Appendix 11

Assessment of Marine Ecological Effects

NORTHPORT EXPANSION PROJECT

ASSESSMENT OF MARINE ECOLOGICAL EFFECTS

COAST & CATCHMENT

ENVIRONMENTAL CONSULTANTS

NORTHPORT EXPANSION PROJECT

ASSESSMENT OF ECOLOGICAL EFFECTS

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2 EXECUTIVE SUMMARY

Northport is seeking consent for a proposed expansion east of their existing facilities at Marsden Point, at the entrance to Whangārei Harbour. The proposed development involves:

- Reclamation within the Coastal Marine Area (CMA) and earthworks to the immediate east of the existing reclamation to expand Northport's footprint by approximately 13.7 hectares. This comprises around 11.7 ha of reclamation within the CMA and 2 ha of earthworks outside the CMA.
- Capital and associated maintenance dredging to enlarge the existing swing basin and deepen it by around two metres, and to enable construction of the new wharf.
- A 520 m long wharf (including the consented, but not yet constructed, 270 m long Berth 4) on the northern (seaward) face of the proposed reclamation.
- Sheet piling and rock revetment structures on the eastern edge of the proposed reclamation.
- Treatment of operational stormwater via the existing pond-based stormwater system.
- Port-related activities on the proposed expansion and wharves.
- Construction of a new tug jetty.
- Replacement of the existing floating pontoon, public access, and public facilities.

The final design will be confirmed during the detailed design phase.

This report provides an assessment of marine ecological effects for the proposed reclamation and dredging (excluding biosecurity issues and effects on birds and mammals), and for operational stormwater discharges from the proposed reclamation/wharf.

Description of the existing environment

Whangārei Harbour is approximately 24 km in length, and has a surface area of around 100 km^2, of which, 58% is intertidal. It has a mean depth of 4 m and a maximum depth of 31 m near Marsden Point. Intertidal sediments in the mid and outer harbour are predominantly sandy, with sediments becoming muddier in the upper harbour. Subtidal sediments around the harbour entrance consist of large areas of gravel-shell lag, interspersed with sand. Intertidal sediments around Northport are predominantly sand, except for the area immediately west of the port, which is muddy sand. Subtidal sediments around Northport consist of sand or gravelly sand.

Monitoring and assessments indicate that sediment concentrations of copper, lead and zinc frequently exceed guideline values in the upper reaches of the harbour but are typically low in the mid to outer harbour, where the port is situated. Sediment nitrogen and phosphorus concentrations are also high in the upper harbour and low in the mid to outer harbour. Similarly, water quality improves down the harbour, with sites near the harbour entrance having the best quality.

Whangārei Harbour has been, and continues to be, subject to significant coastal development and anthropogenic stressors including Whangārei township, Northport, Port

Whangārei, Marsden Point oil refinery,[1] marine farms, and multiple marinas, boat ramps and moorings. Sedimentation from land run-off is a major historical and on-going issue, with an average harbour-wide sedimentation rate of 3.4 mm/year over the last 50–100 years. The main channel of the harbour has been extensively dredged to maintain navigable depths, and further dredging around the entrance to the harbour is contemplated. The harbour is also a popular recreational destination that, among other things, is used for recreational boating, fishing and shellfish harvesting.

Reviews of the ecological habitats and communities of Whangārei Harbour show that the harbour supports diverse and ecologically important marine communities. Approximately 35% of the harbour is designated as a Significant Ecological Area (SEA), with the One Tree Point–Marsden Bay SEA situated adjacent to the western side of Northport. Among other things, the SEA contains seagrass beds and sandflats that provide important feeding habitat for shorebirds. A marine reserve is present across the channel from Northport around Motukaroro Island.

Seagrass was historically abundant in Whangārei Harbour and historically covered around 10–14 km^2 of the harbour. By 1970 it had virtually disappeared from the harbour, but since 1999 it has been expanding in intertidal areas. Around 6 km^2 of seagrass was estimated to be present in the harbour in 2016. Extensive seagrass beds are now present on the intertidal flats between One Tree Point and Northport, and small patches are also present within the proposed reclamation area.

Whangārei Harbour sustains a diverse assemblage of benthic taxa and communities. Benthic communities in upper sections of Hatea and Mangapai Rivers are clearly distinct and typical of those found in upper estuary systems. Further out into the harbour the community patterns are more diverse. Harbour-wide data from 2012 suggested that the intertidal benthic community in Marsden Bay was similar to communities found at other sites around the harbour. Finer scale intertidal sampling around Northport has shown that benthic macrofaunal diversity is relatively high, with variation along and down the shore, and minor community level differences between the western and eastern sides of Northport. Subtidal sampling indicated that infaunal and epifaunal macroinvertebrate diversity is very high around the port, with areas of dense shell, macroalgae meadows, and diverse communities of encrusting organisms. Those habitats are likely to provide shelter, refuge and food for a variety of invertebrates and fishes.

Cockles are widespread in Whangārei Harbour and are particularly abundant around the outer harbour (Marsden Bay, McLeod Bay, Snake Bank and MacDonald Bank). Small cockles were found at moderate to very high abundances on the mid shore across the entire length of Marsden Bay, with the highest densities found near the entrance to Marsden Cove Marina. Quantitative sampling conducted around Northport found that 70–75% of stations on the mid to lower shore contained more than 100 cockles/m^2.

Pipi are present at several sites in the mid to outer harbour, with highest densities inside the harbour found at Marsden Bay. Pipi were previously commercially harvested from Marsden and Mair Banks just outside of the harbour entrance, but commercial harvesting has been prohibited since 2011 and 2014, respectively, due to low biomass levels. A small bed of

[1] The Marsden Point refinery has recently ceased refining activities and has converted to an import and distribution terminal only. Refining NZ is now known as Channel Infrastructure.

juvenile pipi exists up to 300 m west of Northport in the mid shore zone, with mean densities of around 300 pipi/m^2 within this 300 m band. Pipi appear to be patchily distributed and small within the proposed reclamation area, with moderate counts of small (<20 mm, with the majority being <5 mm) pipi obtained from three, mid to upper intertidal stations sampled in 2022.

A large variety of fishes utilise Whangārei Harbour. Fish communities around Northport appear to be similar to those that inhabit nearby reef areas. Leatherjackets, red moki, spotty, sweep, triplefins, kingfish, jack mackerel, two-spot demoiselle, and goatfish were commonly observed around the rock revetments of Northport.

Assessment of Ecological Effects

The assessment of potential marine ecological effects (excluding biosecurity issues and effects on birds and mammals) of the proposed development considers the potential for effects at three scales:

1. The entire harbour system;
2. The outer harbour and entrance zone (OHEZ); and,
3. The areas that the proposed activities are likely to have a material impact on (i.e., dredging and reclamation footprints, and offsite areas indirectly affected).

Table 2 identifies the most relevant system/scale for the assessment of each key effect, along with the corresponding assessment of the level of effect.

Effects on intertidal habitats and communities

Port reclamation will directly eliminate 6.6 ha, or 1.08%, of intertidal habitat, within the OHEZ. The construction of the proposed bird roost on the western side of the port (for the purposes of achieving positive ecological effects with respect to avifauna) will cover a further 0.54 ha of intertidal habitat (0.09% of intertidal habitat in the OHEZ), with natural processes shifting the position and extent of that feature over time. No at risk or threatened species of benthic macrofauna are known to occur in the area.

While intertidal habitats within the proposed reclamation and bird roost appear healthy and contribute to the broader diversity and ecological values of the harbour, the sites themselves do not contain unique or special ecological qualities. That, together with their small scale relative to the overall amount of intertidal habitat within Whangārei Harbour and the OHEZ, suggests that the effects of their construction on the extent of sandy intertidal habitat and the diversity of benthic macrofauna will be moderate at those scales.

Effects on kaimoana shellfish

Reclamation will permanently eliminate existing shellfish from the areas directly affected. The key shellfish affected are cockles, pipi, and possibly scallops. Cockles are a ubiquitous feature of intertidal sites within much of the harbour, whereas the distributions of pipi and scallops are more patchy.

Sampling indicated that the density of cockles present around the site was comparable to other harbour sites. That, together with the small scale of reclamation relative to the broad scale of habitat containing cockles within Whangārei Harbour suggests that effects on cockles at the harbour and OHEZ scales will be low.

Small pipi area present in the proposed reclamation area and around the proposed bird roost, but harvestable sizes were not detected. Pipi were not obtained in samples collected from the proposed dredging area. The effects of dredging and the dredging plume on pipi are therefore considered to be negligible.

Given the widespread distribution of cockles around the harbour, and the absence of harvestable pipi in the proposed reclamation and roost areas, the direct effects on harvestable cockles and pipi are likely to be low at the harbour and OHEZ scales. All cockles and pipi will be lost from the reclamation and roost area.

No live scallops were observed in the reclamation area, but empty scallop shells were apparent around an octopus den, and low numbers of patchily distributed scallops were observed in the proposed dredging and nearby areas. Scallops in the reclamation area would be permanent lost, but they could recolonise dredged areas. It is therefore recommended, that as far and practicable, scallops in areas affected by reclamation and dredging be moved to remote beds prior to those activities commencing.

Effects on subtidal macrofauna

Around 5.1 ha of habitat below chart datum (CD) will be lost beneath the proposed reclamation. Sampling indicates that sediments in that area contain a diverse infaunal community, with similar assemblages of taxa to that found on the western side of Northport. Few large epibiota were observed in video footage taken within the proposed reclamation area, and all are likely[2] to be common. Species directly observed included dense aggregations of turret shells (*Maoricolpus roseus*, but these were probably dead shells occupied by hermit crabs), scattered starfish (*Astropecten polyacanthus*), scattered small sponges, cushion stars (*Patriella regularis*), and a Mediterranean fan worm (*Sabella spallanzanii*), which is a marine pest. An octopus den and numerous small holes in seabed sediments were also observed. The latter are probably worm tubes, shellfish siphons, or crustacean burrows.

While subtidal habitats within the proposed reclamation footprint appear healthy and contribute to the broader diversity and ecological values of the harbour, the site itself does not contain unique or special ecological qualities. The loss of a small proportion (0.28%) of natural subtidal habitat in the OHEZ is unlikely to reduce overall biodiversity values or compromise ecological functions and processes within the zone. That, together with the small scale of reclamation relative to the overall amount of subtidal habitat within the harbour, suggests that the effects of reclamation will be moderate at both scales. However, ecological effects within the reclamation footprint itself will be more significant.

The proposed dredging will: remove the diverse benthic community in undredged areas; recontour and remove substrates from the consented, but yet to be, dredged area; remove biota and substrates that have reformed since previous dredging events; and lead to the alteration of current velocities. Most of those effects are already provided for under the current capital and maintenance dredging consent[3]. Additional effects of the proposed dredging footprint include deepening the existing dredged basin by around 2 m. If the

[2] Sponges and hermit crabs (if present) could not be identified from the footage.

[3] The only change is related to the slight difference between the currently consented and proposed dredging footprints.

characteristics of the seabed substrates at the proposed dredging depth are similar to those existing at the currently consented depth, a similar community of benthic macroinvertebrates is expected to reform once dredging is complete. However, macrofaunal diversity would likely be lower if areas of dense shell were permanently lost.

Modelling predicts that sediment plumes generated during dredging will also affect the surrounding habitat. Subtidal areas predominantly to the west of the port are predicted to be periodically subjected to elevated suspended sediment concentrations. Those effects would be compounded by the impacts of sediment deposition which smothers seabed communities and habitats (particularly shell gravel). The methods used for dredging are predicted to have major influence on sediment mobilisation, dispersal, and deposition. Effects are likely to vary from High at the OHEZ and harbour scales if a trailing suction hopper dredger (TSHD) is used, to Moderate at those scales for cutter suction dredger (CSD) and backhoe dredger (BHD) operations. Based on the high ecological values observed in and around previously dredged areas, and assuming that shell gravel habitat re-establishes, ecological recovery is expected to occur over a period of 5 or more years.

Effects on seagrass and macroalgae

Patches of intertidal seagrass within the proposed reclamation area will be permanently lost within the proposed reclamation footprint. The area covered by those patches is small (around 0.33 ha in 2021) compared to the current extent of seagrass beds within Whangārei Harbour (estimated to be around 6 km^2 in 2016). Therefore, effects on seagrass are expected to be low on harbour and OHEZ scales, equating to a less than minor effect.

Outer parts of Whangarei Harbour contain macroalgae meadows, with diverse, but low biomass species assemblages, that grow on subtidal shell and sediments. Surveys carried out over the past 30+ years, indicate that subtidal macroalgae meadows are a widespread and persistent feature in the harbour. Four "At Risk" species have been recorded in the outer harbour, with two of those species potentially present in areas affected by dredging. However, the potential level of adverse effects on those species is considered to be low, equating to a less than minor effect. Dredging effects on macroalgae communities are expected to include:

- The removal of existing macroalgae and disturbance or removal of substrates they attach to (shell gravel) within the dredging footprint. Those effects are largely provided for under the existing capital and maintenance dredging consent.
- If shell gravel is still present at the dredged depths, or reaccumulates after dredging ceases, then recolonisation by macroalgae is expected to occur in the dredged basin after 5+ years. However, decreases in light levels at the seabed may alter the composition of the macroalgae community within that area.
- Fewer macroalgae are likely to recolonise the dredged area if shell gravel is not present at the dredged depths or does not reaccumulate after dredging ceases. Macroalgae are still likely to attach to other hard substrates such as emergent shellfish (e.g., horse mussels) and other material that accumulates on the seabed.

Based on the presence of macroalgae in and around previously dredged areas, and assuming that gravel-shell lag habitat re-establishes, ecological recovery is expected to occur over a period of 5 or more years. Effects are likely to vary from High at the OHEZ and harbour scales if a trailing suction hopper dredger (TSHD) is used, to Moderate at those scales for cutter suction dredger (CSD) and backhoe dredger (BHD) operations. Risks will be reduced through monitoring and management processes proposed through conditions of consent.

Effects on reef habitat and biota

A reef community has developed on the existing port revetment. Reclamation will eliminate around 155 m of existing rock revetment and create around 483 m of rock revetment. All biota that cannot, or does not, move from the existing revetment structure will be smothered during reclamation. In the medium term (5–10 years), those effects will be offset by the colonisation of a new revetment by a similar reef assemblage. Given that: the existing revetment is an artificial construction; recovery will gradually occur; and more habitat will be created than lost; the effect of reclamation on reef habitat and biota is assessed as positive in the medium to long term at all scales.

Effects on fish

Whangārei Harbour has relatively diverse fish assemblages. Effects on fish are likely to be negligible because of the mobility of fish (relatively small scale of habitat permanently lost), and the likely recovery of habitats of importance to fish in other areas affected. Overall, the effect of losing fish habitat within the proposed reclamation footprint is expected to be low at all scales.

Effects on stormwater discharges

Analysis of available monitoring information and toxicity testing suggests that the current stormwater discharge poses little ecological risk. The existing stormwater system will be upgraded to accommodate runoff from the proposed reclamation areas. Importantly, no logs or other bulk freight will be stored on the proposed reclamation area. Consequently, discharge water quality is expected to be similar, or better, than that provided by the existing system (due to inputs of cleaner stormwater), but discharge loads may increase slightly. Assuming that past monitoring results are representative of existing discharge quality, and that a similar discharge quality will be maintained, the addition of the proposed reclamation area is not expected to cause any additional adverse ecological effects from stormwater discharges. However, it is recommended that monitoring requirements be reviewed to ensure they remain aligned with port operations, and that they provide a timely warning for management intervention if unanticipated changes in the discharge occur.

Cumulative effects

Consents have been obtained for around 104 ha of dredging and reclamation in and around the harbour entrance by Northport and Channel Infrastructure. If all of those consents are implemented, the cumulative ecological effects of those activities are likely to be high, but temporary, at the harbour and OHEZ scales, with recovery expected within 5–10 years.

The overall adverse effects are summarised in Table 1 and Table 2 below. Tables 1 and 2 represent conservative[4] assessments for the reasons outlined in this report.

For completeness:

[4] Reasons why the assessments are conservative are outlined in sections 6.3; 6.3.4.4.2; 6.5.1; and 7.

- The ecological effects of the proposal on threatened or at risk species (seagrass and macroalgae), or the Significant Ecological Areas (SEAs) identified in the Proposed Regional Plan will be in the range of negligible to less than minor (and in some cases temporary).
- Noting that, most of proposed dredging area is already subject to dredging – if best practice methods for managing dredging effects are applied, then the ecological effects on any other potential areas of significant indigenous vegetation and habitats of indigenous fauna under Appendix 5 of the Regional Policy Statement (RPS) could also be kept within minor and/or transitory levels.

Table 1. Summary of the Assessment of Ecological Effects of the proposed development at the scale of the: harbour; outer harbour and entrance zone (OHEZ); and development footprint (the most relevant system for each effect is unshaded).

Potential effects	System		
	Harbour	OHEZ	Footprint
Effects on intertidal sediment habitats and macrofauna	Moderate	Moderate	Very high
Effects on kai moana shellfish	Low	Low	High
Effects on subtidal habitat and benthic macrofauna - Reclamation	Moderate	Moderate	Very high
Effects on subtidal habitat and benthic macrofauna - Dredging	Moderate to High	Moderate to High	Moderate to High
Effects on seagrass	Low	Low	Very High
Effects on macroalgae	Moderate to High	Moderate to High	Moderate to High
Effects on fish	Low	Low	Low
Effects on reef habitat	Low and positive in medium to long term	Low and positive in medium to long term	Low and positive in medium to long term
Effects of stormwater discharges	Low	Low	Low

Table 2. Summary of total cumulative effects of the proposed development assessed against the most relevant system.

Potential effects	Most relevant system	Level of Effect
Effects on intertidal benthic habitats and macrofauna	Harbour	Moderate
Effects on kaimoana shellfish	Harbour	Low
Effects on subtidal habitat and benthic macrofauna- Reclamation	OHEZ	Moderate
Effects on subtidal habitat and benthic macrofauna- Dredging	OHEZ	Moderate to High
Effects on seagrass	Harbour	Low
Effects on macroalgae	OHEZ	Moderate to High
Effects on fish	Harbour	Low
Effects on reef habitat	Harbour	Positive in medium to long term
Effects of stormwater discharges	Beyond the mixing zone	Low

3 BACKGROUND

Northport is seeking consent for a proposed expansion east of their existing facilities at Marsden Point, Whangārei Harbour (Figure 1 to Figure 3). Northport already holds consent to develop Berth 4, encompassing the existing tug berth facility on the eastern side of the port, and to dredge around 60 ha of the seabed along the northern side of the port for a turning basin.

Northport Limited proposes to further expand its facilities through:

- Reclamation within the Coastal Marine Area (CMA) and earthworks to the immediate east of the existing reclamation to expand Northport's footprint by approximately 13.7 hectares. This comprises around 11.7 ha of reclamation within the CMA and 2 ha of earthworks outside the CMA.
- Capital and associated maintenance dredging to deepen the berth and manoeuvring area to depths of 14.5 m (16.1 m mean sea level (MSL)) and 16 m chart datum (CD) (17.6 m MSL) as shown in Figure 3. The extent of the proposed dredging area is similar to the currently consented dredging area, but small parts of the proposed batter slope extend beyond it, and dredging is no longer planned in small parts of the consented area (Figure 3).
- A 520 m long wharf (including the consented but not yet constructed 270 m long Berth 4) on the northern (seaward) face of the proposed reclamation.
- Sheet piling and rock revetment structures on the eastern edge of the proposed reclamation.
- Treatment of operational stormwater via the existing pond-based stormwater system.
- Port-related activities on the proposed expansion and wharves.
- Construction of a new tug jetty.
- Replacement of the existing floating pontoon, public access, and public facilities.
- The creation of a bird roost on the western side of Northport covering around 0.54 ha in the mid to upper intertidal zone (Figure 4) for the purpose of achieving positive ecological effects for avifauna (refer to Reinen-Hamill, 2022 for coastal processes assessment relating to the bird roost; and to the AEE report of Dr Leigh Bull, Boffa Miskell, for avifauna assessment relating to this feature).

The final design will be confirmed during the detailed design phase, as discussed in the AEE.

This assessment primarily relates to the deepening of the consented dredge area, slight changes to the currently consented dredging footprint, the creation of a bird roost on the western side of Northport, and additional reclamation covering around:

- 6.6 ha between mean high water spring and CD;
- 5.1 ha below CD;

Figure 1. Renderings of the proposed Northport development, showing: A. existing port facilities, and B. proposed port facilities (figures provided by Northport).

Stormwater from the additional hardstand created will be directed through Northport's existing stormwater conveyance and treatment system before discharge to the harbour. Importantly, no logs or other bulk freight will be stored on the proposed reclamation area.

Details of the existing stormwater system, including contaminant sources, treatment performance and discharge quality are provided in Poynter and Kane (2015). Briefly, stormwater is conveyed from the site via collection channels to a partitioned settlement pond of approximately 4 ha. Treatment of suspended solids occurs through trapping behind a weir at the terminal end of the collection channel system, and though settlement in two serially connected pond cells. Water is pumped from the final pond cell and discharged, along with stormwater from Marsden Maritime Holdings Ltd, to the harbour via an outfall diffuser beneath the port berths. Stormwater discharges from Northport are managed in accordance with an existing consent (CON20090505532), which includes a range of monitoring requirements and compliance standards. Among other things, water quality standards for the harbour currently include limits on changes to temperature, pH, dissolved oxygen, water clarity and hue, and concentrations of copper, lead and zinc, which are applied from the edge of a 300–350 m mixing zone. A greater range of parameters are also required to be monitored. The existing stormwater discharge consent is to be replaced by one covering stormwater from both the existing and proposed reclamation areas.

Figure 2: Proposed reclamation relative to chart datum and the elevation of mean high water spring tide.

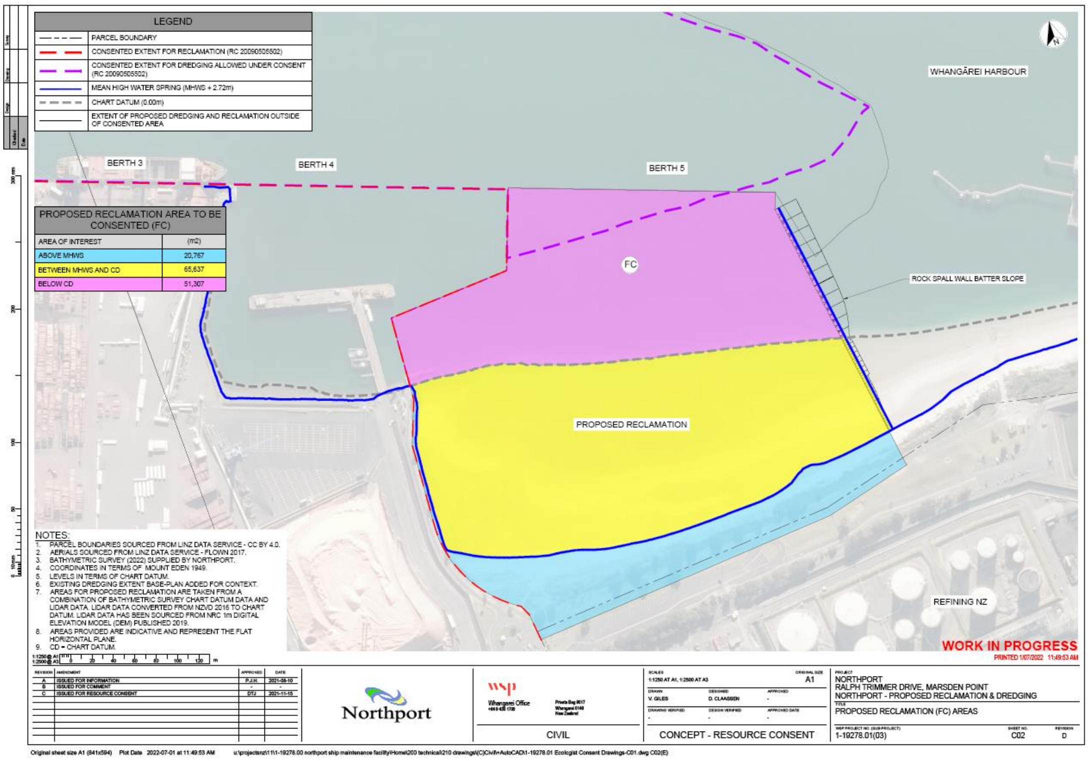
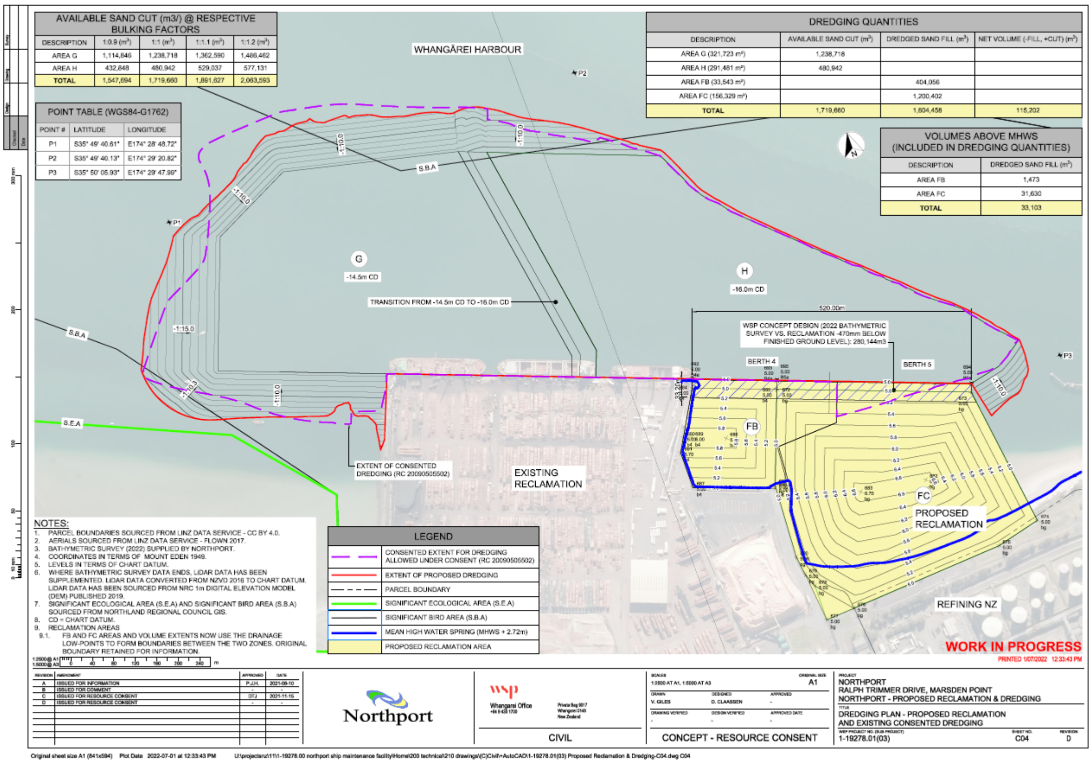


Figure 3. Drawings of the previously consented and proposed Northport reclamation and dredging areas relative to chart datum and the elevation of mean high water spring tide (figures provided by Northport).



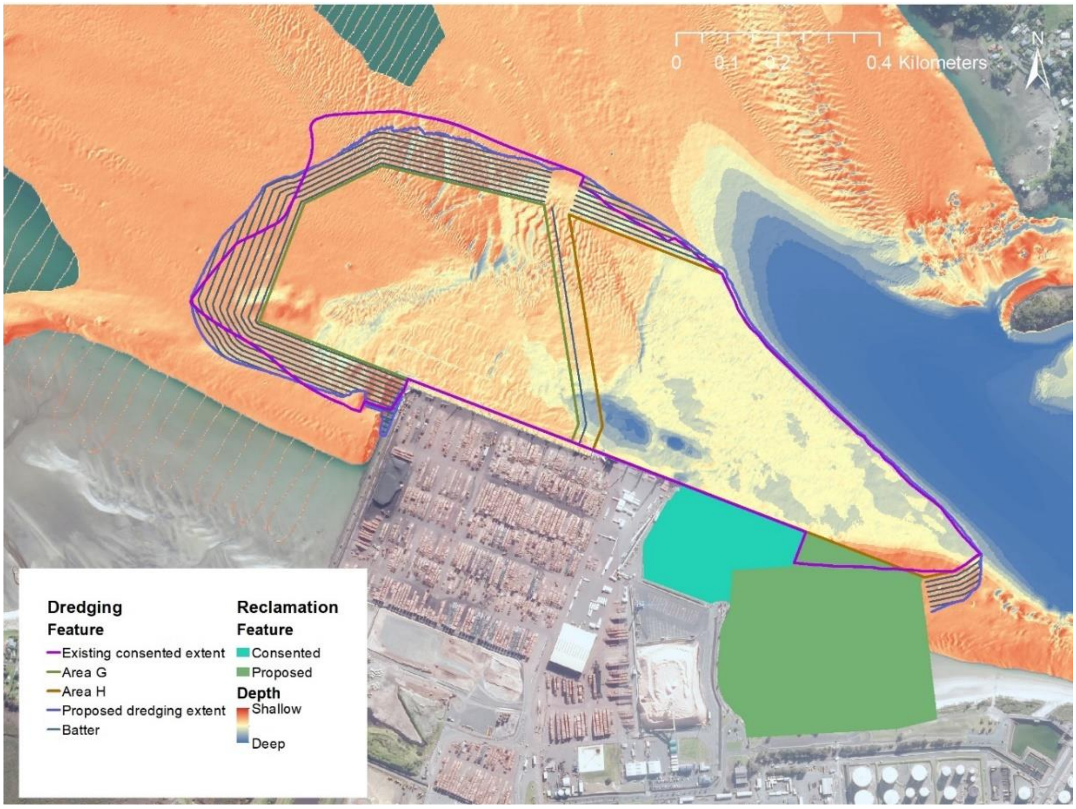
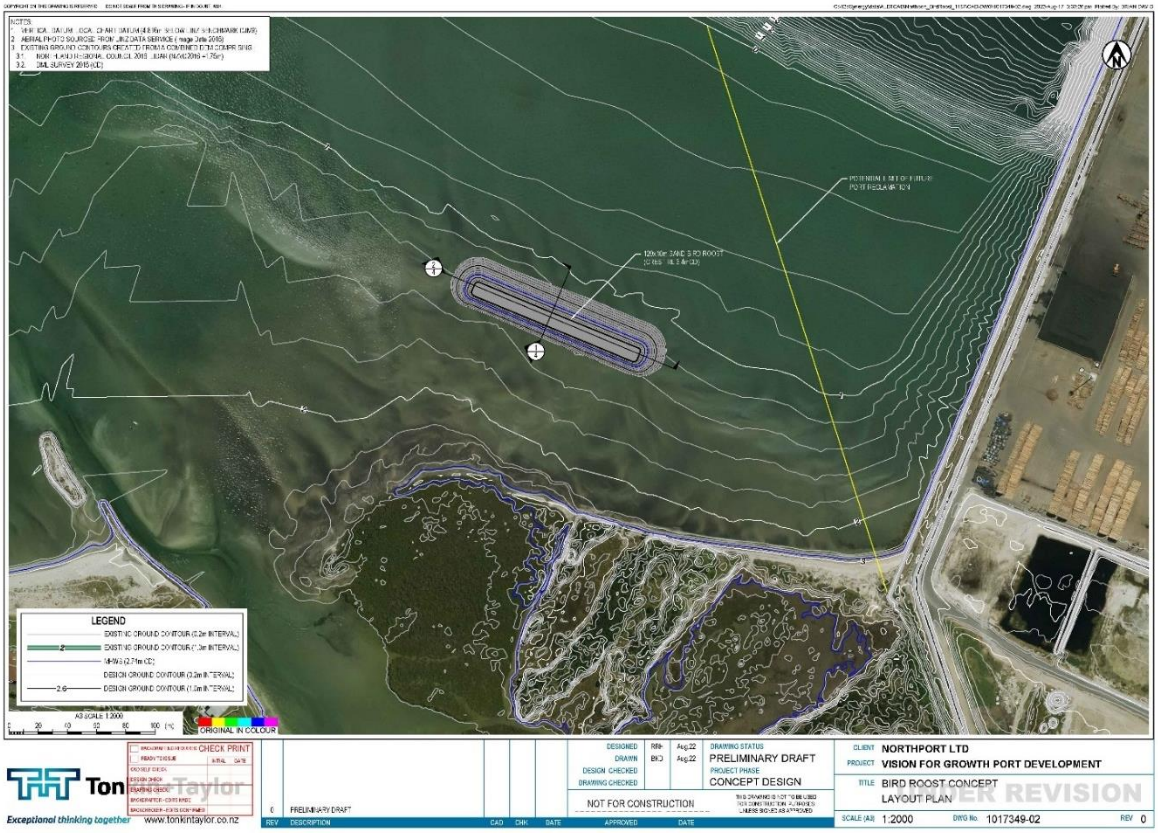


Figure 4: Location of the proposed bird roost, west of Northport.



3.1 DEVELOPMENT SETTING

The proposed reclamation activities will extend existing wharf facilities around 520 m eastward of its existing footprint. Surrounding CMA to the north and west of the proposed dredging and reclamation areas have already been highly modified by similar development, including Northport's consented channel and berth dredging of around 64 ha (excluding batter slopes), and around 33 ha of reclaimed land used to create the existing hardstand and wharf facilities.

Other development in the immediate area includes: facilities associated with Marsden Point Oil Refinery (now an import/distribution terminal only), approximately 50 m east of the port; Marsden Cove Marina approximately 850 m west of the port; and, Marsden Bay township around One Tree Point.

3.2 SCOPE AND PURPOSE OF THIS REPORT

This report assesses the potential marine ecological effects of the proposed Northport development on the existing environment (excluding biosecurity issues, and effects on birds and marine mammals) by:

- consolidating and reviewing available technical information on the values and condition of the proposed development site and the broader ecological system, so that the scale of effect can be characterised in relation to the size and sensitivity of the relevant area of indigenous biodiversity;

- identifying potential ecological effects of the proposed development on the existing environment;
- assessing the ecological significance of effects at local and harbour-wide scales;
- considering and assessing the potential for adverse effects of the proposed development to compound the adverse effects of other activities on the harbour system, and the ecological significance of those cumulative impacts.

In relation to the scope and context of the assessment, we have been advised that:

- Policy D.2.18(5) of the Proposed Regional Plan for Northland provides for potential adverse effects to be assessed using a system-wide approach (e.g., the whole estuary), which recognises that the scale of the effect of an activity is proportional to the size and sensitivity of the area of indigenous biodiversity.
- In addition to the individual effects of the proposed development, the assessment needs to consider the cumulative effects of other future activities, including those of relevant permitted activities and unimplemented resource consents on the existing environment.
- Under the current legal framework, the effects of a proposed activity should be assessed against the environment that exists at the time the application is made. In this case the existing environment includes, among other things, the natural features of the harbour system, and past changes and modifications including existing port development and operations, the Marsden Cove residential/marina development, and more distant developments such as Portland Cement, Port Nikau, and Whangārei Town Basin.
- The existing environment also includes activities that have gained consent and are likely to be implemented in the future, such as:
    - Northport's Berth 4 expansion;
    - dredging to deepen and realign the commercial shipping channel by Channel Infrastructure;
    - the Ruakaka (Bream Bay) wastewater discharge held by Whangārei District Council;
    - Port Nikau marina extension (upper harbour); and,
    - Whangārei Marina Management Trust's new marina (upper harbour).

4 GENERAL DESCRIPTION OF THE HARBOUR

4.1 PHYSICAL CHARACTERISTICS

Whangārei Harbour is one of 11 Northland estuaries that are larger than 1,000 ha, and is the largest of the eight, east coast estuaries within that group (by surface area, total volume and tidal prism at spring high tide - see Hume *et al.*, 2016). The harbour is formed from a shallow drowned valley approximately 24 km in length, and has a surface area of around 10,400 ha, of which, 58% is intertidal. It has a mean depth of 4 m and a maximum depth of 31 m near Marsden Point (Morrison, 2003; Hume *et al.*, 2016).

Figure 5. Key features of Whangārei Harbour (Topomap data from LINZ).

The geology of the northern shore differs substantially from the southern shore. This is reflected in the morphology of the harbour, with the northern shore surrounded by steep, volcanic and greywacke landforms, with a series of open and semi-enclosed bays. In contrast, the southern shore contains shallow tidal creeks and rivers extending into coastal flats underlain by undifferentiated mélange, mud and sand deposits (Edbrooke & Brook, 2009).

