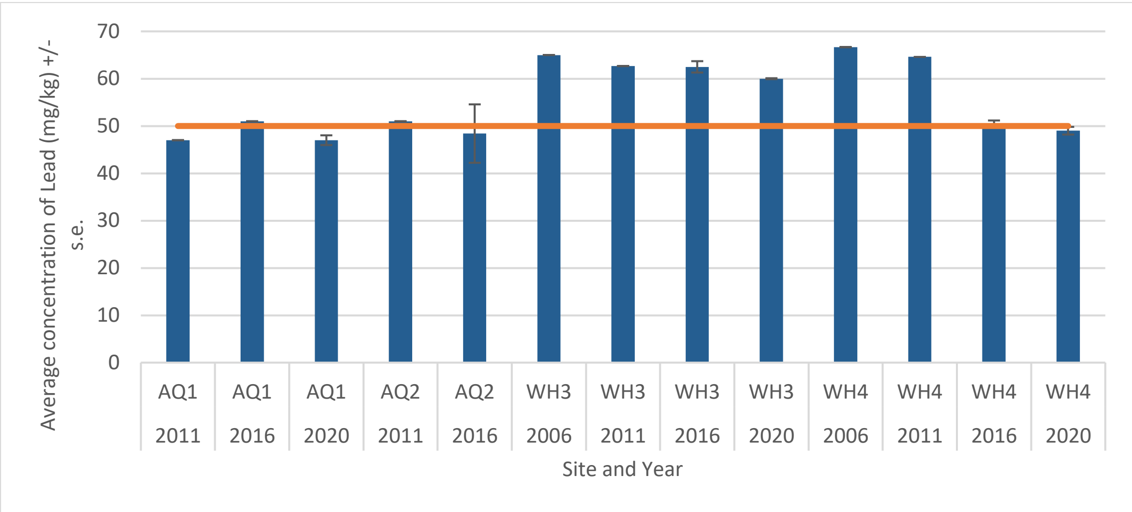


Figure 19: Average concentration of lead in sediment (refer to Figure 13 for sample locations). DGV value is 50 mg/kg.

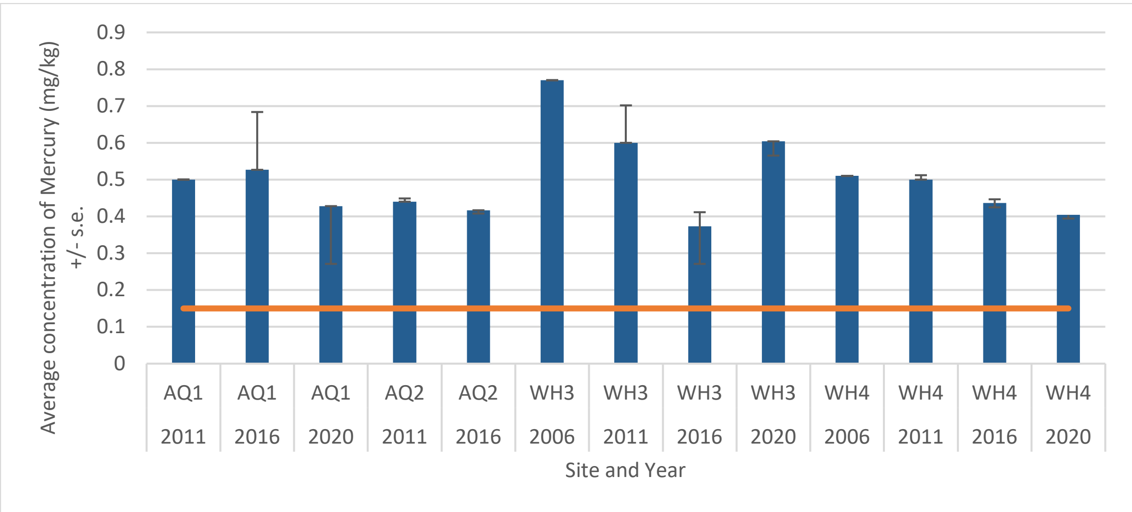


Figure 20: Average concentration of mercury in sediment (refer to Figure 13 for sample locations). DGV value is 0.15 mg/kg.

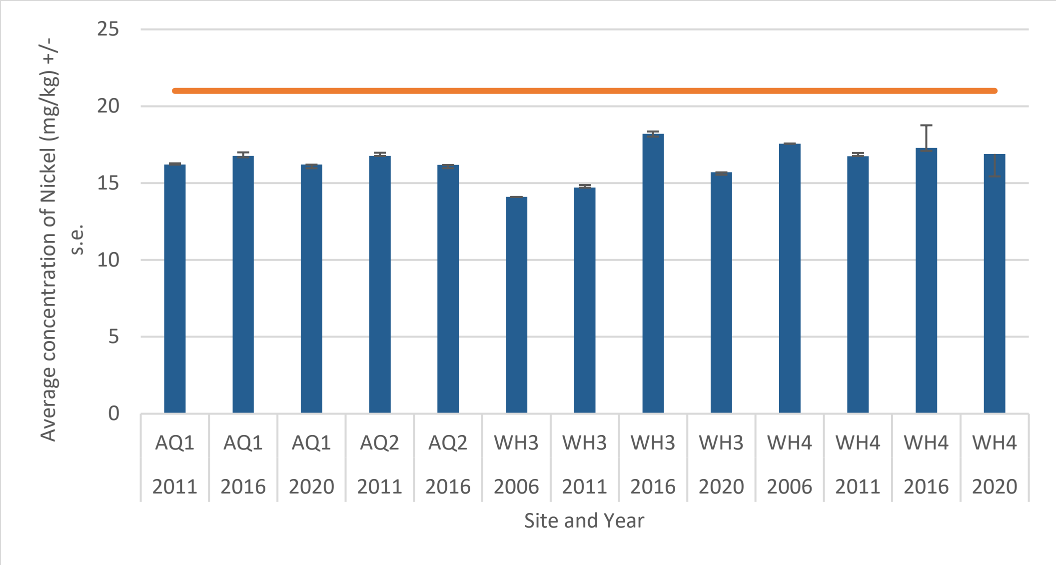


Figure 21: Average concentration of nickel in sediment (refer to Figure 13 for sample locations). DGV value is 21 mg/kg.

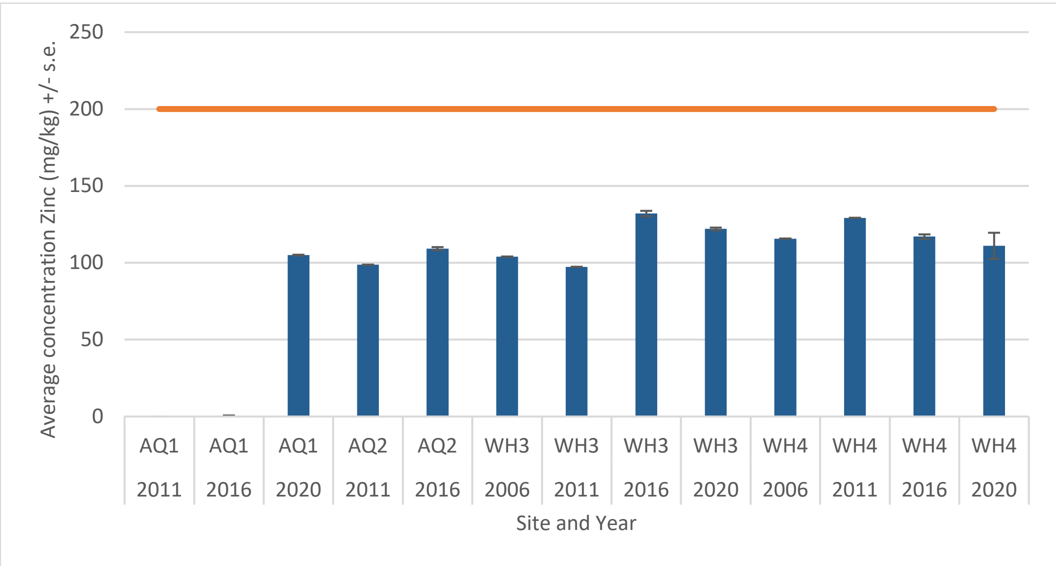


Figure 22: Average concentration of zinc in sediment (refer to Figure 13 for sample locations). DGV value is 200 mg/kg.

As part of the sediment contaminant surveys carried out by GWRC, the proportion of mud (<63µm) was also surveyed (Cummings et al., 2021). The average proportion of mud is shown in Figure 23. Site AQ1 had the lowest proportion of mud at approximately 25%, whereas WH4 had the highest proportion at around 65%. The percentage of mud at WH4 has reduced from 73% in 2016 to 53% in 2020, with the other sites having relatively consistent proportion of mud over time (Figure 23).

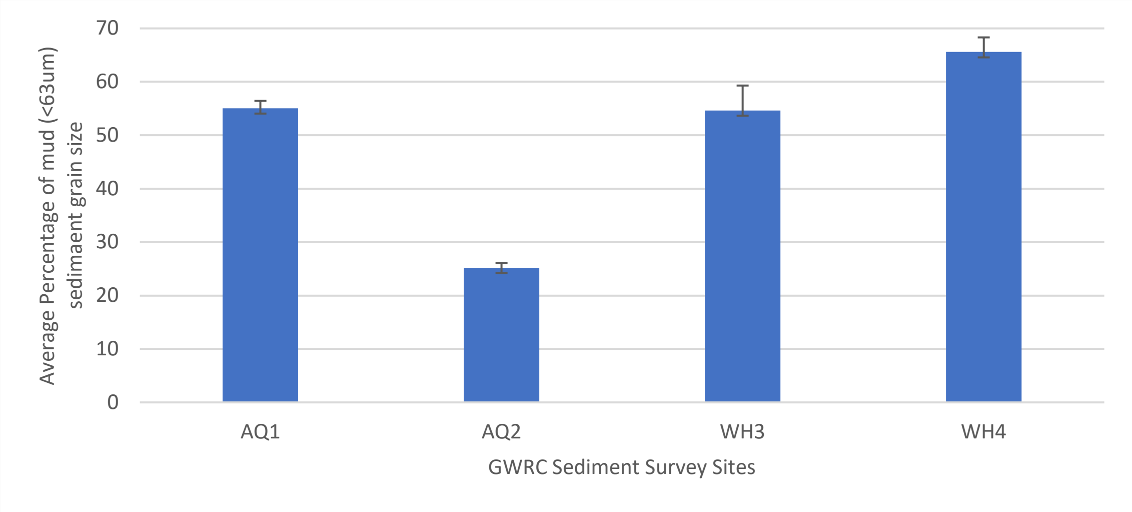


Figure 23: Average percentage of mud at GWRC survey sites (refer to Figure 13 for sample locations)

7.1.5 Maritime New Zealand (MNZ)

MNZ confirmed there are no large commercial fishing vessels operating in Wellington Harbour (Scott Bernie, MNZ, pers. comm. 18 September 2021). Two smaller vessels operate in the harbour, one being crab potting and the other set line fishing. There is no trawling in Wellington Harbour.

7.1.6 *Macrocystis pyrifera* mapping

The macroalgae *Macrocystis pyrifera* (At Risk – Declining)[19] was mapped by Hay (1990) in Wellington Harbour and around Kaiwharawhara (Figure 24 and Figure 25).

Recent mapping of *M. pyrifera* along the adjacent Te Ara Tupua project footprint has been undertaken and shows a band of macroalgae between 5-10m from MHWS along the shore from Ngauranga to Petone (Figure 26), which is visible from the surface (Figure 27).

A dedicated survey was not undertaken initially for this Project when survey data was collected in 2021. No individuals of *M. pyrifera* were detected by the subtidal dive survey sites on transect 1 or 2. Peer review recommended a survey of the coastal edge of the proposed reclamation, which revealed the presence of some sparse individuals within the Project footprint when visually observed from land in 2022. A macroalgae dive survey along the coastal edge of the proposed reclamation was been completed in March 2022 (see section 7.2.2).

[19](Nelson et al., 2019)

Figure 24: Macrocystis beds in the Kaiwharawhara area (Figure 17 from (D'Archino et al., 2019) (from Hay, 1990a)

Figure 25: A comparison of Kaiwharawhara Macrocystis beds recorded by (Hay, 1990), aerial photograph analysis 2013 and ground truthing by observations from a boat in 2017 (Figure 18 of (D'Archino et al., 2019) (Hay, 1990)

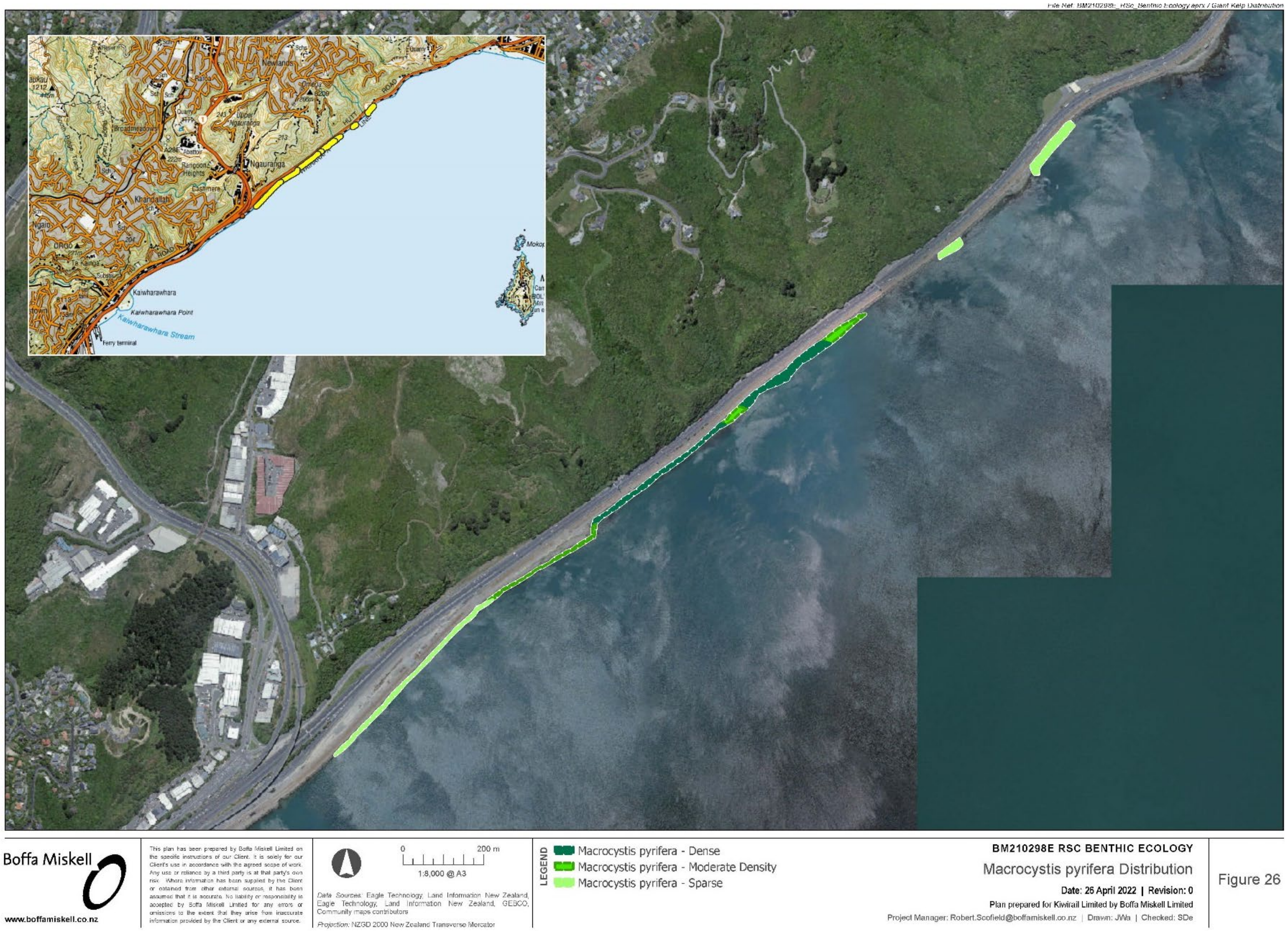


Figure 26: Map of occurrence of M. pyrifera along the Te Ara Tupua alignment.

Figure 27: Photograph[20] along the Te Ara Tupua footprint, showing M. pyrifera visible from surface of water.

7.2 Results of field surveys

7.2.1 Benthic invertebrates

7.2.1.1 Infauna

The benthic infauna data suggests high variability in abundance between sites, with sites T1 and T2 at 20m having the highest number of individuals and some deeper subtidal sites having the lowest abundance of individuals (e.g. T3 40m and T1 60m) (see Figure 2 for transect locations, Figure 28).

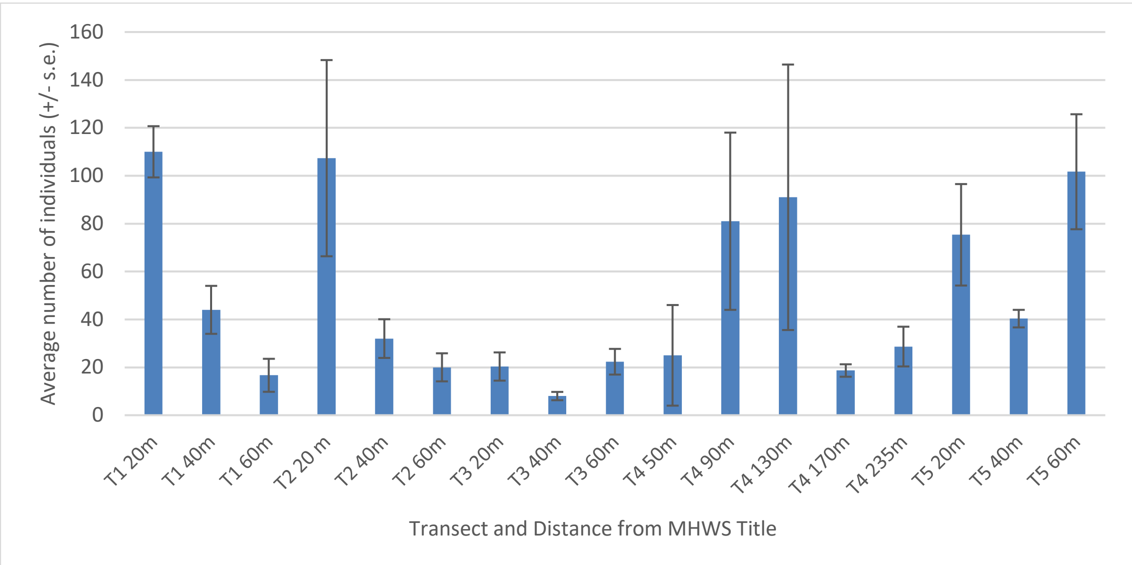


Figure 28: Average number of individual benthic invertebrates by transect and distance from MHWS

[20] Source of photograph Dr Jacqui Bell.

The average number of species was highest at T1 and T2 20m (intertidal sites) with between 20 and 25 taxa present. All other sites had predominantly less than 15 taxa per site, with T3 40m having the lowest taxa number of around 6 (Figure 29).

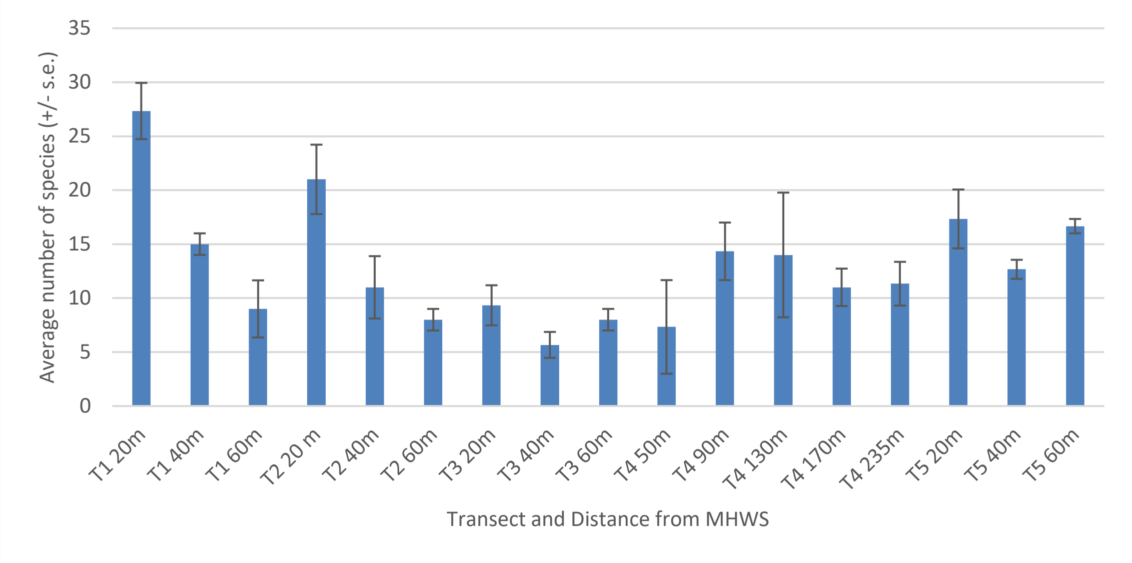


Figure 29: Average number of benthic invertebrate species by transect and distance by MHWS

The average Shannon-Wiener Diversity Index was highest at T1 (>2.5) and T2 20m (approximately 2.4), being assessed as high diversity. All other sites had an index of around 1.5-2.0 (moderate diversity), with only site T4 50m having an average index less than 1.5 (low diversity) (Figure 30).

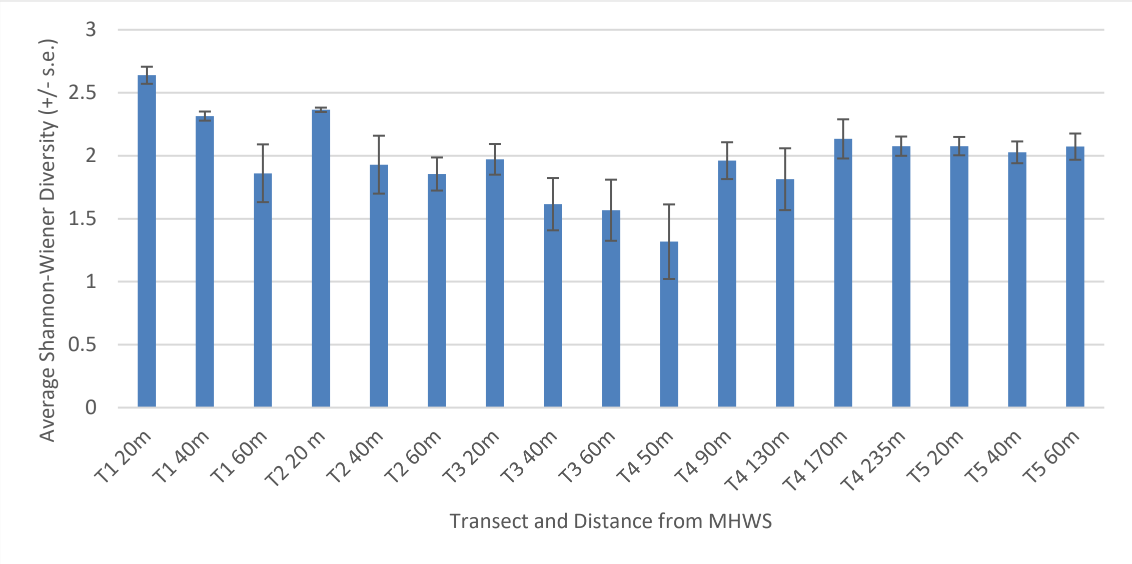


Figure 30: Average Shannon-Wiener Diversity Index by transect and distance from MHWS

A multi-dimensional scaling (MDS) plot and analyses were developed using PRIMER software. The 2D stress for the MDS is relatively high, which indicates that there were difficulties in constraining sites to 2 dimensions. The plot shows that transect 1 at 20m had different benthic community composition to most other sites (Figure 31).

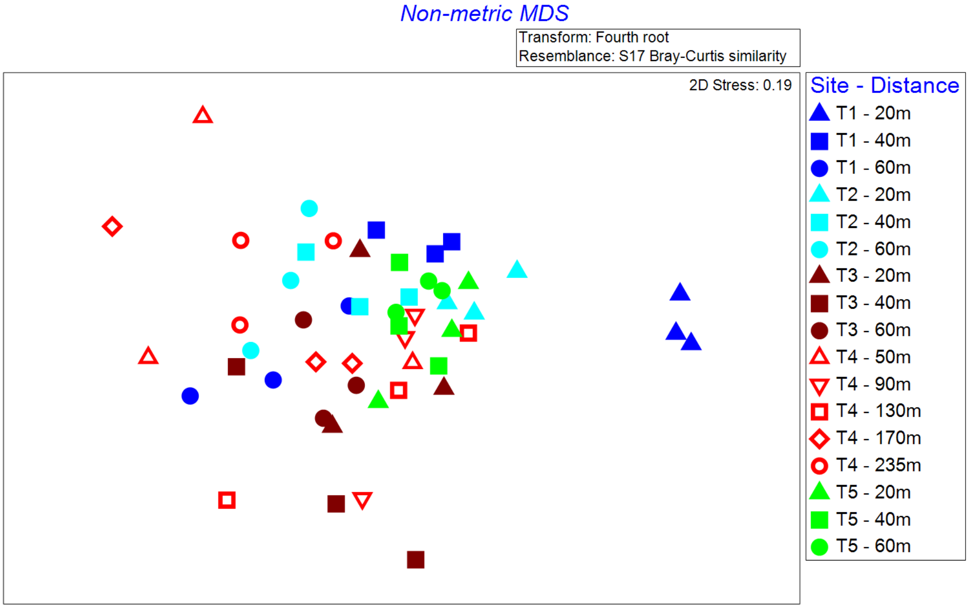


Figure 31. MDS plot showing variability in infauna community composition across the five transects at increasing distance from MHWS. Note the high stress level, indicating that the 2-dimensional arrangement of the observations does not accurately reflect their similarities.

Two sets of multivariate analyses were carried out: one testing differences in infauna community composition among the five transects (Figure 2) and the other testing differences among sampling stations along each transect.

PERMANOVA (permutational analysis of variance) and pair-wise comparisons testing differences in infauna community composition among transects showed that all transect differed from each other, aside from T1 and T2 (Figure 31). T1 and T2 had communities dominated by bivalves and polychaetes (Figure 32 and Figure 33). The most abundant bivalves along T1 were *Arthritica bifurca* and *Corbula zelandica*, while *Theora lubrica*[21] was the common bivalve along T2. *Prionospio multicristata* was the most common polychaete both at T1 and T2. Amphipods (primarily Phoxocephalidae), cumaceans and ostracods (primarily *Scleroconcha* sp.) were also common at T1 and T2 (refer to Figure 33 for SIMPER[22] results and Appendix 1 for raw data). T3 had lower numbers of animals across virtually all taxa compared to all other transects (Figure 33). T4 had fewer amphipods, bivalves and polychaetes but more ostracods (primarily *Scleroconcha* sp.) than T1 and T2 (Figure 32 and Figure 33). T5 had more cumaceans than all other transects, and also good numbers of amphipods, bivalves and polychaetes (Figure 33).