The morphology of the outer harbour and entrance are particularly complex. The flood tide deltas (i.e., Calliope and Mair Banks) sit to the north and south of the entrance channel, respectively, with Calliope being partially, and Mair largely, exposed at low tide. Inside the harbour entrance, the channel is split by Snake Bank to the south and MacDonald Bank to the north, with the main channel running south of Snake Bank and a secondary channel leading to Pārua Bay running between the two deltas. Pārua Bay, on the northern shore of the harbour, is a sheltered, depositional inlet that opens to the outer harbour through a relatively narrow entrance. A shallow shell bank historically traversed the main channel between One Tree and Manganese Points, effectively delineating the outer and mid harbour. However, in 1969 a cut through the shell bank was made during channel dredging (Morrison, 2003).

The mid-harbour section is a rectangular shaped water body, around 8.5 km long and 4 to 5 km wide, with large intertidal and shallow subtidal flats, and a relatively large blind channel running between the main channel and the northern shore. The main channel in the mid-harbour has three defined reaches (Shell Cut, Tamaterau, and Wellington), with depths varying from around 6–16 m. Deeper sections are associated with a series of “holes” in the Wellington Reach. The main channel splits around Limestone Island, with the northern upper harbour branch diverging to head north up Hātea River, past Otaika and Limeburners Creeks, Whangārei Port and Whangārei township. The Southern upper harbour branch becomes Mangapai River, passing Portland and Tokitoki Creek, before branching and terminating as a series of small tidal creeks.

4.1.1 SEDIMENTS

Harbour-wide surveys (Griffiths, 2012; Lundquist & Broekhuizen, 2012) indicate that intertidal sediments in the mid and outer harbour are predominantly sandy, with sediments becoming muddier in the upper harbour and Pārua Bay (Figure 6). Intertidal sediment samples obtained from around Northport show that they predominantly consist of sand, except for samples collected immediately west of the port, which consisted of muddy sand (Figure 8; Spyksma & Brown, 2018). Less information is available for subtidal sediments in the mid to upper harbour, but the entrance has been well studied. Black *et al.* (1989) produced a simplified map of seabed substrates[5] prior to Northport being developed. It showed large subtidal areas of clean and algae encrusted, gravel-shell lag, interspersed with areas containing sand waves, sand ripples and shelly sand (Figure 7). More recent (post-development) sampling indicates that sediments in the outer channel between Northport and Home Point tend to be coarse, with averages of around 20% gravel and 80% sand, with a higher proportion (50%) of gravel around Home Point (West, 2016). Subtidal sediments around Northport also consist of sand or gravelly sand (Figure 8; Ahern, 2020).

Apart from moderately elevated concentrations of the key urban stormwater contaminants (copper, lead and zinc) in the upper harbour sediments near Whangārei, sediment concentrations of heavy metals in the harbour are generally low and below conservative Threshold Effects Level guideline values (TEL; MacDonald *et al.* (1996)), and the less protective Australia and New Zealand default guideline values (DGV; ANZG, 2018) (Griffiths, 2012; Spyksma & Brown, 2018). The exceptions to this were: elevated chromium concentrations at one site (Waikaraka on the northern, mid-harbour shore) that exceeded the TEL guideline; and nickel at three sites, of which, one slightly exceeded the TEL guideline (Waiharohia Canal in the upper harbour[6]) and two exceeded the DGV (the NRC Waikaraka site, and a site sampled by Spyksma and Brown (2018) next to Northport).

Griffiths (2012) highlighted that there are no known point source discharges of nickel or chromium to the harbour, and suggested that elevated concentrations of these metals at some sites may be due to high levels in surrounding catchment soils.

Similarly, highest sediment concentrations of organic carbon, nitrogen and phosphorus have generally been recorded in upper harbour at sites in the Hātea River and to a lesser extent Mangapai River, with the occasional site having elevated concentrations in the mid and outer

[5] By integrating information from photographic and underwater video surveys, side scan imagery, diver observations and sediment analysis.

[6] Chromium concentrations were below the TEL guideline in subsequent NRC monitoring of the Waiharohia Canal site in 2014 and 2016, but the Waikaraka site has not been resampled (Bramford, 2016).

harbour (Griffiths, 2012). Relatively low sediment concentrations of these three indicators have been recorded around Northport (Spyksma & Brown, 2018).

Figure 6. Intertidal sediment types in Whangārei Harbour, adapted from data provided in Griffiths (2012) and Lundquist and Broekhuizen (2012). Note that sand fraction in the former assessment also included gravel.

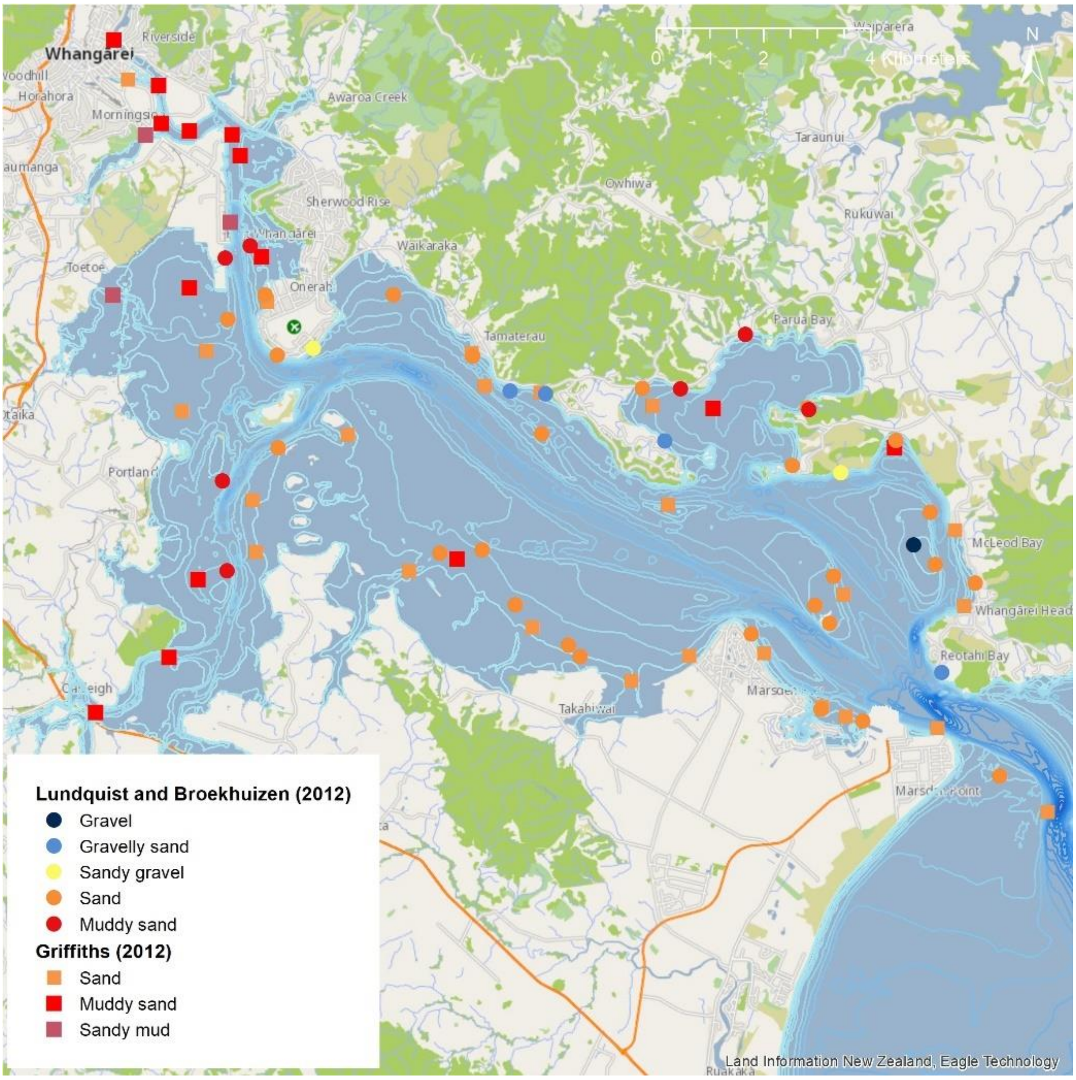


Figure 7. Simplified map of bottom substrates based on the integration of photographic and underwater video surveys, side scan imagery, diver observations and sediment analysis (from Black *et al.* (1989)).

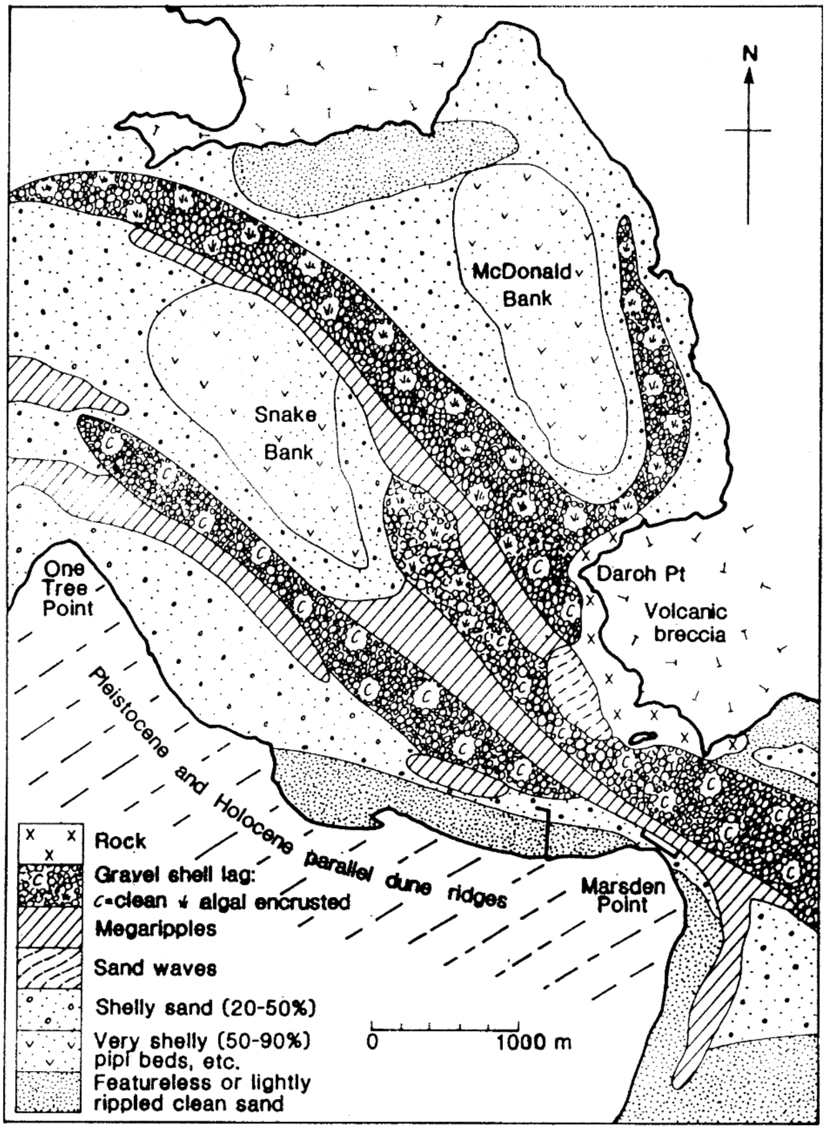


Figure 8. Sediment characteristics in intertidal and subtidal sites in Marsden Bay sampled by 4Sight (see Spyksma and Brown (2018) and Ahern (2020), respectively).

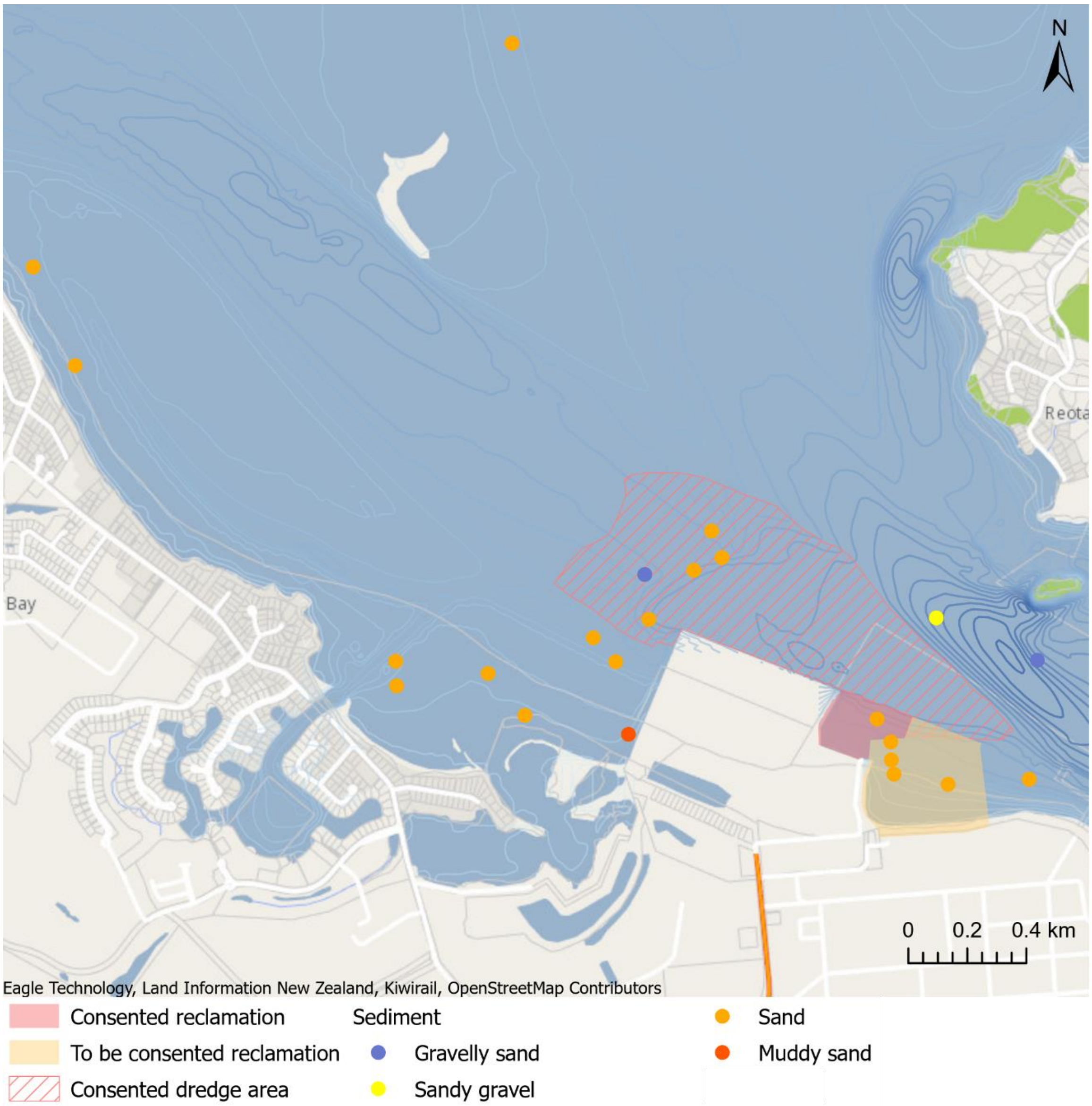
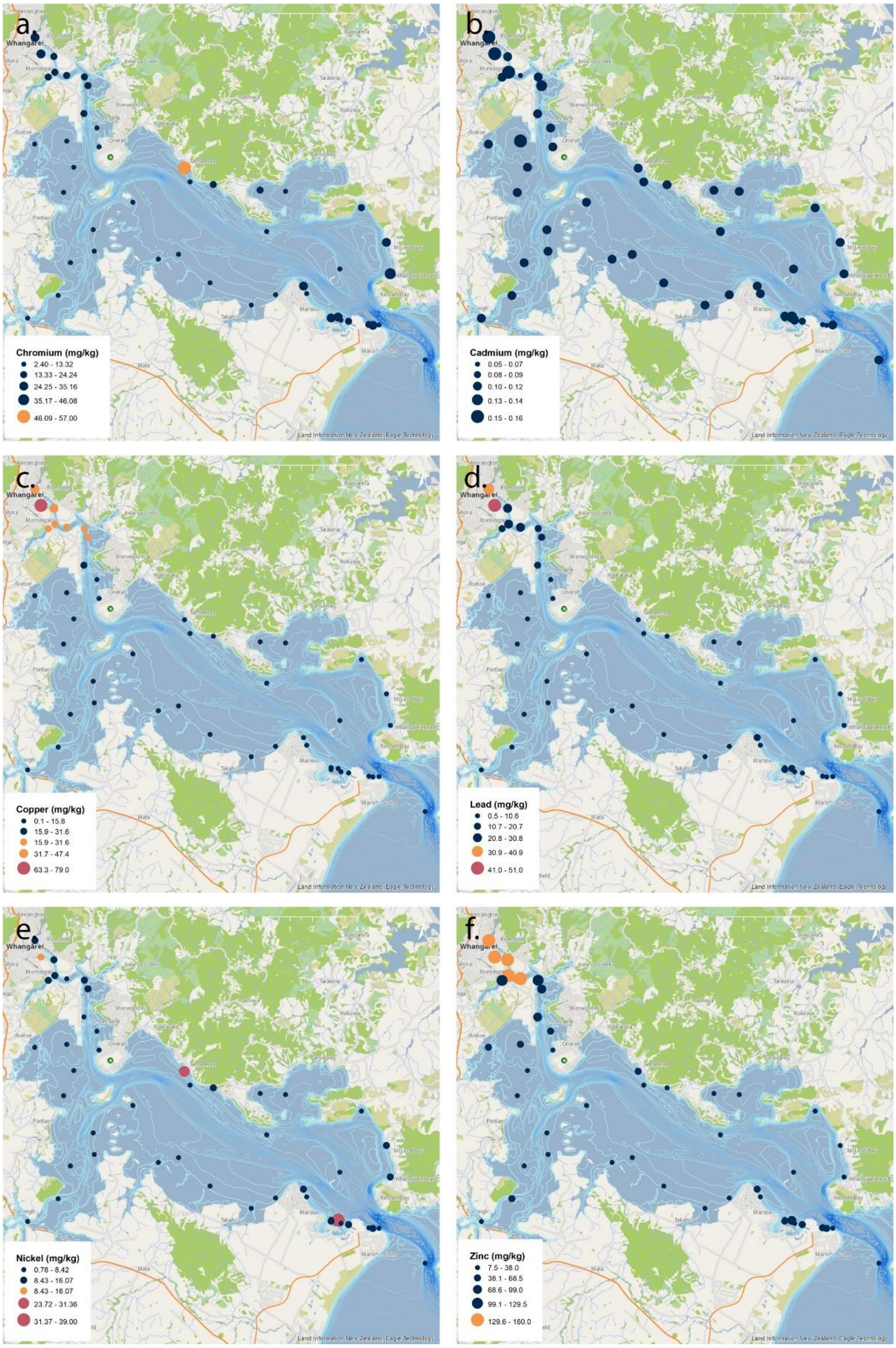


Figure 9. Bubble plots showing sediment concentrations of a) chromium, b), cadmium c) copper, d) lead, e) nickel, and f) zinc in Whangārei Harbour (data consolidated from Griffiths (2012) and Spyksma and Brown (2018)). Bubble colours indicate exceedances of the conservative threshold effects level guideline (TEL, MacDonald *et al.*, 1996) and the less protective Australia and New Zealand default guideline values (DGV; ANZG, 2018), with dark blue <TEL, orange = TEL to DGV, and red > DVG.



4.1.2 WATER QUALITY

Harbour water quality is affected by diffuse urban and agricultural runoff, and point source discharges that, actually or potentially, include wastewater, stormwater, landfill leachate, antifoulants and other contaminants. Water quality is also influenced by natural, physical characteristics. River inputs have a strong influence on water quality in the upper harbour, whereas outer harbour sites are more influenced by tidal exchange with coastal waters.

Water quality has been monitored by Northland Regional Council, at 17 sites in the Whangārei Harbour (Figure 10), but only nine sites are currently monitored. Previously reported results indicated that water quality improves down the harbour, with sites near the harbour entrance having the best quality. Sites in the upper harbour (upstream of Port Whangārei) generally had high concentrations of faecal coliforms, dissolved reactive phosphorus, total phosphorus, nitrate-nitrite nitrogen, ammonium, and high turbidity. In comparison, sites near the harbour entrance had very good water quality, with significantly lower values for all of the above parameters (Tweddle *et al.*, 2011; Griffiths, 2015). Data obtained over the past decade is consistent with those previously reported patterns (Table 3, based on raw data downloaded from NRC, 2021).

For water management purposes, the Proposed Regional Plan (PRP) for Northland includes water quality standards for four coastal water quality management units: 1) Hātea River; 2) tidal creeks; 3) estuaries; and, 4) open coastal water. The sea around Northport falls within the estuary management unit (Figure 10), with the standards for that unit provided in Table 4. Four estuary sites have been monitored at two monthly intervals over the past decade (July 2011 to June 2021): Kaiwaka Point, Tamaterau, One Tree Point and Mair Bank. Except for microbial contaminants, annual values of reported parameters have consistently been below (better than) the proposed standards for the latter three sites. However, the proposed standards for ammoniacal-N, nitrate-nitrite-N, and total phosphorus have not been met in multiple years at the Kaiwaka Point site. Microbial contaminant standards are occasional exceeded at all sites (Table 5; data from NRC, 2021).

Figure 10: Water quality management units in the Proposed Regional Plan for Northland, and NRC State of the Environment water quality monitoring sites.

Table 3: Median values (with number of samples in brackets) obtained from NRC water quality monitoring between July 2011 and June 2021 (raw data downloaded from NRC, 2021).

Site	TSS (g/m³)	Turbidity (FNU)	Dissolved oxygen (mg/L)	Chlorophyll *a* (g/m³)	Ammoniacal-N (g/m³)	NNN (g/m³)	Total P (g/m³)
Town Basin	8.2 (65)	5 (42)	7.5 (84)	0.0024 (76)	0.0655 (84)	0.45 (84)	0.073 (84)
Limeburners Creek	15 (65)	7.015 (42)	6.8 (84)	0.0022 (75)	0.09 (84)	0.455 (84)	0.115 (84)
Kissing Point	12 (65)	5.1 (42)	6.9 (83)	0.0022 (76)	0.0545 (84)	0.22 (84)	0.058 (84)
Kaiwaka Point	11 (65)	4.9 (42)	7.4 (83)	0.0021 (76)	0.023 (84)	0.038 (84)	0.0295 (84)
Otaika Stream at Old Bridge	16 (59)	7.45 (41)	7.6 (68)	0.0021 (70)	0.042 (70)	0.34 (70)	0.031 (70)
Mangapai River	18 (64)	8.62 (41)	6.7 (83)	0.0021 (75)	0.018 (84)	0.0091 (84)	0.028 (84)
Tamaterau	7.1 (64)	2.98 (42)	7.55 (84)	0.0014 (75)	0.011 (84)	0.0093 (84)	0.016 (84)
One Tree Point	5.25 (64)	1.155 (42)	7.7 (83)	0.0015 (75)	0.006 (83)	0.0058 (83)	0.012 (83)
Mair Bank	5.4 (64)	1.06 (42)	7.8 (82)	0.0013 (75)	0.005 (83)	0.0056 (83)	0.011 (83)

Table 4: Water standards for the estuaries coastal water quality management unit in the Proposed Regional Plan for Northland.

Attribute	Units	Compliance Metric	Estuaries
Dissolved oxygen	mg/L	Annual median and minimum	median >6.9, min. of 4.6
Temperature	°C	Maximum change	3
pH	pH units	Annual minimum and maximum	7.0–8.5
Turbidity	NTU	Annual median	<6.9
Secchi depth	m	Annual median	>1.0
Chlorophyll *a*	mg/L	Annual median	<0.004
Total phosphorus	mg/L	Annual median	<0.030
Total nitrogen	mg/L	Annual median	<0.220
Nitrate-nitrite N	mg/L	Annual median	<0.048
Ammoniacal-N	mg/L	Annual median	<0.023
Copper	mg/L	Maximum	0.0013
Lead	mg/L	Maximum	0.0044
Zinc	mg/L	Maximum	0.015
Faecal coliforms	MPN/100 ml	Median and annual 90th percentile	Median ≤14, 90th ≤43
Enterococci	Enterococci /100 ml	Annual 90th percentile	≤200

Table 5: Annual compliance with proposed Northland water quality standards at NRC monitoring sites within the estuaries water quality management unit in Whangārei Harbour. With the exception of chlorophyll *a*, results are based on two monthly sampling data obtained between July 2011 and June 2021. Chlorophyll *a* is based on data from July 2012 to June 2020 (raw data from NRC, 2021).

	Annual compliance with water quality standards (%)			
Parameter	Kaiwaka Point	Mair Bank	One Tree Point	Tamaterau
Enteroccoci	80	100	100	90
Faecal coliforms	70	90	90	100
Dissolve oxygen (concentration)	100	100	100	100
Chlorophyll *a*	100	100	100	100
Ammonia N	30	100	100	100
Nitrate-nitrite-N	60	100	100	100
Total phosphorus	50	100	100	100

4.2 LANDUSE AND COASTAL ACTIVITIES

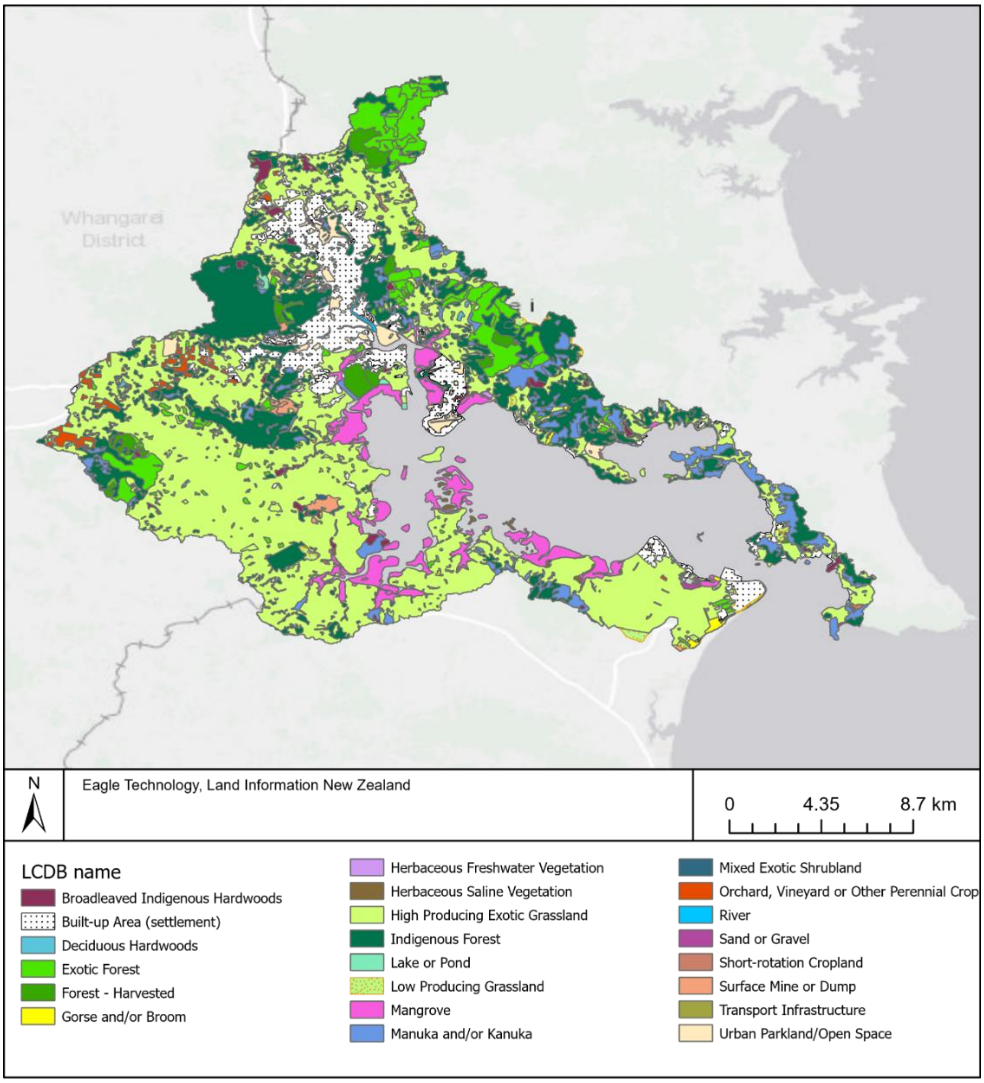
Whangārei Harbour has been, and continues to be, subject to significant coastal development and anthropogenic stressors. Overall, the harbour catchment has an area of around 297 km^2, with the main landuses including pasture (high producing exotic grassland, 45%), indigenous forest (19%), urban areas (10%), and exotic forests (7%) (Figure 11). Sedimentation from land run-off is a major historical and on-going issue, with an average harbour-wide sedimentation rate of 3.4 mm/year over the last 50–100 years (Swales *et al.*, 2013).

Historically, between the 1920s to late 1970s, around 3 million m^3 of sediment fines (of which 90% were under 10 microns in diameter) from the Portland Cement Works were disposed of in the harbour (Millar, 1980). An additional 2 million m^3 of channel dredging material was deposited at various harbour locations in the 1960s (Dickie, 1984). That included around:

- 754,000 m^3 of dredged sediment being pumped on to Snake Bank and the Takahiwai shoreline, reportedly rising Snake Bank from a low mudbank to a permanent high tide shellbank;
- 144,500 m^3 of sediment being dumped at the entrance to Pārua Bay;
- the creation of a chain of six islands off the end of Port Whangārei, which have subsequently been washed away and submerged.

Changes in sediment accumulation rates and sediment sources have been determined from the analysis of dated cores. The upper harbour has now been substantially infilled with eroded catchment soils, leading to mud being transported further downstream and accumulating in the northern bays and inlets. Cores show that sediment in Pārua Bay rapidly accreted on intertidal flats between the mid-1920s to the early 1950s (averaging 12 mm per year). Accretion has since reduced to 2.9 mm per year, most likely due to tidal inundation and associated supply of sediment being restricted as the seabed infilled (Swales *et al.*, 2015). The cores appear to show that habitats in the lower harbour started to be impacted by mud from the upper harbour around the mid-1950s. In Munro Bay, mud has been accumulating at around 3 mm per year since that time and a 15 cm thick mud layer now covers the original shell-rich sand (Swales *et al.*, 2013).

Figure 11. Landuses in the Whangārei Harbour catchment. Data from New Zealand Land Cover Database (LCDB) 4.1 (Landcare Research, Creative Commons 3.0 NZ).



As indicated above, the main channel of the harbour has been extensively dredged over many decades. Throughout much of the 20th century, dredging was carried out to maintain navigable depths through to Onemama Point, Portland and Port Whangārei (Morrison, 2003). The channel from Thumb Point to Whangārei was dredged in 1969, and included a cut through the shell bank between Thumb and Manganese Points (Morrison, 2003). More recently dredging has been carried out, or is contemplated, to provide and maintain access to Channel Infrastructure, Northport and Marsden Cove Marina. This includes:

- dredging of 1.7 million m^3 in 2002 to create Northport's Berths 1 and 2[7];
- dredging of 350,000 m^3 to create Northport's Berth 3[7];
- Northport capital and maintenance dredging consents for the turning basin around the port (see Figure 1);
- Channel Infrastructure capital dredging consents of approximately 3 million m^3, plus ongoing maintenance dredging, to deepen and realign the entrance to the harbour (NRC, 2018a).

Other significant coastal activities (Figure 12) include the development and operation of:

- Marsden Point Oil refinery wharf (now an import and distribution terminal);
- Northport;
- Port Whangārei;
- Marsden Cove Marina, Whangārei Marina, Riverside Drive Marina, and Whangārei Cruising Club, plus two recently consented new marinas. The consented marina off Port Road will involve reclamation of more than 4,500 m^2 (NRC, 2019a).
- Pārua Bay boat ramps and mooring area;
- Golden Cement Works Wharf;
- an oyster farm in Pārua Bay;
- the construction of a railway line across the tidal flats near Ōtaika Creek;
- various slipways, boat ramps and coastal structures such as seawalls.

The harbour is also a popular recreational destination and is used for recreational boating, fishing, and shellfish harvesting (including recreational scallop dredging in the past; see Sections on Fish and Kaimoana shellfish for more information).

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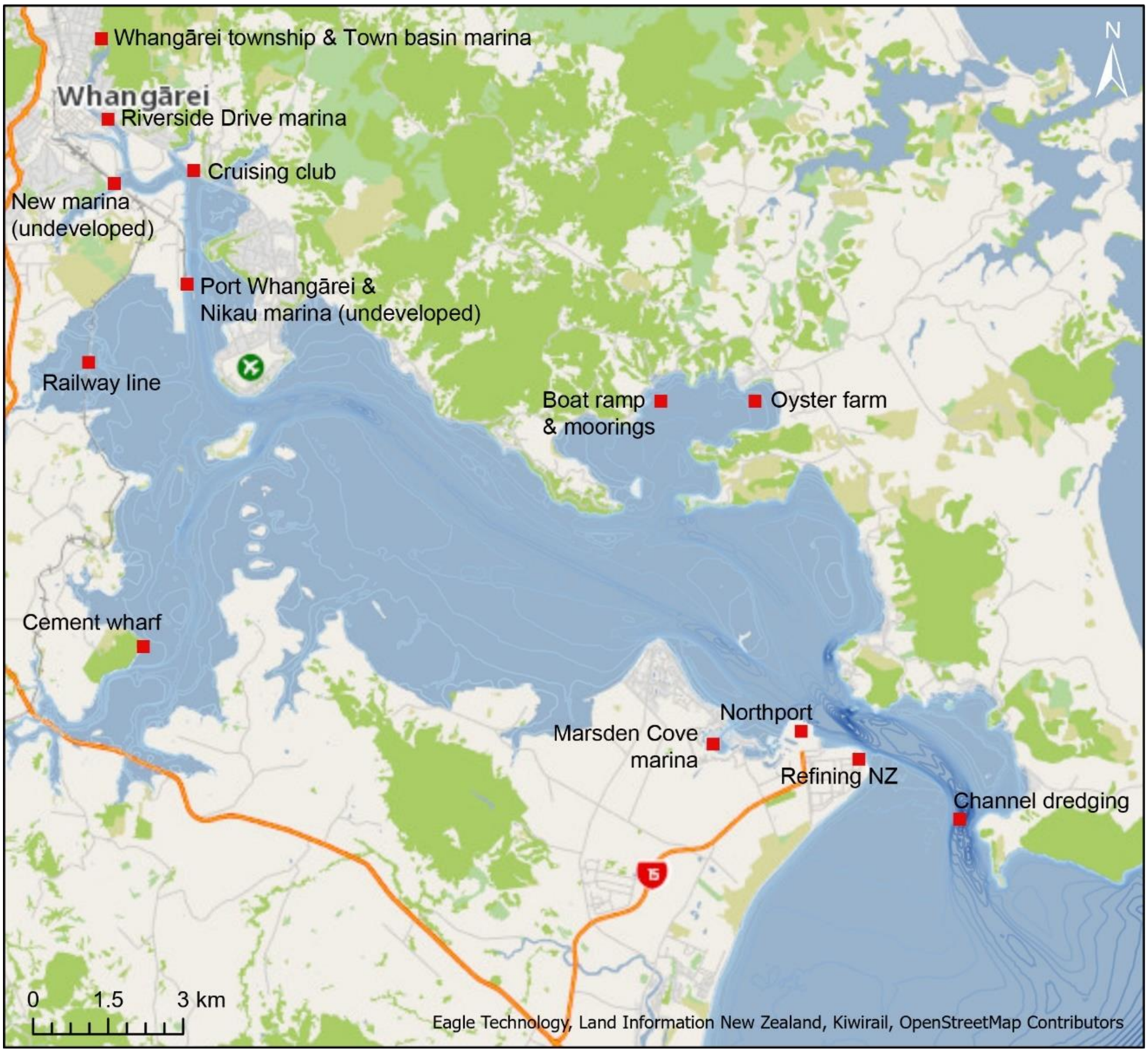
7 https://www.heronconstruction.co.nz/Case+Studies/Northport+Wharf+Development+Berths+1+2+and+3.html

Figure 12. Existing and consented significant coastal developments and activities in Whangārei Harbour.



4.3 SIGNIFICANT ECOLOGICAL AREAS

Reviews of the ecological habitats and communities of Whangārei Harbour show that the harbour supports diverse and ecologically important marine communities. Approximately 35% of the harbour is delineated as a Significant Ecological Area (SEA) (Figure 13) in the Proposed Regional Plan for Northland. The ecological values of the SEAs are briefly summarised below (from NRC, no date).[8]

Northeastern Bays (Area A)—covers the northern bays across the channel from Northport and encompasses the MacDonald and Calliope Banks. The rocky coastal areas have a diverse rocky reef community, including some exceptional sponge communities off Motukaroro Island, which is part of the Whangārei Harbour Marine Reserve. The soft sediment area contains beds of scallops (*Pecten novaezelandiae*), horse mussels (*Atrina zelandica*) and cockles (*Austrovenus stutchburyi*). Seagrass beds (*Zostera muelleri*) are present on the two banks.

[8] Significant Ecological Marine Area Assessment Sheet, Name: Whangārei Harbour Marine Values.

Mair Bank (Area B)—covers Mair and Marsden Banks at the southern entrance to the harbour. The banks provide regionally and nationally significant shellfish habitat, and until recently, supported the largest commercial harvest of pipi (*Paphies australis*) in the country (see section on pipis for more detail).

One Tree Point to Marsden Bay (Area C)—is directly adjacent to the existing western boundary of Northport. Scallops are present in the subtidal areas and seagrass beds are returning to the area, which are known to provide an important nursery area for many coastal fish species. The intertidal areas contain extensive shellfish beds that provide important feeding habitat for shorebirds.

Snake Bank (Area D)—is an important shellfish habitat and feeding area for shorebirds. The bank supported commercial harvest of cockles until 2012 (see section on cockles for more detail).

Takihiwai to Hewlett Point (Area E)—covers an extensive area upstream of One Tree Point. The large intertidal flats contain the largest area of seagrass in the harbour, as well as cockle beds, mangroves and saltmarsh habitats. Horse mussel beds are present in the subtidal areas. Overall, these habitats support a diverse benthic and fish community.

Pārua Bay West (Area F)—covers the western bay of Pārua Bay. The area contains a diverse and healthy shellfish community and patches of seagrass, providing an important habitat for shorebirds and fishes.

Tamaterau to Maganese Point (Area G)—contains a mixture of fringing rocky reef and soft sediment habitats that support a diverse shellfish, invertebrate and fish community.

Waikaraka Mangrove area (Area H)—contains a representative mangrove forest habitat. This SEA also encompasses the Waikaraka part of the Whangārei Harbour Marine Reserve.

Matakohe Island (Area I)—surrounds Matakohe Island and contains a variety of substrates and habitats including sand, mud, coarse gravel, saltmarsh and mangroves. Small shellfish beds exist in the intertidal areas and the area provides an important habitat for shorebirds and fishes.

Portland tidal flats and Onerahi flats (Areas J & K)—are muddy/sandy tidal flats that support significant shellfish beds. The shellfish beds are important feeding areas for shorebirds and fishes.

Figure 13. Proposed Northland Regional Plan Significant Ecological Areas and locations of the Whangārei Harbour Marine Reserve (Waikaraka and Motukaroro) in Whangārei Harbour.

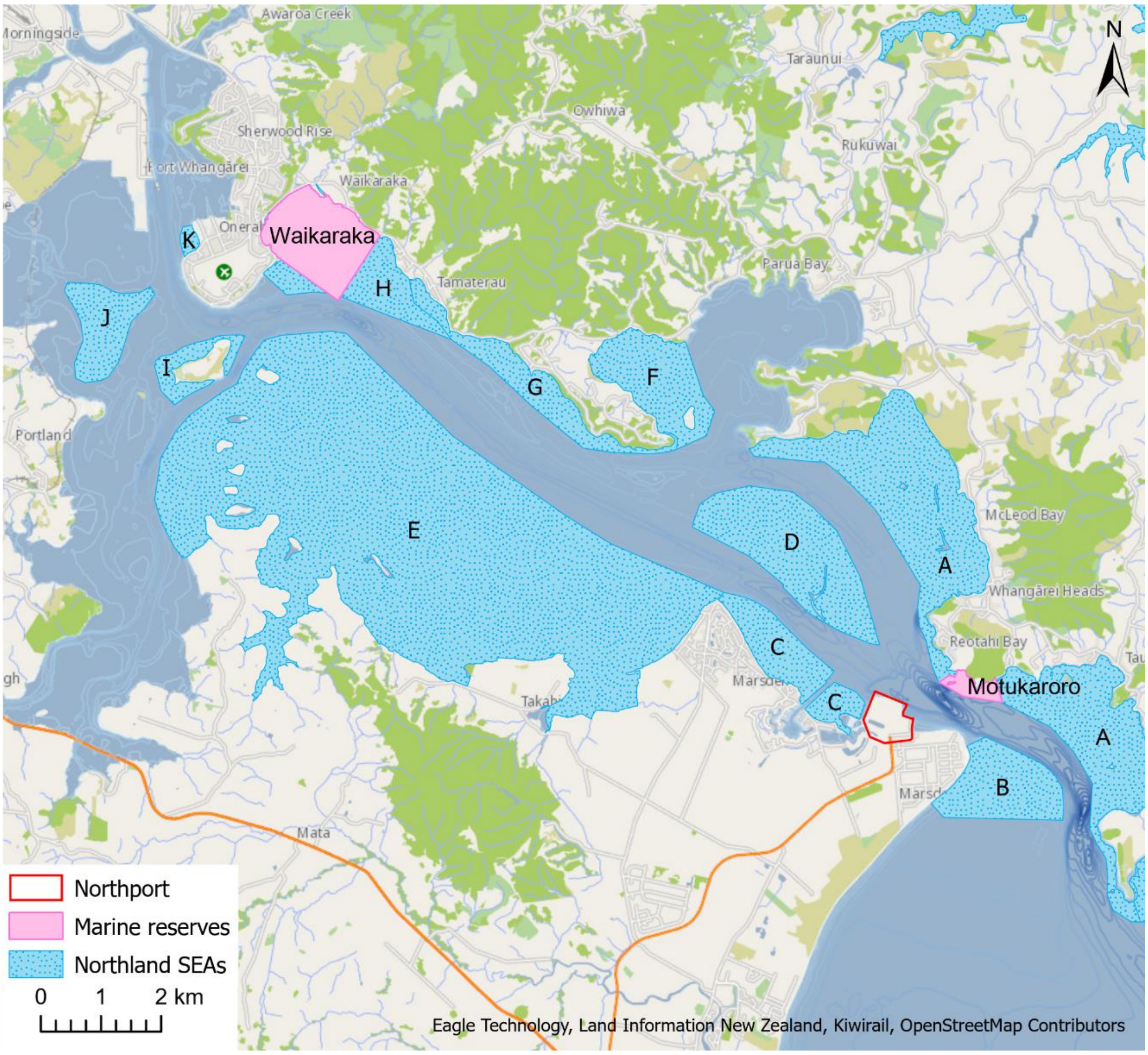


Figure 14. Examples of substrates and biota observed in the Marsden Bay–One Tree Point SEA: A–B. Sandy substrates. C. Abundant cockle shells on the surface. D. Dense seagrass and red algae. E. Dense seagrass and abundant bubble shells (*Bulla quoyii*, see arrows). F. A large flock of royal spoonbills (*Platalea regia*).

5 MARINE ECOLOGICAL VALUES

Ecological values were assessed through:

- a desktop review and analysis of available information and data,
- additional data gathering and analysis, including:
    - a rapid intertidal survey of Marsden Bay;
    - a comprehensive, quantitative survey of benthic macrofauna in Marsden Bay; and,
    - a video survey of subtidal habitats around Northport.

5.1 DESKTOP REVIEW

5.1.1 COASTAL VEGETATION

Specific and general habitat and ecological values of Whangārei Harbour have been assessed in multiple scientific studies since the 1970s. The most conspicuous marine plant in the harbour are the dense stands of mangroves that line a large proportion of the southern and upper harbour shores, but are more restricted on the northern shore and east of Takahiwai Stream (whose mouth is around 2 km west of One Tree Point). Mangroves provide a habitat for a variety of native animals, including several species of fish, birds and insects, but few species are dependent on them. The only species that are dependent on mangroves are: banded rail (*Gallirallus philippensis*) (Bell & Blayney, 2017), which has an 'At Risk: Declining' conservation status; and two endemic insects (a moth and a mite), whose larvae are only found on mangroves. Mangroves are also thought to provide a habitat for juvenile parore, short-finned eels, and grey mullet (Morrisey *et al.*, 2007).

Mangrove extent in the harbour has increased from around 1,008 ha[9] in 1942 to 1,587 ha in 2004 (Smith McNaught Whangarei Ltd, 1976; Kerr, 2010; Griffiths, 2012; DOC, 2014). The expansion of mangrove forests is largely due to sedimentation, which has led to similar changes in many other northern harbours (Hauraki Gulf Forum, 2020). The potential for future expansion is likely to be modulated by the balance between future sea level rise and wave climate (which will limit seaward expansion) and sediment accumulation (which will promote seaward expansion) (see Swales *et al.*, 2008). However, changes in coastal processes at specific sites may lead to localised changes.

The proliferation of mangroves has coincided with a significant reduction in the extent of saltmarsh vegetation, with only very small pockets of natural saltmarsh now remaining. The original extent of saltmarsh vegetation is uncertain, but it was estimated to decrease from: around 556 ha in 1942; to 189 ha in 1985; to 56 ha in 2004; and down to 23 ha in 2015 (Parrish, 1984; Kerr, 2010; Griffiths, 2012; DOC, 2014; NRC, 2019b). Much of the original saltmarsh in the harbour was reportedly destroyed by drainage and reclamation (Mason & Ritchie, 1979). No mangroves are present east of Northport.

Seagrass (*Zostera muelleri*) was also historically abundant in Whangārei Harbour. Aerial photographs from 1942–1968 shows that seagrass covered around 10–14 km^2 of the

[9] Note that the accuracy of this estimate was questioned by May (1984).

harbour (Figure 15) but by 1970 it had virtually disappeared (Reed *et al.*, 2004). Suggested factors involved in the loss of seagrass include increased turbidity and smothering from sediment disposal in the harbour and sediment run-off, and pollution from sewage, industrial spills and urban run-off (Reed *et al.*, 2004). However, the actual causes are uncertain, and significant recovery has occurred over the last two decades. In 1999, small pockets of seagrass were recorded at a few sites (Reed *et al.*, 2004); by 2010 there was around 0.38 km^2 of seagrass in the harbour (DOC, 2014); and by 2016 there was around 6 km^2 of seagrass in the harbour (Figure 16; Matheson *et al.*, 2017; Tan *et al.*, 2020).

Seagrass is abundant on the intertidal flats between One Tree Point and Northport (Lohrer, 2021; Poynter, 2021; Figure 17–Figure 19), including patches within, and near, the proposed development area. Historically, seagrass covered most of the sandflat areas in Marsden Bay (Figure 15). Satellite images from 2012 to 2019 indicate that the distribution and spatial extent of seagrass beds in that area have been highly variable over relatively short periods of time (Figure 18, also see Appendix B in Spyksma & Brown, 2018). Similarly, high levels of temporal variability have been reported in other regions, such as the northern Manukau Harbour where a significant increase in seagrass extent occurred between 2013 and 2021 (Kelly, 2021), and conversely, the central Kaipara Harbour where a significant decline in seagrass extent occurred between 2010 and 2019 (Kelly, 2020).

Seagrass beds can support diverse macrofaunal communities, and of the 25 intertidal sites sampled in Whangārei by Griffiths (2012), the seagrass bed at Takahiwai contained the highest diversity and abundances of macrofauna. Subtidal (but not intertidal) seagrass beds are also known to be an important nursery habitat for juvenile fish (Morrison *et al.*, 2007; Morrison *et al.*, 2014).

5.1.1.1 THREATENED OR AT RISK SPECIES

Seagrass is listed as an "At Risk" species under the New Zealand Threat Classification System (NZTCS) due to the seagrass population being very large, but subject to low to high ongoing or predicted decline. The NZTCS includes the following qualifier for seagrass:

- it is a non-endemic[10] species that is secure overseas; and,
- the seagrass population experiences extreme fluctuations (de Lange et al., 2017).

[10] Endemic species are those that are only found in New Zealand. Native species include endemic species and those that arrived in New Zealand without human assistance. Many native species, including seagrass, naturally occur in other parts of the world.

Figure 15. Extent of seagrass in Whangārei Harbour in 1966 and 2015. Extent in 1966 is from Morrison (2003) and extent in 2015 is from NRC (2020).

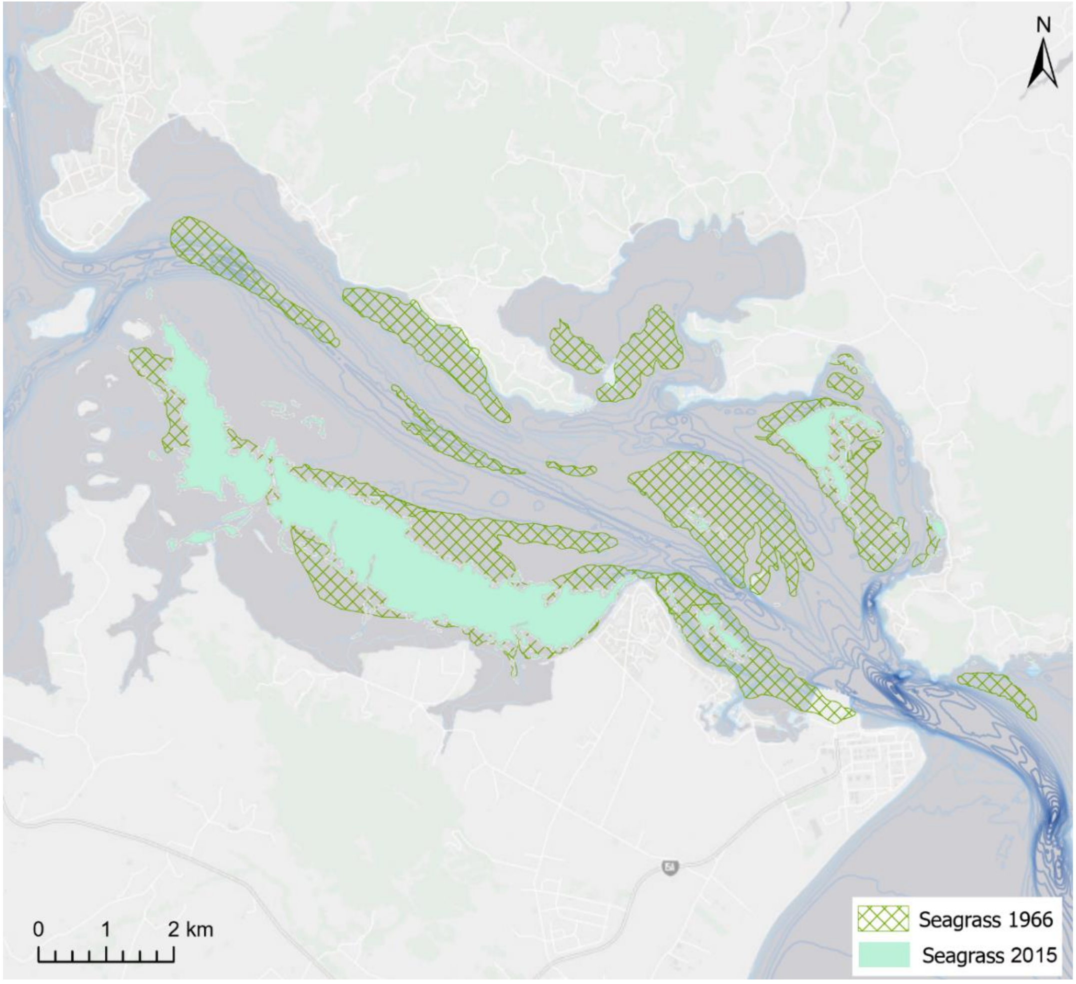


Figure 16: Recent extents of coastal vegetation (excluding macroalgae) in Whangārei Harbour. Data from NRC: seagrass data from 2015 to inform Regional Plan; mangrove and saltmarsh data to inform Regional Plan Mediation Changes.

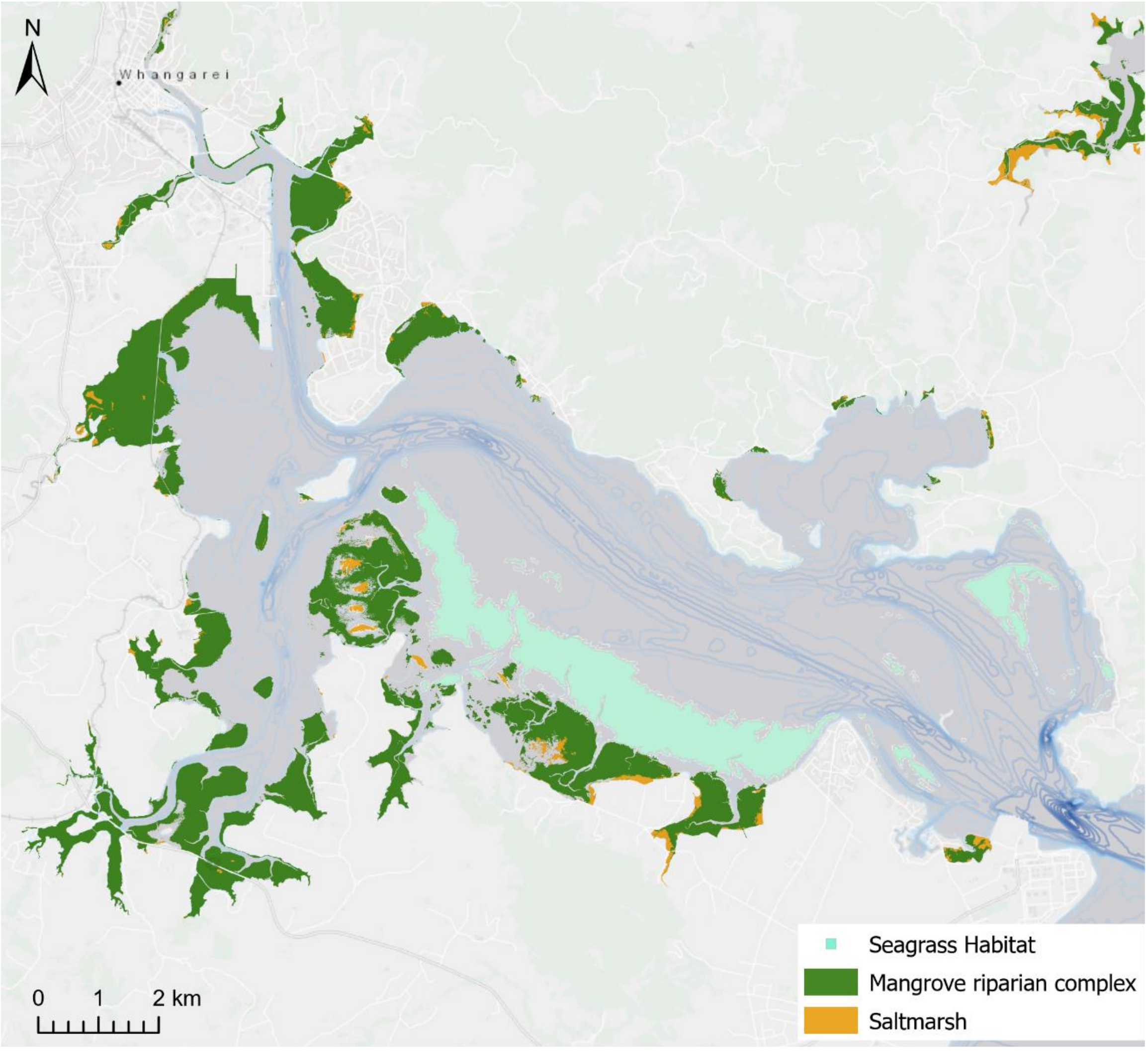


Figure 17: Recent extents of coastal vegetation (excluding macroalgae) near Northport. Data from NRC: seagrass data from 2015 to inform Regional Plan; mangrove and saltmarsh data to inform Regional Plan Mediation Changes.

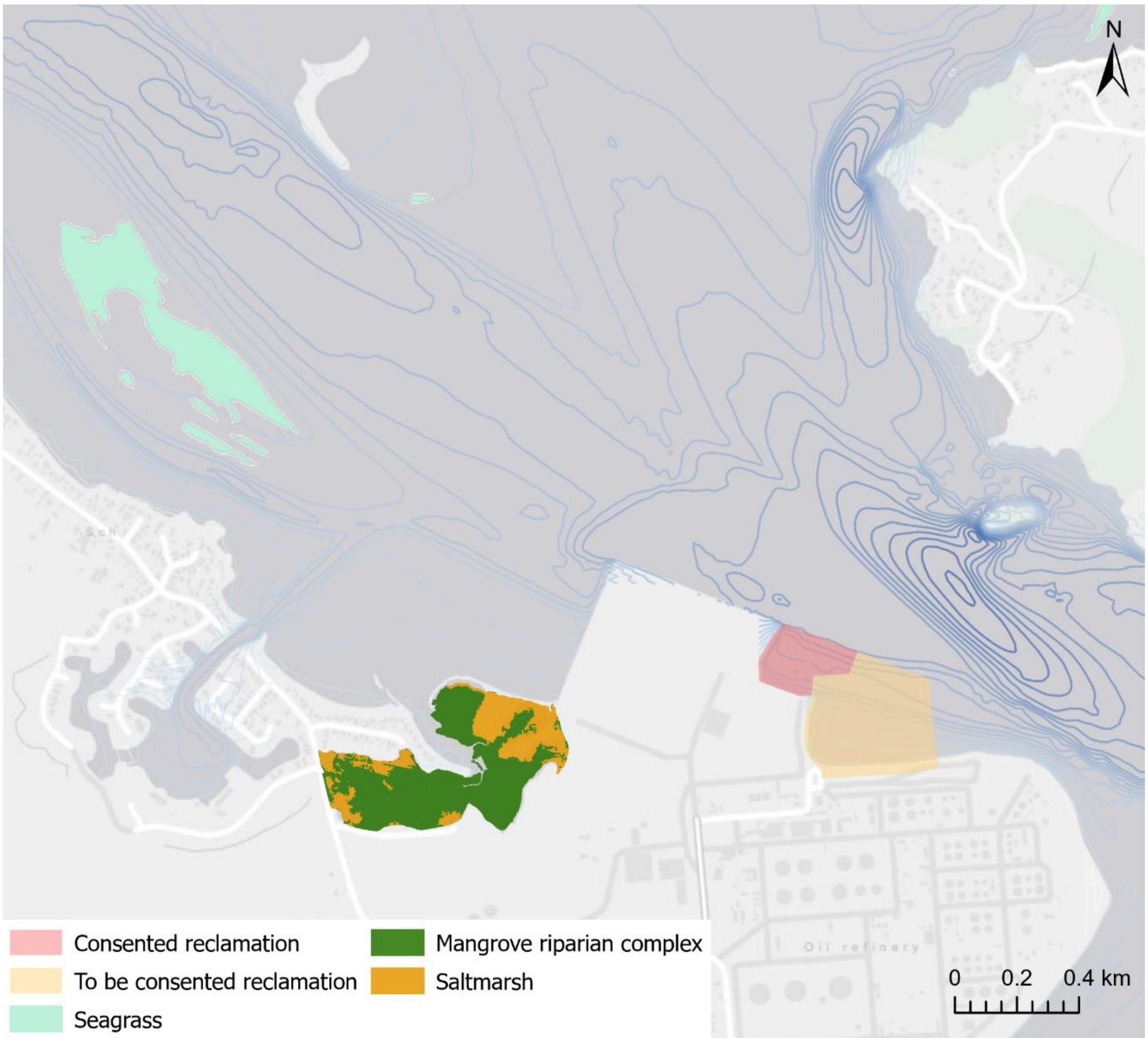
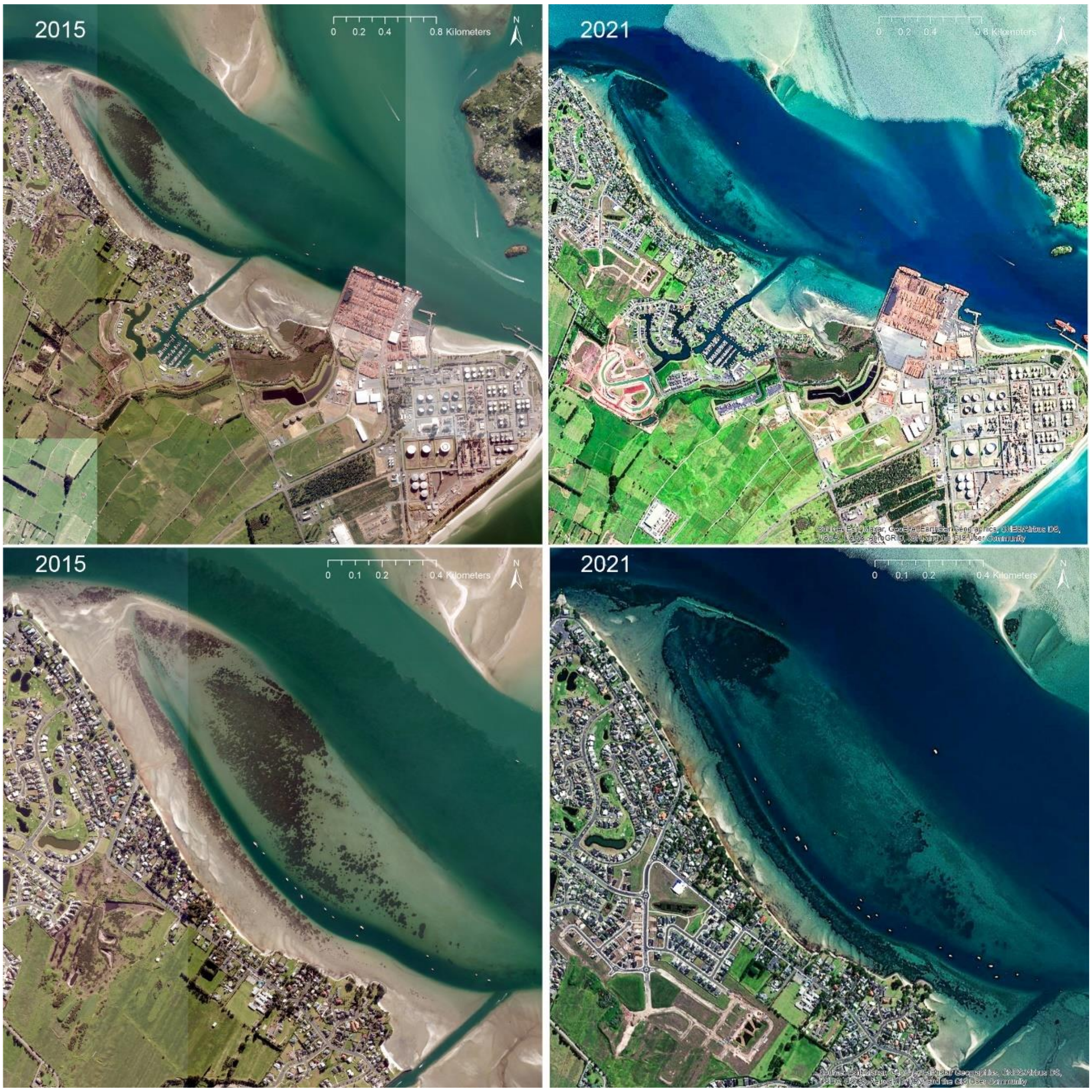


Figure 18: Images showing changes in seagrass extent within Marsden Bay between 2015[11] and 2021[12] at small (top) and large scales (bottom).



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[11] LINZ Data Service, lds-northland-04m-rural-aerial-photos-2014-2016-JPEG

[12] Arc GIS “World Imagery” layer produced by Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Figure 19. Photos of intertidal coastal vegetation around Marsden Bay: A–B. Seagrass patches east of Northport; C–E. Extensive seagrass beds west of the Marsden Cove channel. F. The green alga, *Ulva* sp. G–H. Red algae beds west of the Marsden Cove channel.

5.1.2 MACROALGAE

Natural rocky habitats and associated macroalgae communities are a relatively minor feature of Whangārei Harbour. Intertidal and subtidal reef surveys in the outer harbour and surrounding Bream Bay area indicate they contain typical macroalgae assemblages, with seaweed species including *Corallina officinalis* and common brown algae such as *Carpophyllum angustifolium*, *C. flexuosum*, *C. maschalocarpum, C. plumosum, Ecklonia radiata, Sargassum sinclarii* and *Hormosira banksia* (Morrison, 2003). Natural rocky reef is not present in the Northport area, but port revetments provide hard structure similar to natural reefs. A subtidal survey of those revetments indicates that they have been colonised common macroalgae including *E. radiata, S. sinclairii, C. flexuosum, Dictyota kunthii, Hildenbrandia* sp., *Colpomenia* sp., *Ralfsia* sp., crustose coralline algae and various species of red turfing algae (Spyksma, 2018).

Potentially, of more significance are the macroalgae communities of sediment habitats, known as 'macroalgal meadows'. Black *et al.* (1989) identified and produced a simplified map showing large subtidal areas with algae-encrusted, gravel-shell lag in the outer harbour (Figure 7). A more recent and detailed macroalgae survey recorded 118 macroalgae taxa growing on intertidal and subtidal soft sediments at six sites in the outer harbour, including One Tree Point, Mair Bank and Reotahi Bay (across the channel from Northport) (Neill and Nelson (2016); see Figure 19 F–H for examples). Although algae biomass was low, the number of taxa collected from these sites represented around 28% of the known regional flora across all habitat types. The study demonstrated that:

- areas of low algal biomass can still have a high diversity of taxa;
- macroalgal communities were highly variable in space and time; and,
- algal diversity increased towards the mouth of Whangārei Harbour.

Macroalgae meadows were one of the key ecological features observed in video footage obtained from a recent survey around Northport (see Section 5.4.3).

5.1.2.1 THREATENED OR AT RISK SPECIES

Four of the 119 macroalgae taxa recorded in the outer Whāngārei Harbour by Neill and Nelson (2016) have been listed as "At Risk" under the New Zealand Threat Classification System (NZTCS) (Nelson *et al.*, 2019). They are:

- *Microdictyon mutabile*, an endemic green seaweed that inhabits the mid to low intertidal on sheltered, gently sloping rocks in northern New Zealand. The seaweed forms bushy, turfing pads over the substrate in open (sunny) locations (Adams, 1994; Wilcox, 2018; Nelson, 2020). Wilcox (2018) describes it as a "common and characteristic seaweed of the eastern shores of Auckland" that is present all year round and is commonly epiphytic on coralline algae (*Corallina officinalis*). He identifies Auckland locations where it occurs as Rangitoto Island, Howick, Birkenhead, Archilles Point, Point Resolution (Parnell), Torpedo Bay (Devonport), The Tor (Waiake Beach), Stanmore Bay, Army Bay (Whangaparāoa), Flat Roch (Tawharanui), Motutapu Island, Motuihe Island, The Noises, Hobbs Bay (Tiritiri Matangi Island), Great Barrier Island, and Kaikoura Island.
- *Aeodes nitidissima*, a red seaweed that occupies low intertidal and subtidal rocky habitats on open coasts and sheltered harbours of northern North Island (Wilcox,

2018; Nelson, 2020). In the intertidal, it typically grows in intertidal runnels (Wilcox, 2018). It is unclear whether *A. nitidissima* is an endemic species (Nelson, 2020), as it has also been reported in Tasmania and South Australia (Scott, 2012; Fowles *et al.*, 2018). However, further work is required to confirm whether specimens from Australia and New Zealand are the same species, and to determine the morphological and ecological boundaries of this species (Russell *et al.*, 2009). In Auckland, it is mostly found in the inner Hauraki Gulf, though specimens have been obtained throughout the eastern coast of the Auckland Region, apart from offshore islands. Particularly abundant populations have been recorded from Browns Island and on boulder beaches between Ōrere Point and Kaiaua (Wilcox, 2018).

- *Feldmannia mitchelliae*, a filamentous brown seaweed that is little known and poorly studied in New Zealand (Nelson, 2020), but is fairly common on the east coast of Auckland and widespread internationally (Wilcox, 2018; Guiry, 2020a). For instance, in a study of epiphytic algae growing on seagrass in the Mediterranean Sea, *F. mitchelliae* was found to be one of the two most common species, and one of two species with the highest percent cover. It was also one of two most common species to arrive in Oregon and Washington on recognisable marine debris from the 2011 Japan tsunami (Hansen *et al.*, 2019). In New Zealand, *F. mitchelliae* is known to grow on other seaweeds, seagrass, stones, shells, and mooring ropes. On occasion, nuisance quantities have been reported growing as thick skeins on top of intertidal seagrass in Whāngārei Harbour, and on Neptune's necklace (*Hormosira banksia*) south of Bay of Islands (Nelson *et al.*, 2015). Microscopic examination is required to identify specimens of this species (Nelson, 2020).
- *Hincksia granulosa*, a filamentous brown seaweed that is little known and poorly studied in New Zealand (Nelson, 2020), but is widespread internationally, particularly in temperate seas (Hewitt *et al.*, 1999; Guiry, 2020b). This species has been observed floating on other buoyant seaweeds and plastics, and research suggests that its international geographic distribution may be related to dispersal on floating substrata (Macaya *et al.*, 2016). In New Zealand, it has also been reported on the hull of a fishing vessel (Piola & Conwell, 2010), and is known to grow on other seaweeds and marina pontoons (Wilcox, 2018). Hull fouling has also been proposed as a potential vector for its presence in Port Phillip Bay, Australia (Hewitt *et al.*, 2004). Microscopic examination is required to identify specimens of this species (Nelson, 2020).

All of these species are tagged with the qualifier "Data poor". In relation to that qualifier, the NZTCS manual (Townsend *et al.*, 2008) encourages Expert Panels to make every effort to assign a taxon to a threat category rather than list it as 'Data Deficient', and then use 'Data Poor' (DP) to indicate the uncertainty about the listing due to the lack of data.

5.1.3 BENTHIC MACROFAUNA

5.1.3.1 SEDIMENT DWELLING COMMUNITIES

Variation in the composition of benthic macroinvertebrate communities throughout the harbour was examined using NRC baseline monitoring survey data from 2012 (Griffiths, 2012). Macrofaunal samples were obtained from 38 intertidal/shallow subtidal sites[13]. Raw data from that survey was obtained from NRC and analysed to characterise benthic macrofaunal communities in Whangārei Harbour and determine how community composition varied throughout the harbour[14]. All intertidal and shallow subtidal macrofaunal communities were combined for the analyses.

Overall, 139 taxa were obtained, including 55 polychaete taxa, 39 molluscan taxa, 29 crustacean taxa, and minor contributions from other taxa groups. Numbers of taxa and individuals in pooled site samples varied around the harbour, and while patterns in the upper harbour were discernible (low to moderate diversity, with high numbers of individuals in the uppermost reaches of Hātea and Mangapai Rivers), patterns from the mid and outer harbour sites were more variable (Figure 21). This was reflected in the results of multivariate analyses using average taxa counts from each sampling site that distinguished two distinct macrofauna site clusters in Hātea and Mangapai Rivers containing both intertidal and shallow subtidal sites (clusters b & d in Figure 21). However, four intertidal sites in the central part of the upper harbour clustered with two subtidal mid-harbour sites, and intertidal sites in Pārua and McLeod Bays (cluster g). Other clusters in the mid to outer harbour included:

- cluster f, which included three upper intertidal sites on the broad sand flats of Takahiwai Bay on the southern, mid-harbour shore;
- cluster h, which included eight intertidal sites situated close to channels in the outer (4 sites, including all 3 in Marsden Bay), mid (3 sites), and upper (one site) harbour;
- cluster c, which included two subtidal sites, one in Pārua Bay and one in Munroe Bay on the northern shore;
- cluster a, which included two subtidal sites (Snake Bank and Manganese Point);
- cluster e, which consisted of a single intertidal site off Rat Island.

[13] Three replicate samples were collected from each site using a 150 mm diameter by 150 mm deep cores and sieved to 500 µm.

[14] Data were analysed using standard univariate analyses and multivariate methods including non-metric multidimensional scaling (nMDS), cluster, similarity profile (SIMPROF), and similarity percentages (SIMPER) analyses (using Primer-e V7). Results are presented in spatial and data plots. Where applicable multivariate analyses were carried out using square root transformed data and Bray-Curtis similarity for resemblance estimates.

Figure 20: Bubble plots showing variation in a) numbers of taxa, and b) numbers of individuals in pooled benthic macrofaunal samples (n = 3 cores per site). Data provided by NRC.