[21] Introduced species

[22] SIMPER analysis identifies taxa most responsible for the multivariate distance between experimental treatments

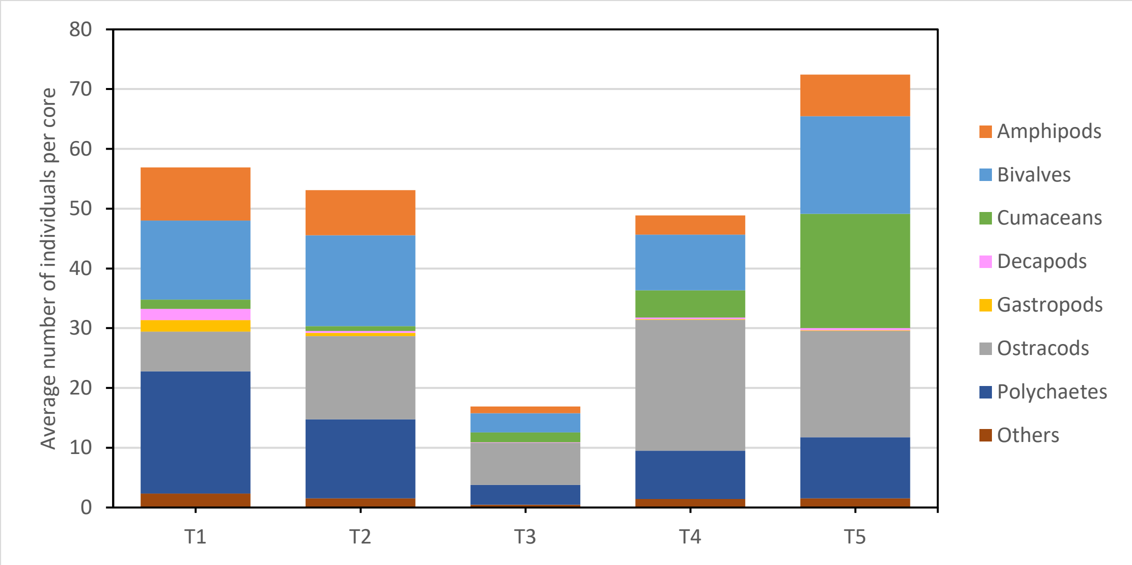


Figure 32: Abundance of the main groups of infaunal animals across the five transects.

PERMANOVA and pair-wise comparisons testing differences in infauna community composition at different distances relative to MHWS, showed significant differences among sampling distances along T1 and T2 (Figure 31).

Along T1, the 20m station had the highest abundance of animals and its infauna composition differed significantly from both the 40m and the 60m station (Figure 31). A number of taxa abundant at the 20m station were absent at the 40m one. These included the bivalve *Corbula zelandica,* unidentified amphipods, the polychaetes *Barantolla lepte* and *Notomastus zeylanicus*, and the crab *Petrolisthes novaezelandiae*. Other taxa were present at the 40m station but not at the 20m one, including the ostracods *Diasterope grisea* and *Scleroconcha* sp., and the bivalve *Theora lubrica* (refer to Figure 33 for SIMPER results and Appendix 1 for raw data). Similarly, several taxa abundant at the 20m station were absent or scarcely abundant at the 60m site. These included a range of polychaetes (*Prionospio multicristata*, *Barantolla lepte*, *Notomastus zeylanicus*, and *Armandia maculate*) the bivalves *Corbula zelandica* and *Arthritica bifurca*, and the crab *Petrolisthes novaezelandiae*. Ostracods (primarily *Scleroconcha* sp.) were the only group more abundant at 60m than at 20m (Figure 33).

Along T2, the 20m station had the highest abundance of animals and its infauna composition differed significantly from the 60m station (Figure 33)). Similar to T1, there was a range of taxa abundant at the 20m station, but absent at the 60m one. This included the polychaete *Prionospio multicristata*, the bivalve *Arthritica bifurca*, cumaceans, the ostracod *Parasterope quadrata* and *Rutiderma* sp., and the urchin *Echinocardium cordatum*. The polychaete *Cossura consimilis* and the ophiuroid stars were among the few taxa present at 60m but not at 20m distance from MHWS along T2 (refer to Figure 33, SIMPER results and Appendix 1 for raw data).

No *Threatened* or *At Risk* benthic invertebrates were detected at any site surveyed.

7.2.2 Macroalgae

A survey undertaken on 22/02/2022 revealed the presence of *Carpophyllum* species of brown kelp (common name flapjack) and sparse individuals of *Macrocystis pyrifera,* primarily adjacent to the coastal edge of transect T2. *Carpophyllum* species are common and not threatened nor At Risk, whereas *M. pyrifera* has a threat classification of At Risk declining (Nelson et al., 2019).

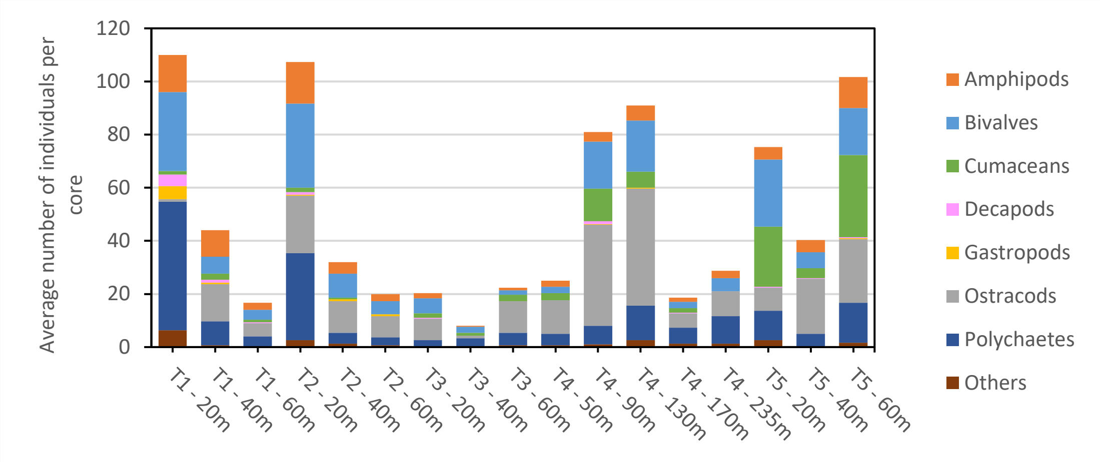


Figure 33. Abundance of the main groups of infaunal animals at increasing distance from MHWS along each transect.

7.2.3 Sediment contaminants

All contaminants surveyed were below the DGV values for indicating potential adverse effects on marine organisms, excluding lead (Australian and New Zealand Governments, 2018) (Figure 34 to Figure 44). Lead concentration was above DGV at almost all sites (Figure 38). Mercury was detected above the DGV values at all sites, especially transects 3-5 (Figure 40). Similarly, the sites surveyed by GWRC revealed mercury above DGV values at all the GWRC sites surveyed closest to the Project area. Mercury is a persistent pollutant globally, as it is the primary source for fossil fuel burning and subsequent atmospheric deposition onto land and water (Gworek et al., 2016).The concentration of all contaminants were higher at transects 3-5 compared to transects 1-2. Sediment from T1 20m could not be analysed for contaminants as the surface sediment sample comprised entirely gravel.

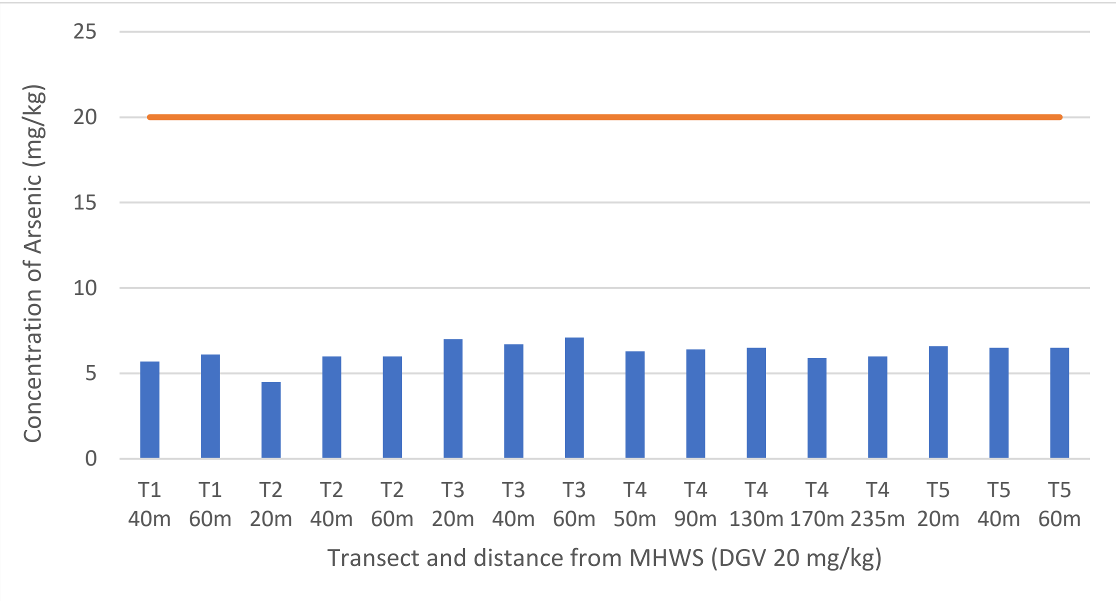


Figure 34: Concentration of arsenic in composite surface sediment samples by transect and distance from MHWS

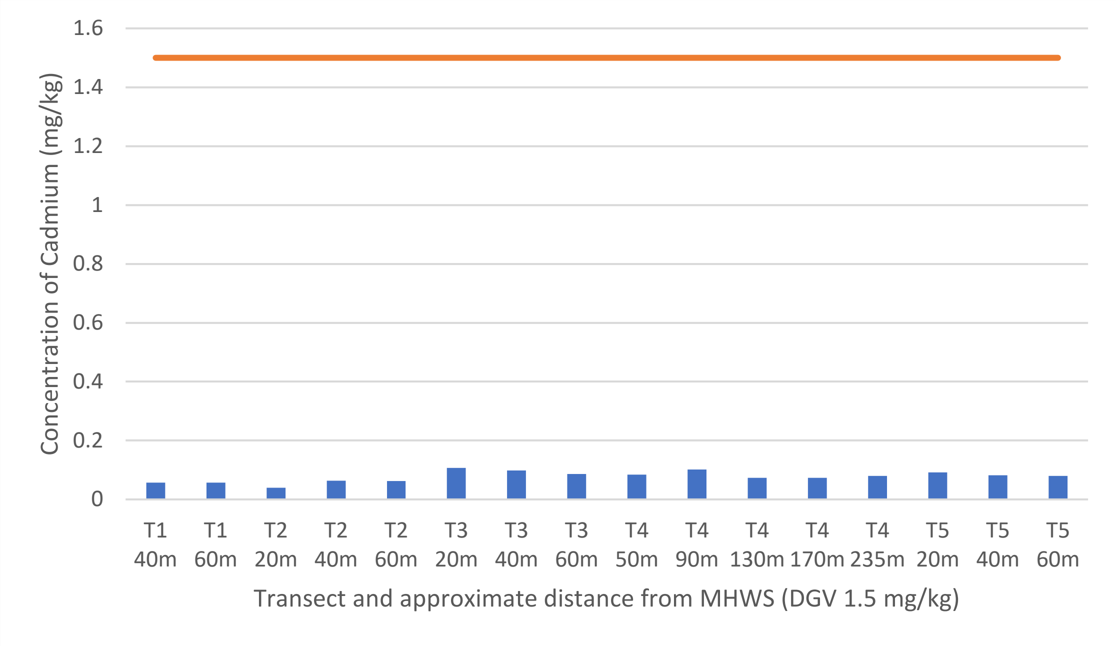


Figure 35: Concentration of cadmium in composite surface sediment samples by transect and distance from MHWS

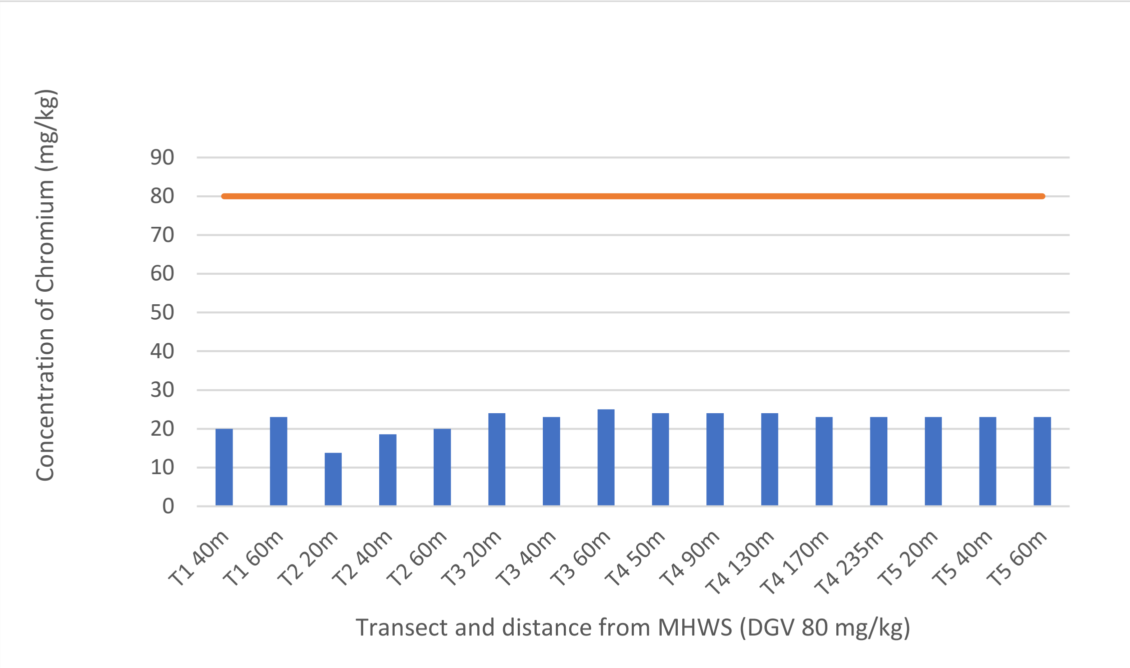


Figure 36: Concentration of chromium in composite surface sediment samples by transect and distance from MHWS

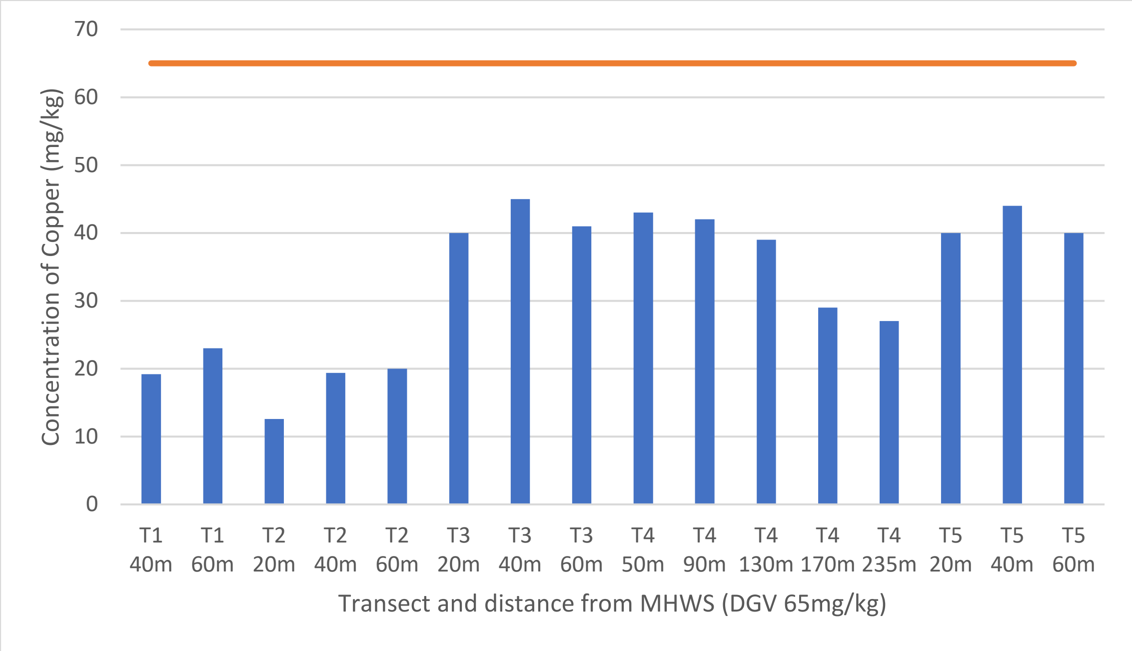


Figure 37: Concentration of copper in composite surface sediment samples by transect and distance from MHWS

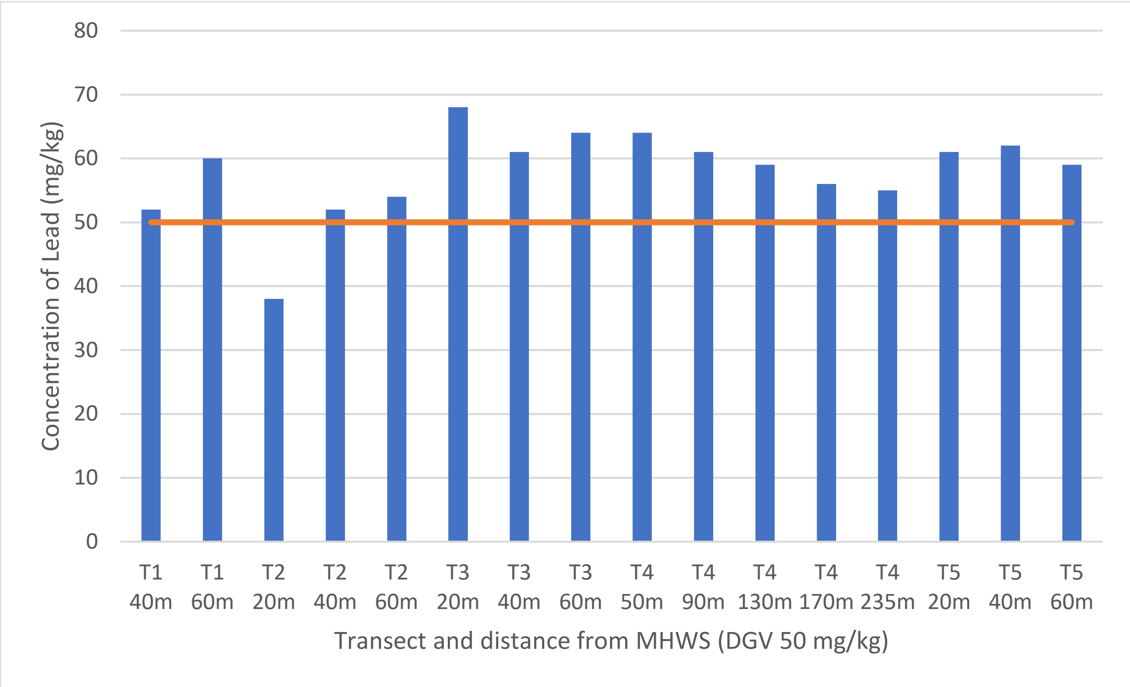


Figure 38: Concentration of lead in composite surface sediment samples by transect and distance from MHWS

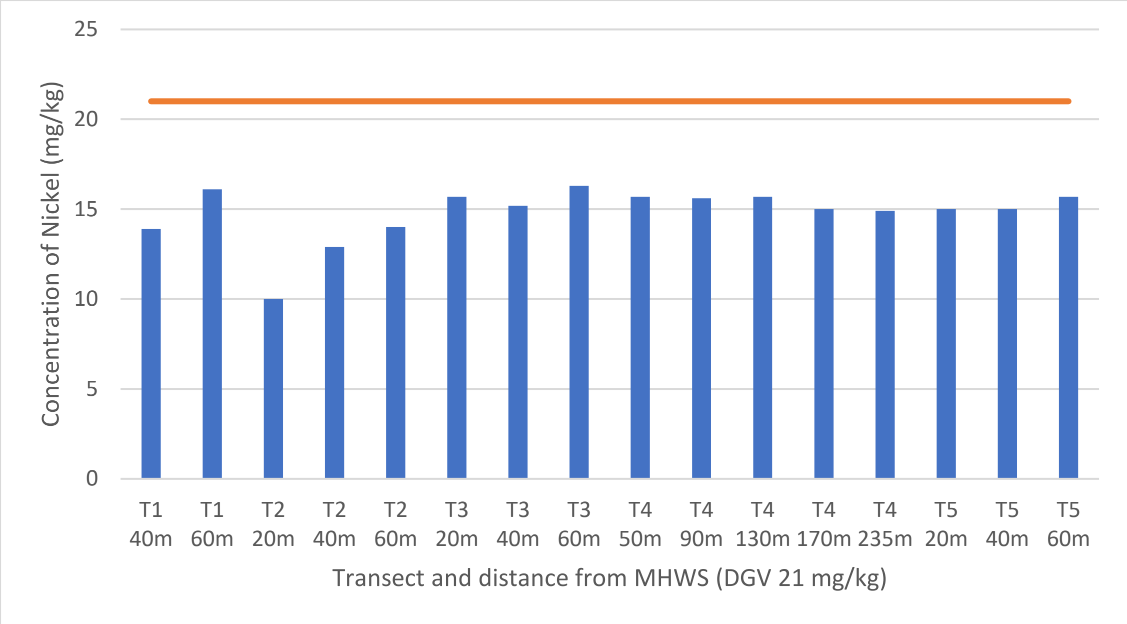


Figure 39: Concentration of nickel in composite surface sediment samples by transect and distance from MHWS

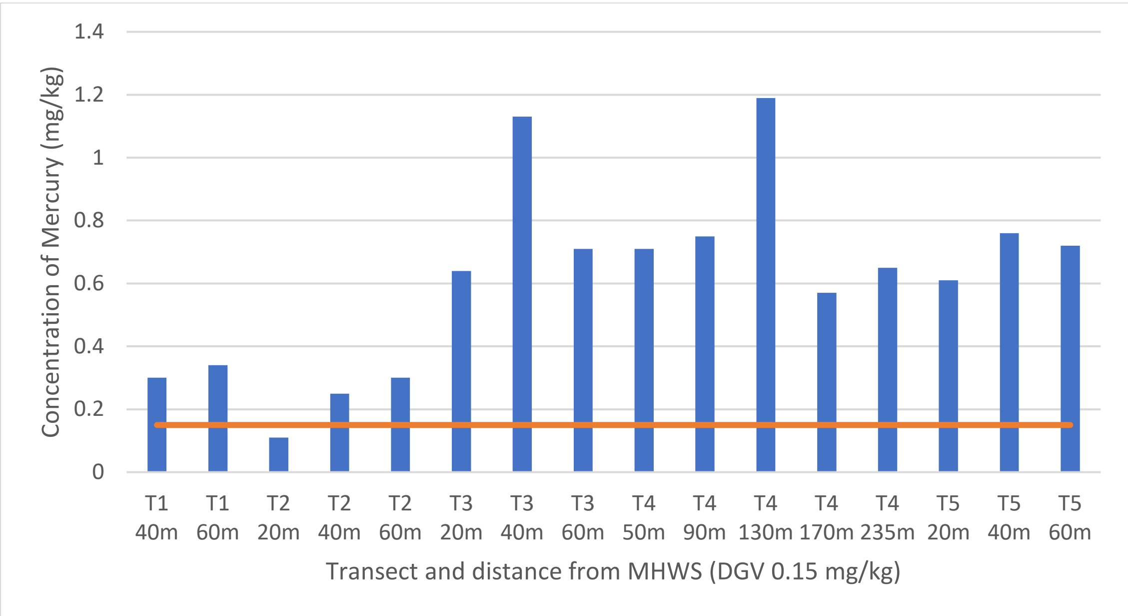


Figure 40: Concentration of mercury in composite sediment samples by transect and distance from MHWS

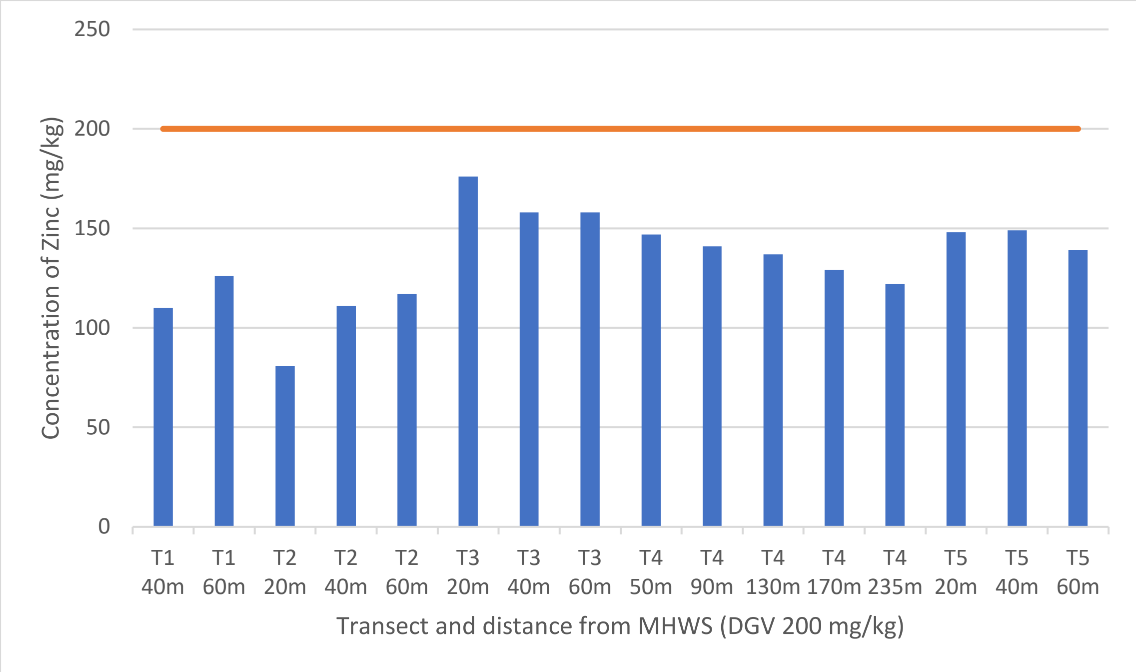


Figure 41: Concentration of zinc in composite surface sediment samples by transect and distance from MHWS

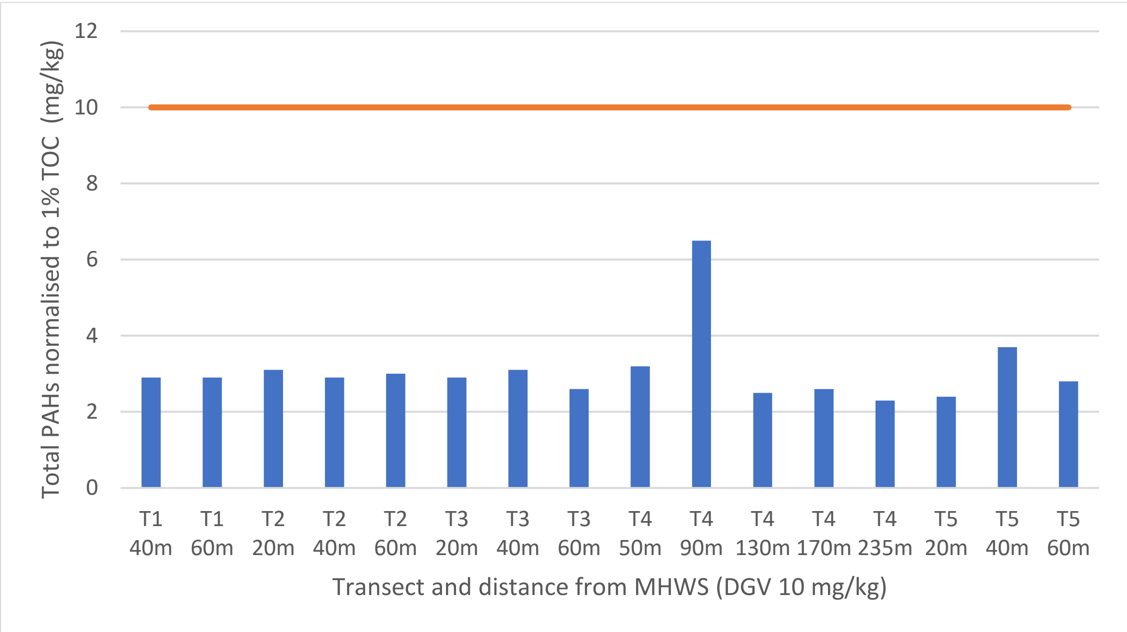


Figure 42: Concentration of total PAHs in composite surface sediment samples by transect and distance from MHWS