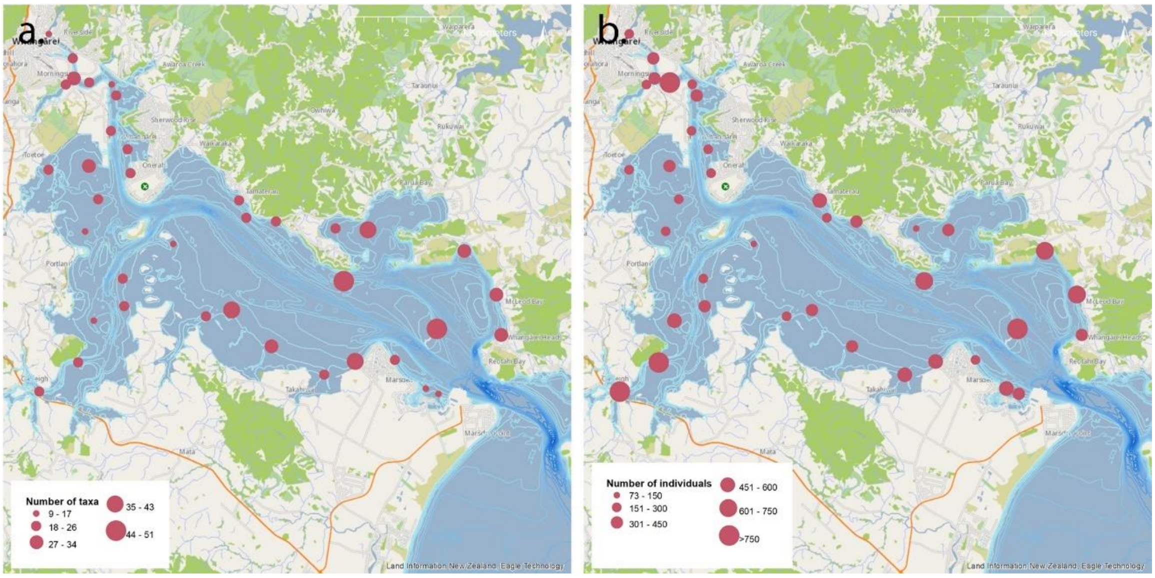
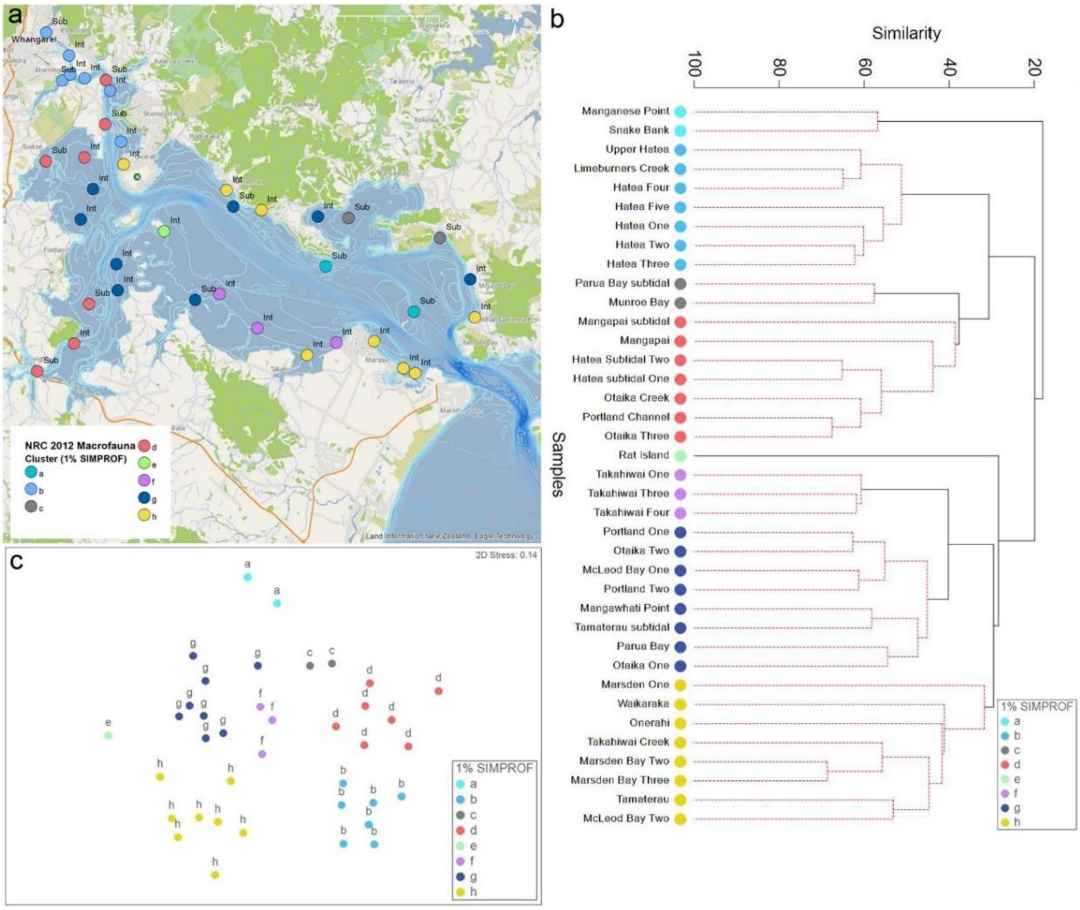


Figure 21: Results of multivariate analyses of macrofaunal community composition of NRC harbour wide macroinvertebrate data (see Griffiths, 2012), showing a) the spatial distribution of significant (1%) clusters (i.e., sites with similar community composition); and the results of analyses used to identify those clusters, including b) cluster and similarity profile analyses, and c) non-metric multidimensional scaling. Intertidal (Int) and subtidal (Sub) sites are labelled in the map.

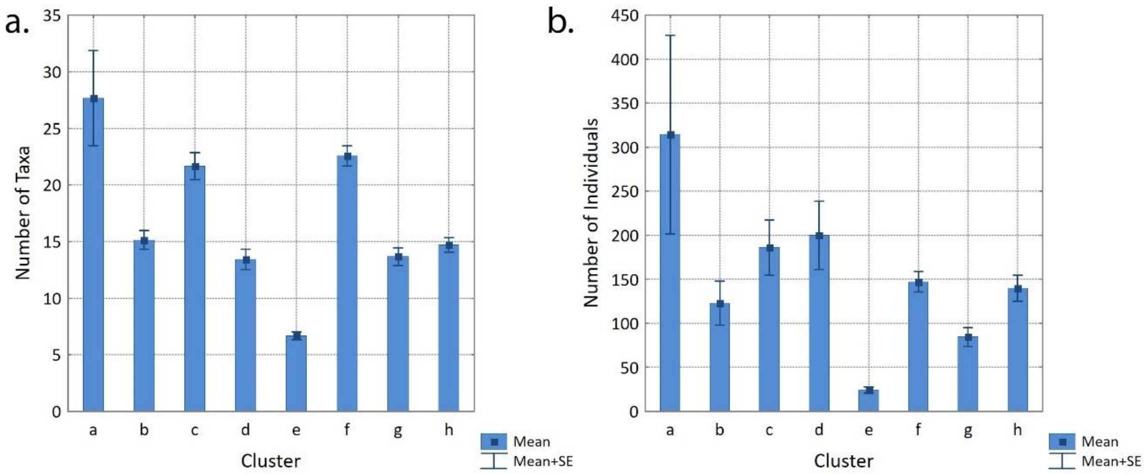


A one-way analysis of variance of $\log_{10}$ transformed taxa and individuals[15] in pooled samples from these clusters detected that there were statistically significant differences among clusters ($p < 0.0001$). Tukey's honestly significant difference tests indicated that sites from cluster h (which contained the intertidal sites closest to Northport) contained significantly fewer taxa than those in clusters a, f and c ($p < 0.05$), but more taxa than cluster e. No significant differences were detected in the mean number of individuals between cluster h samples and samples from other clusters, except for cluster e, which had lower numbers (Figure 22).

Overall, pooled samples taken from cluster h contained 59 taxa, of which 29 were polychaetes, 12 were crustaceans, 16 were molluscs, and the remaining 8 taxa came from 5 other groups. Counts of individual taxa varied substantially among sites within and between clusters. Among the molluscs, nut shells had the highest total counts, followed by cockles, pipi, and wedge shells. Cluster h also had the highest mean counts of cockles and pipi of any cluster. Numbers were patchy, but high counts of both species were obtained from sites near Northport in Marsden Bay. Highest counts of nut shells occurred in Takahiwai Bay (cluster f) and in the central part of the upper harbour (cluster g). Wedge shell numbers were also highest in the central part of the upper harbour (cluster g) and beside Rat Island (cluster e, Figure 23).

Northport is adjoined by the One Tree Point–Marsden Bay (OTP–MB) significant ecological area. An overlay of the site clusters on a map of the NRC coastal SEAs, indicates that all three sampling sites within OTP–MB SEA belong to cluster h, and that four other SEAs also include cluster h sites (Figure 24). None of the taxa obtained from the Marsden Bay sites were unique to those sites.

Figure 22: Mean (± S.E.) numbers of a) taxa, and b) individuals in multivariate community clusters of NRC harbour wide macroinvertebrate data (see Griffiths, 2012).



[15] Transformation was needed to meet the assumption of equal variance.

Figure 23: Mean (± S.E.) counts of a) nut shells *Linucula hartvigiana*, b) cockles *Austrovenus stutchburyi* c) pipis *Paphies australis* and d) wedge shells *Macomona liliana* in multivariate community clusters of NRC harbour wide macroinvertebrate data (see Griffiths, 2012).

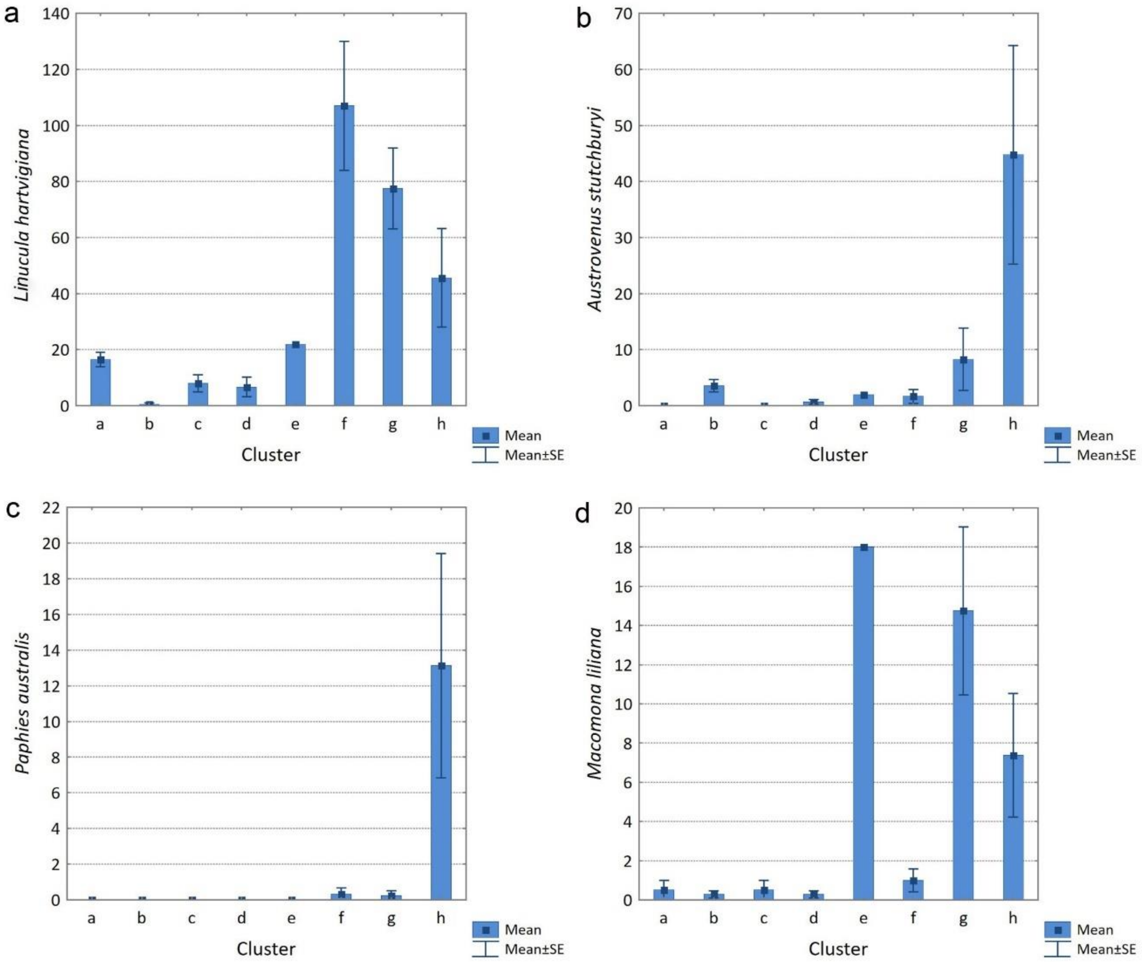
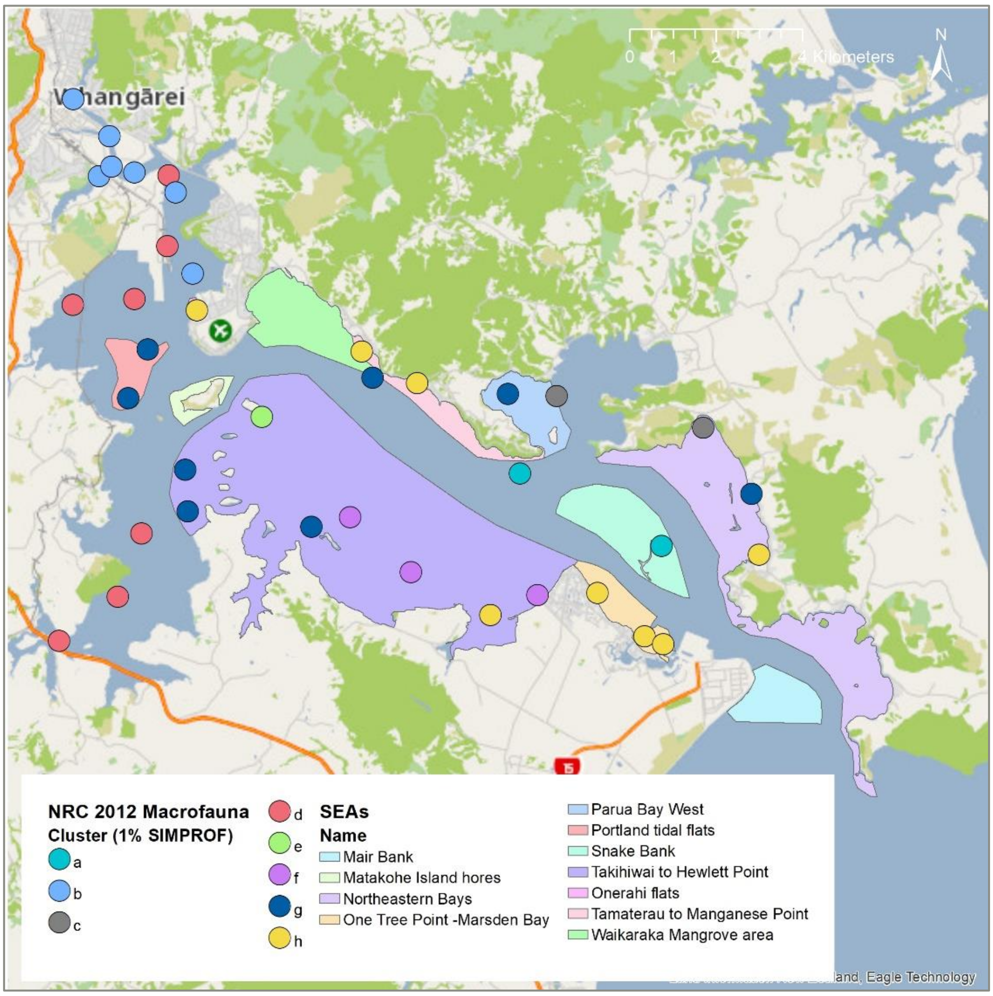


Figure 24: Map of multivariate site clusters of NRC harbour wide macroinvertebrate data (see Griffiths, 2012), overlaid on significant ecological areas from the NRC coastal plan.



Northport has obtained higher resolution data for intertidal and subtidal communities around the port (Spyksma & Brown, 2018; Knue & Poynter, 2021). Results from sampling carried out in December 2017 (Spyksma & Brown, 2018), could not be directly compared with those from 2020 because different service providers were used for the ecological sample processing and clear differences were apparent in the taxonomic resolution, and potentially, species identifications. Therefore, only the 2020 data (processed by the Cawthron Institute). were used for the following analyses

In 2020, sites on the western and eastern sides of the port were sampled, including:

- sites within the proposed reclamation;
- sites from the mid and lower shore, west of the port;
- a remote reference site near One Tree Point.

Overall, the intertidal sandflats surrounding the port were characterised by high benthic diversity (100 taxa were recorded from 87 samples in 2020) and low to moderately high total numbers of individuals (13 to 597 individuals per sample in 2020). Polychaete worms were the most abundant and diverse taxa group (45 taxa, 9048 individuals), followed by crustaceans (31 taxa, 4395 individuals) and molluscs (26 taxa, 664 individuals). Similar to

NRC's broader harbour sampling, taxa were patchily distributed with high abundances at some sites and low or zero counts at others (see Figure 25 for examples).

Non-metric multidimensional (nMDS) scaling plots of 2020 data (Figure 26) indicated that although there was overlap in the composition of intertidal communities sampled at the finer scale, discernible differences were still apparent. However, the relatively high stress value (0.16) suggested that care needed to be taken in the interpretation of the nMDS plot. Cluster and similarity profile analyses of averaged taxa counts, were therefore carried out to identify statistically significant differences among site clusters (Figure 27). Dissimilar communities included:

- the community at one site east of the port differed from the other eastern site, and from those on the western side of the port;
- communities from western mid and low-shore sites differed; and,
- the remote reference site near One Tree Point differed from sites closer to the port.

As noted, one of the two sites in the proposed reclamation area clustered separately from sites west of Northport, but the other eastern site clustered with lower intertidal sites next to the Marsden Cove channel. Only 3 taxa were unique to the former site, whereas 11 taxa were only obtained at latter site.

Similar levels of taxa diversity were obtained in intertidal samples from five stations in Marden Bay (n=1) and Mair Bank (n=4)[16] (Kerr & Grace, 2016), which together contained a total of 97 taxa. Polychaetes, oligochaetes, and/or molluscs tended to be the most abundant taxa groups, but relative abundances varied considerably among sites. The Marsden Bay site was notable for having higher counts of bivalves and cnidarians, which is presumed to have mainly been due to the presence of cockles and an associated anemone *Anthopleura aureoradiata*.

Subtidal communities around the port were sampled using a 8.2 l Ponar grab by 4Sight for Northport in 2019 and 2020 (Ahern, 2020; Knue, 2021b). Samples were obtained from the proposed reclamation and dredging areas, and from surrounding areas that are unlikely to have been previously dredged (Mark Poynter, 4Sight pers. com.). Grab samples (n = 47) were split into quarters, with one quarter being sieved to 0.5 mm, preserved and sent to the Cawthron Institute for macrofauna sorting, identification and enumeration.

Data provided from Northport's subtidal surveys indicated that the seabed around the port contains a very diverse assemblage of benthic macroinvertebrates, with a total of 198 taxa obtained from the 47 samples (mean number of taxa = 35.5 ± 1.9 s.e.). Remarkably similar numbers of taxa were obtained in two recent subtidal surveys of the outer harbour/harbour entrance:

- Kerr and Grace (2016) obtained 197 taxa from 11 stations (5 samples per station);
- West and Don (2016) obtained 189 taxa from 17 stations (1 sample per station).

In the Northport surveys, counts of individuals displayed a skewed distribution with a sample median of 284 and 10th and 90th percentiles of 81 and 799, respectively. Pielou's evenness

[16] 5 samples were obtained from each station using methods similar to those in the other studies described.

varied among samples, but most samples had moderate to high Shannon diversity (Figure 29). Counts of many taxa were very patchy, with over a quarter (57 taxa) being obtained in a single sample. Fourteen taxa obtained from the proposed reclamation area were not found in the other areas sampled, but it is highly unlikely that any of those taxa are unique to the proposed reclamation area.

The most diverse taxa groups were molluscs (63 taxa), annelid polychaetes (59 taxa from 28 families), and crustaceans (48 taxa from 28 families, including 21 decapods). The molluscs included 41 bivalves[17], 14 gastropods (snails), four opisthobranchs (which include taxa like sea hares, sea slugs and nudibranchs), and three chitons. The 20 most abundant taxa included nine polychaetes (particularly *Euchone* sp. and *Spio* sp.), seven small crustaceans (particularly various amphipods, but no decapods), two bivalves, and an ascidian and oligochaete. Most taxa occurred in low numbers, with combined total counts in pooled samples having a median of eight for individual taxa (10th and 90th percentiles of one and 194, respectively).

Multivariate analyses (nMDS, cluster, and SIMPROF) identified 13 statistically significant clusters amongst sampling stations, but the high stress value for the nMDS plot (0.19) suggested that it did not provide a good representation of the data. Mapping of the clusters indicated that community composition displayed more variation in the offshore, rather than longshore direction, with all sites within the proposed reclamation area clustering with sites on the western side of Northport.

5.1.3.1.1 KEY CONCLUSIONS ON SEDIMENT DWELLING COMMUNITIES

In summary, the available data indicates that Whangārei Harbour sustains a diverse infaunal assemblage of benthic taxa and communities. Benthic communities in upper sections of Hātea and Mangapai Rivers are clearly distinct and typical of those found in upper estuary systems. Further out into the harbour the community patterns are more diverse. Large scale data from 2012 suggests that the intertidal benthic community in Marsden Bay, including the Marsden Cove–One Tree Point SEA adjacent to Northport, is similar to that found at sites in other northern, southern and upper harbour SEAs. Those communities were notable for their relatively high counts of pipi and cockles. Finer scale intertidal sampling for Northport (Knue & Poynter, 2021) confirmed the area around the port is characterised by high benthic diversity with variation along and down the shore, and minor differences between the western and eastern sides of Northport. Subtidal sampling also showed that benthic macrofaunal diversity is very high around the port. Overall, the review and reanalysis of existing data confirms the general findings from other assessments of the Northport area, which have also concluded that macrofaunal diversity in benthic habitats around the port is high.

[17] Actual taxa numbers may be lower because 4 taxa were identified as juveniles that could not be assigned to adult taxa.

Figure 25: Bubble plots with examples showing variation in the abundance of taxa, including: a) shrimps from the order Tanaidacea; b) amphipods from the family Atylidae; c) polychaetes from the family Syllidae; d) the polychaete *Prionospio* sp.; e) *Austrovenus stutchburyi* (cockles) and f) *Macomona liliana* (wedge shells) (data from Knue and Poynter 2021).

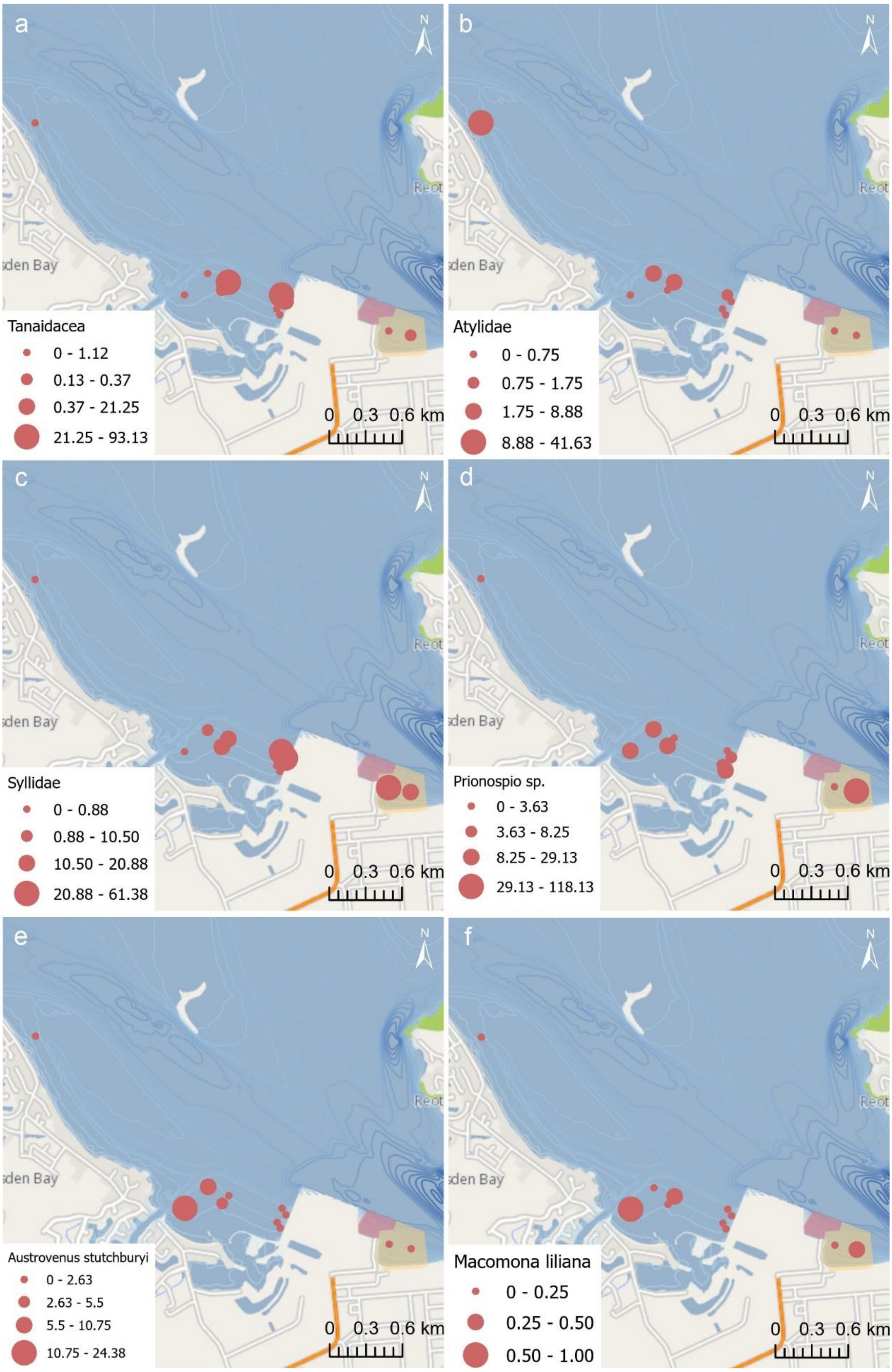


Figure 26: Non-metric multidimensional scaling plots of 2020 intertidal macrofaunal data with samples coloured by a) groups of sites categorised by position relative to the port and tidal elevation, and b) sampling site. Vector plots of Pearson's correlations for key taxa are provided (data from Knue & Poynter, 2021).

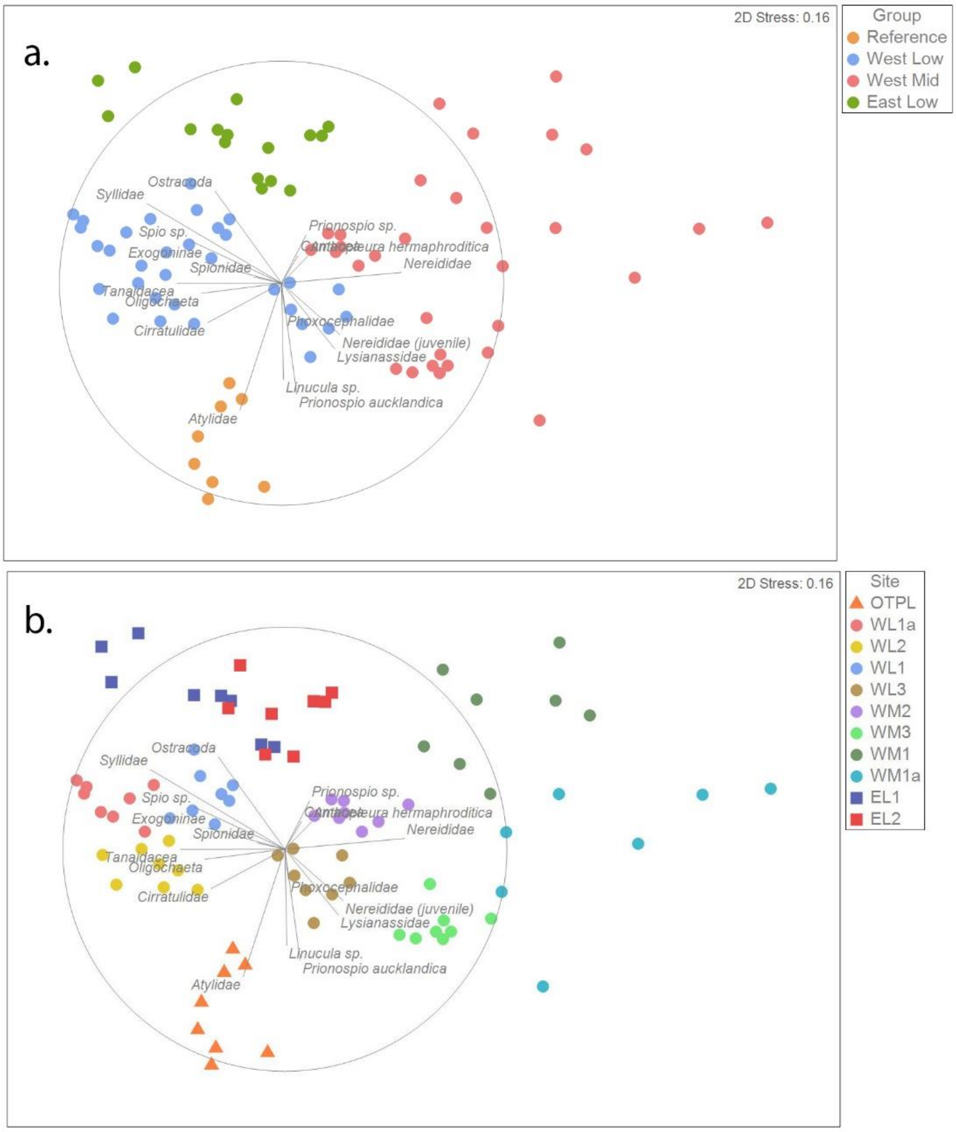


Figure 27: Intertidal site clusters with similar benthic community composition, identified using cluster and similarity profile analysis.

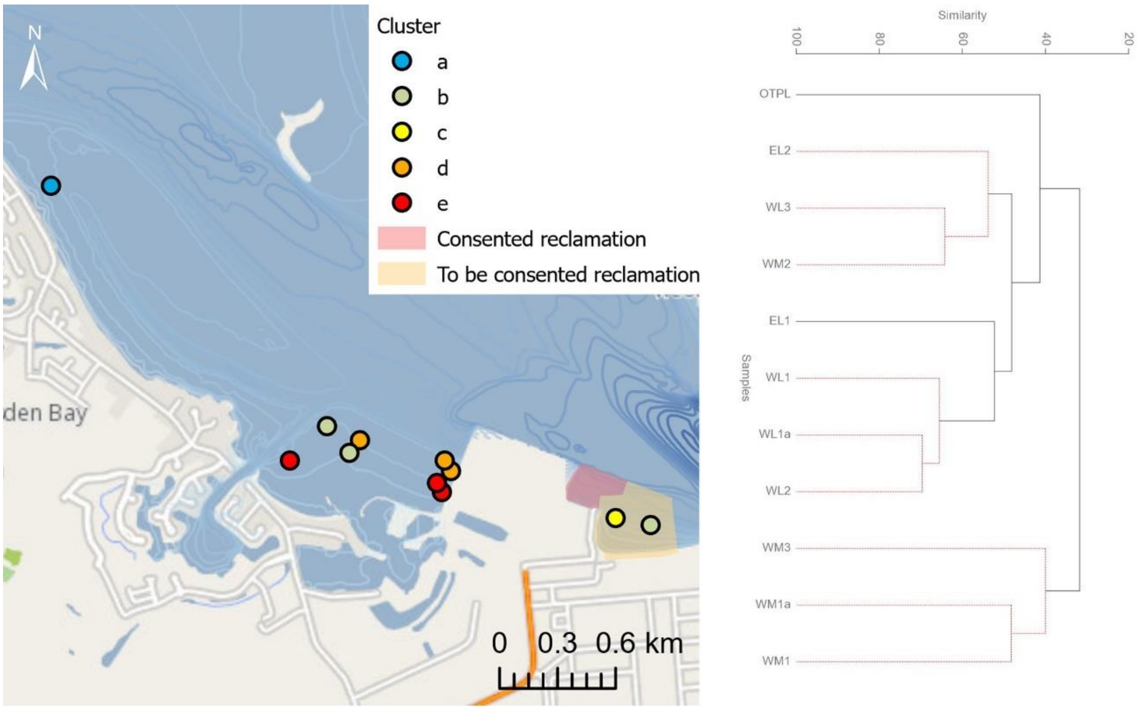


Figure 28: Bubble plots showing the a) diversity (numbers of taxa), b), total abundance (total numbers of individuals) c) evenness (Pielou's evenness), and d) cluster analysis groupings of benthic macrofauna in sediment core samples (data consolidated from Griffiths (2012)).

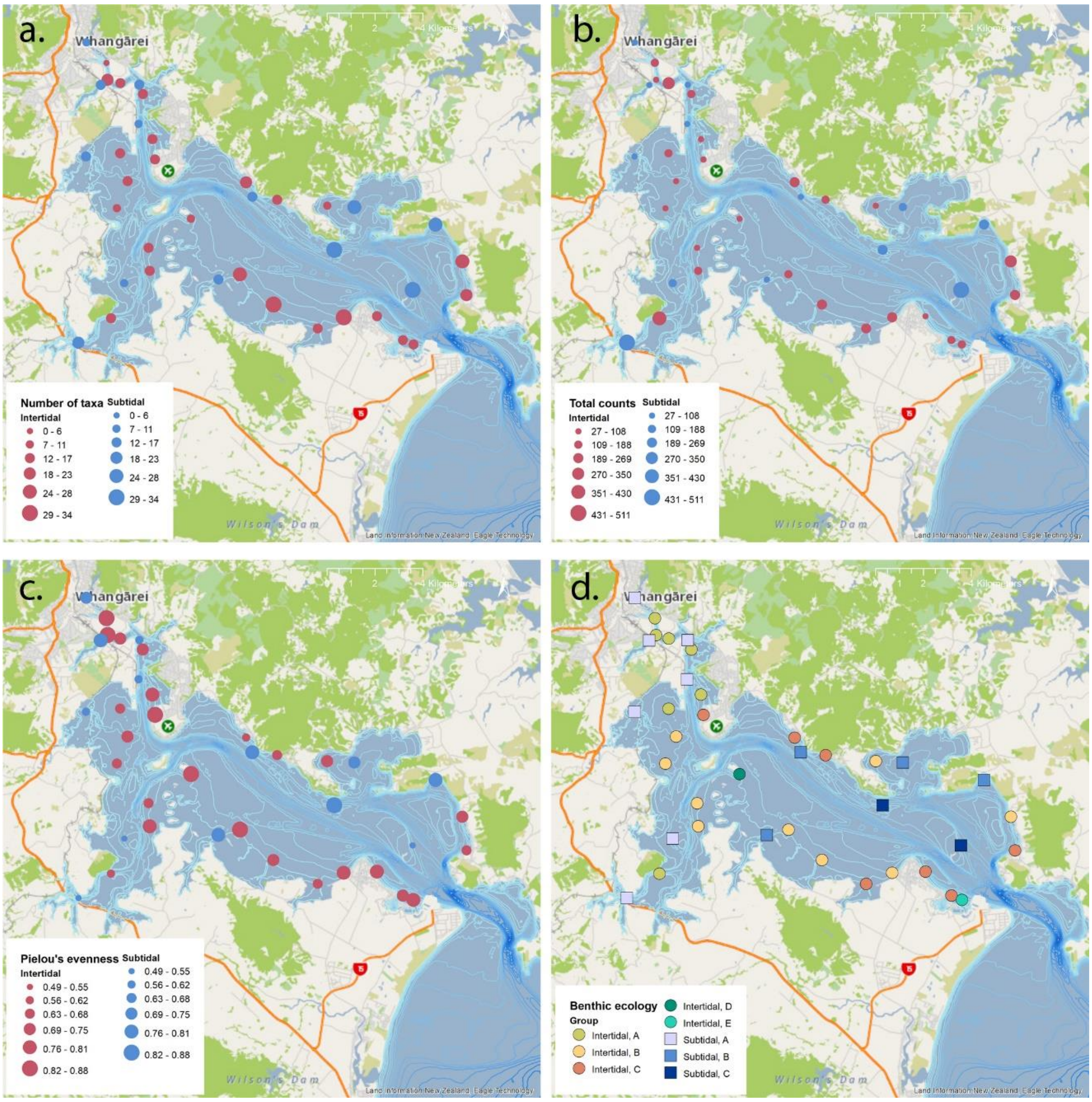


Figure 29: Indicators of macrofaunal diversity and abundance in subtidal samples obtained around Northport in pooled 2019 and 2020 data (Ahern, 2020, 4Sight, unpublished data), a) number of taxa, b) number of individuals, c) Pielou's evenness, and d) Shannon diversity.