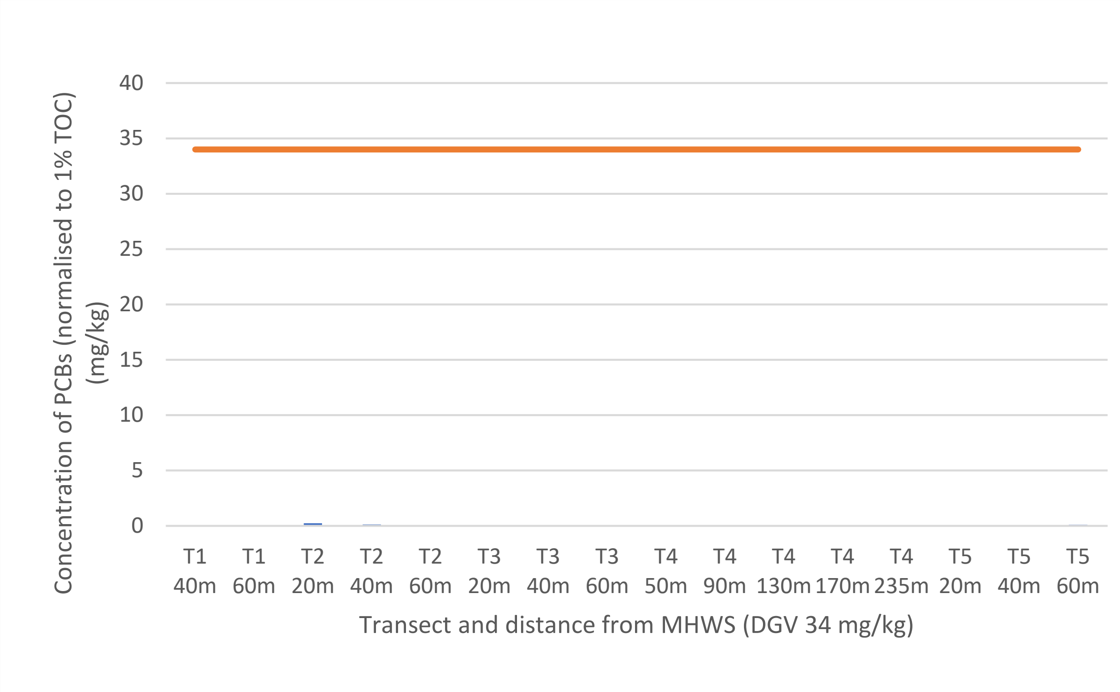


Figure 43: Concentration of PCBs in composite surface sediment samples by transect and distance from MHWS

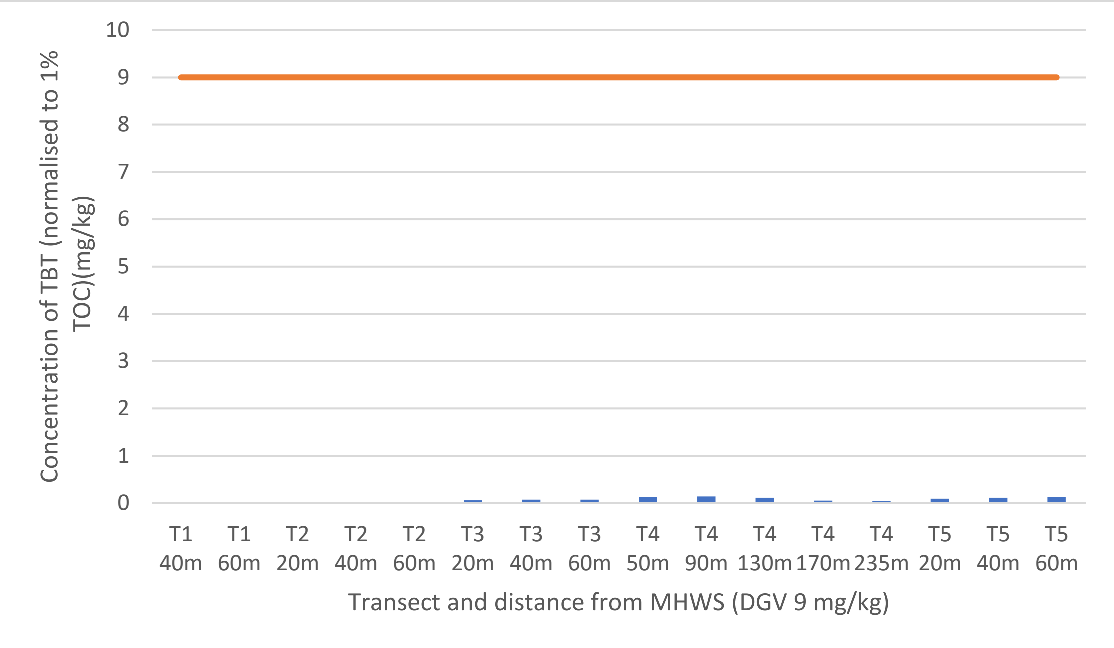


Figure 44: Concentration of TBT in composite surface sediment samples by transect and distance from MHWS

7.2.4 Sediment grain size

Surface sediment samples analysed for proportion of grain sizes indicated most sites comprised greater than 70% silt and clay (Figure 45). Site T1 20m comprised entirely gravel, and site T2 20m comprised 30% silt and clay, with the remaining grain sizes being fine to coarse sand primarily (Figure 45).

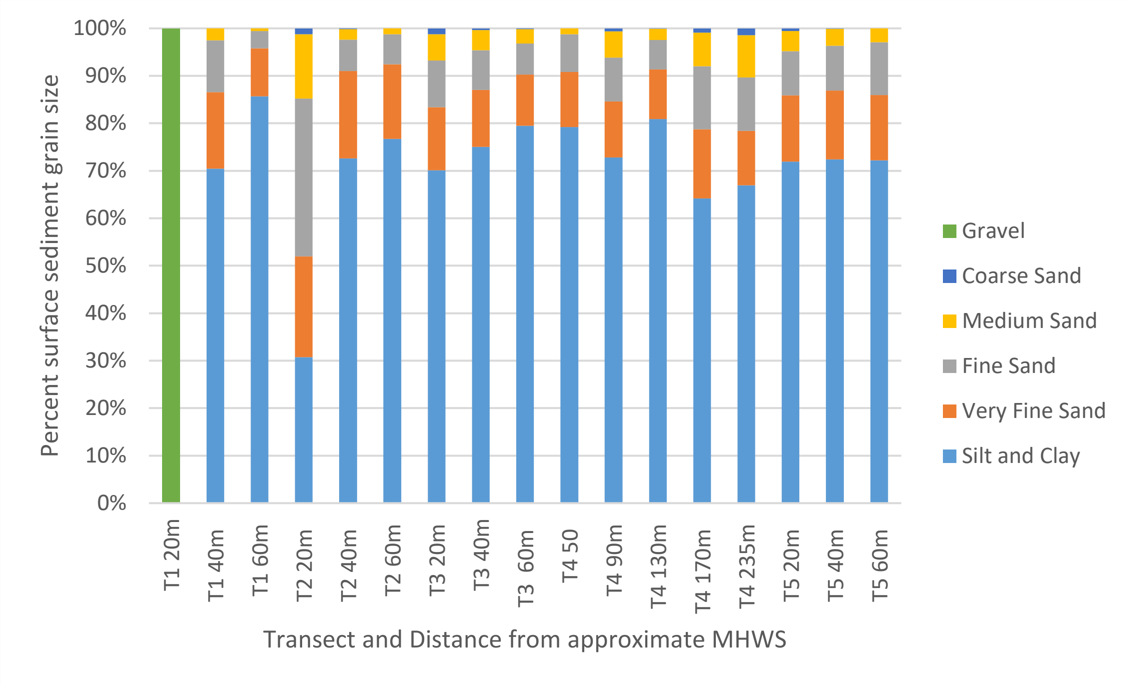


Figure 45: Proportion of surface sediment grain size by transect and distance from MHWS

7.2.1 Fish

Fish species historically important to iwi in the Wellington Harbour have included red cod (*Pseudophycis bachus*), snapper (*Pagrus auratus*), gunard *(Chelidonichthys kumu*), kahawai (*Arripis trutta*),tarakihi (*Nemadectylus macropterus*), john dory (*Zeus faber)*, wrasse (*Notolabrus facicola*), travelly (*Pseudocaranx dentex*), rig (spotted smooth hound) (*Mustelus lenticulatus*), batfish species, various species of shark, and flatfish (e.g. flounder *Rhombosolea plebeia*) (Rob Greenaway & Associates, 2016) (Tonkin & Taylor Ltd, 2016b).

Kahawai, snapper, tarakihi, cod and gurnard are the most commonly caught recreational fish, though there is also a wide variety of the more unusual species such as elephant fish, skate, leather jackets and kingfish.[23]

7.2.2 Redox depth – depth of oxygenated surface sediment

The subtidal visibility did not allow assessment of the depth of oxygenated sediment over anoxic sediment nor identification of epifauna. However, the benthic sediment was noted by the divers to comprise fine anoxic mud which was readily resuspended when disturbed.

8 Assigning Marine Ecological Values

Below, for each survey (or survey site within transects) (T1 to T5 as shown in Figure 2) we assign values to each of the marine ecology characteristics identified in Table 1, and then provide an overall ecological value.

[23] https://stevesfishingshop.co.nz/pages/tips-n-info August 2018

8.1 Benthic invertebrates

Benthic invertebrate abundance was highest at T1 and T2 transects at 20m from MHWS (>100 organisms per core) reflecting high habitat characteristic. Lowest abundance at T3 <40 organisms reflecting LOW habitat characteristic. Abundance at T4 90m and 130m and T5 20m and 60m was between 70-90 individuals reflecting moderate characteristics (Figure 28).

The number of species was highest at intertidal sites T1 20m and T2 20m (with 28 and 21 taxa on average respectively – high habitat characteristic). All other sites had less than 15 species (between low to moderate habitat characteristic) (Figure 29).

The Shannon-Wiener diversity index (a measure of species richness and the evenness of abundance across those species) was highest at T1 20m (above 2.5 – high ecological value), followed by T2 20m and T1 40 (both with an index greater than 2.0 – moderate to high habitat characteristic). T5 50m had lowest index of less than 1.5 (low to moderate habitat characteristic), with all other sites having an index of 1.5 to just over 2.0 (moderate habitat characteristic) (Figure 30).

8.2 Macroalgae

Common flapjack (*Carpophyllum* spp.) (not threatened) and very sparse individuals of *Macrocystis pyrifera* (At Risk, declining) were observed on 22/02/2022 when viewed from the shore within the footprint of the reclamation.

A macroalgae dive survey (Appendix 3) at 15m and 20m from MHWS at the shore adjacent to SH2. Additionally, 6 transects perpendicular to the shoreline were also surveyed. Go-pro videos were analysed to record the macroalgae species present and count the number of *M. pyrifera.*

Results from this dive survey indicated *M. pyrifera* was very patchy and sparse with most of the plants not reaching the surface, about 1m or less tall, or juvenile thalli. Density of *M. pyrifera* was estimated at 1 plant per m^2 or less. Most *M. pyrifera* plants (39) were detected along the 5m transect at a water depth of 2-4m. The most abundant species observed was *Carpophyllum maschalocarpum (*not threatened) which forms an almost continuous belt 5m offshore.

The presence of an At Risk species (*M. pyrifera*) increases the ecological values of the reclamation site.

8.3 Invasive species

With respect to invasive species, the bivalve *Theora lubrica* and the macroalgae *Undaria pinnatifia* were commonly detected. *Theora lubrica* was present at all sites excluding T1 20m (Figure 4) (LOW habitat characteristics).

8.4 Surface sediment contaminants and grain size

Surface sediment contaminants were detected in historic samples, and samples outside of the construction area predominantly.

Surface sediment contaminants collected by BML were below DGV thresholds for all contaminants except lead (above DGV at all sites except T2 20m) and mercury (above DGV at all sites) (Figure 38 and Figure 40).The source of lead could be historic stormwater runoff. The source of mercury in sediments is likely to be burning of fossil fuels and atmospheric deposition to the marine environment (Gworek et al., 2016). Mercury detected at all sites surveyed was above DGV value, highest at transects 3-5. TBT was found in highest concentration at T3, T4 and T5 (closer to the existing wharves and existing Interislander berth site, compared to T1 and T2) (Figure 44). In general, T3-5 has higher contaminant concentrations compared to T1-2. Overall, the contaminants reflect moderate habitat characteristics as most contaminants were below DGV threshold concentrations (apart from lead and mercury).

PAH concentration exceeded DGV in 2015 intertidally on the existing Kaiwharawhara reclamation, particularly close to the Kaiwharawhara estuary (to the south) and the proposed reclamation (to the north). In our study, PAHs were highest T4 90m but significantly below DGV (Figure 42).

Tonkin + Taylor (Contamination Assessment) recorded concentrations of lead, mercury and TBT above DGV values in a number of sediment samples around the existing wharf.

Tonkin + Taylor (Contamination Assessment) recorded total PAHs in marine sediments in 2021 above DGV values at site SD11 adjacent to the mouth of Kaiwharawhara Estuary (Figure 1 of Contamination Assessment). The concentration at Site SD05 (adjacent to existing wharf) was just below the DGV concentration.

GWRC in their surveys of sediment quality at sites AQ1, AQ2, WH3 and WH4 (nearest to the Project works, Figure 13) indicated all contaminants were below DGV values except for mercury and lead at AQ1, AQ2 and WH4 in certain years. This is relatively consistent with our survey of surface at the Project footprint at most sites and also reflects overall MODERATE ecological values.

Sediment grain size comprised 100% gravel at site T1 20m (HIGH ecological values), with all other sites having approximately 70% silt and clay (LOW habitat characteristic), and just T1 60m and T4 130m comprising more than 80% silt and clay (LOW habitat characteristic).

Of the sites surveyed by GWRC, AQ1 had the lowest proportion of mud at approximately 25%, whereas WH4 had the highest proportion at around 65% (Figure 23), which is lower than the sites we surveyed at the Project footprint.

8.5 Redox depth

The depth of oxygenated sediment on top of anoxic sediment layers could not be assessed by the dive team due to poor visibility. However, it is likely that there is little oxygenated sediment above anoxic sediment at sites with >70% silt and clay in surface sediment (LOW habitat characteristic).

8.6 Coastal vegetation

Estuarine/coastal vegetation was largely non-existent (apart from vegetation on Kaiwharawhara Point covered in the terrestrial ecology assessment) due to the CMA edges being reclaimed (LOW habitat characteristics). Macroalgae is discussed in section 8.2 above.

8.7 Habitat modification

This historic reclamation indicates the significant habitat modification of the CMA nearshore boundary over time (LOW habitat characteristic).

8.8 Summary of values

The values assigned to each marine ecology characteristic for each survey transect (T1-T5) are summarised in Table 11. There is a distinction between T1 and T2 transects and all other sites, particularly at 20m from MHWS (sites which are intertidal habitats), having higher ecological values than subtidal transects T3-T5 (Table 11). With respect to the assessment of effects, the transects can be separately valued as per their overall ecological value, with T1 and T2 (intertidal, 20m) adjacent to Kaiwharawhara having high ecological values, T1 40m and 60m subtidal, T2 40m and 60m subtidal having moderate values, T3 having low ecological values, and T4 and T5 having moderate ecological values.

Table 12: Summary of habitat characteristics based on ecological values in Table 1 by survey transect (refer to Figure 2 for transect locations)

Marine characteristic	Intertidal T1 and T2 20m	Subtidal T1 (40-60M)	Subtidal T2 (40-60M)	Subtidal T3	Subtidal T4	Subtidal T5
Benthic invertebrate abundance	High	Moderate	Moderate	Low	Moderate to High	Moderate to High
Number of benthic species	High	Low to Moderate	Low to Moderate	Low	Low to Moderate	Low to Moderate
Shannon-Wiener Diversity	High	Moderate	Moderate	Moderate	Moderate	Moderate
Macroalgae	High	Moderate	Moderate	Low	Low	Low
Invasive species	High	Low	Low	Low	Low	Low
Sediment contaminants	Moderate	Low	Low	Low	Low	Low
Sediment grain size	High	Low	Low	Low	Low	Low
Estuarine/Coastal edge vegetation	Low	Low	Low	Low	Low	Low
Habitat modification	Low	Low	Low	Low	Low	Low
Overall Ecological Value	**High**	**Low to Moderate**	**Low to Moderate**	**Low**	**Moderate**	**Moderate**

9 Assessment of Construction Effects

The following potential construction phase effects (both direct and indirect) on marine ecology were considered for this assessment, which was undertaken at the scale of the construction works:

- Reclamation; and
- Permanent occupation[24]
- Temporary occupation and disturbance
- Cumulative effects.

[24] The primary direct impact of construction of the Project is the permanent loss of benthic (and pelagic) marine habitat through the creation of new land (current CMA that will be modified to be usable area above MHWS) and permanent occupation (structures and material deposited below MHWS within the CMA and associated works to protect the coastal edge). Whilst reclamation and permanent occupation have different definitions, the ecological effect is the same i.e. permanent loss of marine habitat.

9.1 Reclamation

The Project involves approximately 3,220m^2 of reclamation, of which 3,200m^2 relates to the Kaiwharawhara reclamation and 20 m^2 relates to fill behind the seawall.

Construction of the Kaiwharawhara reclamation will require removal of existing beach and rock revetment. Key elements of this reclamation which are relevant to this assessment of effects include:

- The reclamation planned surface area increases the area of the MHWS contour by approximately 3,200 m^2.
- The reclamation fill comprised of AP150 (with minimal cohesive fines), which is uncompacted below water level (0.5 m RL) and compacted above water level. All fill to be used will be uncontaminated.
- The total planned occupation/reclamation of the seabed (including the slope face and revetment) of the Kaiwharawhara reclamation and supporting revetment structure is approximately 6,500m^2 (of which 3,200 m^2 is reclamation).
- The edge of the reclamation will be protected with up to approximately 6,000m^3 of rock, comprised of a double layer of armour rock (D50 = 0.85m, W50 = 1T) and double layer of underlayer rock (D50 = 0.35m, W50 = 70kg) with a geotextile fabric (i.e. Texcel 1200R or similar) underneath.

The potential effects on marine ecology associated with the construction of the reclamation at Kaiwharawhara Point will include the following:

<u>Benthic Organisms</u>

Mortality of all benthic organisms within the reclaimed areas will occur. Benthic invertebrates within the Kaiwharawhara reclamation incorporate a relatively high diversity of organisms, whereas the benthic communities within the smaller reclamation associated with the new wharf are less diverse. No *Threatened* or *At Risk* benthic invertebrates were detected at any sites surveyed.

<u>Fish</u>

Fish located within the reclamation construction areas have the ability to avoid the affected areas and therefore there will be no adverse effects on fish from the proposed reclamation.

<u>Macroalgae</u>

Macroalgae communities associated with the reclamation adjacent to the coast includes common not threated macroalgae (e.g. flapjack) and sparse individuals of *Macrocystis pyrifera* (At Risk – declining (Nelson et al., 2019) which will perish under construction of the reclamation.

The New Zealand Coastal Policy Statement 2010 (NZCPS) Policy 11a requires the avoidance of adverse effects on indigenous taxa that are threatened or at Risk, which includes *M. pyrifera.* Adverse effects of the reclamation on *M. pyrifera* can be avoided by transplanting individuals to adjacent areas where *M. pyrifera* currently exist (see map in Appendix 3). Spores will also be collected for laboratory-based culture development and deployment once on-grown (see Appendix 4 for proposed NIWA methodology).

<u>Suspended Sediment</u>

Suspended sediment is expected to increase during construction. The Coastal Processes Assessment (Section 4.3.1) states sand and gravels will settle close to the coastal edge within minutes to hours with finer sediment held in suspension for longer (hours) and discharged over a larger area depending on wind, tide and wave conditions. The reclamation is proposed to incorporate low fines uncontaminated fill which will minimise any suspended sediment discharge. Any fines released into the CMA would be expected to result in local and temporal discolouration of the water column until the fine sediment settle to the seabed.

Total suspended sediment (*TSS*) at certain concentrations and for sustained periods can cause effects by clogging gill and filter feeding structures and reducing visibility of prey. The effect of sustained elevated TSS includes reduced ability of organisms to feed (through clogging of gill structures and reduced visibility of prey), resulting in decreased fitness of some organisms as many will cease feeding and wait out the adverse environmental conditions (Cummings et al., 2009). Best practice techniques, such as using no fines uncontaminated clean fill material, use of silt curtains and works being carried out in calm weather, will minimise the effects of sediment resuspension and discharge.

Deposited Sediment

Deposited sediment can smother benthic invertebrates and juvenile macroalgae. Sediment deposition above certain thresholds and for sustained periods can cause adverse effects on marine ecology. Effectively, the sediment smothers these environments causing mortality. The biological thresholds over which adverse effects can occur for muddy benthic habitats is 5-10mm for sensitive taxa and >10mm for potential community level effects (Ellis et al., 2002).

Best practice techniques, such as no fines uncontaminated clean fill material, use of silt curtains and works being carried out in calm weather, will minimise the effects of sediment discharge.

Permanent Habitat Loss

Reclamation involves permanent loss of benthic and pelagic marine habitat, mortality of benthic organisms, increased suspended sediment and deposition of suspended sediment, risk of contaminated sediment dispersal, and noise and vibration.

The marine ecological values in the main reclamation area (T1 and T2, Figure 2) have been determined to range from moderate to high (refer to Table 11 above). The magnitude of effect at the scale of the construction works is considered to be High at the scale of the reclamation, involving *'major loss or 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*' (as defined in Table 2). Combined with moderate to high ecological values, the level of effect is assessed as very high to moderate (Table 3).

In accordance with Roper-Lindsay et al., very high to moderate level of effects need to be mitigated, offset or compensated under the effects management hierarchy (refer to Section 3.3, page 8).

Cumulative effects

More than half of Wellington Harbour edges have been modified through armouring or reclamation (38.3 km^2 or 52%)[25] (Stevens, 2018). Whilst the Project occurs along an already highly modified harbour edge, it involves an additional 0.32m^2 of reclamation benthic and pelagic habitat within the harbour, which adds to the cumulative effect of marine habitat loss and modification. The area of reclamation is a small percentage of the total harbour (0.0036%)[26] but it adds to the cumulative loss of marine habitat.

The consented Te Ara Tupua shared pathway involves the loss of 4.6ha of intertidal and shallow subtidal habitat between Ngauranga and Petone. The Eastern Bays Shared Path, across the harbour on the north-eastern side, is predicted to involve 0.3 ha of marine habitat loss (EOS Ecology, 2019). The magnitude of effect of cumulative loss of modified marine habitat is assessed as Low at the scale of the Wellington Harbour.

In combination with High and moderate ecological values, the level of effect of cumulative loss due to reclamation of marine habitat is Low. At the scale of the Wellington Harbour which occupies 89km^2, the loss of habitat on overall harbour marine ecological values due to reclamation is assessed as a

[25] Data provided by Dr Megan Oliver (Greater Wellington Regional Council) for the Wellington Harbour Whaitua. Note that the data includes coastal and estuarine shorelines, the latter of which extends landward to various extents.

[26] Area of Wellington Harbour 89km^2 www.gw.govt.nz/WellingtonHarbour).

Low magnitude of effect (Table 2), with the key marine elements and features of the Harbour unaffected.

The additional permanent habitat loss from reclamation (approximately 3,220m^2) adds to the ongoing and cumulative loss of coastal and near shore subtidal habitats but will not affect the functioning of the Wellington Harbour.

9.2 Permanent occupation

There are a number of areas of the Project that involve permanent occupation of the CMA. The total area of permanent occupation involves permanent habitat loss of 11,085m^2 (see Table 5 page 14, excluding 400m^2 of Kaiwharawhara Estuary, which will involve re-establishment of intertidal sediment and saltmarsh vegetation which is an offset mitigation item). The areas of permanent habitat loss areas are surrounded by undisturbed habitat, and do not comprise an uninterrupted area of 11,085m^2.

Permanent occupation of the benthic and pelagic environment involves permanent loss of marine habitat, mortality of benthic organisms, increased suspended sediment and deposition of suspended sediment, risk of contaminated sediment dispersal, and noise and vibration during construction.

<u>Benthic organisms</u>

Mortality of all benthic organisms within the various areas of permanent occupation will occur. Benthic invertebrates within the Kaiwharawhara revetment area incorporates a moderate to high diversity of organisms, whereas the benthic communities associated with permanent occupation adjacent to the new wharf are less diverse. No *Threatened* or *At Risk* benthic invertebrates were detected at any sites surveyed.

<u>Fish</u>

Fish located within the reclamation construction areas have the ability to avoid the affected areas and therefore there will be no adverse effects on fish as a result.

<u>Macroalgae</u>

Macroalgae communities associated with permanent occupation adjacent to the new wharf (transects 3-5) are less diverse due to the lack of light penetrating deeper wate. No *Threatened* or *At Risk* macroalgae (Nelson et al., 2019) were detected at any sites surveyed where there is permanent occupation proposed.

<u>Effects of elevated TSS</u>

As stated in 9.1 above, suspended sediment is expected to increase during construction. The Coastal Processes Assessment (Section 4.3.1) states sand and gravels will settle in close to coastal edge within minutes to hours with finer sediment held in suspension for longer (hours) and discharged over a larger area depending on wind, tide and wave conditions. Any fines released into the CMA would be expected to result in local and temporal discolouration of the water column until the fine sediment settle to the seabed. Total suspended sediment (TSS) at certain concentrations and for sustained periods can cause effects by clogging gill and filter feeding structures and reducing visibility of prey. The effect of sustained elevated TSS includes reduced ability of organisms to feed (through clogging of gill structures and reduced visibility of prey), resulting in decreased fitness of some organisms as many will cease feeding and wait out the adverse environmental conditions (Cummings et al., 2009).

<u>Effects of deposited sediment</u>

Deposited sediment can smother benthic invertebrates and juvenile macroalgae. Sediment deposition above certain thresholds and for sustained periods can cause adverse effects on marine ecology. Effectively, the sediment smothers these environments causing mortality. The biological thresholds over which adverse effects can occur for muddy benthic habitats is 5-10mm for sensitive taxa and >10mm for potential community level effects (Ellis et al., 2002).

Benthic sediments within the Project area (except T1 and T2 at 20m above the -0.5m contour) are dominated by silt and clay and receive high sediment loads from discharges from the Hutt River and a range of untreated stormwater discharges currently. The discharge of resuspended sediment, which will deposit, from construction of various structures on the benthos, has been minimised by the construction methodology in discussions with Project engineers/designers.

Noise and vibration

The noise and vibration assessment indicates that piling noise occurring at intermittent times during the construction of the Project will affect some fish species. The most sensitive fish to noise and vibration are those with swim bladders used in hearing and which could suffer mortality from construction noise at 207 dB within 60m from the source of the noise. Temporary threshold shifts can also occur in fish at 380m at a dB of 186 (Section 6.3 of Noise and Vibration Assessment). While some fish species may be adversely affected by construction noise, being mobile species, fish can avoid areas of decreased habitat quality. Benthic invertebrates may also be temporarily affected by noise and vibration associated with construction, causing temporary cessation of feeding or spawning (Rako-Gospić & Picciulin, 2019). The magnitude of effect is considered to be low, with minor and temporary shifts away from baseline conditions. Change arising from the loss/alteration will be discernible at the time of noise/vibration, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances/pattern (Table 2). The overall level of effect is low (Table 3).

The marine ecological values (a combination of all characteristics) in the main areas relevant to areas of permanent occupation (T3-5) have been determined to range from low to moderate (refer to Table 11), The magnitude of effect is considered (Table 2) to be moderate to low at the scale of the permanent occupation involving *'Loss or alteration to one or more key elements/features of the existing baseline conditions, such that post-development character, composition and/or attributes will be partially changed'*. Combined with low to moderate ecological values, the level of effects is conservatively assessed as moderate (Table 3).

Moderate level of effects require the effects to be mitigated, offset or compensated under the effects management hierarchy.