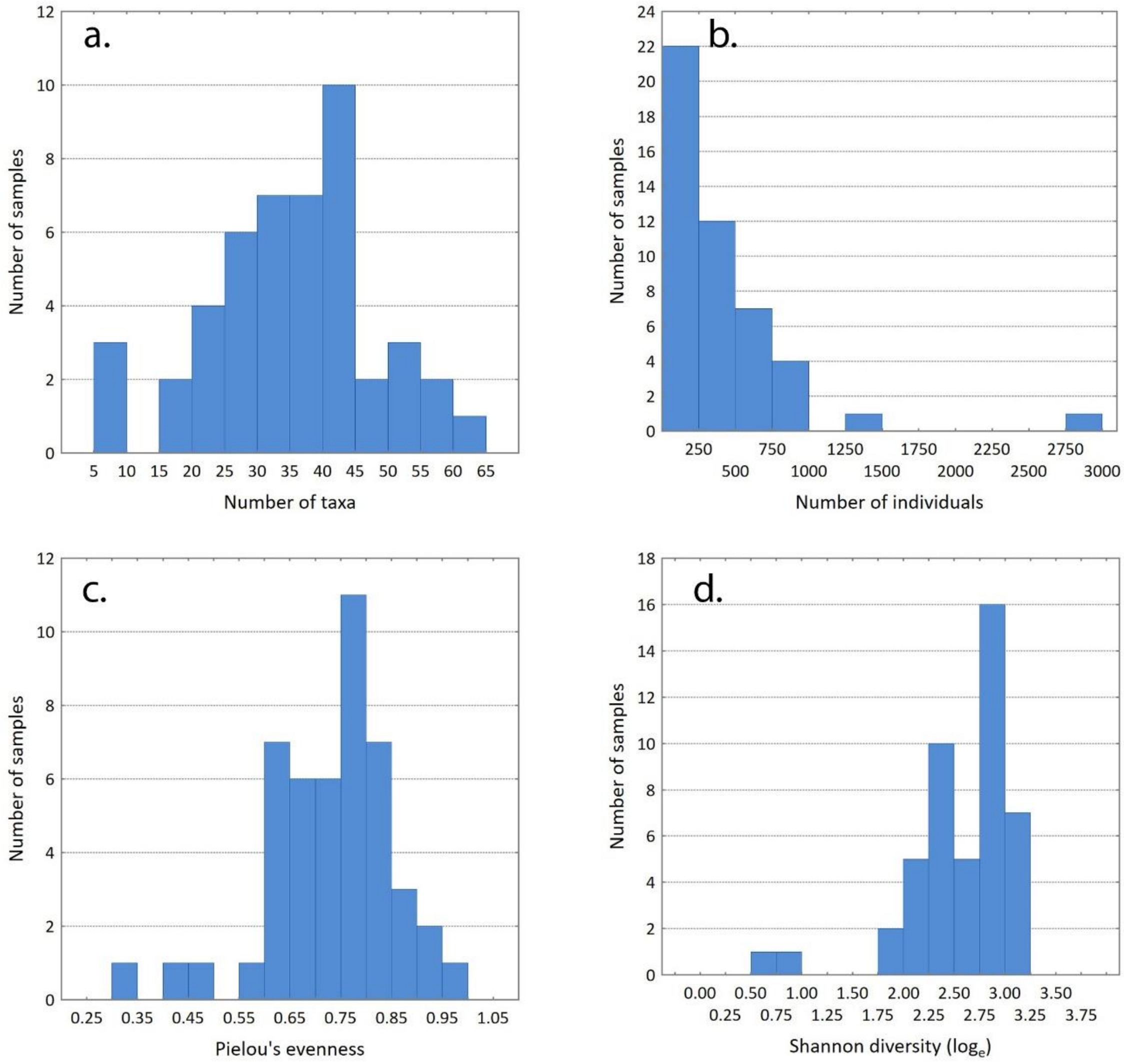
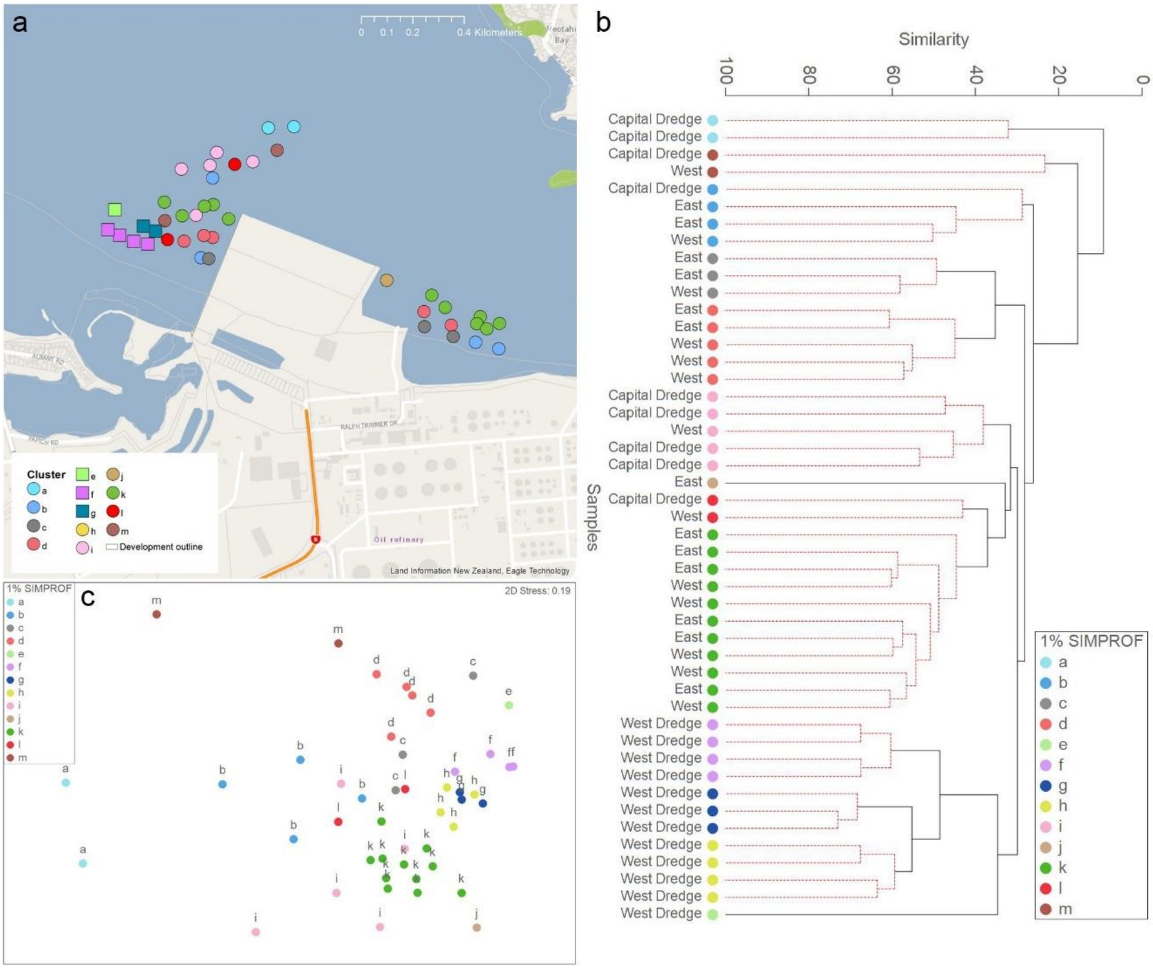


Figure 30: Results of multivariate analyses of macrofaunal community composition in subtidal samples obtained around Northport (pooled 2019 and 2020 data from Ahern (2020) and 4Sight, unpublished data), showing a) the spatial distribution of significant (1%) clusters (i.e., sites with similar community composition); and the results of analyses used to identify those clusters, including b) cluster and similarity profile analyses and c) non-metric multidimension scaling. Square stations in the map are 2020 samples, circles are from 2019.



5.1.3.2 SUBTIDAL EPIBENTHIC COMMUNITIES

Available information on the subtidal ecological values of Whangārei Harbour, indicates that the mid to outer harbour contains a variety of physical seabed and biogenic habitats. Habitat forming macrofaunal species that have been reported include horse mussels *Atrina zelandica*, green lipped mussels *Perna canaliculus*, dog cockles *Glycymeris laticostata*, sponges, ascidians, and dead shell (Morrison, 2003, Parsons *et al.*, 2016). (Figure 70, West & Don, 2016). Drop camera surveys carried out for Channel Infrastructure have also found that sites in the east of the harbour mouth contain a mix of sand and shell gravel (Kerr & Grace, 2016; West & Don, 2016), with scallops, green-lipped mussels, octopus, 11-armed starfish, and macroalgae meadows with turret shells (referred to as algae turf) being reported.

Existing information on the epibenthic communities around Northport was limited. Therefore, a subtidal video survey was carried out in November 2021 to characterise subtidal benthic habitats and communities in and around the proposed dredging and reclamation areas (see Section 5.4.3).

5.1.3.3 THREATENED OR AT RISK SPECIES

One top shell gastropod identified as *Cantharidus* sp. was recorded by 4Sight at one intertidal station in the proposed reclamation area in 2020 (Knue, 2021a), and one bivalve identified as *Mysella* sp. was recorded in the upper intertidal.

The NZTCS database contains five, At Risk, species of *Cantharidus*, including *Cantharidus* sp. A (NMNZ M.59506), *Cantharidus* sp. B (NMNZ M.131607), *Cantharidus antipodum hinemoa, Micrelenchus burchorum*[18], and *Cantharidus festivus*. All are naturally uncommon and range restricted. The distribution of these five species are as follows:

- *C. festivus*—Three Kings Islands, Cape Reinga, and the Far North, 13–88 m (Marshall, 1998);
- *M. burchorum*—Three Kings Islands, Middlesex Bank and King Bank, 7–805 m (Marshall, 1998);
- *C. antipodum*—Otago, Southland, Stewart Island, Snares, Campbell, Auckland and Antipodes Islands (Spurgeon, no date);
- *Cantharidus* sp. 1 (i.e. species A)—Great Island, Three Kings Islands (https://collections.tepapa.govt.nz/);
- *Cantharidus* sp. 2 (i.e. species B)—Three Kings Islands, North Cape, Spirits Bay, Bay of Islands, Poor Knights Islands (https://collections.tepapa.govt.nz/).

In contrast, other New Zealand species of *Cantharidus* are very common, including *Micrelenchus purpureus*[19] and *Cantharidus opalus*. Both species commonly occur on or below seaweeds, such as those growing on revetments and piles around Northport and are widely distributed in New Zealand. Based on:

- the restricted ranges of the five At Risk *Cantharidus* species, which are not near Whangārei;
- the rarity of the At Risk species; and
- the likelihood that *Cantharidus purpureus* and *Cantharidus opalus* are common in the area;

it is extremely unlikely that the top shell obtained from Marsden Bay was one of the At Risk species.

Similarly, only one specimen of the At Risk, and yet to be named, *Mysella* sp. 1 (M.051502) has been recorded in the Te Papa mollusc collection, with that being obtained from Pelorus Sound, Marlborough. The NZTCS lists it as naturally uncommon and range restricted. The checklist of living mollusca from the New Zealand Exclusive Economic Zone lists 10 species of *Mysella* (Spencer *et al.*, 2016), with species such as *Mysella hounselli* known to occur in the Whangārei region (e.g. Cummings *et al.* (1994)). Given that, and the fact that the species obtained from Marsden Bay was distant from the known range of *Mysella* sp. 1, and was

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[18] Previously *Cantharidus burchorum*

[19] Previously *Cantharidus purpureus*

common throughout the upper intertidal zone of the area surveyed (Figure 31), it appears extremely unlikely that the *Mysella* species obtained is the At Risk species.

Figure 31: Counts of *Mysella* sp. obtained from individual 13 cm diameter by 15 cm deep core samples (sieved to 0.5 mm) in June 2022.

5.1.4 KAIMOANA SHELLFISH

5.1.4.1 COCKLES

Cockles (*Austrovenus stutchburyi*) are widespread in Whangārei Harbour. Griffiths (2012) found that cockles were present at most sites sampled throughout the harbour, but a small proportion of the population were of harvestable (>30 mm) size. Highest densities were recorded at Marsden Bay and McLeod Bay, and recent sampling near Northport (Knue & Poynter, 2021) indicates that cockles remain common in the eastern part of Marsden Bay (Figure 32). Further information on cockle distribution, size and abundance in Marsden Bay has since been gathered and is presented in Sections 5.4.1 and 5.4.2.

However, it is likely that the harbour population has decreased from historic levels due to harvesting pressure and high suspended sediment loads (Cummings & Hatton, 2003;

Morrison, 2003). For instance, commercial harvesting for cockles on Snake Bank had a pronounced effect. Cockle harvesting in that area began in the 1980s, with landings of over 500 t per year obtained in the 1990s. Landings steadily declined from 2000, and the fishery was eventually closed in 2012 due to the low biomass of harvestable cockles (Fisheries NZ, 2020). NRC sampling of the Snake Bank, McDonald Bank and Takahiwai cockle populations in 2014 found average densities of 722 cockles/m², 853 cockles/m², and 498 cockles/m² respectively (Figure 32; Griffiths & Eyre, 2014).

5.1.4.2 PIPIS

Pipi (*Paphies australis*) were previously commercially harvested from Marsden and Mair Banks (PPI1A) outside of the harbour entrance, with these banks supplying over 99% of the total commercial landings in New Zealand (Pawley, 2014). Between 1986 and 2011, 87–326 t were landed per annum from PPI1A. However, both recreational and commercial harvest of pipi at Marsden Bank was prohibited in 2011, and at Mair Bank in 2014, due to low biomasses (Fisheries NZ, 2020).

Surveys of Marsden and Mair Banks between 2013–2019 have found that pipis had a very patchy distribution, with low numbers of large (>50 mm) pipi. Mean densities across the entire banks were very low and highly variable due to the patchy distribution, varying between 11–729 pipis/m² for Mair Bank, and 17–166 pipis/m² for Marsden Bank (Pawley, 2014; 2016; Williams *et al.*, 2017; Shirkey, 2019). A survey of a narrow bank on the eastern edge of Marsden Bank in 2018 found much higher densities of pipis in that area (mean = 1284 pipis/m²), but no large (>50 mm) pipis (Berkenbuisch & Neubauer, 2018).

Juvenile pipis are present at several sites in the mid to outer harbour, with highest densities found at Marsden Bay and the western side of Northport (Figure 33 & Figure 37), though very few pipis were of harvestable size (>50 mm) in all areas (Cummings & Hatton, 2003; Griffiths, 2012; Shirkey, 2019). A small pipi bed existed at the western end of Marsden Bay between 2016 and 2019, which contained average densities of between 140–250 pipis/m² overall, and average densities of up to 1929/m² in some strata (Shirkey, 2019). This bed was also noted during a rapid survey in November 2021 (S. Kelly pers. obs.), but it fell between sampling stations (see Section 5.4.1).

Knue and Poynter (2021) found low mean densities of pipi (9–94 pipis/m²) at 4 sites west of Northport, and at high densities at one site (WM1a; 892/m²). Most of the pipis were between 10–40 mm in length, with none larger than 50 mm (Knue & Poynter, 2021). Further information on pipi distribution, size and abundance in Marsden Bay has since been gathered and is presented in Sections 5.4.1 and 5.4.2.

Figure 32. Mean number of cockles/m^2 from sites sampled by Cummings and Hatton (2003), Griffiths (2012), Griffiths and Eyre (2014) and Knue and Poynter (2021). Top map shows the entire harbour and the bottom map shows the area around Northport.

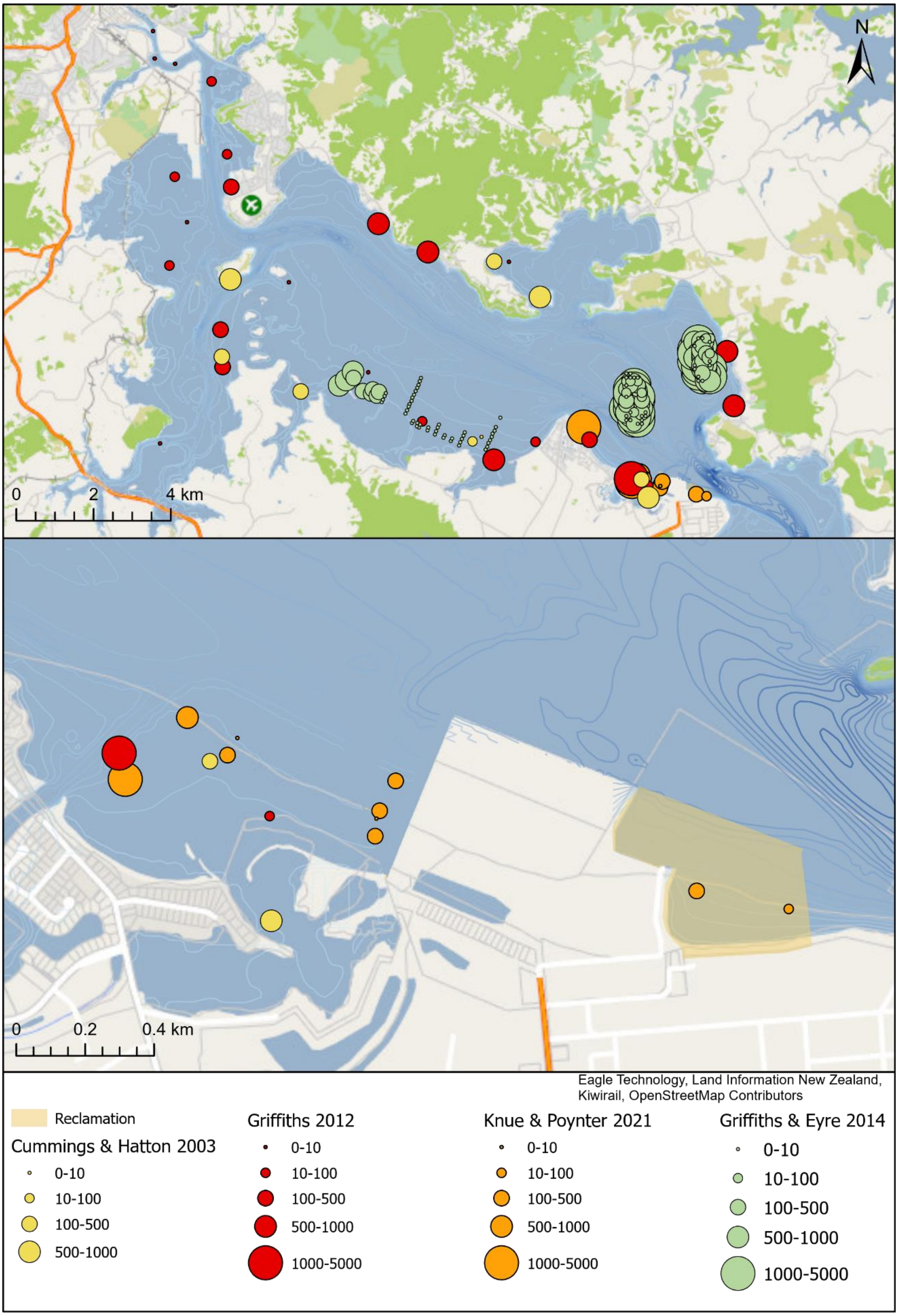
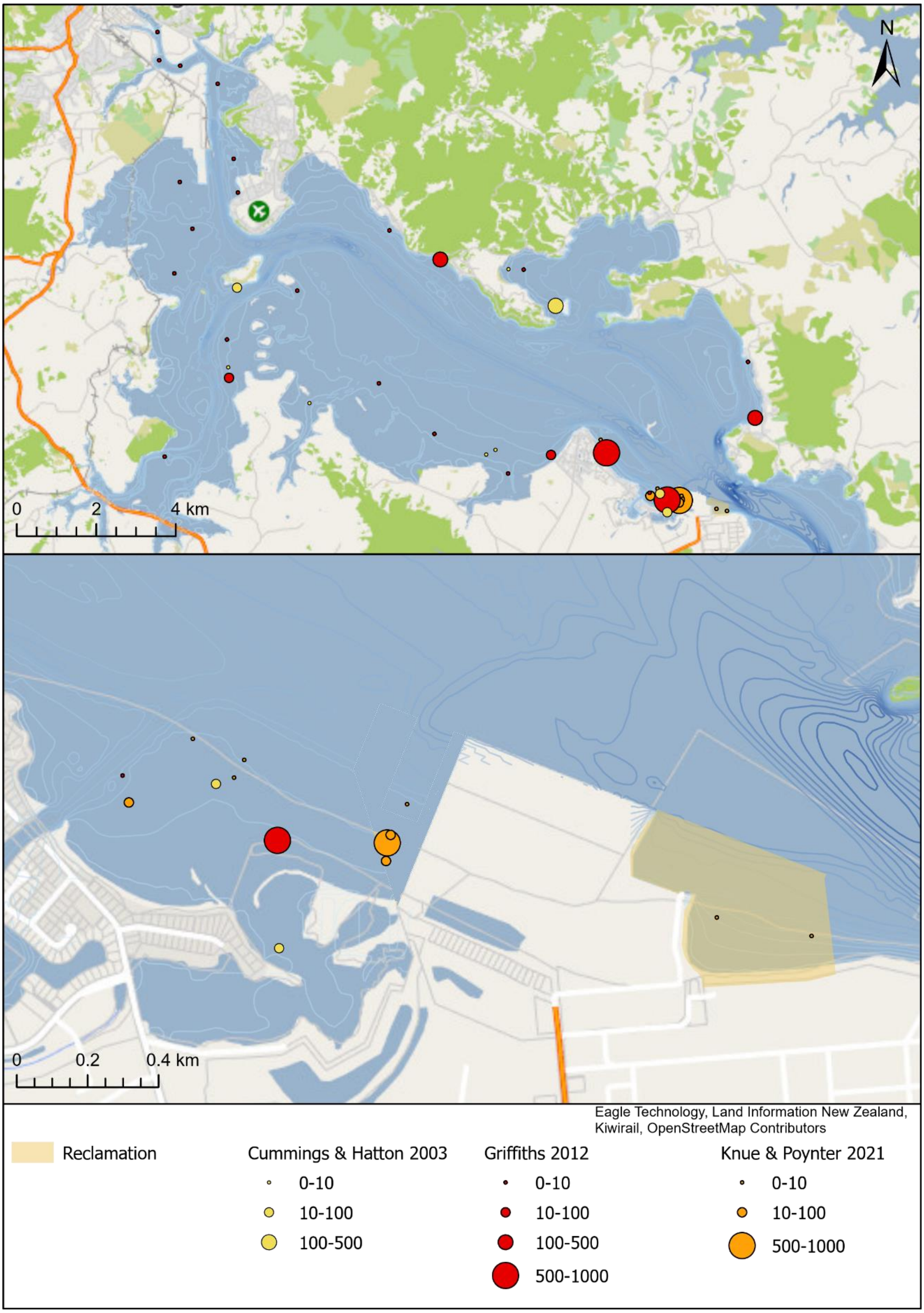


Figure 33. Mean number of pipis/m² from sites sampled by Cummings and Hatton (2003), Griffiths (2012) and Knue and Poynter (2021). Top map shows the entire harbour and the bottom map shows the area around Northport.



5.1.4.3 SCALLOPS

Large scallop beds (*Pecten novaezelandiae*) are, or were historically, found:

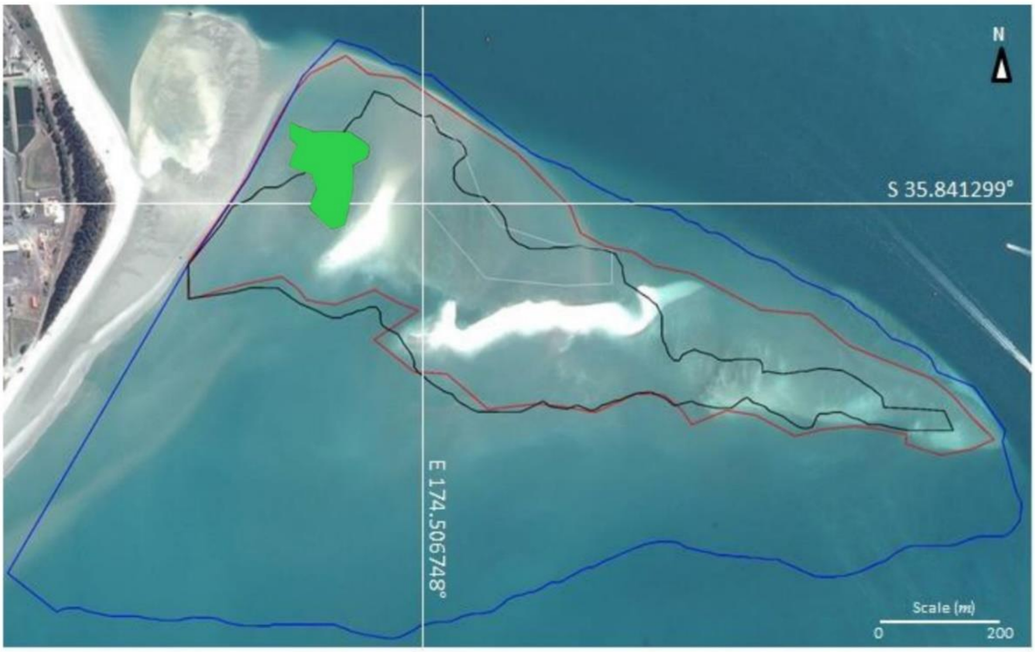
- on the sandflats at Takahiwai;
- in Marsden Bay;
- in Shoal Bay between McDonald and Snake Banks;
- from McLeod Bay along the inside channel as far as Pārua Bay;
- in the channel between Limestone and Rat Islands;
- in bays in, and beyond, the entrance of the harbour from Smugglers Bay to Little Munroe Bay (Mason & Ritchie, 1979; Cummings & Hatton, 2003; Morrison, 2003, Greg Blomfield, Northport pers. com.).

Scallop beds in Smugglers Bay and Urquharts/Taurkiura Bays were surveyed in 2006 and 2007. Mean densities of legal sized scallops (>100 mm) were low, ranging from 0.08–0.05/m^2 at Smugglers Bay and 0.05–0.03/m^2 at Urquharts/Taurkiura Bays in 2006 and 2007, respectively (Williams *et al.*, 2008; Williams, 2009). Recreational scallop dredging has frequently occurred in the harbour around the areas listed above (C. Sim-Smith, pers. obs.), though the Northland scallop fishery was closed on the 1 April 2022 to allow stocks to recover (Parker, 2022).

5.1.4.4 GREEN-LIPPED MUSSELS

Green-lipped mussels (*Perna canaliculus*) were reported to have been common in the channel adjacent to Mair Bank, but were commercially dredged and disappeared in the late 1960s (Mason & Ritchie, 1979; Morrison, 2003). A large mussel bed reappeared on Mair Bank in 2015, which was reported to cover approximately 12,800 m^2 in 2016 (Pawley, 2016). However, the bed was intensively harvested, which prompted the local hapu Patuharakeke to implement a rahui over collection of all shellfish from Mair and Marsden Banks in 2018 (Ministry of Fisheries, 2018). Despite the rahui, the bed has almost completely disappeared, with only a few scattered clumps of mussels observed in recent years (Lee, 2020; A. Carrington, pers. comm.).

Figure 34. Extent of the mussel bed (green polygon) on Mair Bank in Feb 2016 (Figure adapted from Pawley (2016)).



5.2 REEF COMMUNITIES

Whangārei Harbour contains only a limited amount of reef habitat, with most occurring on the northern coastline towards the harbour entrance. Intertidal reefs within the harbour are characterised by common intertidal species including: barnacles (*Chamaesipho columna*), rock oysters (*Saccostrea glomerata*), tubeworms (*Pomatoceros* sp.), *Corallina* sp. algae, and Neptune's necklace (*Hormosira banksia*). Subtidal reef is reported to support various macroalgae, with common species including *Ecklonia radiata*, *Carpophyllum* sp., *Cystophora* sp., and *Sargassum sinclairii*, as well as sponges, green-lipped mussels, kina (*Evechinus chloroticus*) and other familiar reef invertebrates (Morrison, 2003; Kerr, 2005; Kerr & Grace, 2016). Diverse sponge communities are present within the Motukaroro Island Marine Reserve, and low numbers of sub-legal sized crayfish (*Jasus edwardsii*) have been also been found in the reserve (Kerr & Moretti, 2012; Kerr & Grace, 2016). Overall, species assemblages on natural Whangārei reef habitats are typical of those found in north-eastern New Zealand (Morrison, 2003).

Revetments along the western and eastern margins of Northport are narrow artificial reefs, with similar habitat and community values to the naturally occurring reefs in the harbour. A subtidal survey of the revetments indicates that they also contained a reef community typical of north-eastern New Zealand, with a similar assemblage to those reported for natural reefs in the harbour. For example, the macroalgae recorded included: *E. radiata*; *S. sinclairii*; *Carpophyllum flexuosum*; *Dictyota kunthii*; *Hildenbrandia* sp.; *Colpomenia* sp.; *Ralfsia* sp.; various species of red turfing algae; and crustose coralline algae. A variety of common sponges, molluscs and echinoderms were also observed growing on the revetments, along with compound and solitary ascidians, polychaetes including Mediterranean fan worm *Sabella spallanzanii* (a pest species) and the parchment worm *Chaetopterus* sp. A low number of crayfish *Jasus edwardsii,* and a reasonably diverse fish assemblage was also recorded around the revetments, with four species of triplefin and a range of other common reef species that, among others, included: silver drummer *Kyphosus sydneyanus*; red moki *Cheilodactylus spectabilis*; silver sweep *Scorpis lineolata*; big eye *Pempheris adspersa* and marble fish *Aplodactylus arctidens*. Other more cosmopolitan species included kingfish *Seriola lalandi*; trevally *Pseudocaranx dentex*; and parore *Girella tricuspidata* (Spyksma, 2018).

5.2.1 THREATENED OR AT RISK SPECIES

None of the reef species recorded are listed as threatened or at risk.

5.3 FISH

A large variety of fishes utilise Whangārei Harbour (Table 6). Sixteen species were captured by beach seines from shallow, soft sediment habitats in the harbour. The most common species captured from lower harbour sites were, in decreasing order, yellow-eyed mullet, sand goby, garfish, sand flounder and speckled sole (Morrison, 2003).

Larger fish captured from the deeper channels in the harbour include snapper, jack mackerel, parore, rig, eagle rays, grey mullet, sand flounder, trevally, yellow-belly flounder and kahawai (Mason & Ritchie, 1979).

A video survey of 19 sites covering a range of habitats (bare sediment, seagrass, horse mussels, sponges, turfing algae and reef) in the mid to outer harbour found that the most common species observed across all habitats were snapper, spotty, trevally, goatfish, leatherjacket, and parore. The abundance of post-settlement snapper was significantly higher in biogenic habitats (horse mussels, seagrass and sponges) compared to bare sediment or reef, suggesting that these habitats act as important nursery areas for snapper in the harbour (Parsons *et al.*, 2016).

Brook (2002) surveyed fish assemblages at 119 reef sites around the Northland coast, including six sites on the northern side of the outer harbour between Reserve Point and Home Point, where 33 rocky reef species were recorded. Fish assemblages at five of the outer harbour sites grouped with other Northland sites classified as having “impoverished species assemblages in sheltered bays, harbours and exposed west coast sites”. These sites were dominated by parore, spotty, and common, variable and spectacled triplefins. Fish assemblages around Motukaroro Island were different to the other harbour sites, and the site was classified as “moderately diverse assemblages of open coasts”. Common species seen within the Motukaroro Marine Reserve included goatfish, koheru, parore, snapper and spotty (Kerr & Moretti, 2012).

Fish communities around Northport appear to be similar to those that inhabit reefs in and around the harbour. Leatherjackets, red moki, spotty, sweep, triplefins, kingfish, jack mackerel, two-spot demoiselle, and goatfish were commonly observed around the rock revetments of Northport. Other species that were occasionally observed included Sandager’s wrasse, butterfly perch, trevally, silver drummer, parore, big eye, slender roughy and marble fish (Spyksma, 2018).

5.3.1 THREATENED OR AT RISK SPECIES

None of the fish species recorded are listed as threatened or at risk.

Table 6. Fish species recorded to occur in Whangārei Harbour. Species that have been observed around Northport are highlighted in blue.