Cumulative Effects

Permanent marine habitat loss will occur in the various areas due to permanent occupation of the CMA.

More than half of Wellington Harbour edges have been modified through armouring or reclamation (38.3 km^2 or 52%)[27] (Stevens, 2018). Whilst the Project occurs along an already highly modified harbour edge, it involves an additional 0.32m^2 of reclamation and 11,085 m^2 permanent occupation of benthic and pelagic habitat within the harbour, which adds to the cumulative effect of marine habitat loss and modification. The area of permanent habitat loss is a small percentage of the total harbour (0.13%)[28] but it adds to the cumulative loss of marine habitat.

The consented Te Ara Tupua shared pathway involves the less of 4.6ha of intertidal and shallow subtidal habitat between Ngauranga and Petone. The Eastern Bays Shared Path, across the harbour on the north-eastern side, is predicted to involve 0.3 ha of marine habitat loss (EOS Ecology, 2019). The magnitude of effect of cumulative loss of modified marine habitat edge is assessed as Low at the scale of the Wellington Harbour. In combination with High-moderate and moderate-low ecological values, the level of effect of cumulative loss of marine habitat is Low.

At the scale of the Wellington Harbour which occupies 89km^2, the loss of habitat on overall harbour marine ecological values is assessed as a low magnitude of effect (Table 2), with the key marine elements and features of the Harbour unaffected.

[27] Data provided by Dr Megan Oliver (Greater Wellington Regional Council) for the Wellington Harbour Whaitua. Note that the data includes coastal and estuarine shorelines, the latter of which extends landward to various extents.

[28] The Area of Wellington Harbour is 89km^2 www.gw.govt.nz/WellingtonHarbour).

The additional permanent habitat loss from occupation of structures (11,085m^2), in addition to habitat loss from reclamation (approximately 3,200m^2) adds to the ongoing and cumulative loss of coastal and near shore subtidal habitats will not affect the functioning of the Wellington Harbour.

9.3 Temporary occupation and disturbance

Bores for geotechnical investigations are proposed to be installed adjacent to the existing shore (see General Arrangement drawing number WEL-GE-DG-022). Five boreholes (0.9m diameter) will be located at 20m intervals (occupation of 3.18m).

Construction of the new wharf will require installation of a temporary structure adjacent to the proposed new wharf location along the entire length. This structure is anticipated to comprise piers every 5m and 0.29m^2 area of temporary occupation (Table 22 of Coastal Processes Assessment). In addition, a temporary structure will be installed on the existing Kaiwharawhara shore (Figure 2) to enable the loading of barges with material. The temporary occupation is estimated at 5m$^{2.}$ Piles will be driven H piles. Suspended sediment is likely to be very localised to approximately 1m from each pile location (Table 22, Coastal Processes assessment).

Installation of temporary structures will involve the mortality of benthic organisms. Removal of temporary structures after the construction period will enable benthic organisms to naturally re-colonise the disturbed benthic sediment.

- Enabling work – 5 geotechnical bores 3.2m^2
- New Wharf - temporary staging – 0.29m^2
- Barge – impact of temporary wharf on Kaiwharawhara Point - 5m^2
- Nesting Structure – 0.29m^2
- Timber Pile groyne – 0.29m^2
- Pile groyne – 0.29m^2

The temporary occupation and disturbance areas during construction are relatively small and occur in moderate to low ecological areas. The magnitude of effect is considered to be Low (Table 2), with the key marine elements and features of the works unaffected after recolonisation. In combination with moderate/low ecological effects, the low magnitude of effects results in a low to very low level of effect. We do not consider mitigation is required for temporary occupation and disturbance.

9.4 Summary potential construction effects

We have summarised the potential construction effects of the Project (Table 12).

Table 13: Summary of potential construction effects

	Scale of Assessment	Area	Ecological Values	Magnitude of Effect	Level of Effect
Reclamation	Project Scale	~3,220m^2	High to Moderate	High to Moderate	Very High to High
Permanent Occupation	Project Scale	11,085m^2	Moderate to Low	Moderate to Low	Moderate to Low
Temporary Occupation	Project Scale	9.86m^2	Moderate to Low	Low	Low to Very Low

Cumulative Effects of reclamation and permanent occupation	Wellington Harbour	14,305m^2	High to Moderate and Moderate to Low	Low	Low

10 Assessment of Operational Effects

10.1 Sediment disturbance

The coastal processes assessment includes a comprehensive analysis of ferry propeller wash (executive summary and section 3.13.3).

> *Within the wider coastal setting effects the overall effect of this permanent occupation of the seabed on coastal processes is* ***minor****. This is based on the existing site already being exposed to vessel wake, propeller wash, wind waves, and these processes will not be substantially altered by the Project or new vessels. The Project is not expected to alter sediment delivery to the coast via Kaiwharawhara Stream, or sediment transport processes on Kaiwharawhara beach. Likewise, the Project is not expected to influence the long-term erosion trajectory of Kaiwharawhara beach. This is based on the beach's exposure to wind waves not changing, and the influence of vessel wake being consistent with existing operations and the direction of wind waves. Most of the remaining shoreline near the Project area is armoured and is therefore not sensitive to the new operation. Seabed conditions immediately under the berthing wharf and within the nearfield area may be subjected to slightly altered conditions due to ship induced suspended sediment. This will likely result in some scour along the berthing edge of the new wharf and settling (accretion) underneath the new wharf and small areas of the nearfield zone that will experience short periods (i.e., 3 to 5 minutes) of elevated suspended sediment concentrations with each vessel movement but this will rapidly resettle on the seabed (i.e., within 5 to 10 minutes).*

With the mitigation measures in place, the suspended sediment will have negligible effect of coastal processes and therefore minimise the effects on marine ecological values. The ecological values are assessed as moderate to low, and the magnitude of effect is assessed as low and temporary, resulting in a low level of effect.

10.2 Stormwater

Stormwater from the impervious areas of the site will be treated using swales, raingardens and proprietary devices such as Downstream Defenders, which will remove approximately 75% of sediment and associated contaminants. The resultant stormwater quality involves best practice techniques to minimise the discharge sediment and contaminants. The ecological values of proposed discharge of treated storm are moderate to low, having likely historic sources of stormwater contaminants in sediment. The magnitude of effect of treated stormwater discharges are assessed as Low (Table 2), with the key marine elements and features largely unaffected. With the moderate to low ecological values combined with a low magnitude of effect, the level of effect is low to very low.

11 Residual Effects[29]

Having stepped the ecological effects of the Project through the effects management hierarchy in relation to first avoiding, remedying and mitigating as much as possible, the current assessment identified one category of residual effect (permanent marine habitat loss at the scale of the Project footprint) that, because of its absolute (loss of habitat) and permanent nature, cannot be adequately addressed through mitigation. As such, this residual effect must be addressed through the application of the subsequent steps in the effects management hierarchy (refer to Figure 3): offsetting or compensation.

11.1 Effects of Reclamation

11.1.1 Avoid

Reclamation has been avoided as much as possible, through minimising the design by the engineering/design team. The Assessment of Effects on the Environment (AEE) outlines the process by which the location and area of reclamation needed was reached through the design process.

The adverse effects of reclamation on sparsely present threatened (*M. pyrifera)* can be avoided by transplanting individuals to areas outside of the reclamation (into parts of the Te Ara Tupua project where *M. pyrifera* currently exists and will not be disturbed by the Te Ara Tupua construction). In addition to transplanting individual *M. pyrifera* plants to outside of the reclamation area, spores will be collected from some *M. pyrifera* and used in laboratory cultivation of new plants (see Appendix 4 for proposed NIWA methodology).

11.1.2 Remedy

It is not possible to remedy proposed reclamation areas.

11.1.3 Mitigate

Offset mitigation is proposed for the adverse effects of reclamation activity as per following sections.

11.1.4 Off-setting

In reference to offsetting in the marine environment, Dickie et al. (2013) note that it is not essential to develop complex numerical models. Rather, it is more important that key ecological attributes or processes should be present to support a sustainable offset and to ensure that the ecosystems and/or key components of them are sustained with the impact and offset in place. In the following sections we discuss several forms of biodiversity offsetting including like-for-like, trading-up and enhancement offsetting.

11.1.5 Like-for-like

Based on the nature of the residual effect (permanent loss of marine habitat), the options for a like-for-like offset relate to the creation of additional marine habitat. In the marine environment, that ideally

[29] The Assessment of Effects (AEE) covers the National Policy Statements, National Environmental Standards, Regional Policy Statements, and Regional and District Plans. These matters are not repeated in this assessment.

would be though the process of declamation; that being the return of reclaimed land to foreshore and seabed.

Reclamations, which started in the 1850's, have added more than 155 ha to Wellington[30].The major reclamations have centred around increasing the amount of useable flat land for Wellington city, as well as for Port and rail activities. Due to the infrastructure that these reclamations currently support, declamation of these areas is not possible. There are smaller areas of reclamation around the Wellington Harbour that are owned by some of the stakeholders involved in the Port who were involved in the series of meetings to discuss potential offset and / or compensation measures. No areas of declamation were identified in discussion with KiwiRail, Centreport, and GWRC (conversations with Megan Oliver (marine ecologist, GWRC)).

11.1.6 Trading-up

Trading-up is an out-of-kind exchange of biodiversity, and usually involves exchanging the loss of biodiversity of lesser conservation concern for biodiversity of greater conservation concern (e.g. exchanging non-threatened species for a gain in a nationally *Threatened* species) (Maseyk et al., 2018).

In the case of the Project, given the residual effect relates to the marine environment, any form of trading-up would also be required to provide benefits within the marine environment. The marine investigations for the Project detected only common and widespread intertidal and subtidal benthic invertebrate species, with no *Threatened* or *At Risk* taxa being observed. As such trading-up in this instance would involve measures that would increase abundance and / or distribution of *Threatened* or *At Risk* marine species within the Wellington Harbour. We did not detect any *Threatened* or *At Risk* marine invertebrates (apart from *M. pyrifera*) in our surveys and we are not aware of any *Threatened* or *At Risk* resident populations of fish or marine mammals resident within the Wellington Harbour[31] that we may have considered for trading up.

However, the restoration of Kaiwharawhara Estuary and provision of gravel beach on the southern area of the existing Kaiwharawhara Point (true left of the Kaiwharawhara Stream) provide positive measures fish passage for *Threatened* or *At Risk* freshwater fish and foraging habitat (benthic invertebrate) for coastal avifauna respectively.

11.1.7 Enhancement Offsetting

Enhancement offsetting involves enhancing the quality of degraded natural habitats through ecological management. The possibility of using enhancement offsetting options to address the residual effects of the Project are discussed in the following sections.

Offset measures considered not feasible include additional stormwater treatment, provision of additional saltmarsh planting and declamation[32].

11.1.7.1 Kaiwharawhara Estuary Restoration

A proposed naturalisation of the eastern bank of the Kaiwharawhara estuary mouth and southwestern edge of Kaiwharawhara Point are included as part of the offset mitigation for the Project. The opportunity is to enhance the estuary habitat to provide higher quality habitat, especially for freshwater fish passage and spawning.

The proposed concept design for naturalising Kaiwharawhara estuary mouth (Figure 46) includes the following design features:

[30] WCC's Old Shoreline Heritage Trail Brochure

[31] The Te Whanganui-a-Tara region is a natural corridor for the movement of fish, invertebrates and marine mammals between the North and South Islands and from east to west coasts (MacDiarmid et al., 2012).

[32] Contained in Alternatives Assessment Report within the AEE.

- Coastal edge design and wider landform restoration planting; and
- Restoration of true right bank of the Kaiwharawhara Estuary (initial planting of saltmarsh species over c.415m^2) (providing for freshwater fish spawning and enhanced biodiversity).

Figure 46: Concept design for restoration of Kaiwharawhara Estuary and Kaiwharawhara Point

11.1.7.2 Gravel beach habitat on southern existing Kaiwharawhara Point

The intertidal and shallow subtidal habitat along the southern shore of Kaiwharawhara Point currently comprises a mixture of discarded building/construction debris deposited for the historic reclamation of Kaiwharawhara Point, cobbles and some gravels (Figure 47 to Figure 49). The proposed mitigation includes:

- Removal of building/construction debris from the intertidal and shallow subtidal habitat;
- Establishment of naturalised gravel beach (for coastal avifauna foraging on benthic invertebrates) on the southern shore of the Kaiwharawhara Point (2,100m^2).

Figure 47: Southern shore of Kaiwharawhara Point and Kaiwharawhara Estuary mouth.

Figure 48: Construction debris on intertidal shore of Kaiwharawhara Point.

Figure 49: Construction debris and cobbles on the intertidal/shallow subtidal shore of Kaiwharawhara Point.

The additional gravels to be deposited along the upper beach is intended to provide protection in the short- to medium-term for the land area behind (edge of the PV Marshalling area) using a softer design approach. In addition, the gravel beach habitat provides a suitable environment for foraging of some species of coastal avifauna on benthic invertebrates that will establish. This restoration will include removal of ~2,000m³ of fill material from the backshore slope, placement of additional gravel to create a beach over 1,400m² (below MHWS) and 600m² above MHWS and a total of 1,600m² of planting with native species.

11.1.7.1 Living seawalls

One recommended measure to contribute in part to offsetting the Project's residual effects of reclamation of marine habitat relates to the use of living seawalls[33] on appropriate artificial coastal structures (within intertidal range). Living seawalls can be attached to artificial structures in the marine environment to add complexity to these structures and provide habitat for marine life (see Figure 50).

Figure 50: Examples of retrofitted living seawalls.

Living seawalls are designed to mimic the habitat of natural shoreline ecosystems such as rockpools and crevices. The complex panels increase the habitat space available for colonisation of a diverse assemblage of marine life, such as barnacles, seaweeds and shellfish. They also provide shelter from

[33] Sydney Institute of Marine Science and Reef Design Lab.

high temperatures and predation. Living seawalls have been shown to increase the abundance of fish, seaweeds and invertebrates.

Living seawalls are proposed to be installed on the intertidal area within wharf revetment area (diaphragm wall) (covering 124 m^2). This area is the maximum installation area within the Project, confirmed by engineering team and coastal processes expert.

Living seawalls should be monitored annually in order to document the colonisation by marine organisms.

11.1.7.2 Pile sleeves

Pile sleeves, such as those produced by ECOncrete (Figure 51), are designed to create additional marine habitat space to piles and can be fitted according to the pile diameter and concrete constructive requirements for the Project. We recommend pile sleeves are installed on all permanent piles (including wharf piles, nesting structure piles, rock/concrete groyne piles and timber groyne piles) to 80% of their depth (MHS to above sea bed (excluding approximately 20% depth directly above benthos to avoid potential smothering by fine sediment (covering approximately 6,222m^2). This area is the maximum installation area within the Project, confirmed by the engineering team and coastal processes expert.

Figure 51: Example of ECOncrete pile sleeve

11.1.7.3 Constructed rock pools

Artificial intertidal rockpools (such as those designed by ECOncrete, Figure 52) can be integrated into rock revetment to create niche habitat space and water retaining features which mimic natural rock pools and increase marine biodiversity (Figure 52)[34]. Artificial rock pools have been shown to be a successful method of increasing biodiversity to artificial structures, Rockpool dimensions can be fitted to Project requirements. Artificial rock pools are to be installed on the backshunt revetment seaward edge in the intertidal zone at 3.2m centres [35] (covering approximately 60 m^2). This area is the maximum installation area within the Project, confirmed by engineering team and coastal processes expert.

[34] www.econcrete.us

[35] Three rip rap rock diameters between each pool (assumes rockpool diameter of 1.6m)

Figure 52: Example of ECOncrete constructed rock pools.

11.1.8 Assessment of offsetting against Proposed Natural Resources Plan Schedule G2 principles

Schedule G2 of the PNRP (Greater Wellington Regional Council, 2019) outlines the principles to be applied when proposing and considering a biodiversity offset. Table 13 outlines how each of these principles have been applied with regard to offsetting the residual effects associated with the permanent loss of marine habitat for the Project. The only identified potential measures that could be classified as an offset for the residual effects of the permanent loss of marine habitat (reclamation and permanent occupation) is the living seawalls, pile sleeves and constructed rock pools.

While the use of living seawalls, pile sleeves and constructed rock pools as offsets meets a number of the G2 principles (refer to Table 13), it may not of meet Principle 6, being no net biodiversity loss. As discussed below, compensation measures for permanent occupation have therefore been considered and proposed.

Table 14: Implementation of G2 principles for biodiversity offsetting on the Project[36]

PRINCIPLE		IMPLEMENTATION
1) Adherence to the mitigation hierarchy	The proposed biodiversity offset will be assessed in accordance with the mitigation hierarchy set out in Policies P32 and P41. Any proposal for a biodiversity offset will demonstrate how it addresses the residual adverse effects of the activity.	• In terms of the effects management hierarchy, the Project has first sought to avoid and minimise effects through the Project footprint. • A residual effect associated with the permanent loss of ~3,200 m^2 (reclamation) and 11,085 m^2 (permanent occupation) of marine habitat has been identified. • Options for offsetting the effect of the reclamation have been investigated (see Section 9.1, and the identified viable offsets include restoration of Kaiwharawhara Estuary, establishment of gravel beach on the southern area of Kaiwharawhara Point (true left of Kaiwharawhara stream) plus implementation of living seawalls, pile sleeves and constructed intertidal rock pools.
2) Limits to what can be offset	Consideration of biodiversity offsetting is inappropriate where: (a) there is no appropriate site, knowledge, proven methods, expertise or mechanism	• The offset measures (restoration of Kaiwharawhara Estuary, establishment of gravel beach, living seawalls, pile sleeves and constructed rock pools) will be undertaken at

[36] PNRP G2 and G3 also covered in the AEE.

PRINCIPLE		IMPLEMENTATION
	available to design and implement an adequate biodiversity offset, or	appropriate sites within the Wellington Harbour. • The restoration of Kaiwharawhara Estuary and establishment of gravel beaches involve simple, tried and tested techniques. • Living seawalls, pile sleeves and intertidal rockpools and on proposed new structures that provide minimal habitat complexity for intertidal marine sessile community succession. • Living Seawalls is a Sydney Institute of Marine Sciences initiative that builds on years of marine green engineering research that shows retrofitting existing seawalls with habitat enhancing units can improve the ecological performance of artificial structures. • Artificial rock pools and pile sleeves are products to encourage biodiversity produced on artificial structures. Have successfully been used in an international context.
	(b) when an activity is anticipated to cause residual adverse effects on an area after an offset has been implemented where: i. the ecosystem or species are "threatened" (as defined by the New Zealand Threat Classification System categories: Nationally Critical, Nationally Endangered, and Nationally Vulnerable), or ii. the ecosystem is naturally uncommon.	• The marine habitat that will be permanently lost as part of the Project footprint and for which offsets are proposed do not include any *Threatened* or *At Risk* marine species and the ecosystem is not naturally uncommon, and as such the proposed measures are within the limits of biodiversity offsets / compensation.
3) Additional conservation outcomes	Any proposal for a biodiversity offset will demonstrate that the actions taken to achieve positive effects on biodiversity are additional to what would have occurred without the proposed biodiversity offset, including any activities required by any associated resource consent/s.	• Restoration of the Kaiwharawhara Estuary and establishment of gravel beach on the southern shore of Kaiwharawhara Point will have positive biodiversity effects that would not have occurred without those conservation outcomes. • The creation of living seawalls, pile sleeves and constructed rock pools to encourage the colonisation of marine organisms in Wellington Harbour at/adjacent to the Project site is not already required, nor are they already being undertaken or are planned as part of existing management programmes.
4) Landscape context	Any proposals for biodiversity offsetting will: (a) demonstrate that positive effects are achieved preferentially, first at the Project site, then the relevant catchment, then within the ecological district, except where there is an appropriate ecological rationale for doing otherwise, and	• The proposed Kaiwharawhara Estuary restoration and establishment of gravel beach on Kaiwharawhara Point are within the same harbour in which the effect of the Project (permanent marine habitat loss) will occur. • The proposed locations of the living seawalls, pile sleeves and constructed rock pools are within the same harbour within the Project footprint in which the effect of the Project (permanent marine habitat loss) will occur. The sites chosen are appropriate as they will be new structures which have no habitat complexity. • Furthermore, all proposed biodiversity actions will be constructed in areas that are visible to many Wellingtonians and may serve as a form of environmental educational tool.
	(b) complement and contribute to the protection of significant indigenous vegetation, or the habitats of threatened fauna at the local, regional or national level, and	• The Kaiwharawhara Estuary Restoration and establishment of gravel beach on Kaiwharawhara Point contribute to the protection of indigenous flora and fauna. • The living seawalls, pile sleeves and constructed rock pools may provide habitat for intertidal marine organisms within the Wellington Harbour.

PRINCIPLE		IMPLEMENTATION
	(c) take into account available information on the full range of biological, social and cultural values of biodiversity and support an ecosystem-scale approach, and	• The Kaiwharawhara Estuary restoration and establishment of gravel beach takes into account, biological, social and cultural values of biodiversity supporting an ecosystem approach. • The living seawalls, pile sleeves, and constructed rock pools may serve as an environmental educational tool.
	(d) take into consideration other likely future developments, such as competing land use pressures, within the landscape.	• We are not aware of any actual or proposed activities that may impact the proposed Kaiwharawhara Estuary restoration, establishment of gravel beach, living seawalls, pile sleeves and constructed rock pools.
5) Long-term outcomes	Any proposals for biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at least as long as the activity's impacts, and preferably in perpetuity. The proposed biodiversity offset will: (a) demonstrate that management arrangements, legal arrangements (e.g. covenants) and financial arrangements (e.g. bonds) are in place that allow the positive effects to endure as long as the residual adverse effects of the activity, and preferably in perpetuity, and (b) be able to be implemented and enforced in line with any resource consent conditions associated with the activity. These conditions should include: i. specific, measurable and time-bound targets, and ii. mechanisms for adaptive management using the results of periodic milestones to determine whether the biodiversity offset is on track and how to rectify if necessary, and (c) establish roles and responsibilities for managing, governing, monitoring and enforcing the biodiversity offset, and (d) undertake methods by which analysis will identify when milestones of the biodiversity offset are not achieved, and the causes of non-achievement, and how to revise the offset-management plan to avoid similar occurrences.	• KiwiRail will own the new structures that are proposed for living seawalls, pile sleeves and constructed rock pools. • The construction and implementation of the Kaiwharawhara Estuary Restoration, establishment of gravel beach on Kaiwharawhara Point, living seawalls, pile sleeves and constructed rock pools will be included as a consent conditions for the Project. • Within the agreement that KiwiRail (with GWRC and mana whenua) is developing as conditions of consent, the roles and responsibilities for managing the Kaiwharawhara Estuary Restoration, establishment of gravel beach, living seawalls, pile sleeves and constructed rock pools will be established. • The requirement for monitoring ecological success (i.e. biodiversity gain) will be included in the consent conditions for the Project. The monitoring period should be for a minimum of two years. • Consent conditions will specify the quantum of Kaiwharawhara Estuary restoration, establishment of gravel beach, living seawall, pile sleeves and constructed rock pools to be constructed.

PRINCIPLE		IMPLEMENTATION
6) No net biodiversity loss	Any proposals for biodiversity offsets will provide measurable positive effects on biodiversity preferentially, first at the site, then the relevant catchment, then within the ecological district, which can reasonably be expected to result in no net loss and preferably a net gain of biodiversity. No net loss means no reasonably measurable overall reduction in: (a) the diversity of indigenous species or recognised taxonomic units; and (b) indigenous species' population sizes (taking into account natural fluctuations) and long term viability; and	• The provision of a minimum of Kaiwharawhara Estuary Restoration, establishment of gravel beach on Kaiwharawhara Point, created habitat through the construction of the living seawalls, pile sleeves and constructed rockpools only offsets the reclamation that will be permanently lost under the footprint of the Project. Additional measures to compensate for permanent occupation of the marine effects are proposed, as discussed below. • The Kaiwharawhara Estuary restoration and the establishment of a gravel beach on Kaiwharawhara Point will provide ecological benefit to indigenous species and will not adversely affect population sizes. • Currently no marine organisms are inhabiting the proposed structures where the construction of the living seawalls, pile sleeve and constructed rockpools are proposed. As such, this offset measure will not result in a measurable reduction in the population size and long term viability of any affected indigenous species at either a regional or a national level and will add to overall biodiversity.
	(c) the natural range inhabited by indigenous species; and	• The Kaiwharawhara Estuary restoration and the establishment of a gravel beach on Kaiwharawhara Point will provide ecological benefit to indigenous species and will not adversely affect population sizes. • Currently no marine organisms are inhabiting the proposed structures where the construction of the living seawalls, pile sleeve and constructed rockpools are proposed. As such, this offset measure will not result in a measurable reduction in the population size and long term viability of any affected indigenous species at either a regional or a national level. As such, this offset measure will not result in a measurable reduction in the natural range of any indigenous species.
	(d) the range and ecological health and functioning of assemblages of indigenous species, community types and ecosystems; and	Currently no marine organisms are inhabiting the proposed structures where the construction of the living seawalls, pile sleeve and constructed rockpools are proposed. As such, this offset measure will not result in measurable reduction in: • the existing range of any indigenous species, community type or ecosystem; or • the ecological health of any indigenous species, community type or ecosystem; or • the natural functioning of any indigenous community type or ecosystem.
	(e) the cultural use values of indigenous habitats or species.	• The proposed offsets do not result in a measurable reduction in the cultural use values of the affected indigenous habitats or species.
	Any proposals for biodiversity offset will demonstrate: (f) that an explicit calculation of loss and gain has been undertaken as the basis for the biodiversity offset design, and should demonstrate the manner in which no net loss, and preferably net gain of biodiversity, can be achieved by the biodiversity offset, and	• The restoration of Kaiwharawhara Estuary and establishment of gravel beach on Kaiwharawhara Point and the provision of a minimum of 124 m^2 of created habitat through the construction of the living seawalls, 6,222 m^2 of pile sleeves and 60 m^2 of constructed rock pools will offset the residual portion of reclamation of marine habitat will be permanently lost under the footprint of the Project. No explicit loss versus gain calculation has been carried out (or is realistically possible in respect of the marine effects in question).

PRINCIPLE		IMPLEMENTATION
	(g) that the biodiversity offset design and implementation should include provisions for addressing sources of uncertainty and risk of failure in delivering the biodiversity offset, and	• As outlined in sections 11.1.7.1 to 11.1.7.3areas have been identified within and adjacent to the proposed structures where living seawalls, pile sleeves and constructed rock pools should be deployed. • If no colonisation occurs on trial sites (subset of proposed restoration, gravel beach and structure locations), advise should be sought from a qualified marine ecologist to determine the reasons for the lack of colonisation, and recommendations made regarding the restoration efforts and construction and location of the remaining area of living seawalls, pile sleeves and constructed rock pools.
	(h) that the offset is applied so that the ecological values being achieved through the offset are the same or similar to those being lost, and	• Hard shore/rocky areas of habitat lost under the Project include surfaces which encrusting organisms inhabit. Most of the habitat lost is gravel and comprises both epibenthic and infaunal organisms. • The living seawalls, pile sleeves and constructed rockpools will provide similar hard shore habitat. It is anticipated that there will be a 6-month time lag from when the structures are constructed, and colonisation processes are likely to begin to occur.
	(i) the intention to include and use a biodiversity offset management plan that: (i) sets out baseline information on the indigenous biodiversity that is potentially impacted by the proposed activity at both donor and recipient sites, and (ii) demonstrates how the requirements set out in this schedule will be carried out, and (iii) identifies the monitoring approach that will be used to demonstrate how the matters set out in this schedule have been addressed over an appropriate timeframe.	• A Biodiversity Offset Management Plan (BOMP) will be prepared which will include the necessary content as outlined in this principle.

We consider the restoration of the estuary mouth, removal of construction debris, deposition of natural gravel and installation of living seawalls, artificial rock pools and pile sleeves offset the adverse effects of the reclamation activity.

11.2 Effects of Permanent Occupation

Permanent occupation of the marine benthic environment occurs over the Project due to new structures such as wharf piles and groynes. The scale of assessment for permanent occupation is the Project footprint scale. The total area of permanent occupation related to the Project involves 11,085 m^2 of moderate to low ecological habitat (due to benthic sediment contamination, proportion of silt and clay in sediment, reduced benthic invertebrate assemblages, existing modification etc).

This total permanent loss of habitat has been minimised as much as possible through design and cannot be remedied or mitigated/offset (see below sections). Compensation measures for permanent habitat loss (through occupation of the benthos) are required that directly benefit the marine environment.

11.2.7 Avoid

Permanent occupation has been avoided as much as possible, through minimising the footprint of CMA structures as much as possible by the engineering/design team.

11.2.8 Remedy

It is not possible areas to remedy the permanent occupation of the seabed.

11.2.9 Mitigate

It is not possible areas to mitigate the permanent occupation of the seabed.

11.2.10 Offset

Offset mitigation options such as declamation elsewhere in Wellington Harbour are not able to be used to offset the adverse effects of permanent occupation, due to lack of support for owners of existing area of reclamation.

11.2.11 Compensation[37]

We have had informal discussions with Megan Oliver (marine ecologist) from GWRC as to potential compensation options that would benefit the marine environment. Wider programmes and research was part of those discussions and supported by Megan Oliver to provide opportunity for more integrated larger compensation measures, rather than smaller "piecemeal" measures that have been proposed previously in other projects.

The following compensation options have been considered to date (19 January 2022).

a) <u>Seagrass restoration</u>

Currently, the last remnant of seagrass in Wellington Harbour is in Lowry Bay. Seagrass meadows are important ecosystems providing habitat for a range of marine organisms. Seagrass can mitigate for climate change by carbon sequestration and improve coastal water quality by taking up nutrients and contaminants, and trapping sediments.

Restoration of seagrass beds in Wellington Harbour is a priority for GWRC. Potential adverse effects on seagrass are likely numerous, including physical disturbance, light environment and turbidity, sedimentation, current velocity and shear stress, foraging by avifauna, coastal construction, contamination etc. Active seagrass restoration in New Zealand has been carried out by transplanting seagrass from donor meadows (Clark & Berthelsen, 2021). However, moving plants from donor sites can cause damage to the donor sites.

Due to Lowry Bay being the only location of seagrass in Wellington Harbour, and the greater risk involved in success or failure of restoration, plus the wide range of factors likely influencing seagrass survival, a great deal of scientific data is required to support restoration efforts. Many of these factors could be outside the control of the responsible agency to effectively manage.

We have been in contact with Dr Fleur Matheson from NIWA who prepared the assessment of seagrass at Lowry Bay for the Eastern Bays cycleway project. There is no guarantee that the scientific data required to be collected to support restoration efforts (to understand the factors

[37] Compensation is more likely to be subjective, unquantified, and is often arbitrary and is always the least preferable response to effects management. However, if all other options including biodiversity offsetting have been sequentially explored and exhausted or are not available, it may be appropriate to consider using environmental compensation. If compensation is to be used, it should only be as a last resort; and in designing a compensation proposal, best practice approaches and the principles of offsetting should be followed as much as possible ((Maseyk et al., 2018).

influencing the success of any seagrass restoration efforts) will be available in the near future. A potential feasibility study (scope drafted by Dr Matheson) comprising several stop/go points has been prepared.

b) Macroalgae restoration

The Mountains to the Sea Wellington Trust (with seed funding from the Wellington Community Trust), has the aspiration to restore macroalgae forests in Te Upoko o te Ika a Maui (Wellington area), to support regeneration of Te Whanganui-a-Tara's coasts and harbours. Their principles are mana whenua guided, with biodiversity and climate solutions at the heart. The project is called I Love Rimurimu and partners currently include NIWA, Victoria University, Mahanga Bay Sea Vegetables, GWRC and the Wellington community.

Macroalgae is the focus of the Trust's restoration efforts because they are an ecosystem builder, enhance biodiversity, water-quality and climate resilience.

In 2022, the Trust planned activities include establishing a seaweed (macroalgae) spore bank at NIWA and a hatchery set-up at Mahanga Bay Sea Vegetable site. Their initial focus is on Giant Kelp (*Macrocystis pyrifera*) (threat status - At Risk declining) due to the decline of its presence in Wellington Harbour over the past few decades (Figure 25), its value as a habitat builder, and its vulnerability to climate change. In 2023, the Trust expects to be in a position to begin restoration site installation in the marine environment at sites that are informed by both mātauranga and tauiwi knowledge streams, and priority given for degraded sites and species. Beyond 2023, the Trust aims to have a minimum of four Rimurimu restoration sites selected and underway in Te Whanganui-a-Tara.

The Trust is well supported by the scientific community (especially NIWA), iwi and the public, and would benefit from additional funding to proceed with the planned restoration research and restoration sites moving forward.

Rimurimu have worked with NIWA to prepare a research and restoration approach that incorporates input from mana whenua, community, GWRC as part of their wider objectives.

This proposal initially involves research to support the macroalgae expansion, involves upskilling iwi in the research and site selection and involves robust scientific support through NIWA. As this proposal includes research (which inherently involves some "trial and error/success" outcomes) we are not able to confirm that there will no biodiversity loss. However, the approach to engaging in a larger project with an initial research component is supported by Megan Oliver (marine ecologist, GWRC).

c) Stormwater Treatment

Another option considered to improve marine ecological values in Wellington Harbour is to provide treatment to stormwater discharges to the Harbour that are currently untreated: there are numerous discharges to the Harbour that are currently untreated. Third party agreement would have to be sought where treatment would be proposed on land not owned by KiwiRail. Sites would need to be prioritised based on contaminant load (contaminants and sediment). It is not clear at this stage whether such treatment and reduced contaminant load would make a material difference to the marine ecological values overall. However, reduced contaminant load in the Wellington Harbour is a step the right direction for improving marine ecological values, but reduced contaminant load would need to be approached at a whole harbour scale to have positive effects on marine ecological values.

d) Saltmarsh Restoration

In discussion with Megan Oliver (marine ecologist) from GWRC, we recognised saltmarsh habitat could be restored, but no obvious restoration sites were identified outside of the Project area, excluding Kaiwharawhara Estuary.

e) Restoration projects in Porirua Harbour

There are a number of restoration projects in Porirua Harbour which could be supported by compensation, if mana whenua were amenable to compensation work being carried out outside of Wellington Harbour[38]. For example, the coastal edge along the Onepoto Arm of Porirua Harbour that protects the railway corridor from erosion could be subject to a restoration project.

f) Installation of Living Seawalls

Living seawalls could be located outside of the Project arear to increase biodiversity in Wellington Harbour. The city waterfront has been suggested as a potential option. Third party agreement from the owners of the proposed structures would be required.

11.2.11.1 Schedule G3 of the PNRP

In Table 14 we have assessed our biodiversity compensation measures against the principles for biodiversity compensation in Schedule G3 of the PNRP. As outlined in Table 14, we are able to demonstrate which of the compensation measures identified meet the biodiversity compensation principles.

Table 15: Assessment of the Project's adherence to the biodiversity compensation principles for residual effects as outlined in Schedule G3 of the PNRP

PRINCIPLE FOR BIODIVERSITY COMPENSATION	PROJECT COMPLIANCE WITH PRINCIPLE
1) Adherence to the effects management hierarchy	Details have been provided throughout this assessment with regard to how the Project has sought to avoid and mitigate effects in the first instance (e.g. minimise reclamation and permanent habitat occupation). Once all options to avoid and mitigate were exhausted, potential measures to offsetting residual effects (permanent loss of 3,220m^2 of reclamation and 11,085 m^2 of permanent occupation of marine habitat) were explored, included through detailed discussions with a range of key stakeholders. The restoration of the Kaiwharawhara Estuary, establishment of gravel beach on Kaiwharawhara Point, installation of living seawalls, pile sleeves and constructed rock pools were identified as offset measures for reclamation (Section 11.1). However, compensation is required for the loss of marine habitat from permanent occupation. Of particular note, we explored options for declamation of land as a direct offset measure, but were unable to identify any suitable opportunities (Section 11.1). As such, compensation measures were then explored to address the remaining residual effects. The three measures proposed are research into restoration of seagrass beds in Lowry Bay, restoration of macroalgae beds, and treatment of stormwater to the harbour which is currently untreated (Section 11.1.7). Internationally, both habitat rehabilitation and reducing contaminants into the marine environment have been identified as appropriate measures to address impacts in the marine environment.
2) Limits to biodiversity compensation	The marine habitat that will be permanently lost as part of the Project footprint, and for which residual effects need to be compensated, does not include any *Threatened* or *At Risk* species and is not naturally uncommon, and as such the proposed measures are within the limits of biodiversity compensation.
3) Additional conservation outcomes	The compensation measures proposed are additional to the gains/benefits to the marine environment that would have occurred otherwise. Two of the proposed compensation measures are not currently being undertaken; nor are they planned as part of existing management programmes by other stakeholders, whereas the Macroalgae restoration techniques are scientifically established and would benefit from further support. Restoration of *Macrocystis pyrifera* at/adjacent to the Project (At Risk – declining threat status. Significant decline in populations have occurred over the past decades) will provide significant biodiversity and habitat provision benefits. The restoration of this species contributes to protection of significant indigenous vegetation at the local and regional scale. The restoration

[38] Which was not supported for compensation for the Te Ara Tupua project compensation.

PRINCIPLE FOR BIODIVERSITY COMPENSATION	PROJECT COMPLIANCE WITH PRINCIPLE
	programme incorporates an ecosystem approach, including biological and cultural values, whilst considering other activities that may cause pressure to the restoration.
4) Landscape context	The compensation measures for macroalgae restoration proposed can occur close to the Project footprint and take into account the interactions between species, habitats, ecosystems, spatial connections and ecosystem function. Seagrass restoration and stormwater treatment would occur within Wellington Harbour, but distant from the Project area.
5) Long-term outcomes	All three of the proposed compensation measures are intended to occur and endure over the long term. The seagrass restoration option does not have certain long-term outcome as it is in an initial feasibility research stage. The macroalgae restoration project is further advanced and has a higher likelihood of success, especially for Giant Kelp. The treatment of stormwater would have long term benefits of reducing the contribution of contaminants into the harbour, and thereby reducing the cumulative effects on marine biota, water and sediment quality within the Wellington Harbour.
6) Scale of biodiversity compensation	Internationally, both habitat rehabilitation and reducing contaminants into the marine environment have been identified as appropriate measures to address direct impacts on the marine environment. Whilst loss of biodiversity from the Project and biodiversity gains from compensation are not directly quantifiable, it is our expert opinion that the scale of the proposed compensation measures are commensurate to the residual effect of permanent loss of subtidal gravel marine habitat in that: a) Seagrass Restoration Compensation Option Seagrass beds in Lowry Bay on the eastern side of the Harbour are the only known beds in Wellington Harbour. Seagrass provides significant habitat for marine organisms. Significant research would be required to determine the feasibility of restoration. b) Macroalgae Restoration Compensation Option The I love Rimurimu Trust is focussed on the restoration of macroalgae species in the marine environment. Their initial focus is on *Macrocystis pyrifera* which was previously significantly more abundant in the Project area. *Macrocystis pyrifera* provides significant habitat for marine organisms. The restoration programme includes monitoring of success and provisions for addressing uncertainty and risk of failure. c) Stormwater Treatment outside of Project Footprint The loss of habitat is permanent, and the proposed stormwater treatment will be in perpetuity. The stormwater treatment would lower the future contaminant load within the Wellington Harbour.

11.2.11.1.1 Compensation Conclusion

The restoration of macroalgae (Rimurimu project) is the most advanced of the compensation options that have been identified to date, has the highest likelihood of success, and has the ability to involve local iwi, local scientists and the local public. There is an immediate opportunity for KiwiRail to financially support this project and be partly responsible for the marine ecological restoration outcomes. NIWA, the I Love Rimurimu Trust (in conjunction with iwi) and KiwiRail can collectively prepare an adaptive management approach to the restoration of *Macrosystis pyrifera*, set measurable targets, establish roles and responsibilities for the managing, governing, monitoring and enforcing the biodiversity compensation (PNRP Schedule G3 5 a-d) (condition ECOL18). Discussion with Megan Oliver at GWRC has indicated that they are happy to include a research component to the compensation, and keen for the compensation to be part of wider scale project outcomes (Appendix 5).

Our view on the appropriate quantum of compensation for permanent habitat loss for this Project is of the order of $500,000, in accordance with PNRP Schedule G3 (6). The quantum is on the scale of other projects such as Te Ara Tupua ($2-3 million in compensation for a project involving significantly larger area of reclamation and permanent occupation). Provision 6 (a) of Schedule G3 requires explicit calculation of loss and gain of biodiversity. Loss is incorporated in our assessment above, however, gain is more difficult to calculate as the financial contribution is part of a wider Project and involves some degree of uncertainty regarding biodiversity outcomes of the research/ Project. If the compensation does not achieve positive biodiversity outcomes, the compensation will need to be reviewed, with alternative options considered, satisfying G3 6 (b) (condition ECOL18). The appropriate expertise (NIWA marine scientists and iwi) is available to design and implement the biodiversity compensation (G3 (c)).

Discussions can be held with the Trust, local NIWA marine scientists, iwi and GWRC about ensuring that there is research, restoration and monitoring focus on the threatened species *Macrocystis pyrifera* (giant kelp) which was significantly more abundant in Wellington Harbour in previous decades. Restoration of this species would be of significant benefit to the marine ecological values at the Project site and wider Wellington Harbour.

12 Recommended Conditions

In accordance with the findings and recommendations of this assessment, a number of resource consent conditions are recommended to avoid, remedy, mitigate, offset or compensate the adverse effects of the Ferry Terminal Redevelopment project on marine ecology, including the following:

1. The transplantation of *Macrocystis pyrifera* identified within the footprint of the reclamation to an area outside the reclamation, along the western edge of Wellington Harbour, supervised by a Suitably Qualified and Experienced Person.
2. The incorporation of intertidal rock pools within the rock revetment to achieve a minimum hard shore surface area of at least 171m^2.
3. The installation of living seawalls to achieve a minimum area of 290m^2.
4. The installation of pile sleeves to achieve a minimum area of 657m^2.
5. Restoration planting within the Kaiwharawhara Stream Estuary to achieve approximately 400m^2 of established salt marsh habitat.
6. A Biodiversity Offset Management Plan is prepared to set out the specific management procedures, monitoring, and measures to avoid, remedy, mitigate, offset and compensate for impacts from construction activities on the relevant benthic ecological values, to be prepared in consultation with:
   - Representatives from Taranaki Whānui and Ngāti Toa
   - Department of Conservation
   - Greater Wellington Regional Council
   - Wellington City Council.
7. The contribution of $500,000 to the Mountains to Sea Wellington Trust, which shall be directed entirely to the Love Rimurimu Restoration Project, for the specific purpose of Macrocystis restoration in Wellington Harbour (with a preference to the Project site or adjacent to it).

13 Conclusion

The design of the Project has been an iterative process, with many measures implemented to avoid, remedy, minimise or mitigate effects on high and moderate value marine ecological areas and habitats used by *Threatened* and *At Risk* avifauna.

Input was sought from stakeholders and Project partners (including iwi) on a number of occasions throughout the preparation of the application for resource consents and notice of requirement for the Project. This included input in relation to effects management development, including potential ecological offset and compensation measures for the permanent habitat loss in the marine environment. Applying the mitigation hierarchy, opportunities for offset measures were explored, resulting in the proposal for restoration of Kaiwharawhara Estuary, establishment of gravel beach on Kaiwharawhara Point, installation of living seawalls, pile sleeves and constructed rock pools to be installed as offset, having the benefit of increasing marine habitat diversity.

With no other available offset measures, compensation was required. We have assessed three of the most viable compensation measures, with macroalgae restoration of declining *Macrocystis pyrifera* being, what we consider to be, the best compensation.

In our opinion, the potential and actual effects of the Project on ecological values have been appropriately addressed, through the range of measures outlined in this assessment.

KiwiRail has agreed to adopt our recommendations, including in respect of measures to avoid, remedy / minimise, mitigate, and offset / compensate for effects on ecological values. Our recommended measures are reflected in the proposed conditions of consents, which we have reviewed.

14 References

ANZECC. (2000). *Australian and New Zealand guidelines for fresh and marine water quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Australian and New Zealand Governments. (2018). *Australian & New Zealand guidelines for fresh & marine water quality*. www.waterquality.gov.au/anz-guidelines

Clark, D., & Berthelsen, A. (2021). *Review of the potential for low impact seagrass restoration in Aotearoa New Zealand* (Cawthron Report No. 3697). Prepared by Cawthron Institute for Nelson City Council.

Cummings, V., Halliday, J., Hale, R., Greenfield, B., Hailes, S., & Olsen, G. (2021). *Te Whanganui-a-Tara (Wellington Harbour) subtidal sediment quality monitoring: Results from the 2020 survey*. Prepared by NIWA for Greater Wellington Regional Council.

Cummings, V., Vopel, K., & Thrush, S. (2009). Terrigenous deposits in coastal marine habitats: influences on sediment geochemistry and behaviour of post-settlement bivalves. *Marine Ecology Progress Series*, *383*, 173–185.

D’Archino, R., Neill, K. F., Nelson, W. A., Fachon, E., & Peat, C. (2019). *New Zealand macroalgae: Distribution and potential as national scale ecological indicators* (New Zealand Aquatic Environment and Biodiversity Report No. 207). Fisheries New Zealand.

Dickie, I., McAleese, L., Pearce, B., & Treweek, J. (2013). *Marine biodiversity offsetting: UK scoping study*. Final report submitted to The Crown Estate.

Ellis, J., Cummings, V. J., Hewitt, J. E., Thrush, S. F., & Norkko, A. (2002). Determining effects of suspended sediment on condition of a suspension feeding bivalve (*Atrina zelandica*): Results of a survey, a laboratory experiment and a field transplant experiment. *Journal of Experimental Marine Biology and Ecology*, *267*(2), 147–174.

EOS Ecology. (2019). *Eastern Bays shared path: Assessment of environmental effects for intertidal ecology* (EOS Ecology Report No. HUT01-17050–01). Prepared for Hutt City Council.

Freeman, D., Schnabel, K., Marshall, B., Gordon, D., Wing, S., Tracey, D., & Hitchmough, R. A. (2014). *Conservation status of New Zealand marine invertebrates, 2013* (New Zealand Threat Classification Series No. 9). Department of Conservation.

Greater Wellington Regional Council. (2019). *Proposed Natural Resources Plan: Decisions version*. Greater Wellington Regional Council.

Gworek, B., Bemowska-Kalabun, O., Kijenska, M., & Wrzosek-Jakubowska, J. (2016). Mercury in marine and oceanic waters: A review. *Water Air and Soil Pollution*, *227*, 371.

Hay, C. H. (1990). The distribution of *Macrocystis* (Phaeophyta: Laminariales) as a biological indicator of cool sea surface temperature, with special reference to New Zealand waters. *Journal of the Royal Society of New Zealand*, *20*(4), 313–336.

MacDiarmid, A., Nelson, W., Gordon, D., Bowden, D., Mountjoy, J., & Lamarche, G. (2012). *Sites of significance for indigenous marine biodiversity in the Wellington region*. Prepared by NIWA for Greater Wellington Regional Council.

Maseyk, F. J. F., Ussher, G. T., Kessels, G., Christensen, M., & Brown, M. (2018). *Biodiversity offsetting under the Resource Management Act: A guidance document*. Prepared for the Biodiversity Working Group on behalf of the BioManagers Group.

Nelson, W. A., Neill, K., D’Archino, R., & Rolfe, J. R. (2019). *Conservation status of New Zealand macroalgae, 2019* (New Zealand Threat Classification Series No. 30). Department of Conservation.

Rako-Gospić, N., & Picciulin, M. (2019). Underwater noise: Sources and effects on marine life. In C. Sheppard (Ed.), *World Seas: An Environmental Evaluation* (2nd ed., pp. 367–389). Academic Press. http://www.sciencedirect.com/science/article/pii/B9780128050521000231

Rob Greenaway & Associates. (2016). *CentrePort Shipping Channel Deepening Project: Assessment of effects - recreation*. Prepared by Rob Greenaway & Associates for CentrePort Ltd.

Roper-Lindsay, J., Fuller, S. A., Hooson, S., Sanders, M. D., & Ussher, G. T. (2018). *Ecological impact assessment (EcIA). EIANZ guidelines for use in New Zealand: Terrestrial and freshwater ecosystems* (2nd ed.). Environment Institute of Australia and New Zealand.

Stevens, L. (2018). *Whaitua Te Whanganui-a-Tara: Coastal habitat vulnerability and ecological condition* (Salt Ecology Report No. 004). Prepared by Salt Ecology for Greater Wellington Regional Council.

Tonkin & Taylor Ltd. (2016a). *CentrePort Shipping Channel Deepening Project: Sediment characterisation*. Prepared by Tonkin & Taylor Ltd for CentrePort Ltd.

Tonkin & Taylor Ltd. (2016b). *Wellington Harbour Shipping Channel Deepening: Marine ecological assessment*. Prepared by Tonkin & Taylor Ltd for CentrePort Ltd.

Appendix 1: Multi-variate statistical analyses

SIMPER – differences among Transects

Groups Transect 1 & Transect 3
Average dissimilarity = 69.97

	Group Transect 1	Group Transect 3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Phoxocephalidae	1.27	0.58	3.52	1.38	5.03	5.03
Prionospio multicristata	1.32	0.51	3.51	1.4	5.01	10.04
Scleroconcha sp.	0.92	1.33	2.74	1.2	3.91	13.95
Arthritica bifurca	0.66	0.63	2.73	1.04	3.91	17.86
Amphipoda Unid.	0.73	0.16	2.55	0.98	3.65	21.5
Diasterope grisea	0.62	0.11	2.43	0.9	3.48	24.98
Cumacea	0.8	0.92	2.4	0.88	3.43	28.42
Lumbrineridae	0.22	0.61	2.37	0.89	3.39	31.81
Aglaophamus sp.	0.5	0.11	2.2	0.87	3.15	34.96
Cirratulidae	0.44	0	2.17	0.76	3.1	38.06
Cossura consimilis	0.48	0.58	2.17	0.92	3.09	41.16
Cymbicopia hispida	0.47	0.24	2.07	0.88	2.96	44.11
Theora lubrica	0.88	1.04	1.94	1.17	2.77	46.88
Tawera spissa	0.59	0	1.89	1.05	2.7	49.58
Rutiderma sp.	0	0.44	1.77	0.75	2.52	52.11
Corbula zelandica	0.67	0	1.57	0.69	2.25	54.35
Armandia maculata	0.58	0	1.52	0.87	2.18	56.53
Parasterope quadrata	0.48	0	1.5	0.79	2.15	58.68
Ophiuroidea	0.24	0.35	1.46	0.76	2.09	60.77
Melliteryx parva	0.29	0.22	1.34	0.69	1.92	62.68
Rissoidae	0.52	0	1.33	0.88	1.9	64.58
Ennucula strangei	0.22	0.11	1.31	0.58	1.88	66.46
Nemertea	0.47	0	1.29	0.83	1.85	68.31
Lysianassidae	0.48	0	1.28	0.85	1.83	70.14
Upogebia sp.	0.33	0	1.18	0.67	1.69	71.83
Barantolla lepte	0.5	0	1.17	0.68	1.67	73.51
Petrolisthes novaezelandiae	0.44	0	1.03	0.68	1.47	74.98
Notomastus zeylanicus	0.42	0	1	0.66	1.43	76.41
Pectinaria australis	0.11	0.22	0.95	0.59	1.36	77.77
Halicarcinus cookii	0.35	0	0.91	0.68	1.3	79.08
Sigalionidae	0.22	0	0.84	0.52	1.2	80.28

Polydora sp.	0.22	0	0.73	0.5	1.04	81.32
Polynoidae	0.24	0	0.72	0.52	1.03	82.35
Maoricolpus roseus	0.28	0	0.61	0.53	0.87	83.22
Leptochiton inquinatus	0.26	0	0.6	0.53	0.86	84.08
Ischnochiton maorianus	0.24	0	0.57	0.53	0.81	84.89
Maldanidae	0.26	0	0.57	0.52	0.81	85.7
Dorvilleidae	0.24	0	0.53	0.52	0.76	86.47
Spirorbidae	0.24	0	0.53	0.52	0.76	87.23
Hesionidae	0.22	0	0.53	0.52	0.75	87.98
Chiridota nigra	0.22	0	0.53	0.52	0.75	88.74
Anomia trigonopsis	0.22	0	0.49	0.53	0.69	89.43
Decapoda (larvae Unid.)	0.11	0	0.47	0.35	0.67	90.1

Groups Transect 2 & Transect 3
Average dissimilarity = 61.23

	Group Transect 2	Group Transect 3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Diasterope grisea	1.09	0.11	4.16	1.64	6.79	6.79
Phoxocephalidae	1.36	0.58	3.79	1.38	6.18	12.98
Aglaophamus sp.	0.83	0.11	3.6	1.37	5.88	18.86
Prionospio multicristata	0.81	0.51	3.21	1.17	5.24	24.1
Cumacea	0.6	0.92	3	0.99	4.9	29
Arthritica bifurca	0.57	0.63	2.86	1.01	4.68	33.68
Lumbrineridae	0.48	0.61	2.65	0.94	4.32	38
Cossura consimilis	0.39	0.58	2.63	1	4.29	42.29
Theora lubrica	1.71	1.04	2.59	1.29	4.23	46.52
Scleroconcha sp.	1.66	1.33	2.44	0.89	3.99	50.51
Rutiderma sp.	0.44	0.44	2.38	0.96	3.89	54.4
Echinocardium cordatum	0.58	0	2.2	0.9	3.59	57.99
Ophiuroidea	0.33	0.35	2.13	0.82	3.48	61.46
Cymbicopia hispida	0.47	0.24	2.03	0.84	3.31	64.77
Lysianassidae	0.52	0	1.8	0.86	2.94	67.71
Cominella glandiformis	0.35	0	1.63	0.69	2.66	70.37
Amphipoda Unid.	0.37	0.16	1.6	0.73	2.61	72.99
Sabellidae	0.22	0.11	1.22	0.6	1.99	74.98
Pectinaria australis	0.24	0.22	1.19	0.7	1.94	76.91
Parasterope quadrata	0.37	0	1.05	0.69	1.71	78.63
Melliteryx parva	0	0.22	0.99	0.5	1.62	80.25
Varinucula gallinacea	0.26	0	0.97	0.46	1.59	81.84
Hemiplax hirtipes	0.24	0.11	0.9	0.61	1.46	83.3
Sigalionidae	0.22	0	0.85	0.47	1.38	84.68
Phylo novazealandiae	0.22	0	0.8	0.53	1.31	85.99
Tanaidacea	0.24	0	0.78	0.53	1.28	87.27

Owenia petersenae	0.26	0	0.73	0.52	1.19	88.46
Bivalvia Unid. (juv)	0.15	0	0.73	0.35	1.19	89.65
Prionospio yuriel	0.11	0.13	0.7	0.45	1.14	90.78