Family	Common name	Scientific name	Observed habitat	Reference
Triakidae	Rig	*Mustelus lenticulatus*	Channels, soft sediment	Mason and Ritchie (1979)
Dasyatidae	Short-tail stingray	*Bathytoshia brevicaudata*	Reef, outer harbour	Kerr and Moretti (2012)
Myliobatidae	Eagle ray	*Myliobatis tenuicaudatus*	Channels, soft sediment	Mason and Ritchie (1979)
Muraenidae	Yellow moray	*Gymnothorax prasinus*	Reef, outer harbour	Brook (2002)
Congridae	Conger eel	*Conger verreauxi*	Reef, outer harbour	Brook (2002)
Clupeidae	Pilchard	*Sardinops neopilchardus*	Shallows, soft sediment, upper harbour	Morrison (2003)
Engraulididae	Anchovy	*Engraulis australis*	Shallows, soft sediment, mainly upper and mid harbour	Morrison (2003)
Retropinnidae	Smelt	*Retropina retropina*	Shallows, soft sediment, upper and mid harbour	Morrison (2003)
Moridae	Rock cod	*Lotella rhacina*	Reef, outer harbour	Brook (2002)
Hemiramphidae	Garfish	*Hyporhampus ihi*	Shallows, soft sediment, whole harbour	Morrison (2003); Parsons *et al.* (2016)
Trachichthyidae	Slender roughy	*Optivus elongatus*	Reef, revetments, outer harbour	Venus (1984); Brook (2002); Spyksma, 2018
Zeidae	John dory	*Zeus faber*	Reef, outer harbour	Brook (2002); Kerr and Moretti (2012)
Sygnathidae	Black pipefish	*Stigmatopora nigra*	Reef, outer harbour	Kerr and Moretti (2012)
Scorpaenidae	Scorpion fish	*Scorpaena papillosus*	Reef, outer harbour	Brook (2002)
Serranidae	Butterfly perch	*Caesioperca lepidoptera*	Reef, revetments, outer harbour	Brook (2002); Spyksma (2018)
	Pink maomao	*Caprodon longimanus*	Reef, outer harbour	Brook (2002)
Carangidae	Koheru	*Decapterus koheru*	Reef, outer harbour	Kerr and Moretti (2012)

Family	Common name	Scientific name	Observed habitat	Reference
	Trevally	*Pseudocaranx dentex*	Channels, soft sediment, reef, revetments, outer harbour	Mason and Ritchie (1979); Brook (2002); Parsons *et al.* (2016)
	Kingfish	*Seriola lalandi*	Reef, revetments, outer harbour	Kerr and Moretti (2012); Spyksma (2018)
	Jack mackerel	*Trachurus novaezealandiae*	Channels, soft sediment, revetments	Mason and Ritchie (1979); Kerr and Moretti (2012); Spyksma, 2018
Arripidae	Kahawai	*Arripus trutta*	Channels, reef, soft sediment, outer harbour	Mason and Ritchie (1979); Kerr and Moretti (2012)
Sparidae	Snapper	*Chrysophrys auratus*	Shallows, channels, soft sediment, reef, whole harbour	Mason and Ritchie (1979); Brook (2002); Morrison (2003); Parsons *et al.* (2016)
Mullidae	Goatfish	*Upeneicthys lineatus*	Soft sediment, reef, revetments, mid to outer harbour	Brook (2002); Parsons *et al.* (2016)
Pempheridae	Bigeye	*Pempheris adspera*	Reef, revetments, outer harbour	Venus (1984); Brook (2002); Spyksma, 2018
Kyphosidae	Silver drummer	*Kyphosus sydneyanus*	Revetments	Spyksma (2018)
Scorpididae	Sweep	*Scorpis lineolatus*	Reef, revetments, outer harbour	Brook (2002); Kerr and Moretti (2012); Spyksma, 2018
	Blue maomao	*Scorpis violaceus*	Reef, outer harbour	Brook (2002); Kerr and Moretti (2012)
Girellidae	Parore	*Girella tricuspidata*	Shallows, channels, soft sediment, reef, revetments, whole harbour	Mason and Ritchie (1979); Venus (1984); Brook (2002); Morrison (2003); Parsons *et al.* (2016)
Chironemidae	Hiwihiwi	*Chironemus marmoratus*	Reef, outer harbour	Brook (2002); Kerr and Moretti (2012)

Family	Common name	Scientific name	Observed habitat	Reference
Aplodactylidae	Marblefish	*Aplodactylus arctidens*	Revetments	Spyksma (2018)
Cheilodactylidae	Red moki	*Cheilodactylus spectabilis*	Reef, revetments, outer harbour	Brook (2002); Kerr and Moretti (2012); Spyksma, 2018
Mugilidae	Yellow-eyed mullet	*Aldrichetta forsteri*	Shallows, soft sediment, whole harbour	Morrison (2003)
	Grey mullet	*Mugil cephalus*	Channels, soft sediment	Mason and Ritchie (1979)
Pomacentridae	Two-spot demoiselle	*Chromis dispilus*	Reef, revetments, outer harbour	Venus (1984); Brook (2002); Spyksma, 2018
Labridae	Sandager's wrasse	*Coris sandeyeri*	Revetments	Spyksma (2018)
	Spotty	*Notolabrus celidotus*	Shallows, soft sediment, reef, revetments, whole harbour	Venus (1984); Brook (2002); Morrison (2003); Parsons *et al.* (2016)
	Purple wrasse	*Notolabrus fucicola*	Reef, outer harbour	Brook (2002); Kerr and Moretti (2012)
	Scarlet wrasse	*Pseudolabrus miles*	Reef, outer harbour	Brook (2002); Kerr and Moretti (2012)
Odacidae	Butterfish	*Odax pullus*	Reef, outer harbour	Kerr and Moretti (2012)
Pinguipedidae	Blue cod	*Parapercis colias*	Reef, outer harbour	Brook (2002)
Tripterygiidae	Spotted robust triplefin	*Forsterygion capito*	Reef, outer harbour	Brook (2002)
	Yellow-and-black triplefin	*Forsterygion flavonigrum*	Reef, outer harbour	Brook (2002)
	Common triplefin	*Forsterygion lapillum*	Reef, revetments, outer harbour	Brook (2002); Spyksma (2018)
	Oblique swimming triplefin	*Forsterygion maryannae*	Reef, revetments, outer harbour	Venus (1984); Spyksma (2018)
	Banded triplefin	*Forsterygion malcolmi*	Reef, outer harbour	Brook (2002)
	Estuarine triplefin	*Forsterygion nigripenne*	Shallows, soft sediment, upper harbour	Morrison (2003)

Family	Common name	Scientific name	Observed habitat	Reference
	Variable triplefin	*Forsterygion varium*	Reef, revetments, outer harbour	Brook (2002); Spyksma (2018)
	Blue-eyed triplefin	*Notoclinops segmentatus*	Reef, outer harbour	Brook (2002)
	Longfinned triplefin	*Ruanoho decemdigitatus*	Reef, outer harbour	Brook (2002)
	Spectacled triplefin	*Ruanoho whero*	Reef, revetments, outer harbour	Brook (2002); Spyksma (2018)
Blenniidae	Crested blenny	*Parablennius laticlavius*	Reef, outer harbour	Brook (2002)
Gobiidae	Bridled goby*	*Arenipobius bifrenatus*	Shallows, soft sediment, upper harbour	Morrison (2003)
	Exquisite goby	*Favonigobius exquisitus*	Shallows, soft sediment, mainly upper and mid harbour	Morrison (2003); Parsons *et al.* (2016)
	Sand goby	*Favonigobius lentiginosus*	Shallows, soft sediment, mainly mid and outer harbour	Morrison (2003)
Pleuronectidae	Speckled sole	*Peltorhamphus latus*	Shallows, soft sediment, whole harbour	Morrison (2003)
	Yellow-belly flounder	*Rhombosolea leporina*	Shallows and channels, soft sediment, upper and mid harbour	Mason and Ritchie (1979); Morrison (2003)
	Sand flounder	*Rhombosolea plebia*	Shallows and channels, soft sediment, whole harbour	Mason and Ritchie (1979); Morrison (2003)
Monacanthidae	Leatherjacket	*Parika scaber*	Soft sediment and reef, mid to outer harbour	Brook (2002); Parsons *et al.* (2016)

* Introduced species

5.4 ADDITIONAL DATA GATHERING AND ANALYSIS

Additional information on marine communities and habitats around Northport was obtained to fill specific knowledge gaps, or update and expand the coverage of existing information. This included:

- Obtaining updated and expanded information on shellfish abundance, size and distribution in Marsden Bay.
- Obtaining updated and expanded information on infaunal macroinvertebrates in Marsden Bay to:
    - support the assessment of effects on avifauna,
    - support an assessment of the effects of constructing a proposed bird roost on intertidal ecology; and,
    - to expand the coverage of existing datasets;
- Obtaining new information on subtidal epibenthic communities around Northport to fill a knowledge gap.

5.4.1 RAPID INTERTIDAL SURVEY OF SHELLFISH IN MARSDEN BAY

Updated information on the presence and extent of edible shellfish on the intertidal sandflats of Marsden Bay was obtained through:

- A rapid qualitative survey of the intertidal area west of the Marsden Cove access channel, and on the eastern side of Northport.
- A quantitative survey of pipi and cockle numbers between Northport and the Marsden Cove access channel, where previous survey results suggested a significant juvenile pipi bed was located.

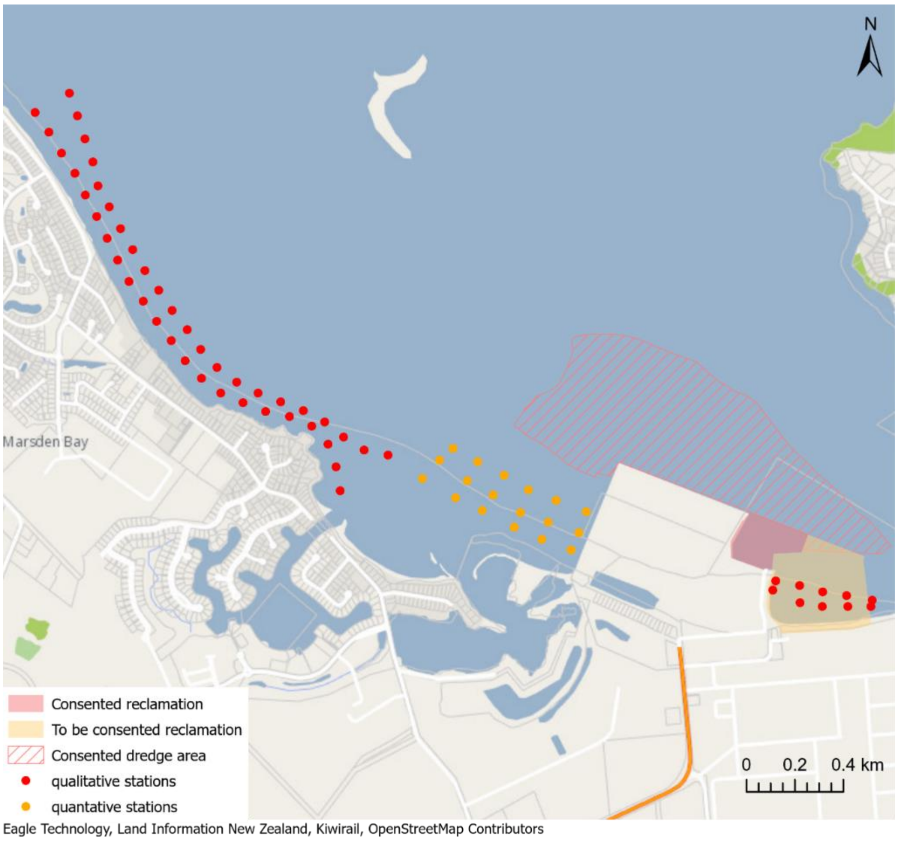
The surveys were conducted on the 8 November 2021.

5.4.1.1 METHODS

For the rapid qualitative survey, the areas west of the Marsden Cove access channel and on the eastern side of Northport were walked over at low tide. Fifty-four stations on the mid and lower intertidal zone were examined for cockles and pipis, and their abundance was ranked from 0 (absent) to 5 (very high). Notes were made on the presence of seagrass, macroalgae, and other notable features (Figure 35).

For the quantitative survey of pipi and cockle numbers, a further 18 stations between Northport and the Marsden Cove access channel were sampled using a 13 cm diameter corer (Figure 35). Samples were sieved using a 4 mm sieve and the number of pipis and cockles present were counted. Pipi lengths were also measured.

Figure 35. Location of the qualitative and quantitative intertidal survey stations sampled in November 2021.



5.4.1.2 RESULTS

Moderate to very high abundances of cockles were observed on the mid shore across the entire length of Marsden Bay, with the highest densities found near the entrance to Marsden Cove Marina (Figure 36). Almost all the cockles found were below 'harvestable' size. Quantitative sampling conducted around Northport found that 9/12 stations on the mid to lower shore west of Northport contained more than 100 cockles/m^2.

The intertidal survey of Marsden Bay found very few pipi were present along the bay. A small bed of juvenile pipi exists up to 300 m west of Northport in the mid shore zone, with mean densities of around 300/m^2 within this 300 m band (Figure 37). All pipis found were less than 35 mm in length. No pipi were found east of Northport.

Seagrass was recorded at most low-shore stations west of the Marsden Cove access channel and at some low-shore stations within the proposed reclamation area on the eastern side of Northport. Few of the mid-shore stations contained seagrass (Figure 38).

Figure 36. Abundance of cockles in Marsden Bay found in the qualitative and quantitative intertidal surveys conducted in November 2021.

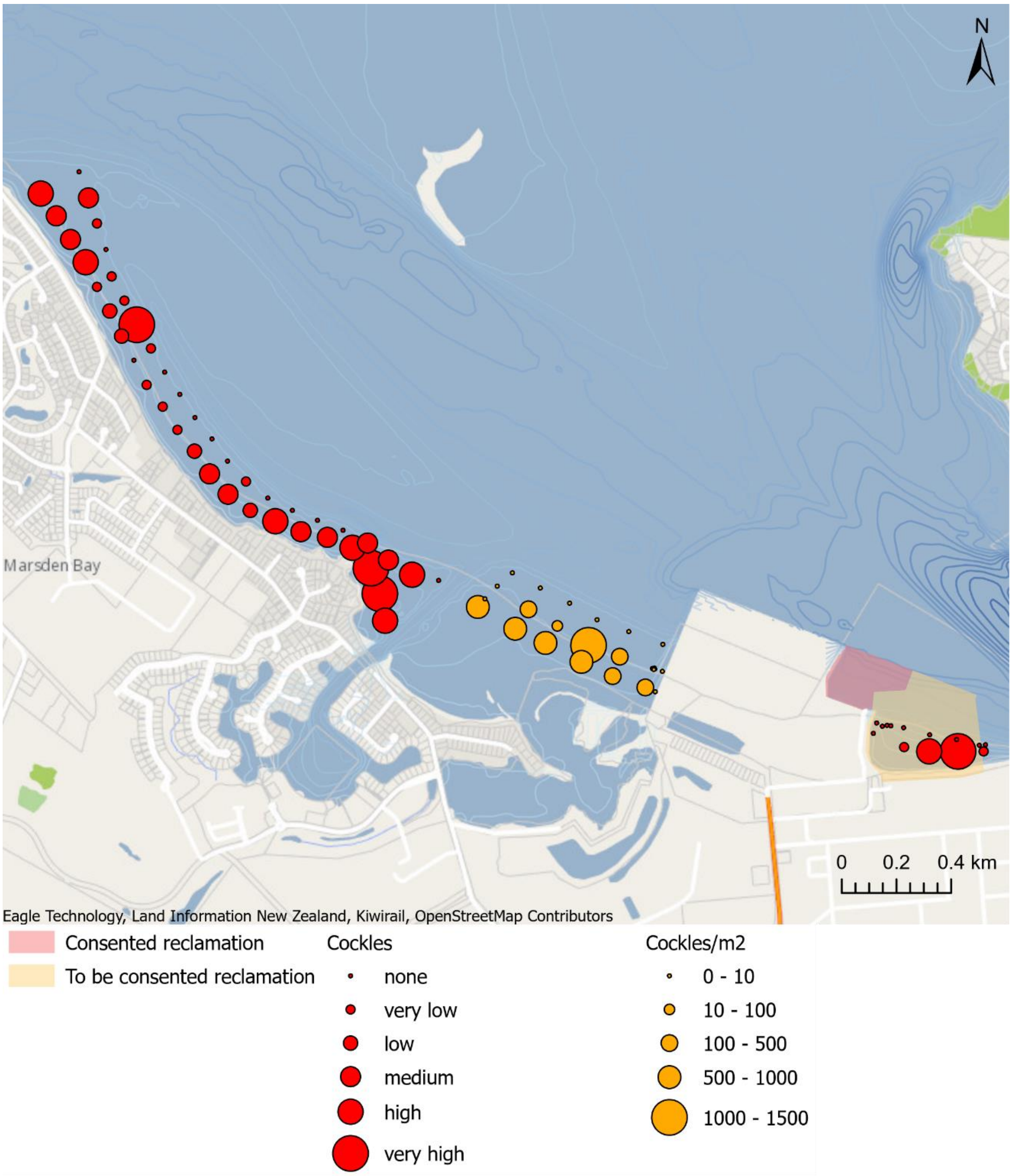


Figure 37. Abundance of pipis in Marsden Bay found in the qualitative and quantitative intertidal surveys conducted in November 2021.

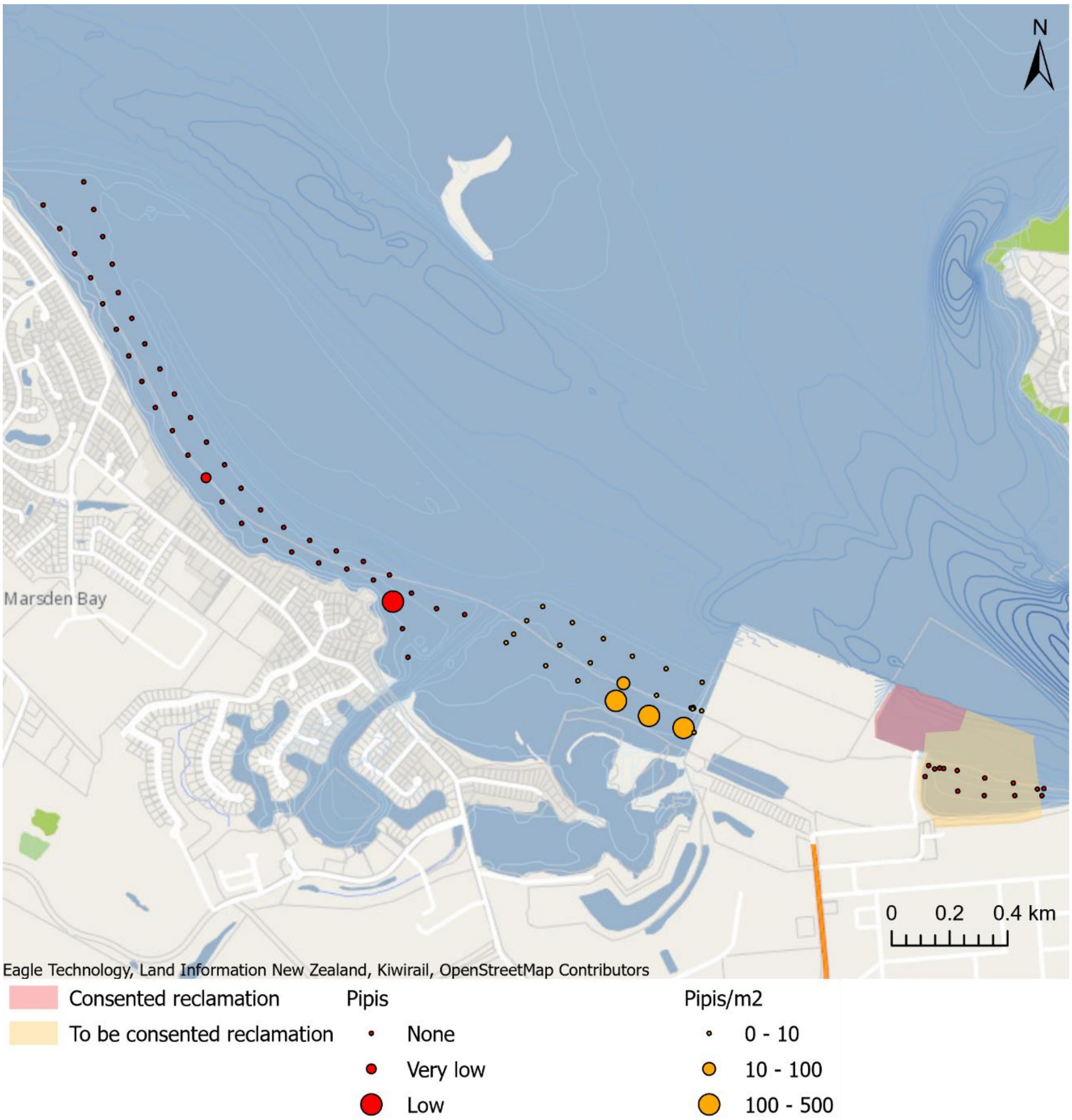


Figure 38. Presence of seagrass found during the intertidal survey conducted in November 2021.

5.4.2 QUANTITATIVE SURVEY OF THE DISTRIBUTION OF INTERTIDAL MACROINVERTEBRATE INFAUNA IN MARSDEN BAY

5.4.2.1 METHODS

Benthic ecological samples were collected from the area between One Tree Point and the Channel Infrastructure (Marsden Refinery) wharf using a stratified random design, with sampling effort based on the size of the following intertidal zones (Figure 39):

- One Tree Point to the Marsden Cove Channel (One tree Point and Channel west in Figure 39);
- Marsden Cove Channel to Northport (Channel east and Northport west in Figure 39);
- the proposed reclamation area;

- the area between the proposed reclamation area and the Channel Infrastructure wharf (Reclamation east in Figure 39).

Eighty samples were initially allocated across these zones, with three additional samples being allocated to the area between the proposed reclamation area and the Channel Infrastructure wharf to achieve a minimum number of five samples per zone (total n = 83).

Sampling was carried out between 13 and 14 June 2022, near a low spring tide. At each sampling station, a single 13 cm diameter × 15 cm deep core was obtained, sieved to 0.5 mm, preserved in isopropyl alcohol (IPA), and sent to an experienced taxonomist for sorting, identification, and enumeration.

Total numbers of taxa and total counts of individuals were determined for each sampling station and the results mapped in GIS using a combination of point and interpolated heat maps produced through Kriging. Clusters with similar macroinvertebrate communities were also identified using multivariate analyses (see below) and differences in numbers of taxa and individuals among those clusters were also examined using univariate plots and one-way ANOVA in Statistica (v12).

Non-metric multidimensional scaling (MDS) agglomerative hierarchical and non-hierarchical (kRCluster) cluster analyses, similarity profile tests (SIMPROF) and analysis of similarities (ANOSIM), and analysis of similarity percentages (SIMPER) were used to examine variation in overall community composition and to identify the key taxa involved in determining overall spatial patterns (using Primer-E ver.7). Count data were square root transformed prior to analysis with the analyses based on Bray Curtis similarities.

Note that each point in the MDS plots represented the macrofaunal community at one sampling station and that communities represented by points plotted close together are more similar than communities represented by points further apart.

Figure 39. Stations sampled in the July 2022 quantitative survey of benthic macrofauna in Marsden Bay.

5.4.2.2 RESULTS

Ninety-seven taxa and 10,952 individual macroinvertebrate specimens were obtained from the 83 Marsden Bay core samples. Bubble plots and heat maps of taxa numbers and individual counts (Figure 40) show that the diversity and abundance of macroinvertebrates varied across the survey area with marked differences apparent between intertidal sites on the western and eastern side of Northport. Numbers of taxa in core samples was uniformly high on the western side of the port compared to the eastern side. Numbers of individuals were also higher on the western side but counts varied along the shore.

Similarly, total counts of specimens from major taxa groups displayed substantial variation across the survey area, with stations on the eastern half, and east of the proposed reclamation areas tending to have relatively low counts (Figure 40). Multidimensional scaling and agglomerative hierarchical cluster analysis with similarity profile tests identified 13 statistically significant clusters that displayed variation along and down the shore (Figure 42). Community composition in core samples taken from the eastern side of Northport varied and became more dissimilar from the communities obtained from western cores towards the east.

Four broader groupings[20] were determined using non-hierarchical kR-clustering (Figure 43):

1. Communities in upper to mid-shore stations on both sides of Northport (Cluster A).
2. Communities in stations associated with raised sand/shell ridges on both sides of Northport (Cluster B).
3. Communities in easternmost stations (Cluster C).
4. Communities in low-shore stations on the western side of Northport (Cluster D).

Analysis of similarities detected statistically significant differences in community composition between all four kR clusters ($P<0.001$).

Differences between the easternmost cluster (Cluster C, which included cores from stations inside the proposed reclamation area and further towards the east), and Clusters A and D were further examined using SIMPER. It showed that 15 taxa were responsible for 70% of the dissimilarity between Clusters A and C, and Clusters C and D (Figure 44). Those differences were due to the smaller numbers of most taxa in Cluster C samples. The exceptions were polychaete worms including *Capitella capitata*, Syllidae, Exogoninae, and amphipod crustaceans from the family Urothoidae. One-way ANOVA and Tukey's honestly significant difference tests showed that the overall number of taxa and individuals[21] varied significantly among all clusters ($P<0.01$), with the Cluster C sites having lowest values for both indicators (Figure 45). While not specifically tested, the presence of seagrass appeared to have little effect on overall community composition (Figure 42 and Figure 43).

Cockles were common throughout most of the survey area but were not obtained from cores east of the proposed reclamation area (Figure 46). Small pipi were also common, but numbers were generally low. High mean counts of pipi ≤5 mm in size were obtained from the proposed reclamation area, but numbers were patchy (Figure 46). The high mean value for ≤5 mm pipi was driven by two of the seven stations in the proposed reclamation area having counts of 16 and 18 pipi, with the remaining stations having counts of 0 to 3 pipi.

[20] Other grouping numbers were examined, but four clusters appeared to provide the best discrimination between down-shore and long-shore habitats, noting that additional variation is nested within each cluster.

[21] Data were $\log_{10}+1$ transformed prior to analysis to meet assumptions of normality and equal variance.

Figure 40: Bubble plots and interpolated (by Kriging) heat maps of: A. the number of macroinvertebrate taxa and B. total counts of all macrofauna obtained from core samples in Marsden Bay.

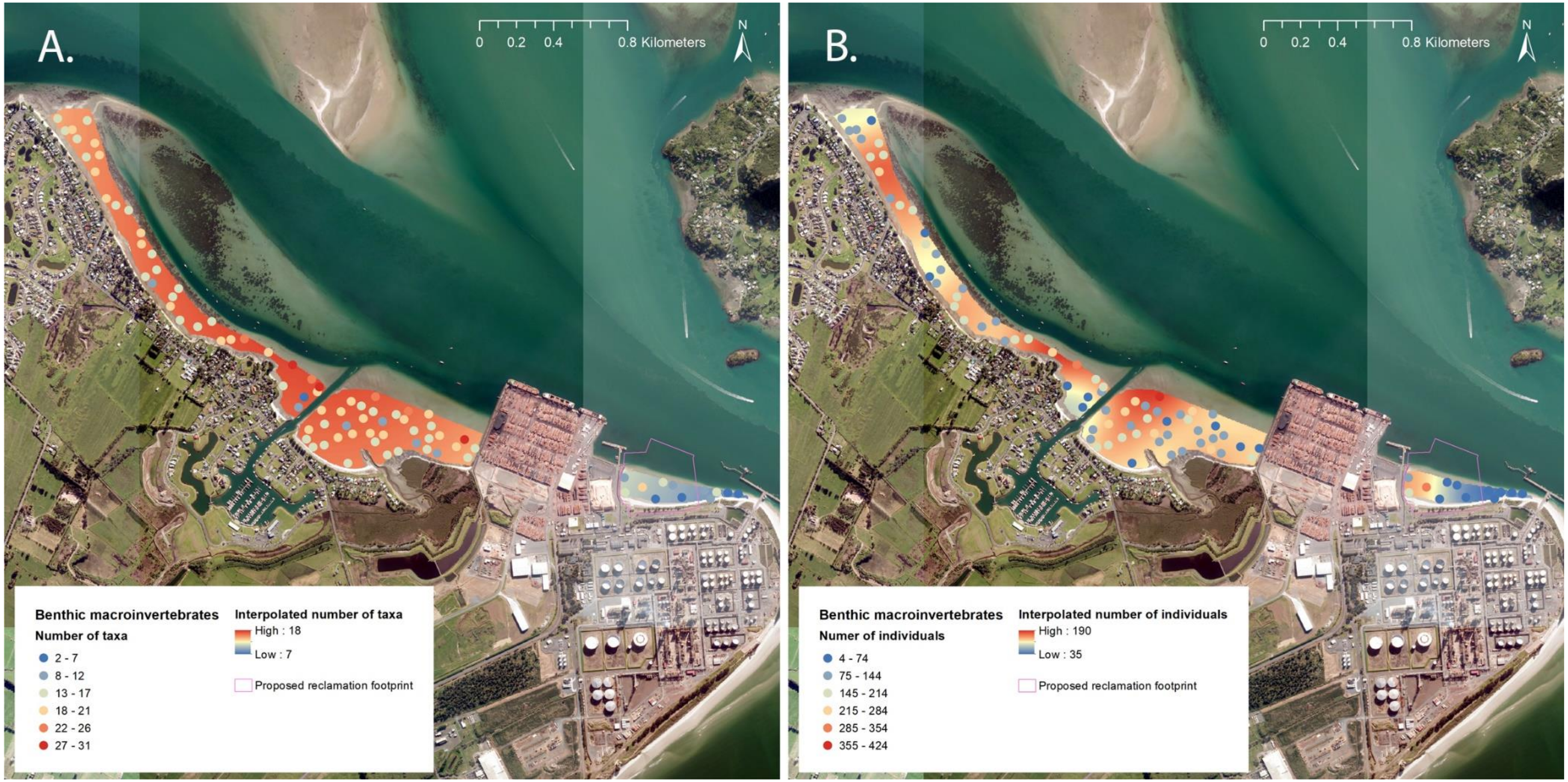


Figure 41: Heat maps showing spatial variation in total counts of specimens from six taxa groups: A. bivalves, B. gastropods, C. isopods, D. amphipods, E. cumaceans, and F. polychaete worms.

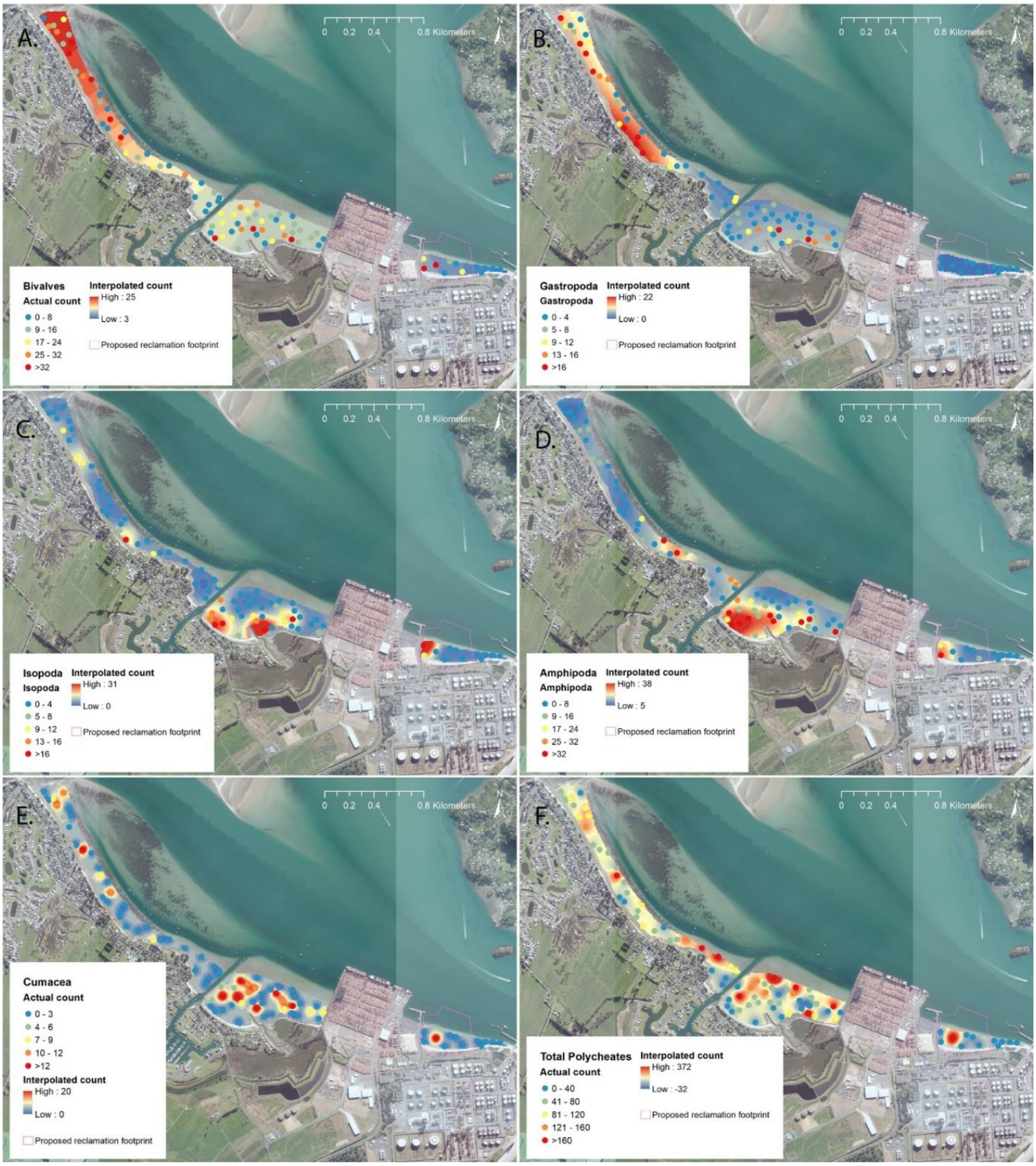


Figure 42: Multidimensional scaling plot and map showing macroinvertebrate community clusters identified using agglomerative hierarchical cluster analysis and similarity profile testing. Stations containing seagrass are highlighted by red squares in the map.

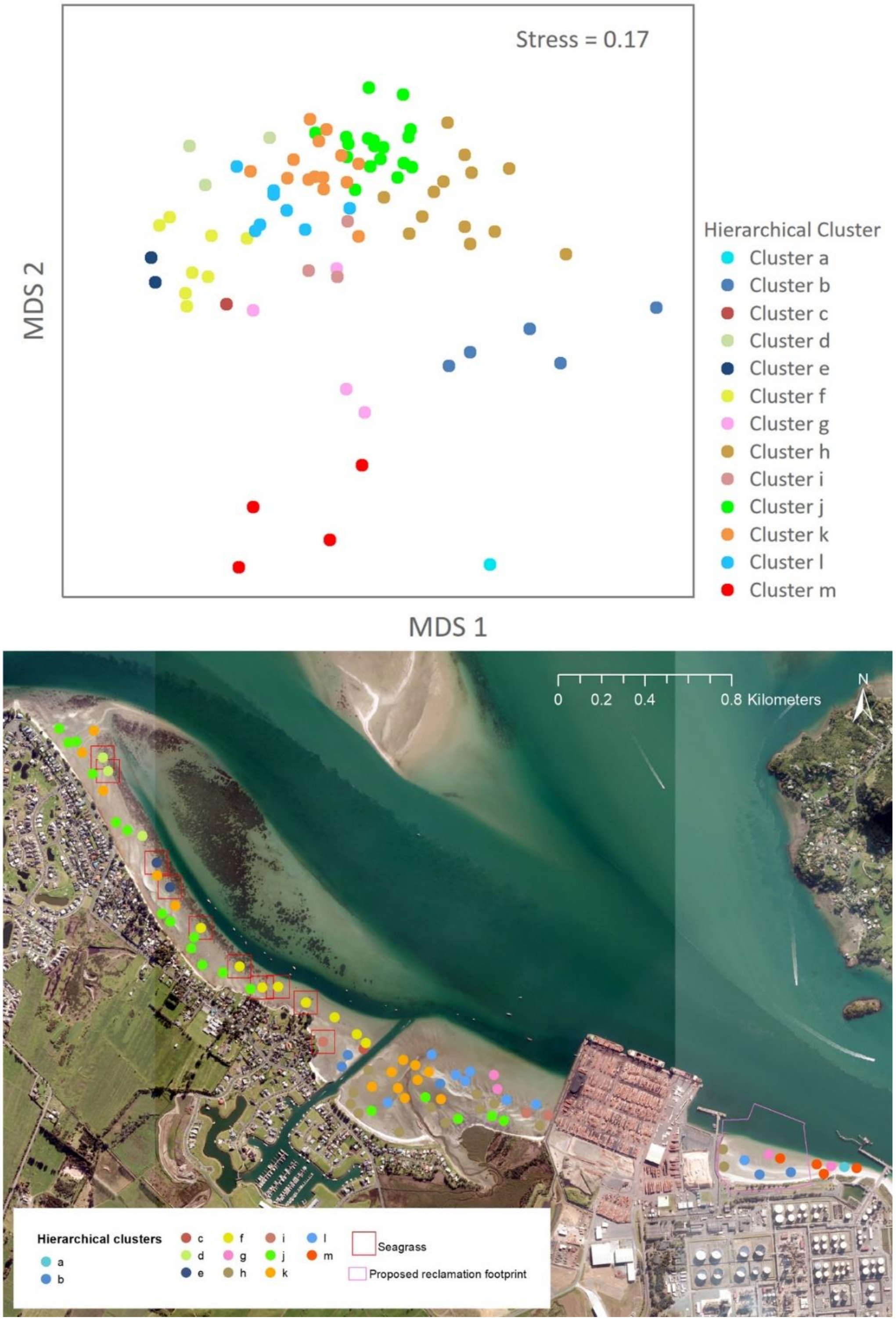


Figure 43: Multidimensional scaling plot and map showing macroinvertebrate community clusters identified using non- agglomerative kR Clustering with 4 groups specified. Stations containing seagrass are highlighted by red squares in the map.