Groups Transect 1 & Transect 4
Average dissimilarity = 69.15

	Group Transect 1	Group Transect 4				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Prionospio multicristata	1.32	0.37	3.28	1.43	4.74	4.74
Phoxocephalidae	1.27	0.93	2.8	1	4.05	8.79
Theora lubrica	0.88	1.12	2.67	1.04	3.86	12.65
Scleroconcha sp.	0.92	1.81	2.66	1.8	3.84	16.49
Cumacea	0.8	0.93	2.63	1.07	3.8	20.3
Diasterope grisea	0.62	0.38	2.19	0.92	3.17	23.46
Amphipoda Unid.	0.73	0.07	2.15	0.92	3.11	26.58
Cossura consimilis	0.48	0.95	2.15	0.98	3.11	29.69
Aglaophamus sp.	0.5	0.75	2.07	0.94	3	32.69
Arthritica bifurca	0.66	0.49	1.99	1.06	2.88	35.57
Cirratulidae	0.44	0.42	1.88	0.76	2.72	38.3
Cymbicopia hispida	0.47	0.33	1.87	0.89	2.71	41
Lumbrineridae	0.22	0.61	1.78	0.94	2.58	43.58
Tawera spissa	0.59	0.2	1.74	0.89	2.51	46.1
Parasterope quadrata	0.48	0.2	1.43	0.83	2.07	48.16
Nemertea	0.47	0.28	1.42	0.86	2.06	50.22
Corbula zelandica	0.67	0	1.42	0.68	2.06	52.28
Armandia maculata	0.58	0	1.37	0.86	1.98	54.25
Upogebia sp.	0.33	0.21	1.32	0.73	1.91	56.17
Melliteryx parva	0.29	0.32	1.21	0.74	1.75	57.92
Lysianassidae	0.48	0.07	1.2	0.85	1.74	59.66
Rissoidae	0.52	0	1.19	0.86	1.73	61.38
Rutiderma sp.	0	0.44	1.1	0.66	1.59	62.97
Barantolla lepte	0.5	0	1.06	0.67	1.53	64.51
Ennucula strangei	0.22	0.07	1.04	0.53	1.5	66
Maldanidae	0.26	0.2	1.02	0.65	1.48	67.48
Varinucula gallinacea	0.11	0.2	0.96	0.51	1.39	68.87
Phylo novazealandiae	0	0.33	0.95	0.63	1.38	70.24
Petrolisthes novaezelandiae	0.44	0	0.93	0.68	1.35	71.59
Notomastus zeylanicus	0.42	0	0.9	0.65	1.31	72.9
Hesionidae	0.22	0.23	0.9	0.67	1.3	74.2
Ophiuroidea	0.24	0.21	0.89	0.67	1.28	75.48
Sigalionidae	0.22	0.07	0.85	0.56	1.23	76.71
Polynoidae	0.24	0.08	0.82	0.55	1.19	77.89

Halicarcinus cookii	0.35	0	0.82	0.67	1.18	79.08
Aricidea sp.	0	0.21	0.75	0.46	1.08	80.16
Echinocardium cordatum	0.11	0.2	0.7	0.57	1.02	81.17
Polydora sp.	0.22	0	0.64	0.49	0.92	82.1
Tanaidacea	0	0.2	0.59	0.47	0.85	82.94
Cominella glandiformis	0.11	0.13	0.56	0.49	0.81	83.76
Maoricolpus roseus	0.28	0	0.56	0.52	0.8	84.56
Leptochiton inquinatus	0.26	0	0.54	0.52	0.78	85.35
Pectinaria australis	0.11	0.07	0.53	0.41	0.77	86.12
Ischnochiton maorianus	0.24	0	0.52	0.52	0.75	86.86
Prionospio yuriel	0	0.22	0.51	0.48	0.73	87.6
Dorvilleidae	0.24	0	0.49	0.52	0.7	88.3
Spirorbidae	0.24	0	0.49	0.52	0.7	89
Chiridota nigra	0.22	0	0.48	0.52	0.69	89.69
Anomia trigonopsis	0.22	0	0.44	0.52	0.64	90.33

Groups Transect 2 & Transect 4
Average dissimilarity = 61.42

	Group Transect 2	Group Transect 4				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Theora lubrica	1.71	1.12	3.39	1.03	5.52	5.52
Diasterope grisea	1.09	0.38	3.22	1.21	5.25	10.77
Phoxocephalidae	1.36	0.93	2.91	0.96	4.74	15.5
Cumacea	0.6	0.93	2.84	1.14	4.62	20.13
Cossura consimilis	0.39	0.95	2.68	1.1	4.36	24.49
Prionospio multicristata	0.81	0.37	2.51	0.99	4.09	28.58
Aglaophamus sp.	0.83	0.75	2.18	0.82	3.55	32.13
Arthritica bifurca	0.57	0.49	2.07	1.02	3.37	35.49
Lumbrineridae	0.48	0.61	2.05	1	3.33	38.83
Echinocardium cordatum	0.58	0.2	1.91	0.85	3.11	41.94
Cymbicopia hispida	0.47	0.33	1.82	0.85	2.96	44.9
Scleroconcha sp.	1.66	1.81	1.8	1.38	2.94	47.84
Rutiderma sp.	0.44	0.44	1.77	0.91	2.89	50.73
Ophiuroidea	0.33	0.21	1.66	0.7	2.71	53.43
Lysianassidae	0.52	0.07	1.62	0.85	2.64	56.07
Cominella glandiformis	0.35	0.13	1.49	0.71	2.43	58.5
Cirratulidae	0	0.42	1.43	0.71	2.33	60.83
Varinucula gallinacea	0.26	0.2	1.4	0.61	2.28	63.11
Phylo novazealandiae	0.22	0.33	1.35	0.76	2.2	65.31
Amphipoda Unid.	0.37	0.07	1.33	0.64	2.17	67.47
Parasterope quadrata	0.37	0.2	1.17	0.8	1.9	69.38
Tanaidacea	0.24	0.2	1.11	0.68	1.81	71.18
Tawera spissa	0.15	0.2	1.08	0.54	1.75	72.94

Sabellidae	0.22	0.07	0.92	0.55	1.5	74.43
Melliteryx parva	0	0.32	0.92	0.57	1.49	75.92
Nemertea	0	0.28	0.89	0.56	1.45	77.37
Sigalionidae	0.22	0.07	0.87	0.52	1.42	78.79
Aricidea sp.	0	0.21	0.84	0.47	1.36	80.15
Hesionidae	0.13	0.23	0.83	0.58	1.35	81.49
Owenia petersenae	0.26	0.07	0.78	0.57	1.27	82.77
Maldanidae	0	0.2	0.76	0.47	1.24	84.01
Pectinaria australis	0.24	0.07	0.75	0.55	1.23	85.24
Upogebia sp.	0	0.21	0.75	0.46	1.22	86.46
Prionospio yuriel	0.11	0.22	0.7	0.59	1.14	87.61
Bivalvia Unid. (juv)	0.15	0	0.62	0.33	1.01	88.61
Goniadidae	0.11	0.13	0.6	0.49	0.97	89.59
Hemiplax hirtipes	0.24	0	0.57	0.51	0.92	90.51

Groups Transect 3 & Transect 4
Average dissimilarity = 62.43

	Group Transect 3	Group Transect 4				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Cumacea	0.92	0.93	3.88	1.17	6.21	6.21
Theora lubrica	1.04	1.12	3.54	1.02	5.67	11.89
Scleroconcha sp.	1.33	1.81	3.46	1.1	5.55	17.43
Phoxocephalidae	0.58	0.93	3.46	1.14	5.54	22.97
Arthritica bifurca	0.63	0.49	3.21	0.95	5.14	28.11
Cossura consimilis	0.58	0.95	3.08	0.98	4.94	33.05
Lumbrineridae	0.61	0.61	3.06	0.9	4.9	37.95
Aglaophamus sp.	0.11	0.75	2.95	1.15	4.72	42.67
Rutiderma sp.	0.44	0.44	2.74	0.91	4.39	47.07
Prionospio multicristata	0.51	0.37	2.66	0.91	4.26	51.33
Cirratulidae	0	0.42	1.83	0.72	2.94	54.26
Melliteryx parva	0.22	0.32	1.82	0.72	2.92	57.18
Ophiuroidea	0.35	0.21	1.82	0.75	2.91	60.09
Cymbicopia hispida	0.24	0.33	1.73	0.73	2.77	62.87
Diasterope grisea	0.11	0.38	1.61	0.72	2.58	65.45
Phylo novazealandiae	0	0.33	1.32	0.65	2.12	67.57
Varinucula gallinacea	0	0.2	1.18	0.44	1.89	69.45
Nemertea	0	0.28	1.12	0.57	1.8	71.25
Tawera spissa	0	0.2	1.11	0.44	1.78	73.03
Pectinaria australis	0.22	0.07	1.11	0.55	1.77	74.8
Aricidea sp.	0	0.21	1.09	0.49	1.75	76.55
Prionospio yuriel	0.13	0.22	1.08	0.57	1.74	78.29
Amphipoda Unid.	0.16	0.07	1.05	0.41	1.68	79.97
Maldanidae	0	0.2	0.99	0.49	1.59	81.56

Goniadidae	0.11	0.13	0.97	0.49	1.55	83.11
Upogebia sp.	0	0.21	0.96	0.47	1.54	84.65
Tanaidacea	0	0.2	0.81	0.49	1.3	85.95
Hesionidae	0	0.23	0.79	0.49	1.27	87.21
Ennucula strangei	0.11	0.07	0.78	0.4	1.25	88.46
Sabellidae	0.11	0.07	0.75	0.41	1.21	89.67
Echinocardium cordatum	0	0.2	0.6	0.49	0.97	90.64

Groups Transect 1 & Transect 5
Average dissimilarity = 62.02

	Group Transect 1	Group Transect 5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Cumacea	0.8	1.94	3.08	1.33	4.96	4.96
Scleroconcha sp.	0.92	1.83	2.28	1.67	3.68	8.64
Rutiderma sp.	0	0.85	2.25	1.47	3.63	12.27
Theora lubrica	0.88	1.84	2.22	1.71	3.58	15.86
Prionospio multicristata	1.32	1.41	2.2	1.17	3.55	19.41
Phoxocephalidae	1.27	1.34	2.01	0.93	3.24	22.65
Diasterope grisea	0.62	0.74	1.9	1.15	3.07	25.72
Cymbicopia hispida	0.47	1.02	1.74	1.1	2.81	28.53
Lysianassidae	0.48	0.71	1.72	0.99	2.77	31.3
Amphipoda Unid.	0.73	0.22	1.71	1.07	2.75	34.05
Arthritica bifurca	0.66	0.37	1.69	1.01	2.72	36.77
Aglaophamus sp.	0.5	0.93	1.58	1.13	2.55	39.32
Cossura consimilis	0.48	0.37	1.57	0.95	2.53	41.85
Tawera spissa	0.59	0.22	1.39	1.03	2.24	44.09
Parasterope quadrata	0.48	0.35	1.38	0.89	2.23	46.32
Cirratulidae	0.44	0.22	1.35	0.86	2.17	48.5
Hesionidae	0.22	0.51	1.34	0.89	2.16	50.65
Corbula zelandica	0.67	0	1.25	0.69	2.02	52.67
Lumbrineridae	0.22	0.47	1.24	0.89	2	54.67
Armandia maculata	0.58	0	1.18	0.88	1.9	56.57
Rissoidae	0.52	0.11	1.13	0.91	1.81	58.38
Ophiuroidea	0.24	0.33	1.08	0.78	1.74	60.13
Nemertea	0.47	0	0.98	0.85	1.58	61.71
Upogebia sp.	0.33	0.11	0.97	0.72	1.56	63.27
Sabellidae	0	0.38	0.94	0.66	1.52	64.79
Barantolla lepte	0.5	0	0.93	0.68	1.5	66.3
Sigalionidae	0.22	0.22	0.91	0.69	1.47	67.77
Echinocardium cordatum	0.11	0.28	0.91	0.58	1.47	69.24
Melliteryx parva	0.29	0.22	0.9	0.74	1.46	70.69
Halicarcinus cookii	0.35	0.11	0.83	0.75	1.34	72.04

Petrolisthes novaezelandiae	0.44	0	0.82	0.69	1.32	73.36
Notomastus zeylanicus	0.42	0	0.79	0.66	1.28	74.64
Polynoidae	0.24	0.11	0.76	0.6	1.23	75.87
Ennucula strangei	0.22	0	0.72	0.52	1.16	77.03
Maldanidae	0.26	0.11	0.63	0.62	1.01	78.04
Philine auriformis	0	0.22	0.61	0.5	0.99	79.03
Bivalvia Unid. (juv)	0	0.22	0.61	0.51	0.98	80.01
Dosinia greyi	0	0.22	0.57	0.5	0.92	80.93
Trachyleberis sp.	0	0.22	0.55	0.51	0.88	81.82
Heterothyone alba	0	0.22	0.55	0.51	0.88	82.7
Heteromastus filiformis	0	0.22	0.54	0.51	0.88	83.57
Polydora sp.	0.22	0	0.53	0.51	0.85	84.42
Maoricolpus roseus roseus	0.28	0	0.49	0.53	0.8	85.22
Varinucula gallinacea	0.11	0.11	0.48	0.48	0.78	86
Leptochiton inquinatus	0.26	0	0.48	0.53	0.77	86.77
Ischnochiton maorianus	0.24	0	0.45	0.53	0.73	87.5
Dorvilleidae	0.24	0	0.43	0.52	0.7	88.2
Spirorbidae	0.24	0	0.43	0.52	0.7	88.89
Chiridota nigra	0.22	0	0.42	0.53	0.67	89.57
Anomia trigonopsis	0.22	0	0.39	0.53	0.63	90.2

Groups Transect 2 & Transect 5
Average dissimilarity = 51.87

	Group Transect 2	Group Transect 5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Cumacea	0.6	1.94	4.08	1.6	7.87	7.87
Prionospio multicristata	0.81	1.41	3.22	1.69	6.21	14.08
Rutiderma sp.	0.44	0.85	2.24	1.29	4.31	18.39
Cymbicopia hispida	0.47	1.02	2.1	1.16	4.04	22.43
Lysianassidae	0.52	0.71	1.88	1.06	3.63	26.06
Diasterope grisea	1.09	0.74	1.84	1.02	3.55	29.62
Phoxocephalidae	1.36	1.34	1.77	0.96	3.41	33.02
Arthritica bifurca	0.57	0.37	1.7	0.96	3.28	36.3
Echinocardium cordatum	0.58	0.28	1.67	0.99	3.22	39.53
Cossura consimilis	0.39	0.37	1.62	0.89	3.13	42.66
Lumbrineridae	0.48	0.47	1.49	1	2.88	45.54
Hesionidae	0.13	0.51	1.44	0.89	2.78	48.31
Parasterope quadrata	0.37	0.35	1.36	0.84	2.61	50.93
Ophiuroidea	0.33	0.33	1.35	0.84	2.61	53.54
Theora lubrica	1.71	1.84	1.35	1.45	2.6	56.14
Sabellidae	0.22	0.38	1.27	0.81	2.45	58.59

Amphipoda Unid.	0.37	0.22	1.2	0.8	2.31	60.9
Cominella glandiformis	0.35	0	1.08	0.69	2.09	62.99
Scleroconcha sp.	1.66	1.83	1.05	1.31	2.03	65.02
Aglaophamus sp.	0.83	0.93	1.01	0.76	1.94	66.96
Bivalvia Unid. (juv)	0.15	0.22	0.98	0.61	1.89	68.85
Sigalionidae	0.22	0.22	0.96	0.68	1.84	70.69
Varinucula gallinacea	0.26	0.11	0.85	0.58	1.63	72.32
Phylo novazealandiae	0.22	0.11	0.8	0.61	1.53	73.86
Tawera spissa	0.15	0.22	0.78	0.63	1.51	75.36
Cirratulidae	0	0.22	0.74	0.51	1.43	76.8
Trachyleberis sp.	0.11	0.22	0.71	0.6	1.37	78.17
Philine auriformis	0	0.22	0.67	0.51	1.3	79.47
Hemiplax hirtipes	0.24	0.11	0.67	0.62	1.3	80.76
Dosinia greyi	0	0.22	0.62	0.51	1.2	81.96
Heterothyone alba	0	0.22	0.6	0.52	1.15	83.11
Heteromastus filiformis	0	0.22	0.59	0.52	1.14	84.25
Tanaidacea	0.24	0	0.58	0.53	1.12	85.37
Melliteryx parva	0	0.22	0.57	0.52	1.1	86.47
Owenia petersenae	0.26	0	0.55	0.53	1.06	87.53
Pratulum pulchellum	0.13	0.13	0.52	0.48	1.01	88.54
Rissoidae	0.11	0.11	0.5	0.48	0.97	89.51
Boccardia sp.	0.11	0.11	0.48	0.48	0.93	90.44

Groups Transect 3 & Transect 5
Average dissimilarity = 59.19

	Group Transect 3	Group Transect 5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Cumacea	0.92	1.94	3.56	1.5	6.01	6.01
Prionospio multicristata	0.51	1.41	3.49	1.52	5.9	11.91
Phoxocephalidae	0.58	1.34	3.19	1.45	5.38	17.3
Cymbicopia hispida	0.24	1.02	3.1	1.53	5.24	22.54
Aglaophamus sp.	0.11	0.93	3.01	1.9	5.09	27.63
Lysianassidae	0	0.71	2.77	1.3	4.68	32.31
Theora lubrica	1.04	1.84	2.75	1.57	4.65	36.96
Scleroconcha sp.	1.33	1.83	2.42	1	4.09	41.05
Diasterope grisea	0.11	0.74	2.38	1.26	4.02	45.07
Rutiderma sp.	0.44	0.85	2.24	1.11	3.78	48.85
Arthritica bifurca	0.63	0.37	2.23	1.07	3.77	52.62
Lumbrineridae	0.61	0.47	2.13	1.02	3.59	56.22
Cossura consimilis	0.58	0.37	2.07	1.06	3.51	59.72
Hesionidae	0	0.51	1.68	0.87	2.84	62.57
Ophiuroidea	0.35	0.33	1.65	0.88	2.79	65.36
Sabellidae	0.11	0.38	1.41	0.75	2.38	67.74

Parasterope quadrata	0	0.35	1.3	0.66	2.2	69.94
Melliteryx parva	0.22	0.22	1.19	0.71	2.01	71.95
Amphipoda Unid.	0.16	0.22	1.09	0.63	1.83	73.78
Echinocardium cordatum	0	0.28	1.02	0.51	1.73	75.51
Cirratulidae	0	0.22	0.94	0.53	1.58	77.09
Heteromastus filiformis	0.11	0.22	0.91	0.62	1.53	78.62
Philine auriformis	0	0.22	0.83	0.52	1.41	80.03
Bivalvia Unid. (juv)	0	0.22	0.82	0.53	1.39	81.42
Dosinia greyi	0	0.22	0.76	0.52	1.28	82.71
Sigalionidae	0	0.22	0.76	0.53	1.28	83.99
Trachyleberis sp.	0	0.22	0.72	0.53	1.22	85.21
Heterothyone alba	0	0.22	0.72	0.53	1.21	86.42
Prionospio yuriel	0.13	0.11	0.7	0.49	1.18	87.6
Pectinaria australis	0.22	0	0.68	0.52	1.15	88.75
Tawera spissa	0	0.22	0.66	0.53	1.12	89.87
Hemiplax hirtipes	0.11	0.11	0.58	0.49	0.98	90.85

Groups Transect 4 & Transect 5
Average dissimilarity = 60.18

	Group Transect 4	Group Transect 5				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Prionospio multicristata	0.37	1.41	3.78	1.8	6.28	6.28
Cumacea	0.93	1.94	3.74	1.29	6.21	12.49
Theora lubrica	1.12	1.84	3.12	1.16	5.18	17.67
Cymbicopia hispida	0.33	1.02	2.77	1.4	4.6	22.26
Phoxocephalidae	0.93	1.34	2.52	1.09	4.19	26.45
Rutiderma sp.	0.44	0.85	2.39	1.24	3.97	30.42
Lysianassidae	0.07	0.71	2.34	1.17	3.89	34.31
Cossura consimilis	0.95	0.37	2.3	1.28	3.83	38.14
Diasterope grisea	0.38	0.74	2.01	1.13	3.34	41.48
Scleroconcha sp.	1.81	1.83	1.77	1.35	2.94	44.42
Lumbrineridae	0.61	0.47	1.76	1.04	2.93	47.35
Arthritica bifurca	0.49	0.37	1.74	0.91	2.89	50.24
Aglaophamus sp.	0.75	0.93	1.66	0.89	2.77	53.01
Hesionidae	0.23	0.51	1.61	0.92	2.67	55.67
Cirratulidae	0.42	0.22	1.46	0.83	2.42	58.1
Parasterope quadrata	0.2	0.35	1.29	0.73	2.14	60.24
Ophiuroidea	0.21	0.33	1.27	0.76	2.11	62.34
Sabellidae	0.07	0.38	1.17	0.7	1.94	64.29
Echinocardium cordatum	0.2	0.28	1.14	0.64	1.9	66.19
Melliteryx parva	0.32	0.22	1.14	0.76	1.9	68.08
Phylo novazealandiae	0.33	0.11	1.08	0.72	1.79	69.87
Tawera spissa	0.2	0.22	1.01	0.66	1.68	71.55

Philine auriformis	0.13	0.22	0.9	0.6	1.5	73.05
Upogebia sp.	0.21	0.11	0.88	0.58	1.47	74.52
Varinucula gallinacea	0.2	0.11	0.87	0.57	1.44	75.96
Amphipoda Unid.	0.07	0.22	0.84	0.55	1.4	77.36
Maldanidae	0.2	0.11	0.81	0.58	1.35	78.71
Sigalionidae	0.07	0.22	0.78	0.57	1.29	80
Nemertea	0.28	0	0.77	0.58	1.28	81.28
Dosinia greyi	0.07	0.22	0.77	0.56	1.27	82.55
Bivalvia Unid. (juv)	0	0.22	0.72	0.51	1.2	83.75
Prionospio yuriel	0.22	0.11	0.71	0.6	1.18	84.93
Aricidea sp.	0.21	0	0.7	0.49	1.17	86.1
Trachyleberis sp.	0	0.22	0.64	0.52	1.06	87.15
Heterothyone alba	0	0.22	0.63	0.52	1.06	88.21
Heteromastus filiformis	0	0.22	0.63	0.52	1.05	89.26
Polynoidae	0.08	0.11	0.62	0.43	1.02	90.28

SIMPER – differences among positions relative to MHWS

T1

Groups 20 & 40
Average dissimilarity = 73.97

Species	Group 20 Av.Abund	Group 40 Av.Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Corbula zelandica	2.01	0	3.85	8.42	5.21	5.21
Amphipoda Unid.	1.52	0	2.93	5.63	3.96	9.17
Diasterope grisea	0	1.51	2.91	8.56	3.93	13.11
Barantolla lepte	1.5	0	2.87	5.09	3.88	16.99
Scleroconcha sp.	0	1.43	2.71	3.65	3.67	20.66
Theora lubrica	0	1.38	2.64	6.16	3.57	24.23
Petrolisthes novaezelandiae	1.31	0	2.52	5.8	3.41	27.64
Notomastus zeylanicus	1.25	0	2.44	3.38	3.3	30.94
Arthritica bifurca	1.59	0.4	2.3	1.78	3.11	34.05
Armandia maculata	1.41	0.33	2.08	2.09	2.81	36.86
Prionospio multicristata	2.31	1.31	1.9	3.05	2.57	39.43
Rissoidae	1.23	0.33	1.72	1.66	2.32	41.75
Melliteryx parva	0.88	0	1.69	1.31	2.29	44.04
Aglaophamus sp.	0	0.83	1.63	1.26	2.2	46.24
Maoricolpus roseus roseus	0.84	0	1.52	1.31	2.05	48.29
Lysianassidae	1.11	0.33	1.48	1.45	2.01	50.3
Leptochiton inquinatus	0.77	0	1.47	1.33	1.99	52.29
Maldanidae	0.77	0	1.41	1.27	1.9	54.19
Ischnochiton maorianus	0.73	0	1.4	1.33	1.89	56.08
Ophiuroidea	0.73	0	1.4	1.33	1.89	57.97
Cymbicopia hispida	0	0.73	1.36	1.31	1.84	59.81
Nemertea	1.06	0.33	1.36	1.44	1.83	61.64
Dorvilleidae	0.73	0	1.33	1.3	1.8	63.44
Spirorbidae	0.73	0	1.33	1.3	1.8	65.23
Hesionidae	0.67	0	1.29	1.31	1.74	66.97
Chiridota nigra	0.67	0	1.29	1.31	1.74	68.71
Cumacea	0.77	0.91	1.29	1.06	1.74	70.45
Anomia trigonopsis	0.67	0	1.21	1.33	1.63	72.09
Halicarcinus cookii	0.73	0.33	1.16	1.12	1.57	73.65
Parasterope quadrata	0.67	0.77	1.07	1	1.45	75.1
Polynoidae	0.4	0.33	0.97	0.89	1.31	76.41
Lumbrineridae	0.33	0.33	0.88	0.84	1.19	77.61

Polydora sp.	0.33	0.33	0.86	0.84	1.17	78.78
Upogebia sp.	0.33	0.33	0.86	0.84	1.17	79.94
Tawera spissa	0.77	1	0.86	1.03	1.16	81.1
Scintillona zelandica	0.44	0	0.76	0.67	1.02	82.13
Myriochele sp.	0	0.4	0.73	0.66	0.98	83.11
Ruditapes largillierti	0.33	0	0.71	0.67	0.96	84.07
Sphaerosyllis sp.	0.33	0	0.71	0.67	0.96	85.03
Flabelligeridae	0.33	0	0.71	0.67	0.96	86
Cossura consimilis	0	0.33	0.67	0.66	0.91	86.91
Decapoda (larvae Unid.)	0	0.33	0.67	0.66	0.91	87.82
Leptomya retiaria retiaria	0	0.33	0.64	0.66	0.86	88.68
Acanthochitona zelandica	0.33	0	0.63	0.67	0.86	89.54
Syllidae	0.33	0	0.63	0.67	0.86	90.39

Groups 20 & 60
Average dissimilarity = 89.97

Species	Group 20 Av.Abund	Group 60 Av.Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Prionospio multicristata	2.31	0.33	4.61	2.96	5.12	5.12
Corbula zelandica	2.01	0	4.6	6.06	5.12	10.24
Arthritica bifurca	1.59	0	3.6	5.89	4	14.24
Barantolla lepte	1.5	0	3.43	4.49	3.82	18.06
Armandia maculata	1.41	0	3.25	6.5	3.61	21.67
Petrolisthes novaezelandiae	1.31	0	3.02	4.67	3.36	25.03
Scleroconcha sp.	0	1.33	3.02	4.94	3.36	28.39
Notomastus zeylanicus	1.25	0	2.93	3.02	3.26	31.64
Theora lubrica	0	1.27	2.89	5.15	3.22	34.86
Rissoidae	1.23	0	2.77	8.16	3.08	37.94
Phoxocephalidae	1.58	0.52	2.67	1.47	2.97	40.91
Lysianassidae	1.11	0	2.53	5.1	2.82	43.72
Cossura consimilis	0	1.11	2.51	8.17	2.79	46.51
Nemertea	1.06	0	2.42	8.24	2.69	49.21
Melliteryx parva	0.88	0	2.03	1.28	2.26	51.46
Amphipoda Unid.	1.52	0.67	1.99	1.52	2.21	53.68
Tawera spissa	0.77	0	1.82	1.2	2.02	55.7
Maoricolpus roseus roseus	0.84	0	1.79	1.3	1.99	57.69
Leptochiton inquinatus	0.77	0	1.76	1.31	1.95	59.64
Ischnochiton maorianus	0.73	0	1.67	1.31	1.86	61.5

Ophiuroidea	0.73	0	1.67	1.31	1.86	63.35
Maldanidae	0.77	0	1.67	1.25	1.85	65.2
Cirratulidae	0.33	1	1.62	1.3	1.8	67.01
Dorvilleidae	0.73	0	1.57	1.28	1.74	68.75
Spirorbidae	0.73	0	1.57	1.28	1.74	70.5
Halicarcinus cookii	0.73	0	1.55	1.32	1.73	72.22
Hesionidae	0.67	0	1.54	1.28	1.71	73.94
Chiridota nigra	0.67	0	1.54	1.28	1.71	75.65
Ennucula strangei	0	0.67	1.45	1.3	1.61	77.26
Aglaophamus sp.	0	0.67	1.45	1.3	1.61	78.87
Cymbicopia hispida	0	0.67	1.45	1.3	1.61	80.48
Anomia trigonopsis	0.67	0	1.43	1.31	1.59	82.07
Parasterope quadrata	0.67	0	1.43	1.31	1.59	83.65
Cumacea	0.77	0.73	1.34	1.01	1.49	85.14
Upogebia sp.	0.33	0.33	0.98	0.83	1.09	86.24
Polynoidae	0.4	0	0.9	0.66	1	87.23
Scintillona zelandica	0.44	0	0.89	0.66	0.98	88.22
Ruditapes largillierti	0.33	0	0.87	0.66	0.97	89.18
Sphaerosyllis sp.	0.33	0	0.87	0.66	0.97	90.15

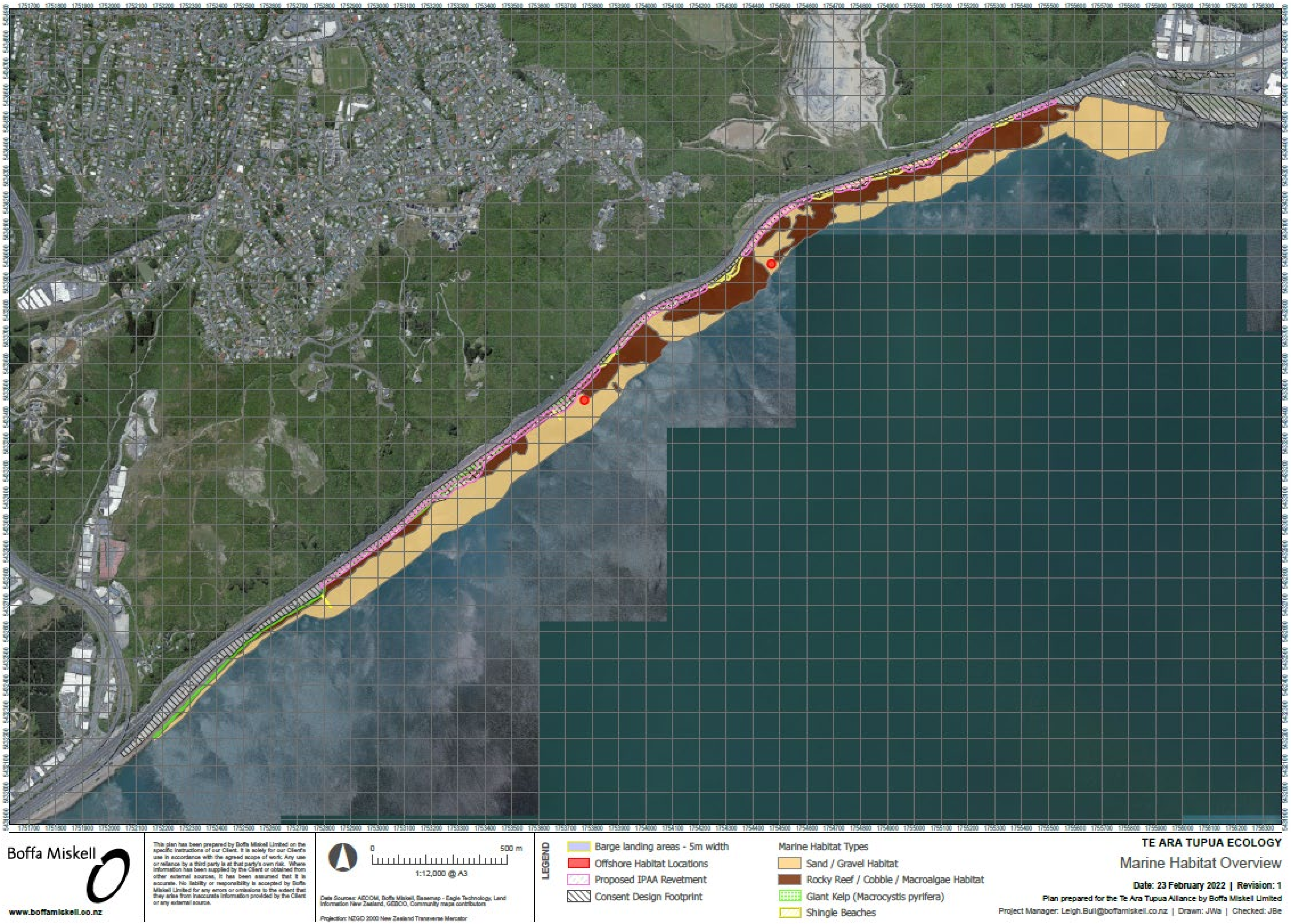
T2

Groups 20 & 60
Average dissimilarity = 68.84

Species	Group 20 Av.Abund	Group 60 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Prionospio multicristata	2.11	0	5.77	12.95	8.39	8.39
Arthritica bifurca	1.31	0	3.72	4.17	5.4	13.78
Cossura consimilis	0	1.17	3.29	4.63	4.77	18.56
Cumacea	1.13	0	3.23	3.62	4.69	23.24
Parasterope quadrata	1.11	0	3.06	7.89	4.44	27.68
Echinocardium cordatum	1	0	2.83	4.69	4.11	31.79
Phoxocephalidae	1.8	0.89	2.61	1.2	3.79	35.58
Rutiderma sp.	1	0	2.49	1.3	3.62	39.2
Theora lubrica	2.19	1.31	2.31	4.01	3.35	42.55
Tanaidacea	0.73	0	2.28	1.32	3.31	45.86
Amphipoda Unid.	0.77	0	2.26	1.13	3.28	49.14
Lysianassidae	0.89	0.33	2.17	1.22	3.16	52.3

Owenia petersenae	0.77	0	2.12	1.31	3.08	55.38
Ophiuroidea	0	0.67	1.95	1.26	2.83	58.2
Cymbicopia hispida	1.06	0.33	1.94	1.4	2.82	61.02
Lumbrineridae	0.77	0	1.89	1.33	2.75	63.78
Hemiplax hirtipes	0.73	0	1.84	1.25	2.68	66.45
Cominella glandiformis	0	0.67	1.8	1.27	2.62	69.07
Pectinaria australis	0.73	0	1.8	1.32	2.62	71.69
Diasterope grisea	1.19	0.89	1.78	1.17	2.58	74.27
Varinucula gallinacea	0.33	0.44	1.43	0.86	2.07	76.34
Tawera spissa	0.44	0	1.24	0.66	1.79	78.13
Sigalionidae	0.33	0.33	1.17	0.82	1.7	79.84
Phylo novazealandiae	0.33	0	1.16	0.66	1.69	81.52
Bivalvia Unid. (juv)	0	0.44	1.16	0.65	1.69	83.21
Aglaophamus sp.	0.67	0.67	1.15	0.82	1.67	84.88
Pareugyriodes filholi	0.4	0	1.12	0.66	1.62	86.5
Scleroconcha sp.	1.79	1.46	0.97	1.6	1.4	87.9
Paraprionospio pinnata	0.44	0	0.96	0.67	1.39	89.29
Rissoidae	0.33	0	0.94	0.66	1.36	90.66

Appendix 2: Map from Te Ara Tupua Project showing M. pyrifera on southern part of shore


Boffa Miskell
www.boffamiskell.co.nz
This plan has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use in accordance with the agreed scope of work. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.
0
500 m
1:12,000 @ A3
Data Sources: AECOM, Boffa Miskell, Basemap - Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Projection: NZGD 2000 New Zealand Transverse Mercator
LEGEND
Barge landing areas - 5m width
Offshore Habitat Locations
Proposed IPAA Revetment
Consent Design Footprint
Marine Habitat Types
Sand / Gravel Habitat
Rocky Reef / Cobble / Macroalgae Habitat
Giant Kelp (Macrocystis pyrifera)
Shingle Beaches
TE ARA TUPUA ECOLOGY
Marine Habitat Overview
Date: 23 February 2022 | Revision: 1
Plan prepared for the Te Ara Tupua Alliance by Boffa Miskell Limited
Project Manager: Leigh.Bull@boffamiskell.co.nz | Drawn: JWa | Checked: JBe

Appendix 3: NIWA subtidal macroalgae survey report

Objective

NIWA were contracted by Boffa Miskell to undertake a survey of macroalgae to the North of the Kaiwharawhara quarry/knoll, running alongside SH2 for approximately 150 m.

The presence/absence and density of *Macrocystis*, plus observations of other dominant macroalgae in the survey area were also recorded.

Methods

The macroalgal survey was carried out on the 9/03/2022 by two divers using SCUBA. The diving survey included:

- Four transects (T1-T4) parallel to the shoreline at 5, 10, 15, 20 m offshore (0m was taken from mean high water springs), over 150 m in length (depth ranging between 1 to 12 m). The area along the transect was inspected and videoed using a GoPro, with the aid of underwater scooters. The transects started about 50-60 m to the left (south) of the concrete storm water outflow (Fig. 1). *Macrocystis* plants along these transects were counted by analysing the GoPro videos. Note that juvenile plants may have been missed in the counts.
- An inspection of the seaweed patch was carried out by following its outer edge (T5).
- Six transects (Perp 1 to Perp 6) perpendicular to the shoreline were also conducted. These were variable length due to the varying width of the seaweed bed. A tape was run out from the shore into the shallow subtidal area until the algal assemblages were clearly absent. The transects ranged between 3.5 to 8 m in depth at their furthest point. Along the transects the divers recorded *Macrocystis pyrifera* plants within 1 m on each side of the tape. The first transect was placed out from the concrete stormwater outflow structure as this was where the seaweed bed started and the adjacent perpendicular transects each placed about 20-25 m apart.

Underwater videos were recorded with a GoPro camera with Keldan floodlights for all transects and inspections of the algal bed.

The divers towed a progress float with a GPS unit to map the transect positions and delimit the extent of the seaweed patch.

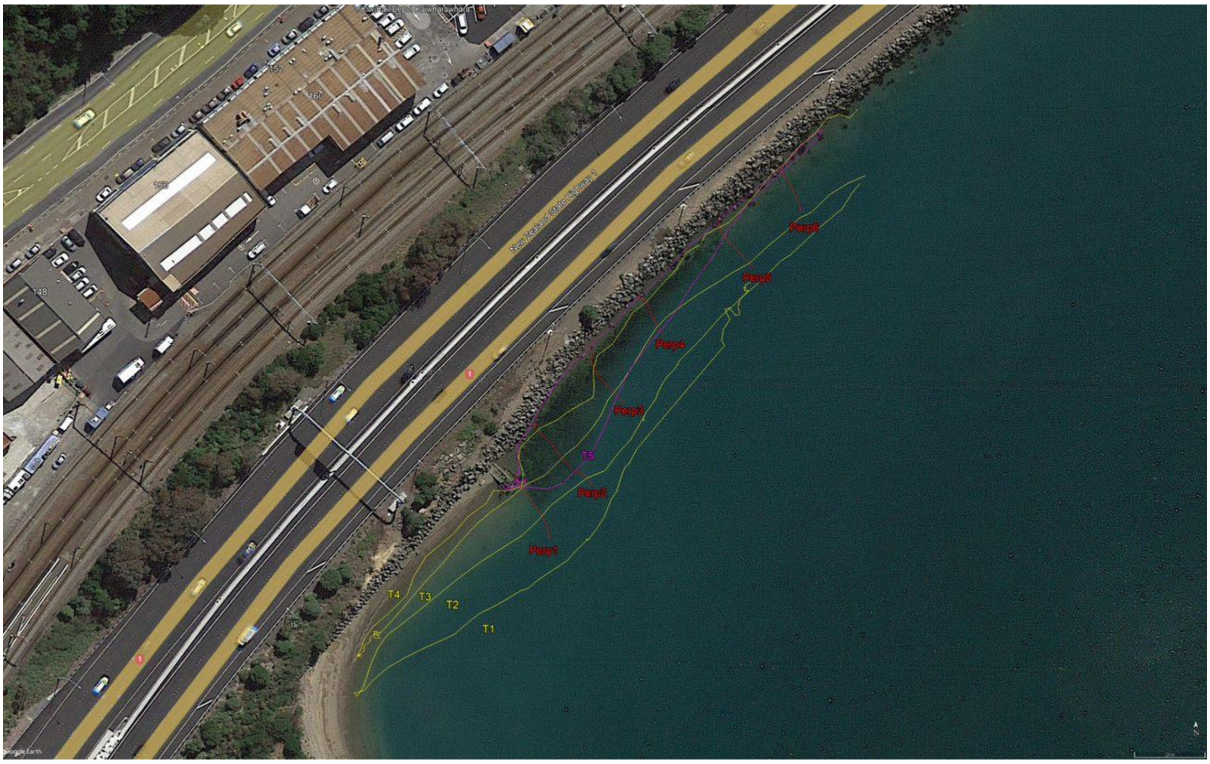


Figure 1. Kaiwharawhara. Yellow lines = transects parallel to the shoreline (T1-T4). Red lines Transects perpendicular to the shoreline (perp1-perp6). Pink line delimitation of seaweed patch.

RESULTS

Overall *Macrocystis pyrifera* was very patchy and sparse with most of the plants not reaching the surface, about 1 m or less tall, or juvenile thalli. *Macrocystis* density was estimated at 1 plant per m^2 or less. *Macrocystis* was absent along the transect 20 m offshore, a single plant was observed along the transect 15 m offshore, and three along the transect 10 m offshore. Most of the plants, 39, were observed along the 5 m offshore transect at depth of 2-4 m. The perpendicular transects also showed low numbers of *Macrocystis* plants with the most, 10, recorded along transect perp 3.

Transect	**Min depth**	**Max depth**	***Macrocystis* plants count**
T1 20m offshore	1 m	11.5 m	0
T2 15m offshore	1 m	8 m	1
T3 10m offshore	1 m	5 m	3
T4 5m offshore	1 m	2 m	39
Perp 1	0.5 m	8 m	1
Perp 2	0.5 m	6 m	5
Perp 3	0.5 m	2.8 m	10
Perp 4	0.5 m	3.7 m	0

Perp 5	0.5 m	4.4 m	2
Perp 6	0.5 m	4.2 m	2

The most abundant species observed was *Carpophyllum maschalocarpum* which forms an almost continuous belt as observed along the transect which was 5 m offshore. The coverage of *Carpophyllum* was very dense (100-80%) in shallow water (about 1- 2 m depth) and became sparse going into deeper water (4-6m). Sparse patches of *Carpophyllum* were observed along the transect 10 m offshore, while along the 15 and 20 m offshore transects only sparse, or drift plants were observed. The seaweed coverage decreased going into deeper water as observed along the perpendicular transects. Other species observed were the invasive kelp *Undaria pinnatifida*, patches of *Ulva* spp., *Codium fragile* and crustose coralline algae.

The substrate in shallow water (1-3 m) was dominated by unconsolidated cobbles and gravel on firm sand with some sparse boulders or artificial structures. The cobbles become sparse going in deeper water (4-6 m) where the sediment was mostly sand/mud with sparse gravel.

The delineated edge of the seaweed patch (T5) had a circumference of 278 m, the total area covered by the patch was approximately 1200 m^2. The northern end of the patch was poorly defined as plants became patchy and species composition changed from predominantly large *Macrocystis* to smaller *Ulva* and *Codium* species heading south to north along the shoreline. The seaward extent of the bed was also less well defined as plants transitioned from solid weed bed to clumps and individuals with increasing depth.

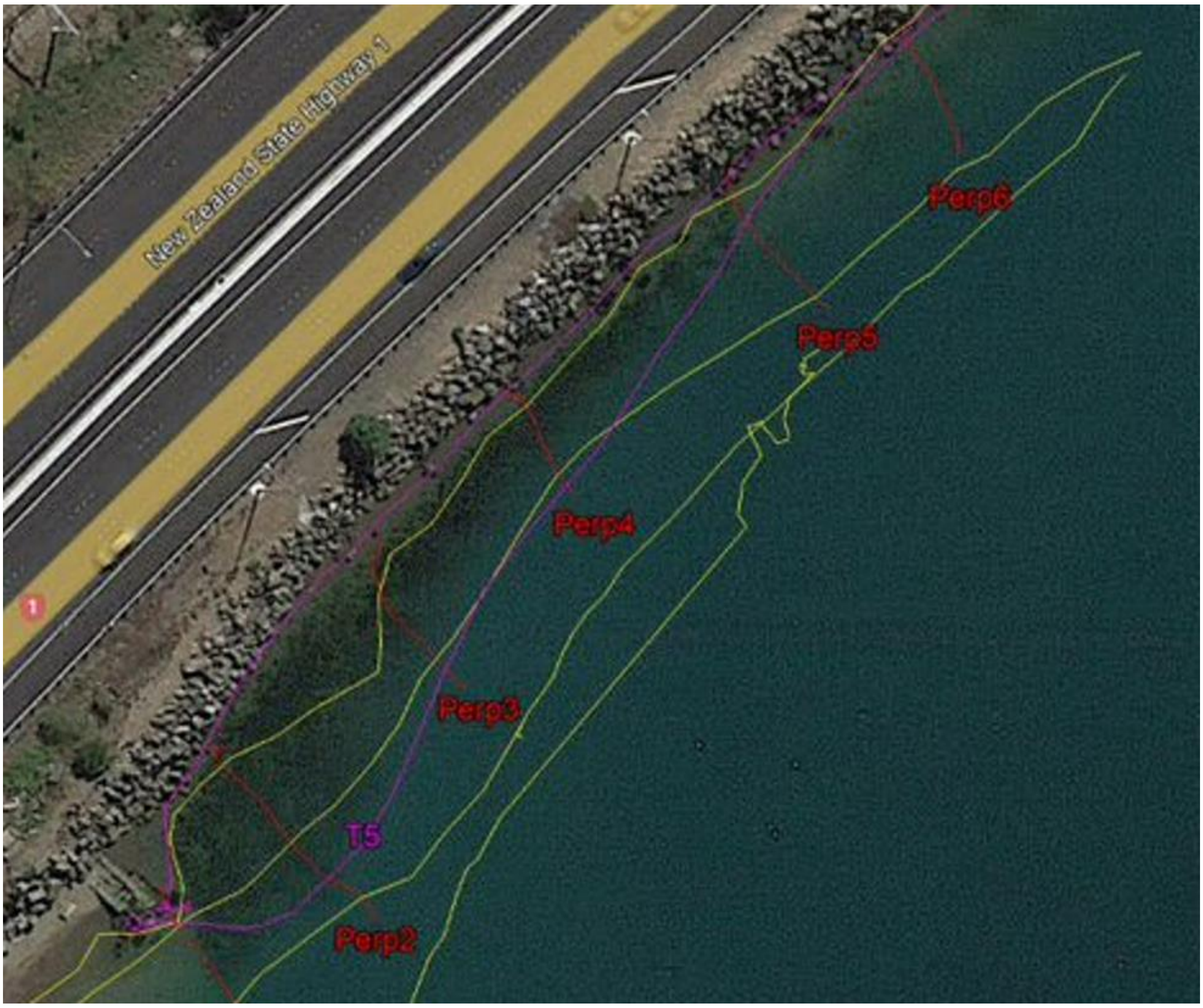


Figure 2. Seaweed patch delimited by the pink line (T5).

Transect T1 - 20 m offshore

Macrocystis was not observed along the entire transect. Towards the end of the transect, sparse drift plants of *Carpophyllum*, *Undaria pinnatifida* as well sparse patches of *Ulva* sp. were observed.

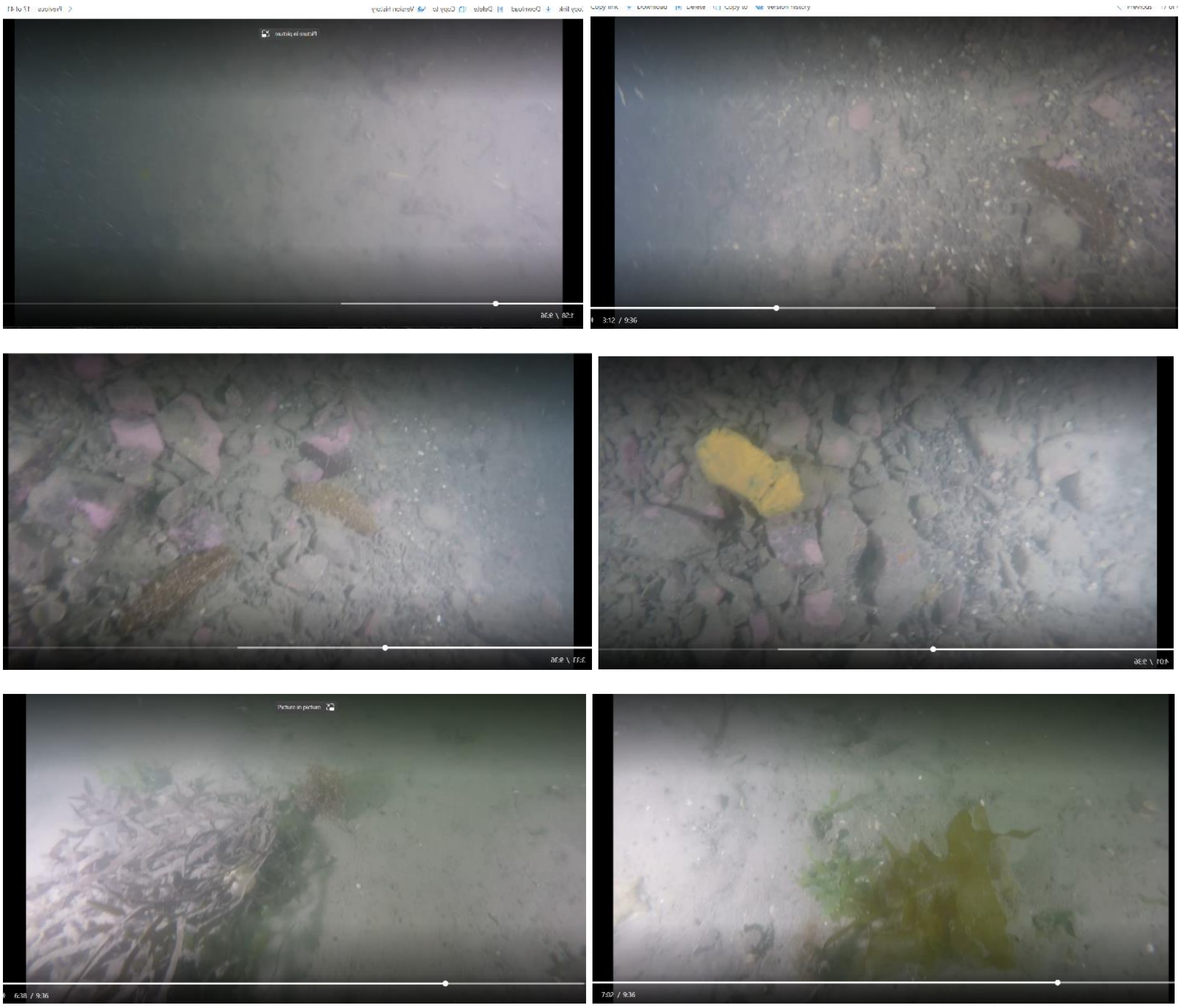


Figure 3. Screen shots from the Go Pro video showing substrate, cobbles covered by crustose coralline algae, invertebrates (e.g. holothurian and sponges) and sparse seaweed, *Carpophyllum maschalocarpum* and *Undaria pinnatifida* along the transect 20 m offshore.

Transect T2 - 15 m offshore

A single plant of *Macrocystis* was observed along the entire transect. Sparse patches of *Ulva* spp. and sea urchins on sand/mud were observed and isolated plants of *Carpophyllum maschalocarpum*.

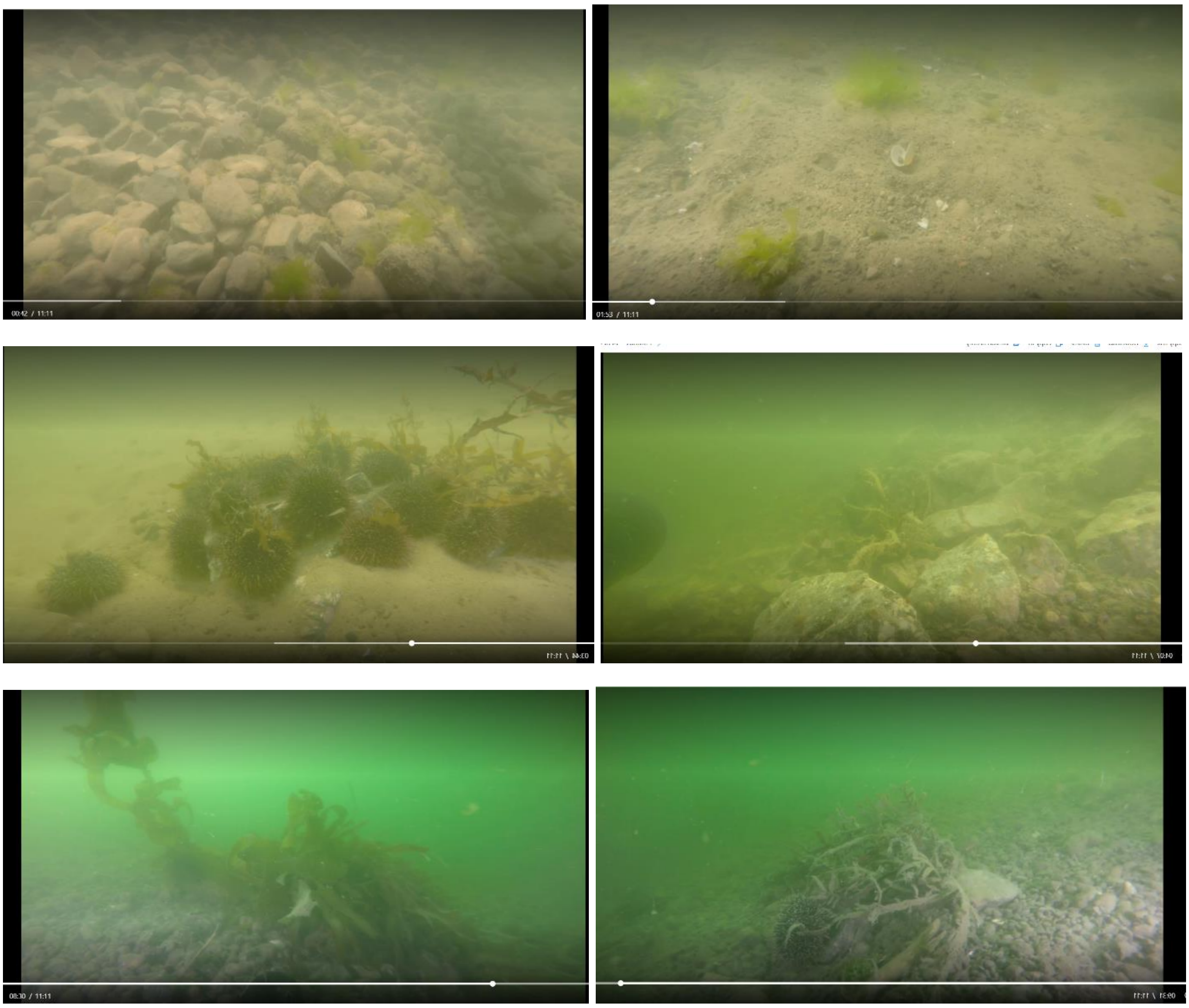


Figure 4. Screen shots from the Go Pro video showing substrate (cobbles or sand/mud), sparse patches of *Ulva* spp. sea urchins, isolated plants of *Carpophyllum* and *Macrocystis* along the transect 15 m offshore.

Transect T3 - 10 m offshore

Sparse seaweed patches observed along the transect, mostly *Carpophyllum maschalocarpum* and *Undaria pinnatifida.* Three *Macrocystis* plants were observed.