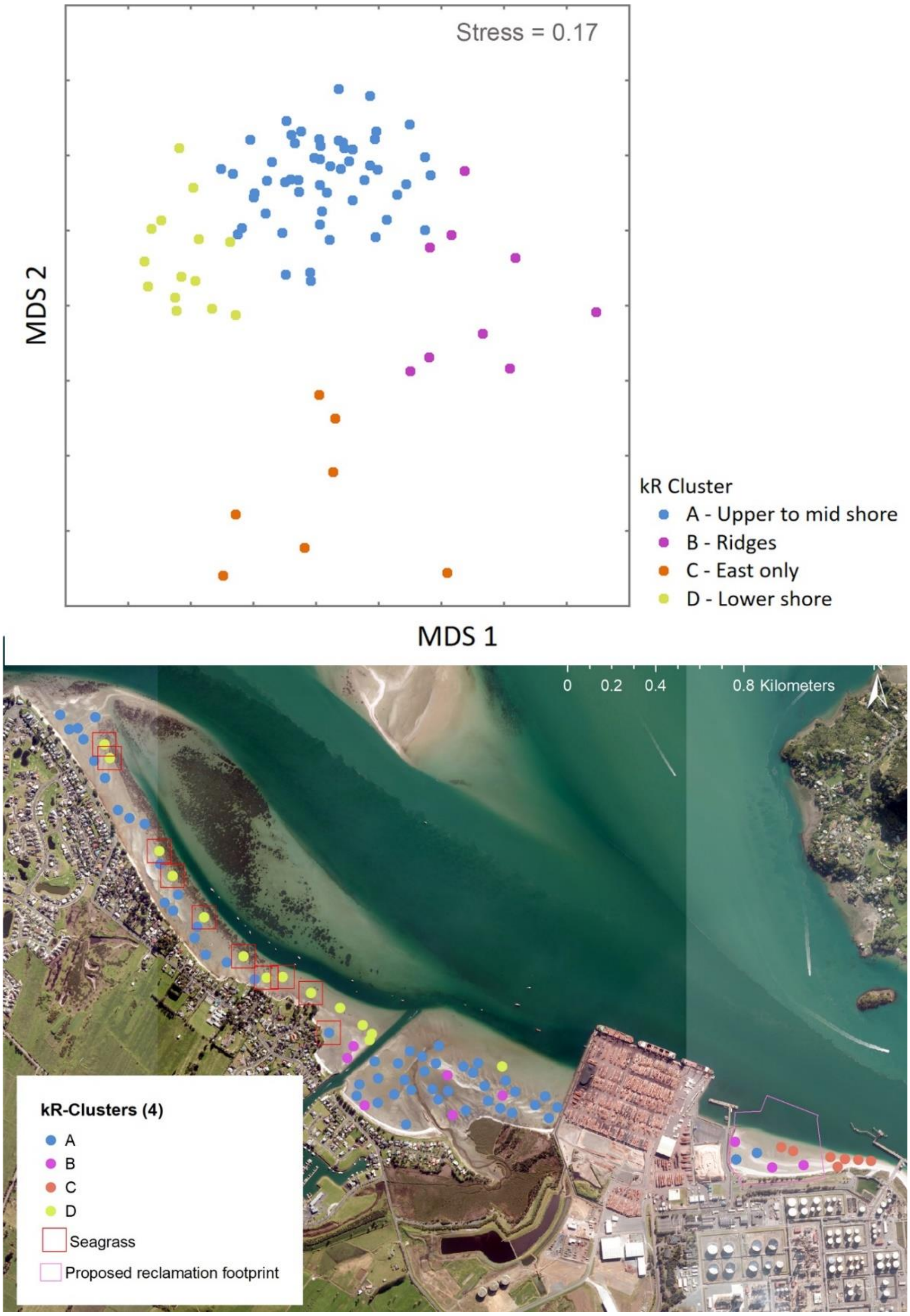
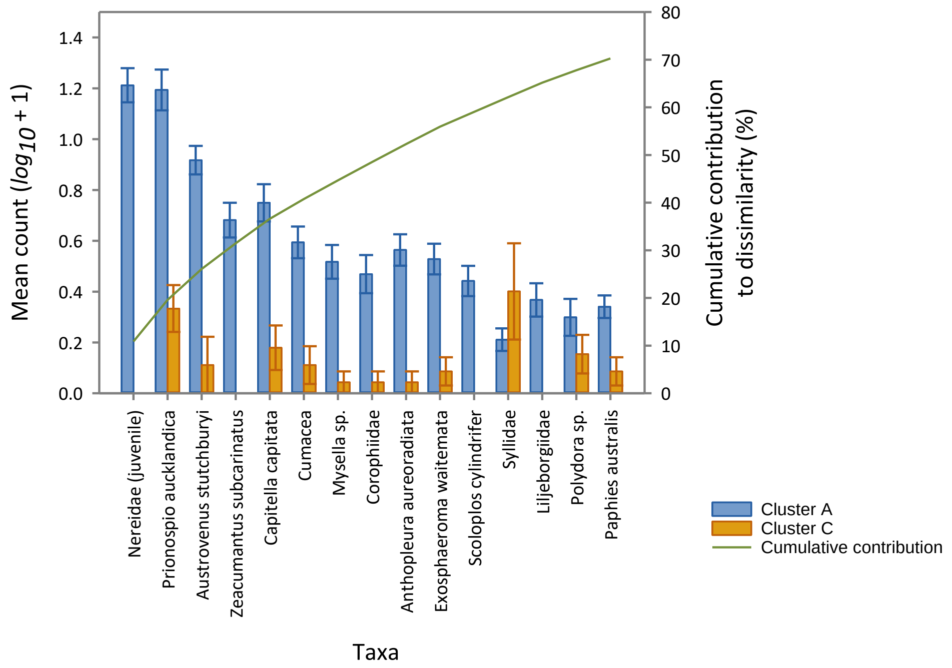


Figure 44: Differences in mean (± S.E.) counts of the 15 taxa (respectively) responsible for 70% of the dissimilarity between A) Clusters A and C; and B) Clusters C and D.



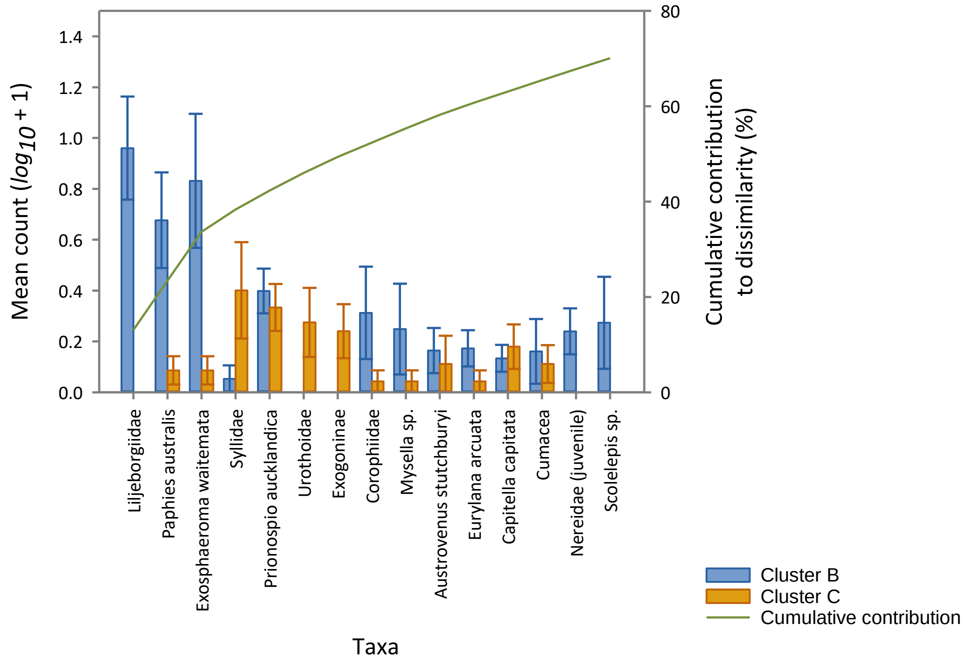


Figure 45: Plots of mean (± 95% C.I.) numbers of A. individuals and B. taxa in samples within Clusters A to D.

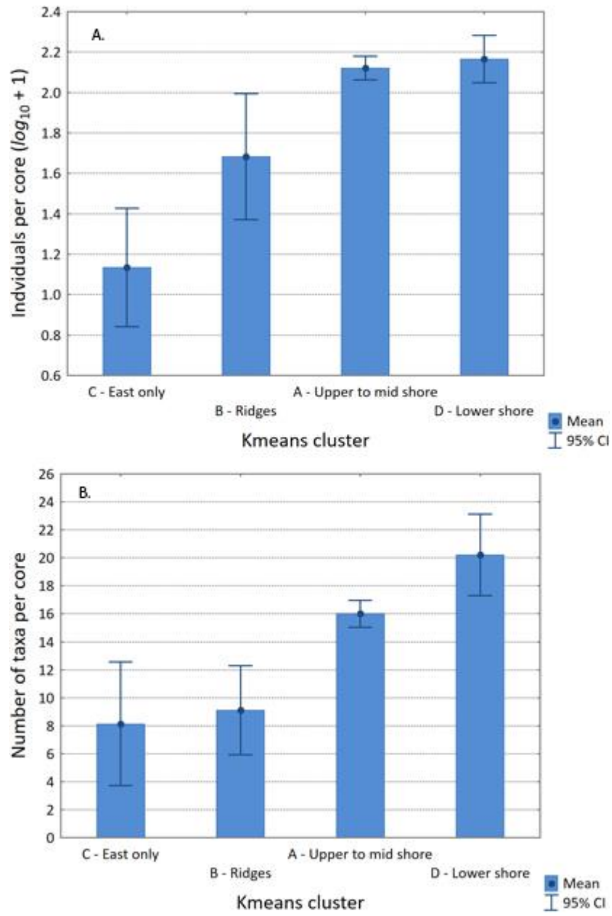


Figure 46: Variation in the abundance and size distributions of a. cockles and b. pipi in areas along Marsden Bay (see Figure 39 for the extents of each area).

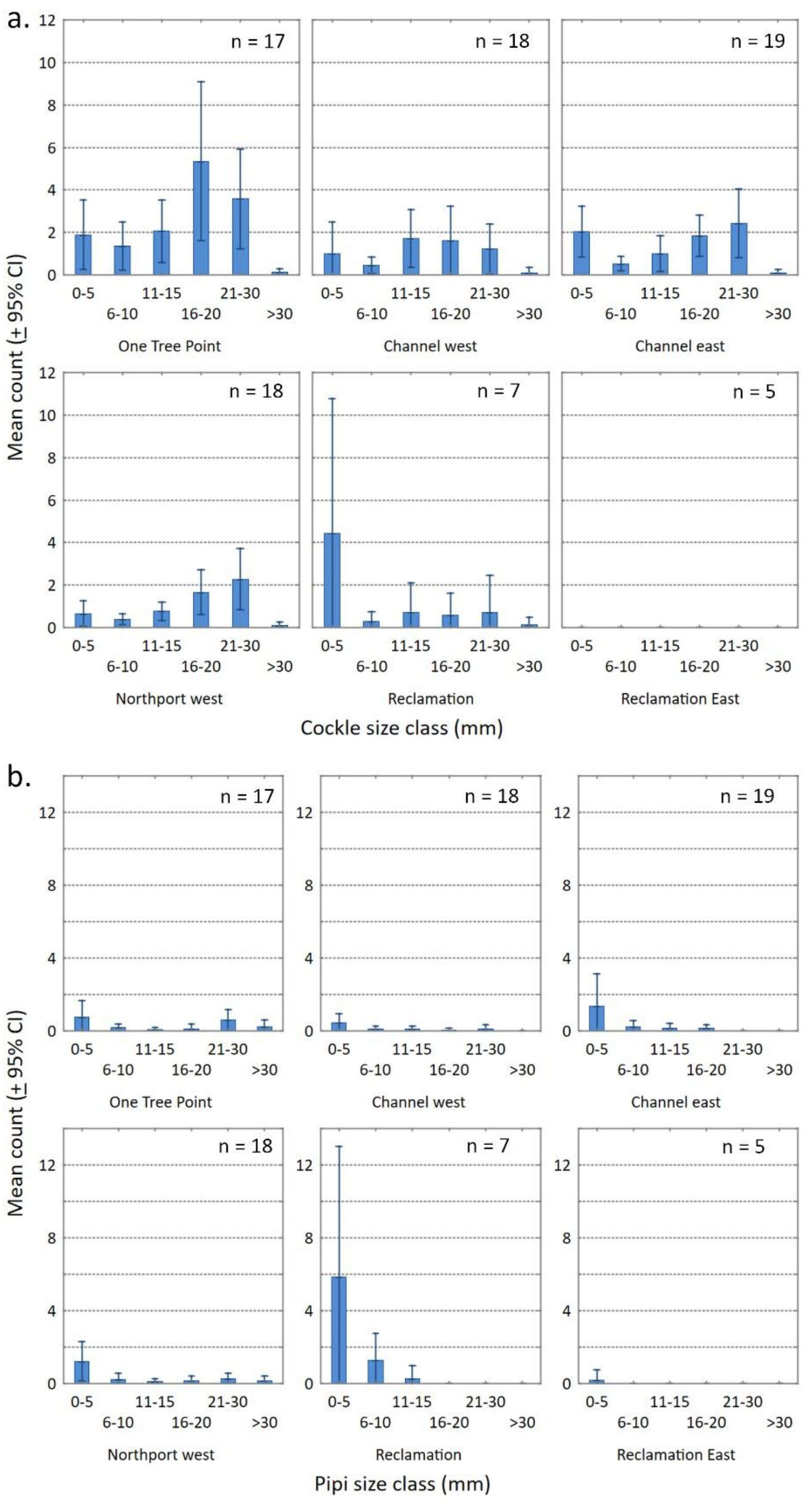
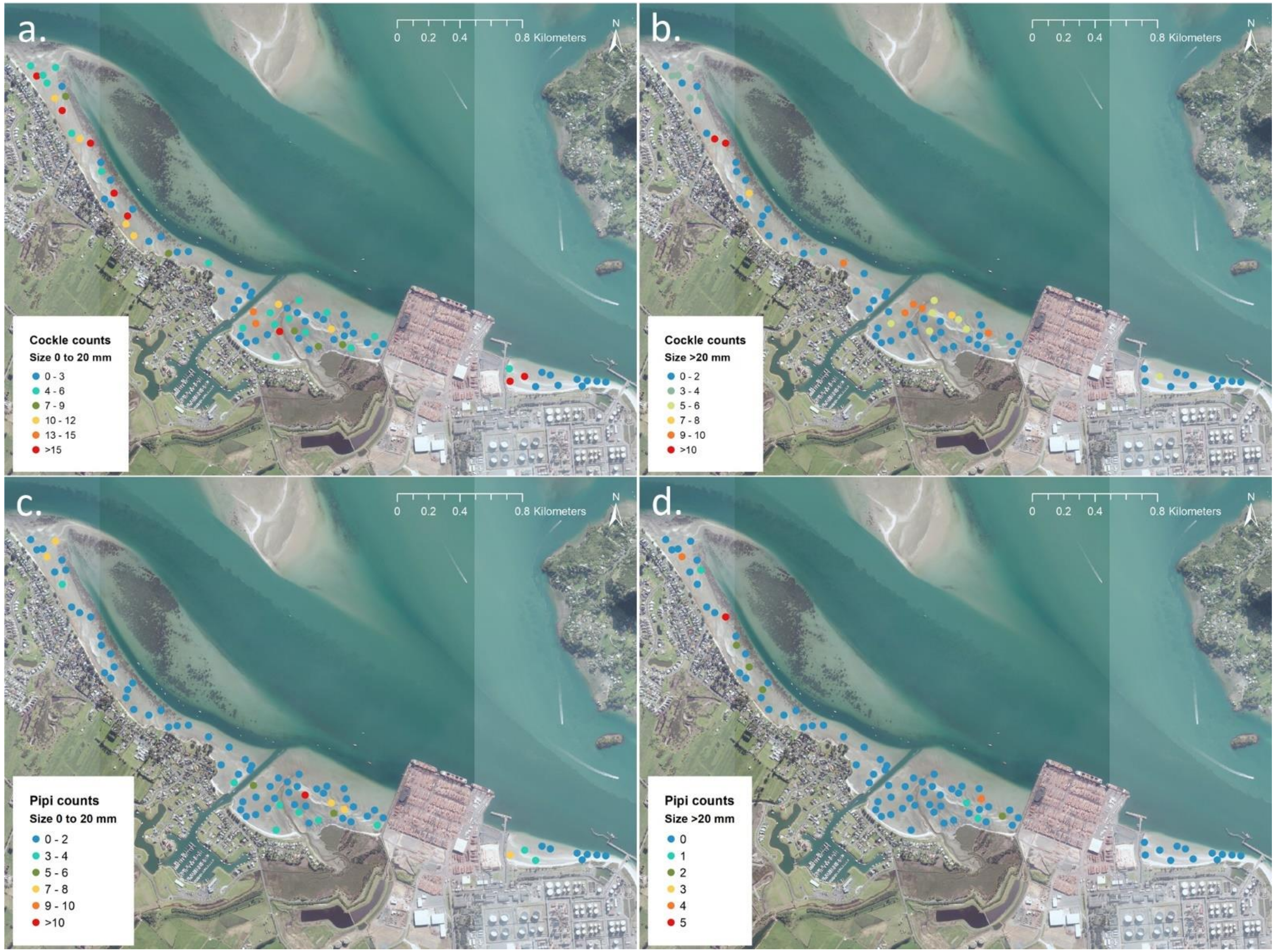


Figure 47: Variation in the abundance of a. cockles 0 to 20 mm in size, b. cockles > 20 mm in size, c. pipi 0 to 20 mm in size, and d. pipi > 20 mm in size.



5.4.3 SUBTIDAL EPIBENTHIC VIDEO SURVEY

5.4.3.1.1 METHODS

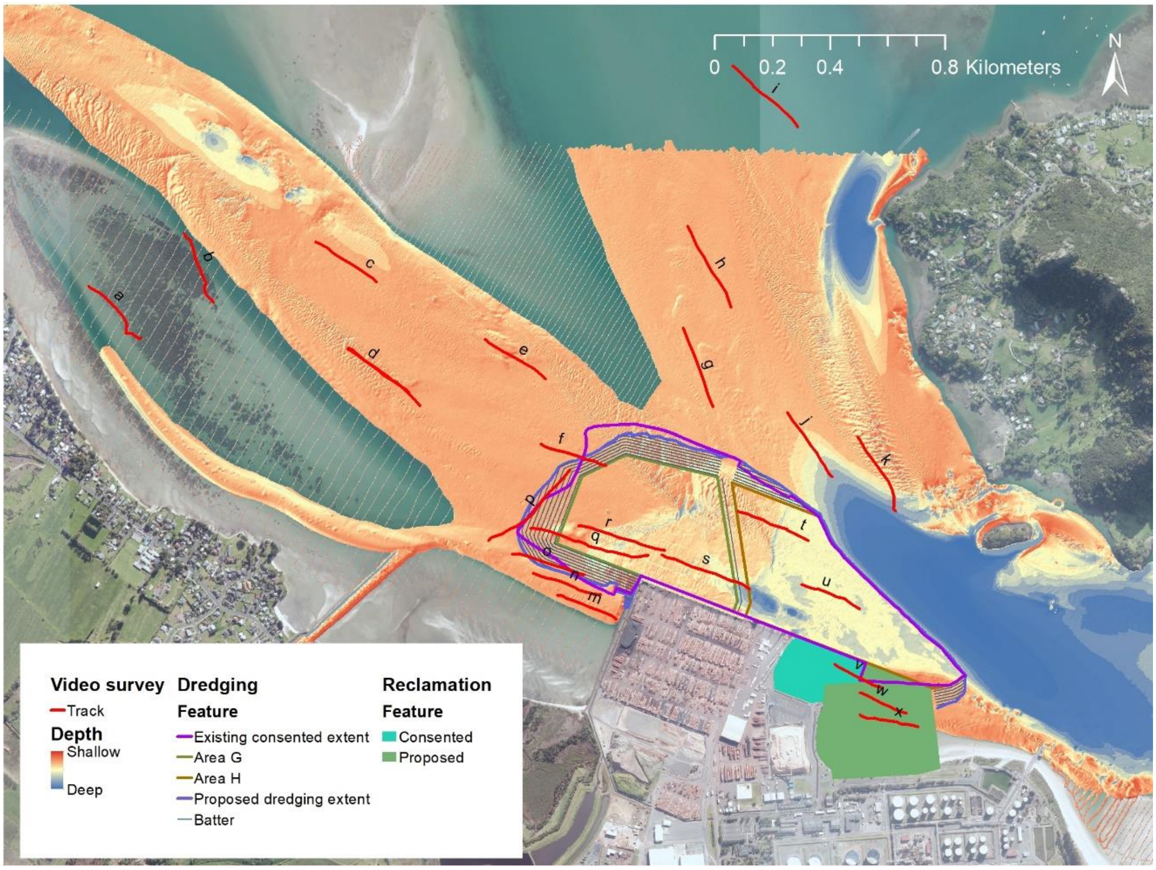
Video transects were recorded using a surface-fed camera and Blackmagic Video Assist 3G recorder with embedded GPS coordinates. A Hero 6 Go-pro camera was also used as a back-up video system and to provide complimentary footage from a different perspective and field of view.

Video transects (Figure 48) were approximately 200 m long and included:

- 2 transects from within the consented and partially dredged area;
- 3 transects from the fully dredged area;
- 4 transects from the western side of Northport;
- 3 transects from the proposed reclamation area;
- 9 transects from channel reference areas;
- 2 transects from subtidal areas that aerial photographs suggested contained seagrass beds (Figure 18).

Video footage was analysed by playing it in a darkened room and noting the occurrence of substrate changes, biogenic habitat, or large emergent benthic species. Images of the key features observed in the transects were saved from video frames (stills).

Figure 48: Video transect run lines overlaid on an image of channel bathymetry (provided by Northport), consented dredging area, and proposed dredging area as modelled by MetOcean.



5.4.3.1.2 RESULTS

Video footage indicated that the ecological values of subtidal seabed habitats and communities around Northport were generally high, and largely consisted of patchy and/or contiguous sand and biogenic features including:

- extensive areas of shell;
- macroalgae meadows;
- areas that are almost completely covered with a variety of sessile organisms including macroalgae, sponges, bryozoans, hydroids and other invertebrates;
- numerous small holes in sediments, which are likely to be worm tubes, shellfish siphons, and/or crustacean burrows.

Large biota observed included the starfish (mainly *Astropecten polyacanthus*), horse mussels, scallops, cushion stars (*Patriella regularis*), anemones, horn shells (likely to be *Maoricolpus roseus*), Mediterranean fan worm (*Sabella spallanzanii*), hydroids and bryozoans (Figure 49 to Figure 55).

Considerable variation was observed in the habitats and communities present in areas surveyed. Transects through the proposed reclamation area (Figure 49) displayed clear changes towards the shore, with habitat in the:

- outer transect (v. in Figure 48) consisting of sand with little epibiota;

- central transect (w. in Figure 48) consisting of sand with patches of red algae densely packed with turret shells (possibly dead shells occupied by hermit crabs), scattered starfish (*A. polyacanthus*), algae, sponges, and an octopus den;
- inner transect (x. in Figure 48) consisting of bare sand with numerous cushion stars.

Three inshore transects on the western side of Northport (transects m. to o. in Figure 48) also contained sand, dense patches of red algae (some with dense aggregations of turret shells) scattered sponges, and scattered to moderate densities of starfish. Isolated kelp[22], and scattered patches of low-density seagrass were also present in that area. The outermost transect through the western side (Transect p. in Figure 51) appeared to contain coarser sediments with dense beds of red algae, a bed of large red or brown algae, and sand and shell gravel with numerous small holes likely to be formed by worm tubes, shellfish siphons, and/or crustacean burrows.

Clear transitions were also observed along two transects that were run through the consented but undredged area, down a dredge batter slope and out onto the seafloor of the previously dredged area (Transects q. and r. in Figure 48). The consented but undredged area contained a mix of sand and shell gravel, with scattered algae, and a variety of other species including occasional scallops, starfish, sponges, anemones, and octopus (as indicated by a den, Figure 51). The batter slope consisted of bare sand, while the seafloor of the previously dredged area was almost completely covered with a variety of sessile organisms including sponges, bryozoans, hydroids and macroalgae (Figure 52). Other parts of the previously dredged area (Transects s. to u. in Figure 48) contained a mix of sand, scattered and dense shell, and biogenic species such as scattered algae and sponges (Figure 53).

Surrounding reference areas (Figure 54 and Figure 55) also contained a mix of sand and shell gravel habitats with scattered to dense algae beds and localised areas containing sparse seagrass. Notable features that were not observed in the areas previously described above were:

- reasonably high numbers of horse mussels at the eastern end of Transect c.
- a high diversity and abundance of algae in Transect i, together with relatively high numbers of bushy hydroids;
- patches with high densities of anemones in Transect e.

Drop camera surveys carried out for Channel Infrastructure have also found that sites east of the survey area contain a mix of sand and shell gravel (Kerr & Grace, 2016; West & Don, 2016), with scallops, octopus, 11-armed starfish, macroalgae meadows with turret shells (referred to as algae turf) being reported. However, macroalgae meadows did not appear to be as common a feature. That may be an artifact of the sampling methods used, with the photographs taken only covering small areas of the seabed.

[22] Dense kelp and isolated Mediterranean fan worms were observed along the revetment.

Figure 49. Video stills taken from within the proposed reclamation area: A. Sand with abundant holes caused by an unknown animal in the outer transect (v. in Figure 48). B. Comb star (*Astropecten polyacanthus*, white arrow) and ball sponge (blue arrow) in the central transect (w. in Figure 48); C. A very dense aggregation of horn shells (possibly dead *Maoricolpus roseus* shells with hermit crabs) amongst red algae in the central transect; D. The pest, Mediterranean fan worm (*Sabella spallanzanii*) in central transect; E. An octopus den surrounded by empty scallop shells in central transect; F. Cushion stars (*Patiriella regularis*) in the inshore transect (x. in Figure 48).

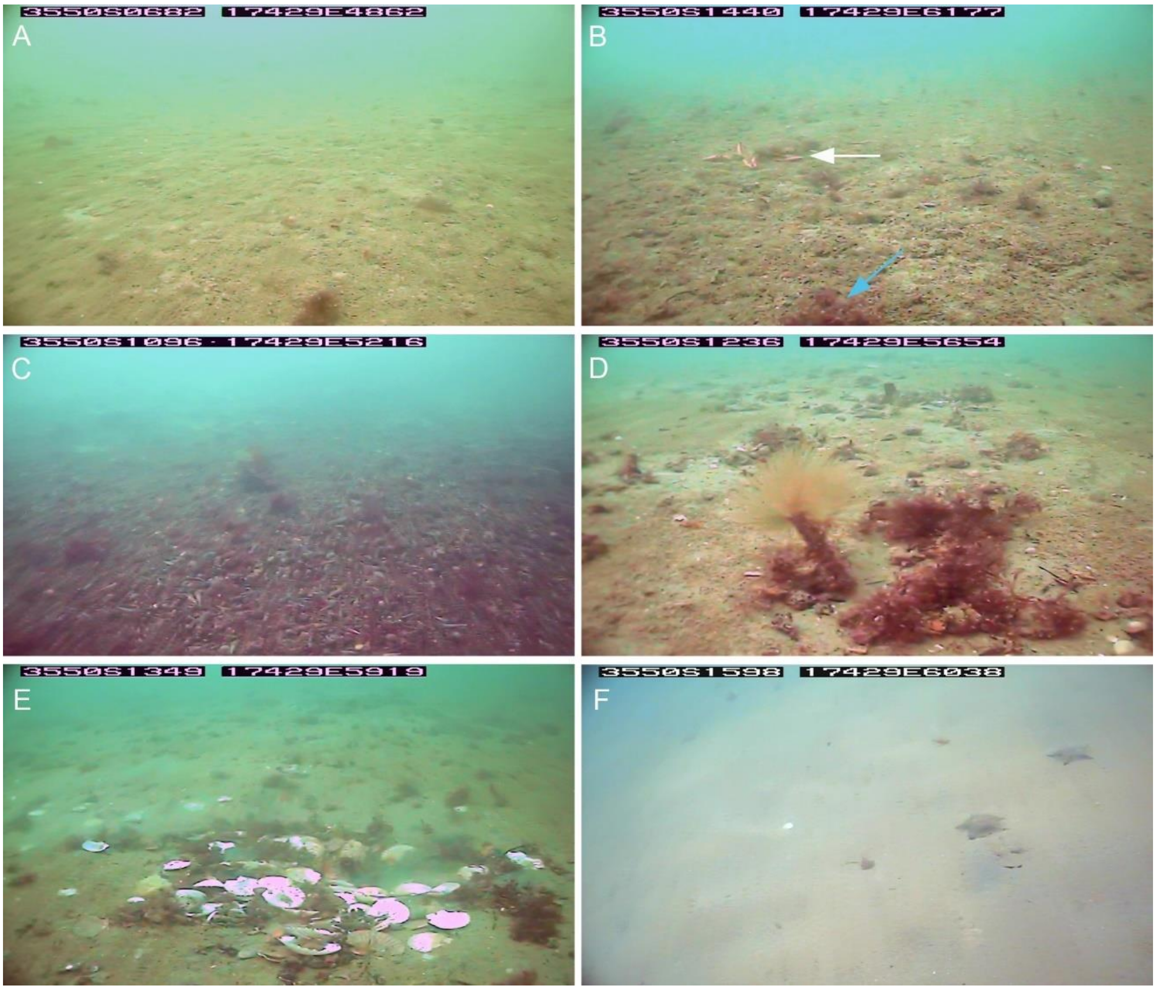


Figure 50. Video stills taken from west of Northport (Transects m to o in Figure 48): A. Patch of sparsely distributed seagrass; B. A comb star amidst a dense patch of red macroalgae; C. Several comb stars on sand; D. A bed of red macroalgae with a high density of turret shells; E. Worm tubes protruding through the surface; F. Macroalgae and a Mediterranean fan worm (arrow) growing on the rock revetment.

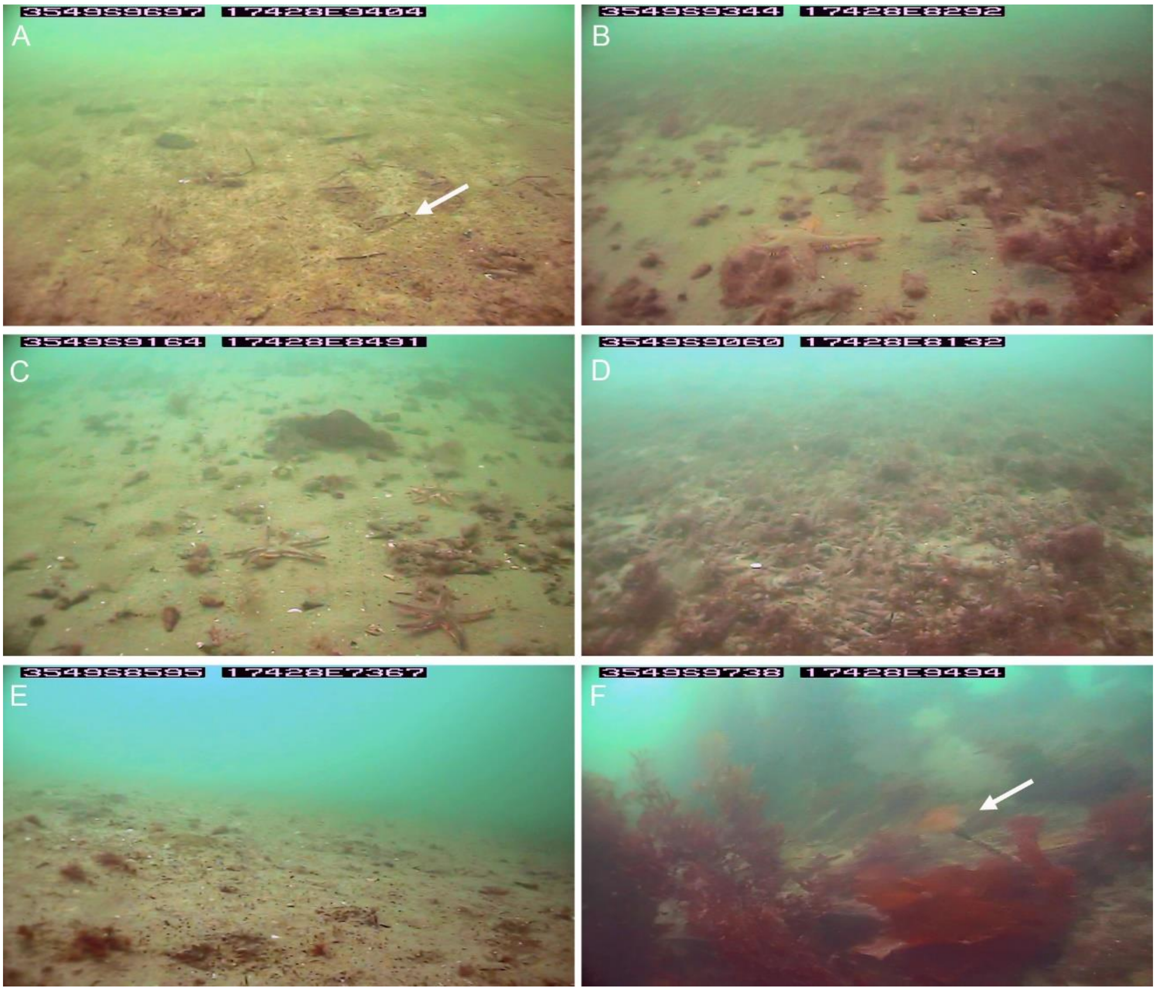


Figure 51. Video stills taken from the proposed batter west of Northport (Transect p. in Figure 48): A. Dense bed of red algae with anemones; B. Bed of scattered, large red or brown algae; C. Shell gravel with numerous tubes or burrows; D. Sand with numerous tubes or burrows and a comb star.

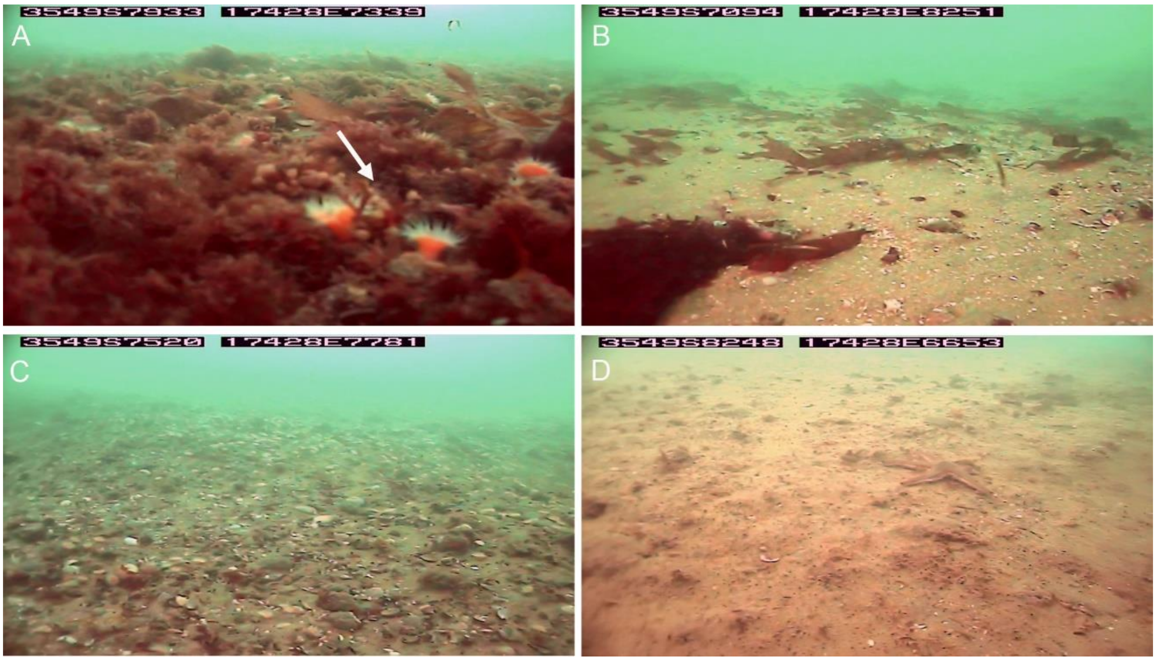


Figure 52. Video stills taken from within the consented dredge area to the northwest of Northport (Transects q & r in Figure 48): A. Sand and shell above the existing batter slope with red algae, an 11-armed starfish (white arrow), small sponge (red arrow) and anemone (green arrow); B. Dense shell with scattered sponges (arrows) above the batter slope; C. Octopus den on sandy habitat with scattered algae above the batter slope; D. Scallops on sandy habitat above the existing batter slope; E. The existing sandy batter slope; F. The boundary between the existing batter slope and the bottom of the dredged basin; G & H. Dense encrusting fauna on dense shell/gravel present at the bottom of the dredged basin.