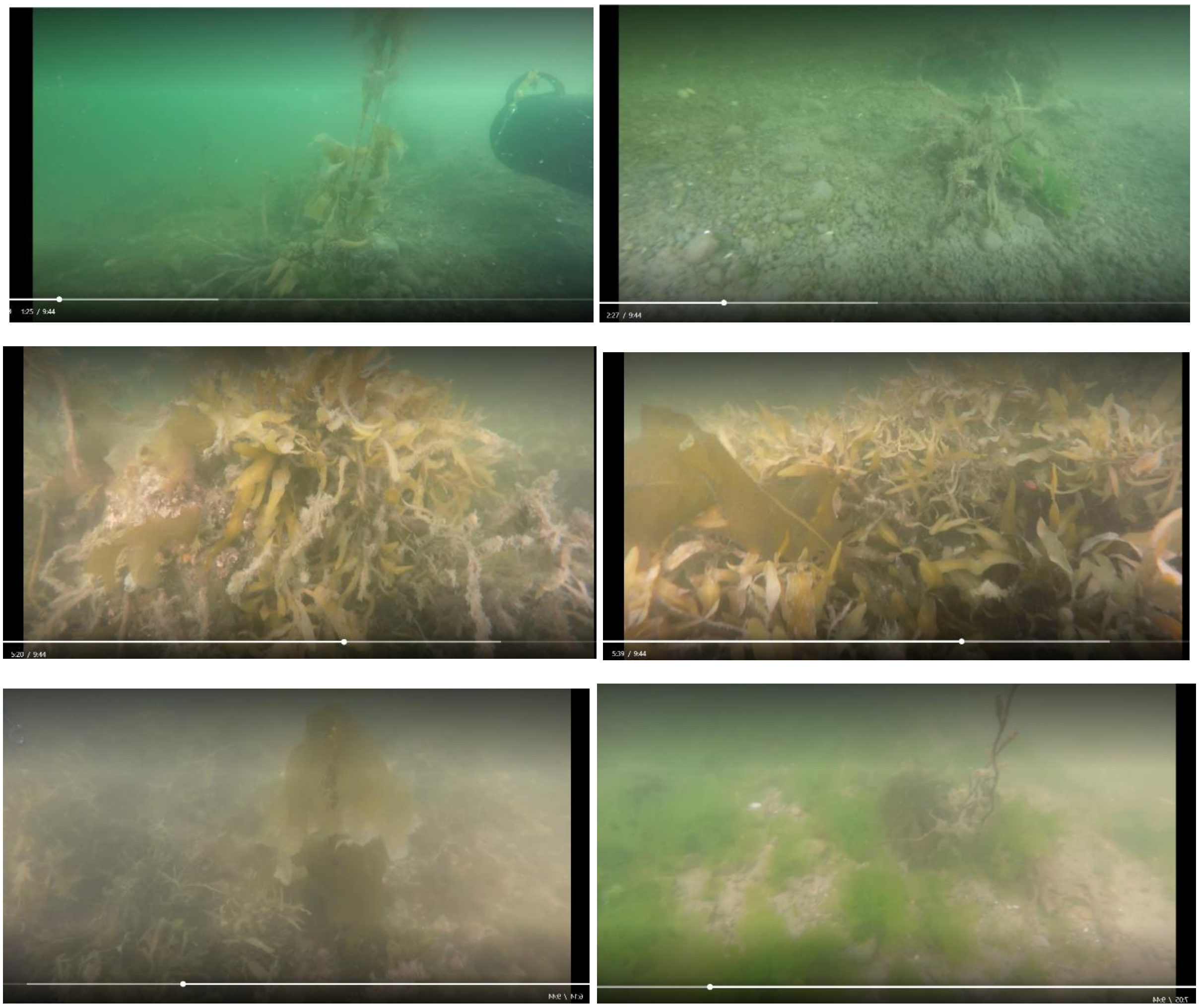


Figure 5. Screen shots from the Go Pro video showing isolated plants of *Macrocystis,* patches of *Carpophyllum* with *Undaria* and patches of *Ulva* spp. along the transect 10 m offshore.

Transect T4 - 5 m offshore

This transect was mostly dominated by seaweed assemblages starting in proximity to the concrete structure. About 39 plants of *Macrocystis* were observed along the transect while *Carpophyllum maschalocarpum* was the dominant species forming almost a continuous belt, intermixed with *Ulva* spp. patches and *Undaria pinnatifida*. Crustose coralline algae were observed on boulders or gravel.

Figure 6. Screen shots from the Go Pro video showing substrate (cobbles) *Macrocystis* and dense patches of *Carpophyllum* and *Ulva* spp. along the transect 5 m offshore.

Transect Perp 1

Transect perp 1 characterised by sparse seaweed on the concrete structure just below the water surface, presence of sparse patches of *Ulva* sp., clusters of sea urchins and drift plants of *Carpophyllum maschalocarpum*. Substrate was mostly sand/mud with sparse gravel. Transect ran to 21 m offshore.

Figure 7. Screen shots from the Go Pro video along the transect Perp 1 going from shallow to deeper water.

Transect Perp 2

Transect perp 2 was characterised by a dense *Carpophyllum maschalocarpum* band extending over 10 m from the shoreline, mixed with *Undaria pinnatifida* and sparse *Ulva* sp. *Carpophyllum* became less dense with depth. Five plants of *Macrocystis* were observed along the transect intermixed with *Carpophyllum.* Substrate was mostly cobbles, gravel and small boulders. Transect ran to 24 m offshore.

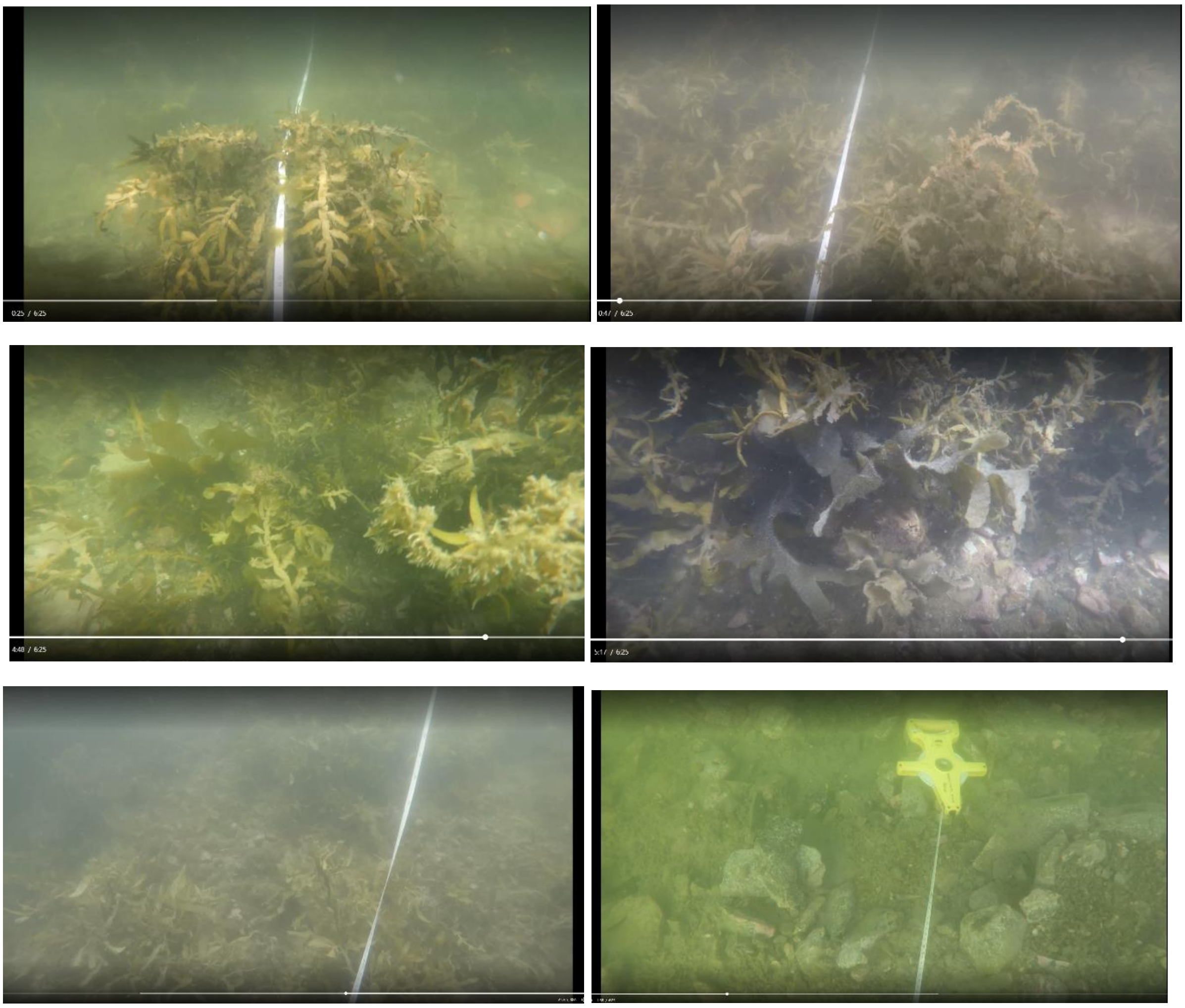


Figure 8. Screen shots from the Go Pro video along the transect Perp 2 going from shallow to deeper water.

Transect Perp 3

Ten plants of *Macrocystis* were observed along transect perp 3, interspersed with the *Carpohyllum maschalocarpum* band, extending about 8 m from the shoreline. *Undaria pinnatifida* and *Ulva* sp. were also observed. Substrate was mostly cobbles, gravel and small boulders. Transect ran to 15 m offshore.

Figure 9. Screen shots from the Go Pro video along the transect Perp 3 going from shallow to deeper water.

Transect Perp 4

Transect perp 4 was characterised by patches of *Carpophyllum maschalocarpum* extending up to 7-8 m from the shoreline, mixed with *Undaria pinnatifida* and with the *Carpophyllum* becoming less dense with depth. *Macrocystis* was not observed along this transect. Substrate was mostly cobbles, gravel and small boulders. Transect ran to 13 m offshore.

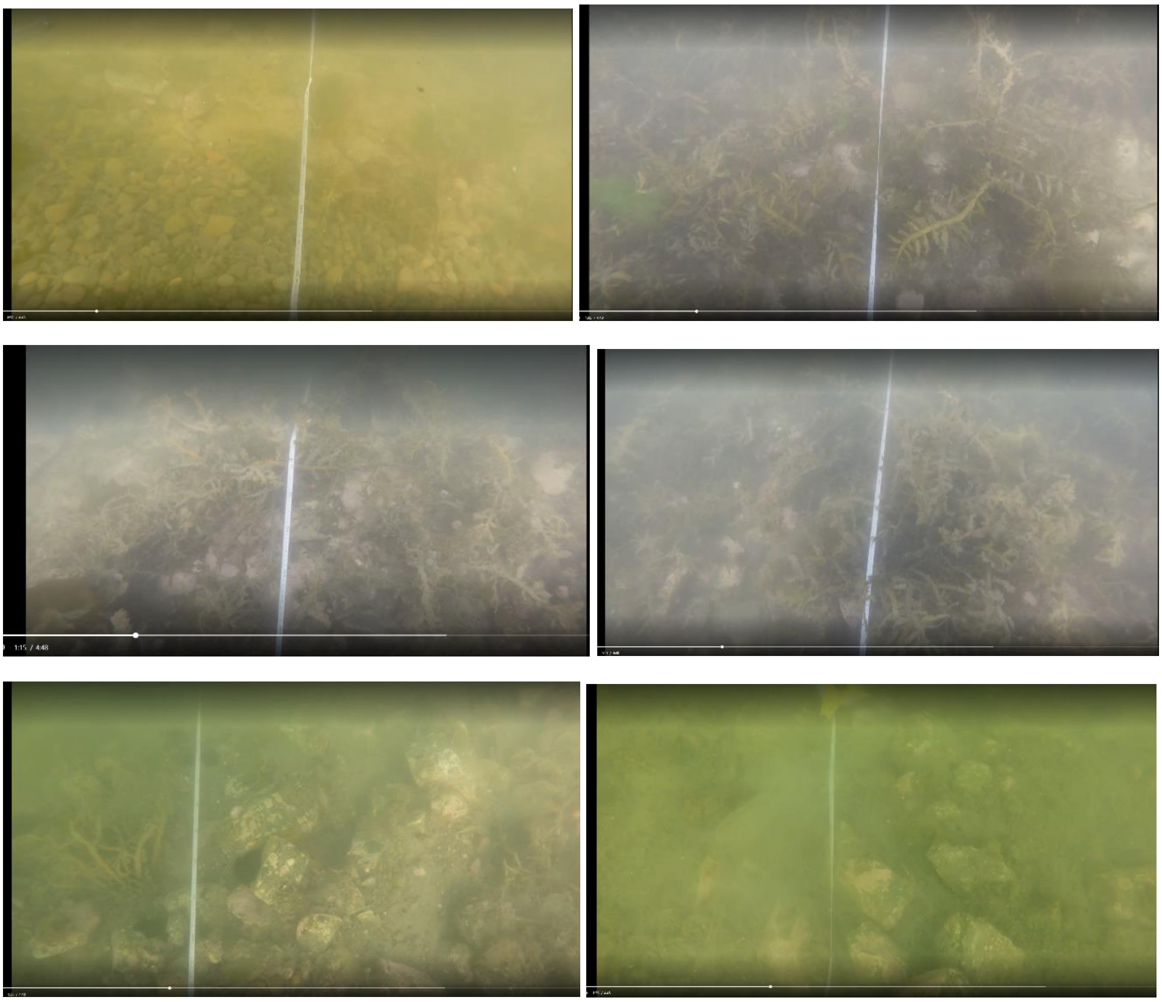


Figure 10. Screen shots from the Go Pro video along the transect Perp 4 going from shallow to deeper water.

Transect Perp 5

Transect perp 5 was characterised by low seaweed coverage, mostly in scattered patches of *Ulva* sp., *Codium fragile*, *Undaria pinnatifida.* Two plants of *Macrocystis* were observed. Substrate was mostly cobbles, gravel and small boulders. Transect ran to 15 m offshore.

Figure 11. Screen shots from the Go Pro video along the transect Perp 5 going from shallow to deeper water.

Transects Perp 6

Transect perp 6 was characterised by low seaweed coverage, mostly represented by scattered patches of *Ulva* sp., *Codium fragile*, and *Undaria pinnatifida.* One plant of *Macrocystis* was observed attached on a boulder just below the surface. Substrate was mostly cobbles and gravel. Transect ran to 15 m offshore.

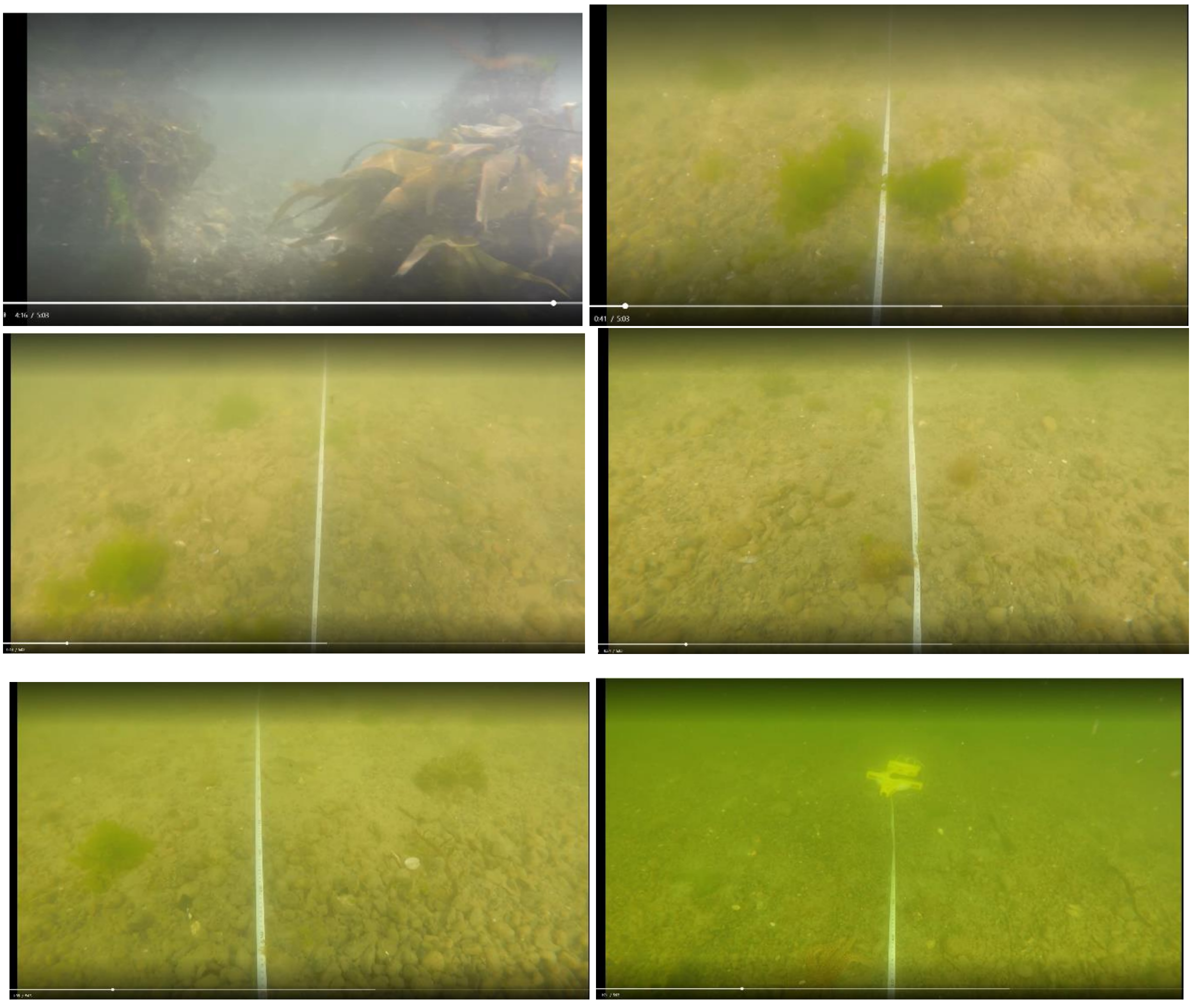


Figure 12. Screen shots from the Go Pro video along the transect Perp 5 going from shallow to deeper water.

Transect T5 circumference around the seaweed bed

The underwater videos acquired following the perimeter of the seaweed bed reinforced the data which was recorded with the parallel and perpendicular transects. *Carpophyllum* density was found to decrease with depth, *Macrocystis* plants were sparse, and common species observed were *Undaria pinnatifida* and *Ulva* sp. and occasionally *Codium fragile*. Substrate consisted of cobbles with crustose coralline algae and small boulders.

Figure 13. Screen shots from the Go Pro video along T5 showing isolated plants of *Macrocystis*.

Discussion

Macrocystis pyrifera at Kaiwharawhara was present in low density with about 1 plant per m^2 and predominantly only in one small isolated seaweed bed. Most of the plants were less than 1 m tall and did not reach the surface. The survey was carried out at the end of a warm summer and it is likely that *Macrocystis* has been affected by higher temperatures in the harbour and it might recover during winter. Several plants were juveniles. *Carpophyllum maschalocarpum* was the dominant species, similar to other areas in the harbour, occurring in dense patches from the low intertidal to shallow subtidal with its density decreasing with depth. The invasive kelp *Undaria pinnatifida* was common and large patches of *Ulva* sp. were observed.

Appendix 4: NIWA methodology for transplanting M. *pyrifera*

Transplanting and collection of sporophytes of *Macrocystis pyrifera (from Dr Roberta D'Archino – NIWA Macroalgae expert)*.

Plants of *Macrocystis pyrifera* will be collected from Kaiwharawhara from depths of 2-4 m by removing their holdfast with part of the substratum, if possible. In case the rock is too hard to be broken with hammer and chisel. The plants will be removed with a blunt-tipped knife with careful attention made to minimise damage to the holdfast. Juvenile plants and adults, less than 1 metre tall, will be removed. Individuals for transplanting will be selected based on their condition, particularly being free of substantial epibiotic fouling and degraded.

Collected kelps will be placed in fish bins and kept shaded moist and cool on the boat, for the time necessary to prepare the plants for the transplanting. All the plants will be measured, tagged and annotated, in order to see if the individuals with rock have succeeded or if attachment is needed. The plants removed without the substrates will be re-attached to cobbles or small boulders, previously collected, using latex rubber bands or other materials. The plants will be transported to the field site within 2-3 hours of the collection. The divers will carefully reposition the individuals, possibly finding crevices and boulders that could hold or shelter the plants. An underwater video will be taken to document the transplanting.

Collection of fertile portions of sporophytes (sori) will be made on the same day of the transplanting and kept moist and cooled until the transplanting operations are completed. Once in the laboratory, sori will be cleaned with freshwater, wiped off with paper towels and the non-fertile portions of the thalli removed. The sori will be packed in paper towels, stored overnight at 12°C. In the morning sori will be placed in flasks with sterilised seawater enriched with F2 medium and left 1 hour or more for sporulation. The spore slurry will be poured on the previously conditioned gravel placed in large containers in the Marine Environmental Manipulation Facility (MEMF) where growing conditions, lights, water flow and temperature can be manipulated. Part of the spore slurry will be kept in red light and low temperature as a gametophyte seed bank for future reseeding. The gametophytes can be kept for months under these conditions, preventing reproduction and the development of the sporophyte.

After 3-4 months we propose to monitor the transplanted plants and to release the seeded gravel in the field. Where possible, any material used to re attach the plants will be removed. Monitoring will be conducted every 3 months up to one year from the transplanting (4 days diving – after the initial 3 days of diving. All the diving operations will be documented by underwater videos or photos.

Appendix 5: Rimurimu/NIWA proposal for compensation for occupation of CMA

Restoration Proposal: Prepared for KiwiRail

By Mountains to Sea Wellington (Love Rimurimu Regeneration)

Taranaki Whānui (Research, Monitoring & Mātauranga)

And NIWA (Research & Monitoring)

The Love Rimurimu Restoration Project

The Love Rimurimu Restoration Project was initiated by the Mountains to Sea Wellington Trust in 2021, with founding partners, to champion and pilot the regeneration of native seaweed forests in the 'blue belt' of Te Upoko o Te Ika a Maui. Seed funding for the project was received from the Wellington Community Trust through their Climate Change Fund.

Aspirations & Values:

The Love Rimurimu Project aims to:

- Establish four Seaweed and Marine Restoration sites by 2024, increasing carbon sequestration, ecological resilience and marine biodiversity.
- Develop a tool kit for marine restoration including support for planning, aquaculture techniques, education & research which can be utilised in other regions.
- Uphold mana whenua leadership in marine restoration priorities and sites of importance.
- Build knowledge - supported by leading scientists and researchers -and share know-how to support partners working in restoration.
- Explore and support innovative harvest uses, and other economic/ecological opportunities.
- Advocate at central and local government for marine restoration and as part of 'Blue Belt" priorities.
- Build a community of like-minded organisations and individuals around the project, and strengthen community knowledge, buy-in and support for seaweed restoration.

Additional funding (via this proposal) would be used to help us achieve this work, and to extend the project. It would provide solid resourcing for mana whenua leadership within the project, and for vital research, monitoring and technical expertise.

Background

MTSW was approached by Boffa Miskell, on behalf of KiwiRail, to investigate seaweed restoration as a potential 'offset' project to habitat damage that will be caused during works at the Interislander Ferry terminal. This proposal has been prepared with this objective in mind; however, it also brings together collaborations and a range of work around, and for, the health and mauri of Wellington Harbour and coast.

In preparing this proposal we have spoken with GWRC and worked with Dr Roberta D'Archino, Dr Wendy Nelson (NIWA) and Lee Rauhina August (NIWA/Taranaki Whānui).

We present this proposal in the interests in advancing the aims of the Love Rimurimu restoration project, and to carefully consider the selection of seaweeds and sites most appropriate for regeneration. NIWA would carry out much of this research, and in partnership with Taranaki Whānui would guide priority research, sites and species.

Timeline & Proposed works

We propose to begin work in October 2022 – with a view to have our first regeneration sites underway by May 2023.

PRE-CONTRACT:

To achieve this timeline, a considerable amount of groundwork has already begun. This includes (or will be underway at start of contract) the following:

- An established project team for Love Rimurimu, including the expertise of leading Phycologists who have supported the project since its beginnings in 2020.
- Monitoring and environmental stress research being undertaken by Post-Doctoral students under Dr Chris Cornwall at Victoria University and funded through the Eurofins Foundation from March- October 2022.
- Initial scoping of suitable sites based on the current knowledge base of published observations within the Harbour by supervised students in summer 21/22.
- Additional research funding for climate resilience of restoration species.
- Initial work on a 'spore bank' and research at NIWA since 2021.
- Presentation to mana whenua Taranaki Whānui by students from local kura on their preferred sites for seaweed restoration (a youth-led initiative). This is an opportunity to share existing mātauranga with which to begin discussions to inform restoration site priorities (due to take place in March/April 2022).

- Some initial wānanga and research on priority sites for Taranaki Whānui the first of which scheduled to start on 10 Sept.
- Initial conversations and scoping around Kaiwharawhara and Cultural Health Indicators.

<u>Year 1 (July 2022 – June 2023) – Funded by KiwiRail</u>

- Establish a Taranaki Whānui Lead role within the project – Resourced from this budget for Years 1 & 2, and to support coordination, and a wānanga series to build knowledge.
- In collaboration with Taranaki Whānui, and a review of existing mātauranga, data and knowledge, select restoration sites and priority species to commence pilot areas.
- Utilise existing baseline surveys and site assessments, Cultural Health Monitoring, and ascertain where additional baseline research is required
- Establish a macroalgae technician role at MTSW to maintain a 'spore bank' at NIWA; including experiment with approaches to long-term care of seed stock; develop site-appropriate approaches to out-planting materials and early life-stages to enable field trials.
- Establish a 'hatchery' system to grow out seaweeds to out-planting sizes.
- Confirm research and monitoring stream priorities for Year 1 – 4 (NIWA)
- Begin Planting Trials in 2 sites within the Harbour
- Build and share knowledge, information, and public communication around projects progress. Report back to Kiwi Rail at 6-monthly intervals on project progress.

<u>Year 2 (July 2023 – June 2024)- Funded by KiwiRail.</u>

- Minimum of 2 larger scale restoration sites underway. Size and location to be determined based on considerations/constraints identified above
- Long-term monitoring/research plans & activities moving into Year 2 lead by NIWA
- Research and growth experiments on-going to inform techniques/ methodologies to enhance success and growth rates.

<u>Year 3 & 4 .June 2024 – July 2026. Additional budget will be sought for Years 3 & 4.</u>

- Long term monitoring of restoration sites
- Maintenance, further out-planting where needed
- Expansion into a further 2 sites.
- Published data available for public use and to inform and support restoration**.**

PROJECT ROLES

MTSW

LRR Project Coordination/Reporting and Collaboration
Development of Tool kit, public information and comms/science communication around the project.
Seaweed 'Spore Bank" role (1.5 FTE for first 2 years)
Part of Marine Aquaculture Role (0.125 for first 2 years)

NIWA

Research and Monitoring – Dr Wendy Nelson, Dr Roberta D'Archino
In field work – NIWA monitoring/tech team
Technical Marine Expertise– Dr Neil Barr

Taranaki Whānui

Lead Role – Lee Rauhina-August
Research pathways to inform site selection/Māturanga & Wānanga

Restoration Sites

Physical materials, substrates, anchors, out-planting and maintenance activities– over life span of project.

Agreement Between NIWA and MTSW

NIWA and MTSW have prepared this proposal together, in collaboration with Lee Rauhina August (Taranaki Whānui). This is a draft proposal and further refinement is needed once approved.

Budget for work carried out by NIWA (still to be scoped) would be provided directly to NIWA in a contractual agreement between NIWA & KiwiRail for research, monitoring and field work.

MTSW will be funded for partial funding of an existing Aquaculture Role, Development of a Seaweed Hatchery/Husbandry Role, and Love Rimurimu Project Management and Administration, coordinating the many elements of the project.

The purpose of the Love Rimurimu project has been stated above. With this in mind all knowledge developed through the restoration project will be made available in the public domain to assist other regions working to undertake similar restoration endeavours.

In regard to research components, researchers working within the project will get first the opportunity to publish their findings before information is released, with all efforts being made to publish data in a timely fashion to allow it to be shared publicly as soon as possible.

Sensitive Information for mana whenua may however be safe-guarded into perpetuity. This will be guided by mana whenua in the first instance.