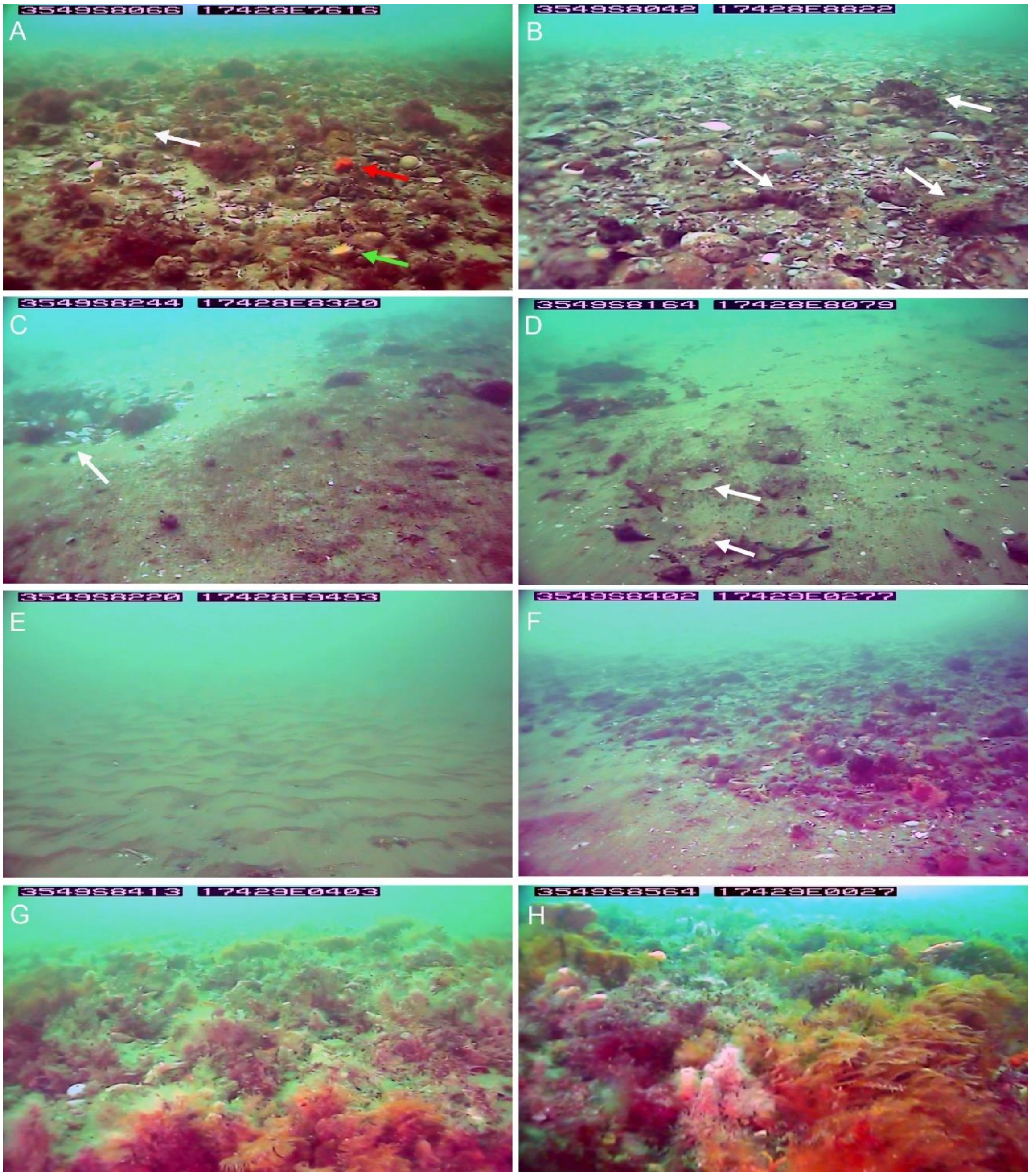


Figure 53. Video stills taken from within the existing dredge area to the north of Northport (Transects s to u in Figure 48): A. Bare sand; B. Sand with scattered shell; C. Dense shell gravel; D–E. Various small sponges; F. A leatherjacket (*Parika scaber*).

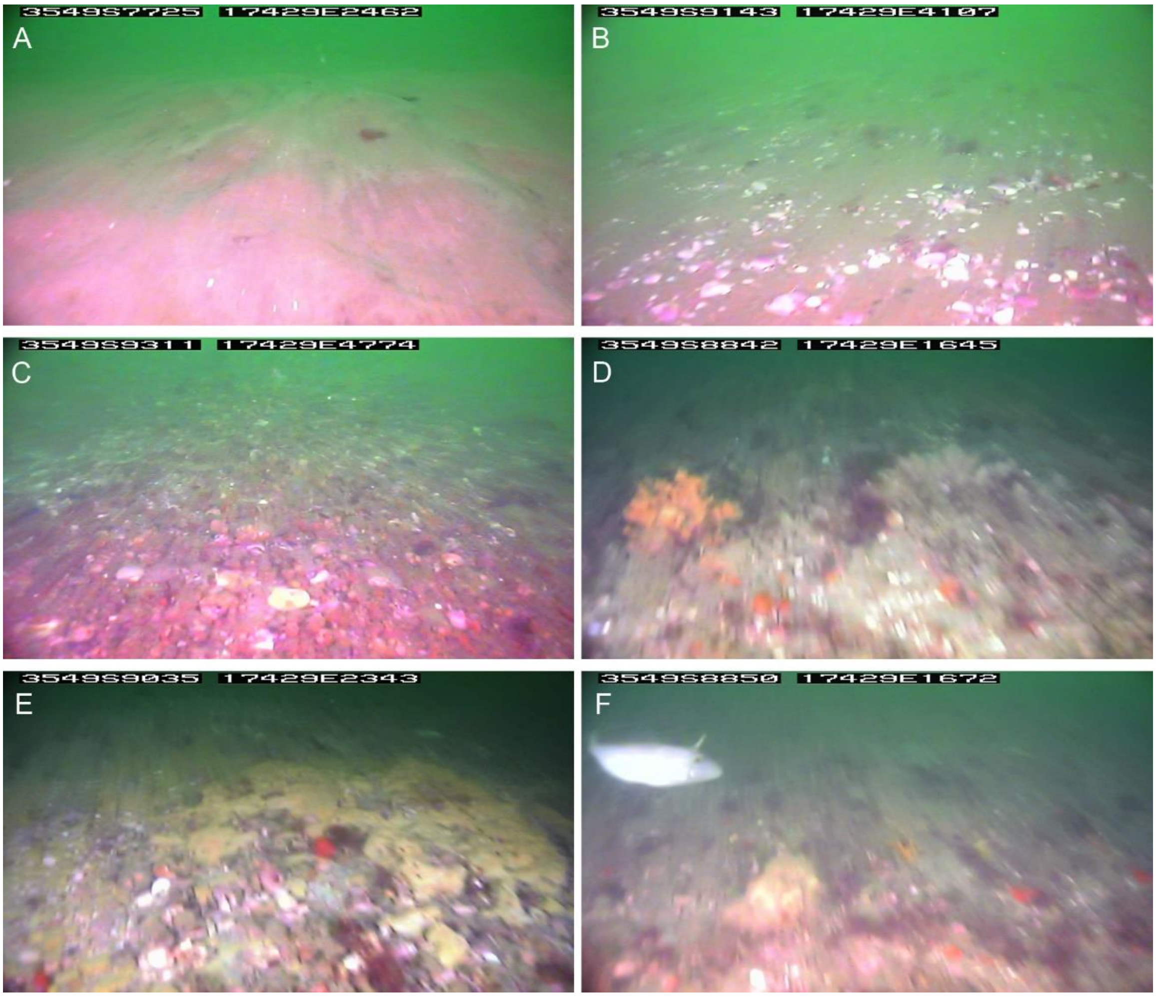


Figure 54. Video stills taken from potential seagrass areas showing sparse seagrass (Transects a & b in Figure 48).

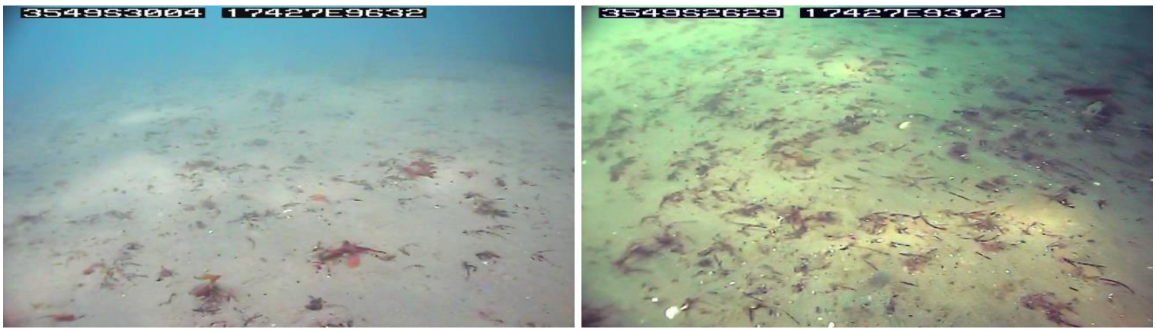
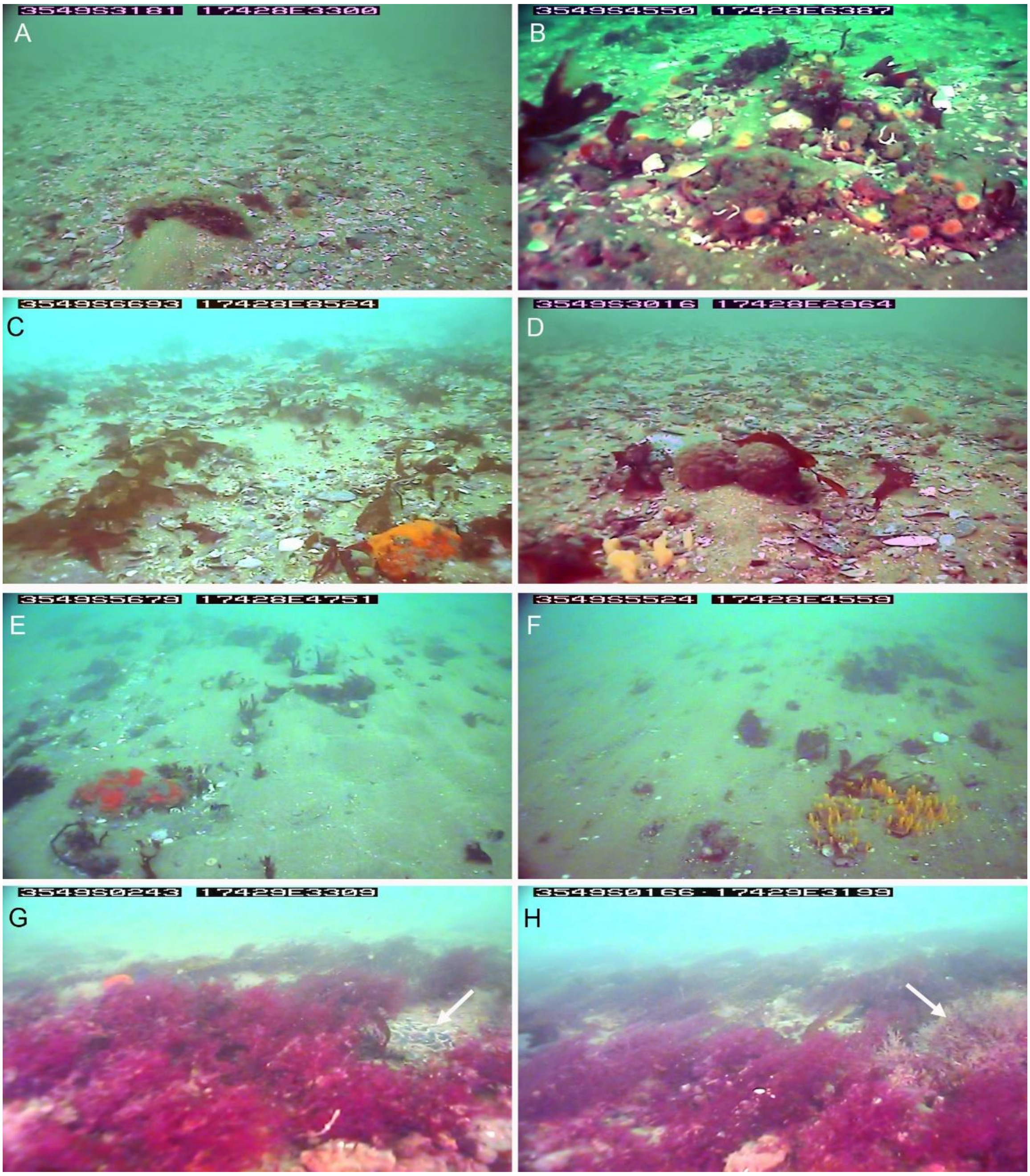


Figure 55. Video stills taken from within the reference areas (Transects c to i in Figure 48): A. Horse mussel (*Atrina zelandica*); B. Anemones growing on small rocks; C–F. Various sponges and macroalgae; G. Dense red macroalgae and a rigid bryozoan (arrow); H. Dense red macroalgae and a bushy hydroid (arrow).



6 ASSESSMENT OF ECOLOGICAL EFFECTS

6.1 THE SYSTEM

Potential effects are assessed using a system-wide approach, which recognises that the scale of effects from the proposed activities is proportional to the size and sensitivity of the area of indigenous biodiversity. The consolidation, review, and analysis of existing information, together with the data gathered through the rapid intertidal and subtidal video surveys, illustrates that the harbour ecological system is made up of at least four distinct zones:

- the outer harbour and entrance including flood and ebb tide deltas, a channel complex, and relatively narrow intertidal sandflats;
- Pārua Bay, on the northern shore of the harbour, which is a largely enclosed, sheltered, depositional inlet;
- the mid-harbour between the shell bank that historically traversed the main channel and Limestone Island, with its broad intertidal and subtidal flats, and channel system;
- the sheltered upper harbour, that splits into Hātea and Mangapai Rivers which narrow upstream and become increasing influenced by freshwater inputs and adjoining landuses.

Northport sits within the outer harbour and entrance zone (OHEZ, Figure 56): a physically complex zone subject to strong currents with around 610 ha above chart datum and 1,970 ha below chart datum. It contains diverse physical habitats, extensive areas of biogenic habitat (including extensive shell gravel beds, seaweed meadows, seagrass beds, sponges, horse mussels, scallops, and significant beds of other shellfish). This is reflected in the high diversity of ecological taxa in that zone. The coastal margin and central area of this zone almost completely consist of SEAs (and a marine reserve), with areas that have not been mapped as SEAs mainly consisting of subtidal channels (see Figure 13). Therefore, the OHEZ is considered to be a discrete and ecologically significant system, against which the scale of effects from the proposed activities are considered (in addition to the harbour scale).[23]

At Tables 2 and 21 the most relevant system/scale for the assessment of each key effect has been identified, along with the corresponding assessment of the level of effect.

[23] For completeness in the assessment of effects that follows effects have been assessed at the footprint scale, notwithstanding that this is not the most relevant scale/context.

Figure 56: Outer harbour and entrance zone defined for this assessment, with areas above (intertidal) and below (subtidal) chart datum overlaid (based on LINZ bathymetry data).

6.2 ASSESSING / RANKING THE SIGNIFICANCE OF EFFECTS

Adverse effects occur along a continuum ranging from no effects on the values of interest to their complete loss. Environmental Institute of Australia and New Zealand (EIANZ) guidelines rank the magnitude of adverse environmental effects for terrestrial and freshwater impacts using five categories (Roper-Lindsay *et al.*, 2018), while Quality Planning guidelines rank adverse effects using six categories, which take into account both the magnitude of effects and their potential to be remedied or mitigated (Quality Planning, 2017). Unlike terrestrial and freshwater ecosystems, few practicable and proven options are available for actively remedying or mitigating most marine impacts. We have therefore adopted the EIANZ guideline terminology for assessing the magnitude of marine effects in this report (Table 7).

The EIANZ guidelines also include criteria for assigning ecological values to terrestrial and freshwater habitats. However, similar guidelines are not provided for marine habitats. Values were therefore assessed using information gathered through the literature review and additional assessments.

In this report a “Low” EIANZ effect is considered to be a “less than minor” effect under the applicable RMA planning/legal framework; and a “Moderate” EIANZ effect is considered to straddle a “minor” and “more than minor” range.

Table 7: Ranking systems developed the EIANZ (Roper-Lindsay *et al.*, 2018) for assessing the magnitude of adverse environmental effects.

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

6.3 RECLAMATION AND DREDGING - GENERAL

Reclamation and dredging have direct and indirect effects on marine biota. They include:

- Loss of marine habitat and biota living within reclamation and dredging footprints, with associated effects on related values, including ecological biodiversity, productivity, and other environmental services.
- Indirect effects arising from alteration to currents, wave and/or sedimentation patterns.
- The effects of sediment suspension, dispersal, and deposition beyond dredged areas.
- Displacement of species that utilise the reclamation areas, but do not permanently live within them.
- Effects associated with hardening the shoreline around reclamations.
- Construction-related effects, associated with establishing temporary staging areas, or having machinery working in the CMA beyond the reclamation footprint. Such effects tend to occur immediately after activity starts and recover relatively quickly after activity ceases. Note that, we understand all physical work will be contained within the reclamation footprint, so in this case, effects beyond that footprint are not expected.

Around 6.6 ha of habitat between mean high-water spring and chart datum and 5.1 ha of habitat below chart datum will be lost beneath the proposed reclamation (excluding already consented areas).

The proposed development also requires capital and associated maintenance dredging to enlarge the existing swing basis and deepen it by around two metres, and to enable construction of the new wharf. This involves around 61 ha of subtidal seabed, most of which is within an area covered by an existing dredging consent. Consequently, a total combined area of around 73 ha will be directly impacted by the proposed reclamation and dredging.

Substrates within the proposed reclamation area consist of open, sandy intertidal and subtidal sediments (see Figure 8 & Figure 49), and a rock revetment running along the eastern edge of the existing hardstand. Open, sandy intertidal sediments are a widespread feature of the central upper, mid and outer harbour, particularly on the southern shore (Figure 6).

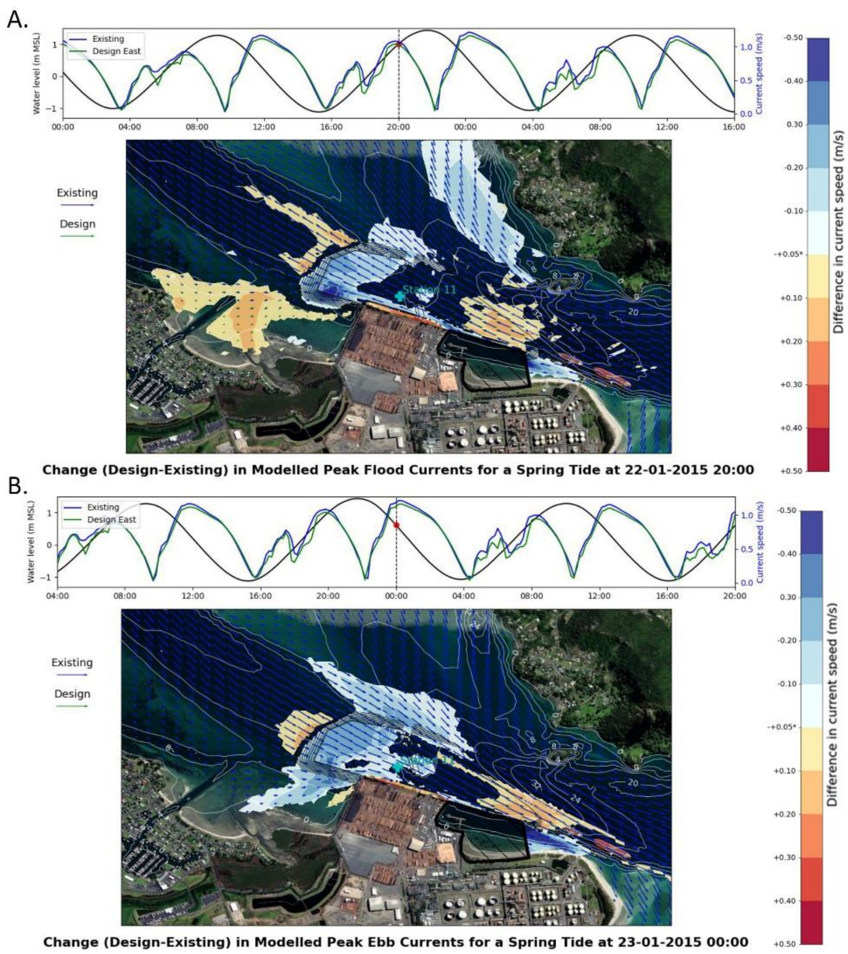
Reclamation will lead to the permanent loss of habitat and biota within the reclamation footprint. The loss of marine habitat and biota can have consequential impacts on broader ecosystem values, such as productivity and nutrient cycling. Some sediment accretion may also occur at the eastern edge of the reclamation and along the edge of the main channel (Reinen-Hamill, 2022).

Dredging results in the unavoidable loss of surface substrates, epibiota and infauna within the area directly affected. Estimated recovery times of benthic communities following the cessation of dredging depends on the substrates and communities present. Rates of recovery reported in the literature indicate that recovery takes: 6–8 months for muddy communities; 2–3 years for sandy/gravelly communities; and 5–10 years for coarser sediment communities (see Newell *et al.*, 1998 for review). Consequently, regularly dredged areas with coarse sediments are unlikely to fully recover between events. Furthermore, a permanent change in community composition can occur if the characteristics of subsurface substrates that are exposed by dredging differ from the original seabed substrates.

Deepening of the dredge basin will also have consequential impacts on tidal currents (Berthot & Watson, 2022), including:

- Reduced current velocities, particularly in the western side of the proposed dredging basin (largely due to deepening of the consented, but yet to be, dredged area), and directly east of the proposed reclamation (due to the obstruction and diversion of flows).
- Reduced current velocities along the northern shore, opposite Northport, during flood tides due to deepening, directing more of the tidal prism through the main channel.
- Increased current velocities along the existing berths, above the western batter, and in certain conditions on the eastern side of the proposed dredging basin.

Figure 57: Modelled current vectors for the existing and proposed reclamation layout and difference in current magnitude during the peak of a A) flood and B) ebb spring tide. White depth contours are from the existing case and the black design lines display the proposed reclamation and dredging. Potential changes less than 0.05 m/s are masked as they are within the magnitude of model error and were not considered as a meaningful change (adapted from Berthot & Watson, 2022).



Sediment mobilisation and increased turbidity generated by the dredging process also has the potential to adversely affect marine biota in surrounding areas. The magnitude of off-site effects will depend upon:

- the amount of suspended sediment generated (which depends on factors including dredging methods, sediment characteristics, the duration and timing of dredging, and the amount of sediment dredged);
- dispersal and dilution;
- background concentrations of suspended sediment and turbidity; and
- species sensitivity.

High levels of suspended sediment can cause:

- Reduced growth or mortality or a depth restriction of subtidal macroalgae and seagrass due to reduction in light levels. For example, sediment mobilised during maintenance dredging in Tauranga Harbour was found to increase light attenuation[24] by 46%. However, this was less than the natural variation in light attenuation between high tide and low tide (70%) (Coppede Cussioli, 2018).
- Reduced filtration and clearance rates, reduced growth and lower survival of shellfish and other filter feeders. For example, adult pipis, cockles and scallops can continue to feed at high concentrations of suspended sediment for short durations (<1 week), but in the long term, show adverse effects at total suspended sediment (TSS) concentrations of more than 60–70 mg/l, 300–350 mg/l, and 100 mg/l, respectively (Wilber & Clarke, 2001; Nicholls *et al.*, 2003; Hewitt & Norkko, 2007; Coppede Cussioli, 2018). Horse mussels are also sensitive to suspended sediment and show adverse effects on condition at 80 mg/l (Ellis *et al.*, 2002).
- Negative effects on deposit feeders. Concentrations above 300 mg/l for 9 days adversely affected the intertidal wedge shell *Macomona liliana*. After 14 days of high exposure, most wedge shells had died or were lying exposed on the surface (Gibbs & Hewitt, 2004).

Negative impacts on the health of marine biota may be compounded if contaminants are present in dredged sediments. However, available information indicates this is not an issue in the proposed Northport dredging area (see Section 4.1.1).

Modelling of sediment dispersal plumes was done for three potential dredging methods: trailing suction hopper dredger (TSHD), cutter suction dredger (CSD), and backhoe dredger (BHD). The models were run for dredges operating continuously from a fixed position for 24 hours a day, 7 days a week, over a 1-month period (Cussioli *et al.*, 2022). That, together with comparisons between previous modelling results and observations from actual dredging campaigns, suggests the modelling was conservative and indicative of the upper bound of potential effects (Reinen-Hamill, 2022). Also note that modelling of predicted sediment depositional depths did not account for any resuspension and redispersal of the sediment. On that matter, MetOcean (2021a) states that:

[24] The reduction in light intensity as it travels through water due to absorption or scattering of photons.

“The cumulative deposition footprints obtained from the simulations assume that sediments stay in place once they settled on the seabed. In reality, some sediment resuspension is possible, with modulations with respect to the sediment type, notably percentage of fines and corresponding critical shear stress, degree of consolidation and ambient bed shear stress magnitude. In that sense, the presented deposition maps inform on the initial sediment deposition patterns. They can be considered relatively conservative since subsequent sediment resuspension and further dispersion is possible, thus potentially reducing the initial deposition thickness. That being, it is also possible that some local accumulation areas could develop notably in low flow regions, which could locally increase deposition thickness relative to the “initial-deposition” maps.”

Consequently, the models are generally expected to over-predict TSS concentrations and deposition depths. However, in the absence of alternative predictions, the following assessments of ecological effects are based on the modelling results.

Key findings of ecological relevance from the dispersal plume modelling are presented in Figure 58 and Figure 59. Briefly, they indicate that:

- Sediment plumes generated by BHD are likely to be very localised and of little, if any, ecological consequence.
- For CSD, sediment will disperse in a narrow band beyond the dredging area. Mean concentrations are predicted to rapidly decline with distance, to levels that are likely to be of little ecological consequence.
- TSHD was predicted to produce the largest sediment plume and the highest sediment concentrations. The modelling predicted that a large plume of sandy-silt will extend in a band along the southern, subtidal portion of the main channel, with mean concentrations predicted to rapidly decline with distance from the TSHD (Figure 58). A silty-sand plume was predicted to have a similar form but was more limited in extent. Model predictions showed near-bed concentrations of sandy-silt exceeding 20 mg/l for <30% of the time beyond the dredging footprint, with the percentage of time declining with distance. The predictions also showed that concentrations in a smaller area exceeded 160 mg/l for <30% of the time, and comparisons between the existing and proposed scenarios showed that the plume footprint reduced in size as dredging progressed and depth increased. At the proposed depth, near-bed sandy-silt concentrations of >160 mg/l will be largely contained with the dredged area (Figure 59).

For reference, background, concentrations of TSS at One Tree Point are low, with a median of 5.4 mg/l and a maximum of 19 mg/l recorded in surface waters between 2014 and 2021 (NRC, 2021).

Figure 58: Comparison of mean total suspended sediment concentrations at surface, mid water and near-bed levels (top to bottom) for TSHD (left) and CSD (middle) dredging at site 1a and for BHD dredging at site Berth Pocket (right), over the existing bathymetry. Results are shown for the sandy silt. The dredger is assumed to dredge continuously over the 1-month simulation period. TSS were masked below 5 mg/l (from Cussioli *et al.*, 2022).

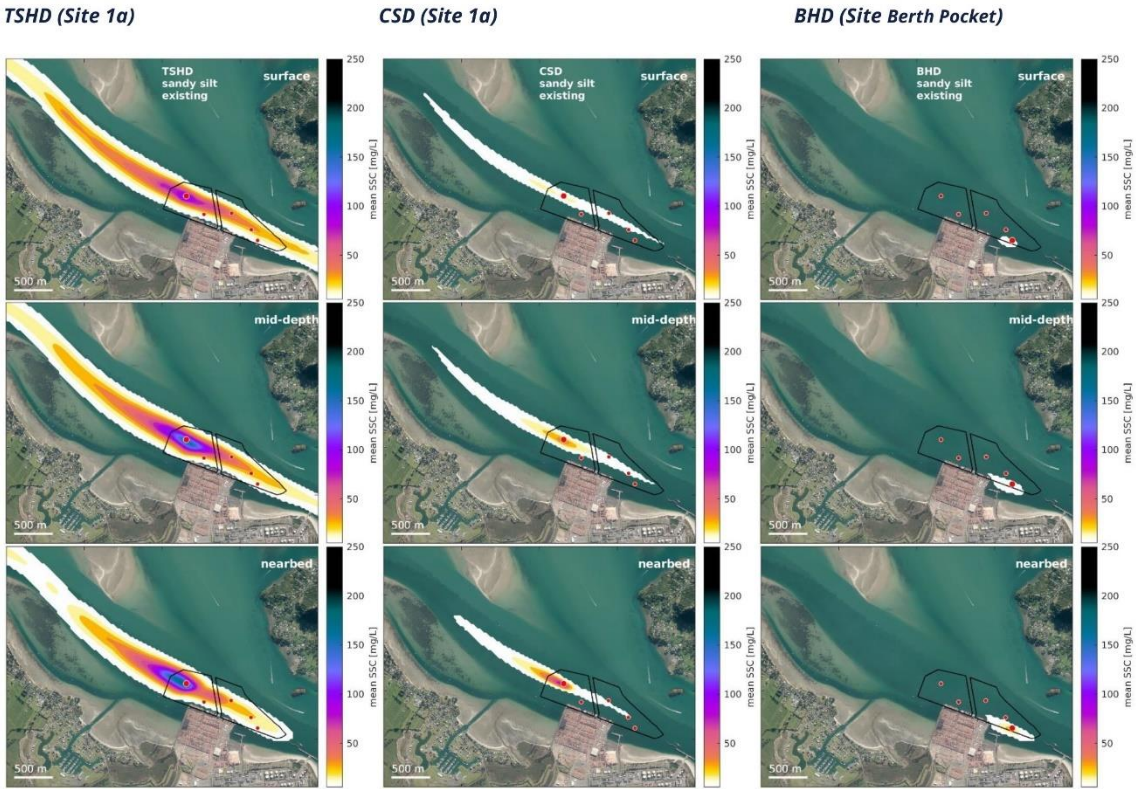
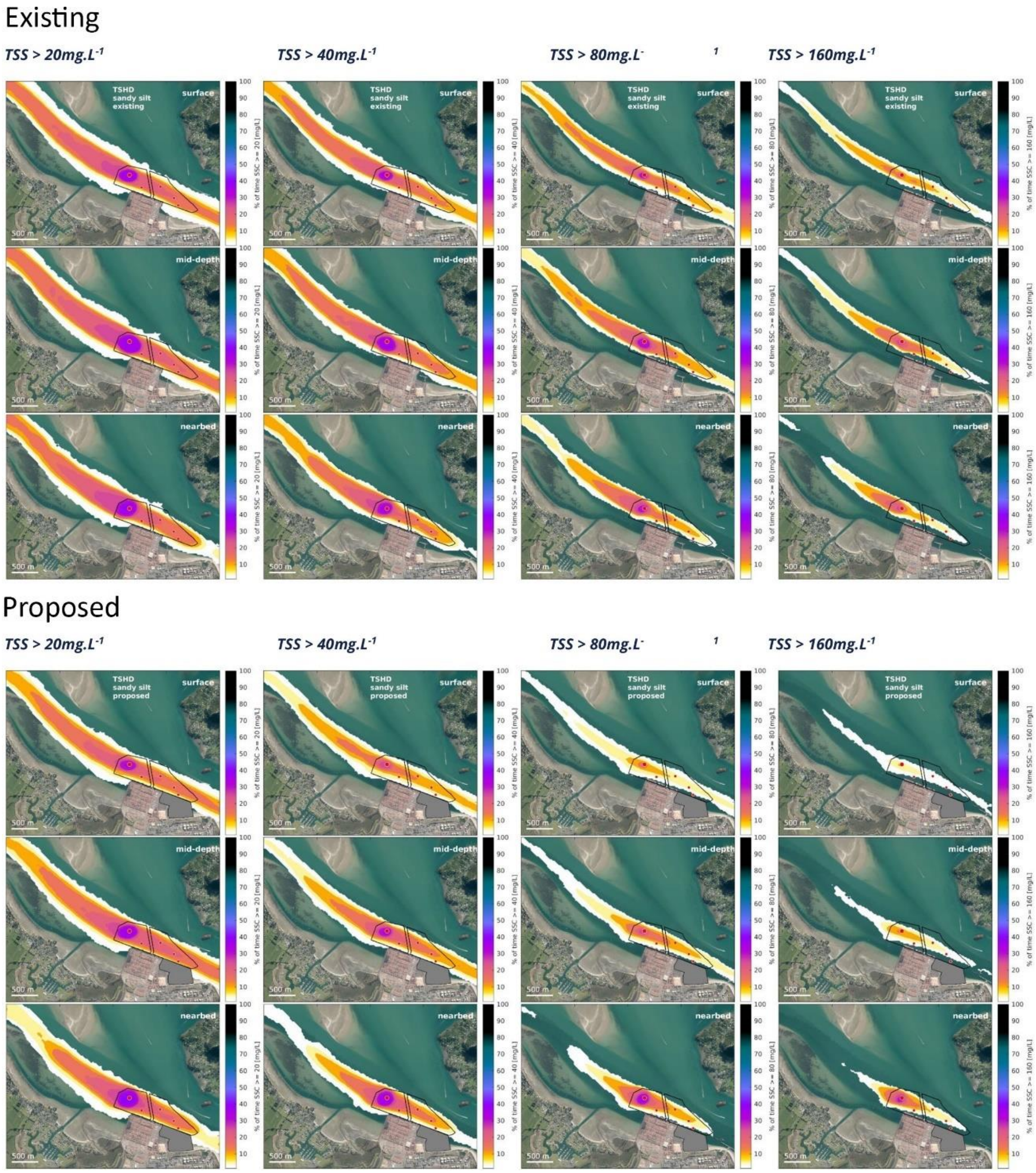


Figure 59: Percentage of time total suspended sediment concentrations are above thresholds of 20, 40, 80 and 160 mg/l (left to right), at surface, mid water and near-bed levels (top to bottom) for TSHD dredging at site 1a, over the existing and proposed bathymetry. Results are shown for the sandy silt. The dredger is assumed to dredge continuously over the 1-month simulation period. Results were masked below 1% (adapted from Cussioli *et al.*, 2022).



Modelling of sediment deposition was done for the same three dredging methods described earlier (TSHD, CSD, and BHD), and the models were also run continuously over a 1-month period (Cussioli *et al.*, 2022). Sediment depositional depths are predicted to be greatest within the dredging footprint and immediately west of the footprint (Figure 60). Predicted deposits of ≥ 5 mm are confined to the subtidal channel, with localised depositional depths of up to 1.5–2 m predicted. Sediment deposited to the west of the dredge basin is expected to be returned to the dredged area over time (Reinen-Hamill, 2022).

Key findings of ecological relevance from the modelling are presented in Figure 60 and Figure 61. Briefly, for sandy silt, they indicate that:

- Sediment deposition associated with the modelled BHD scenario is predicted to occur along the northern face of Northport and in localised areas east and west of the reclamation for the existing and proposed scenarios modelled (Figure 60).
- For CSD, the modelling predicts that sediment will accumulate in a band in the centre of the main channel, with depositional thickness rapidly declining with distance. Depositional thickness and extent also decreases with dredging depth. At the existing bathymetry, deposition of > 10 cm was mainly predicted to occur in a relatively narrow band of approximately 2.7 ha that extended around 450 m past the dredging area. At the proposed bathymetry, deposition of > 10 cm beyond the dredged area was confined to a wider but shorter area of around 2.7 ha on the western side (Figure 60). Deposition thicknesses of between 1 and 10 cm were predicted to occur in areas of approximately 16.7 ha and 10 ha (based on estimates taken from Figure 60).
- For TSHD, the modelling predicts that sediment will accumulate in a band in the centre of the main channel, with depositional thickness rapidly declining with distance. Depositional thickness and extent also decreases with dredging depth. At the existing bathymetry, deposition of > 10 cm was predicted to occur over approximately 14.4 ha band that extended around 800 m past the dredging area. At the proposed bathymetry, deposition of > 10 cm was confined to a wider but shorter area of around 10.7 ha on the western side of the dredging area (based on estimates taken from Figure 60). In both cases deposition thicknesses of between 1 and 10 cm were predicted to occur over large areas of channel towards the east and west.

Figure 60: Comparison of final cumulative sediment deposition thickness for TSHD (left) and CSD (middle) dredging at site 1a, and for BHD (right) dredging at site Berth Pocket (right), over the existing (top) and proposed (bottom) bathymetries. Results are shown for the sandy silt. Deposition thickness was masked below 5 mm and the 1 and 10 cm contours are shown in grey (dashed and solid lines respectively) (from Cussioli *et al.*, 2022).

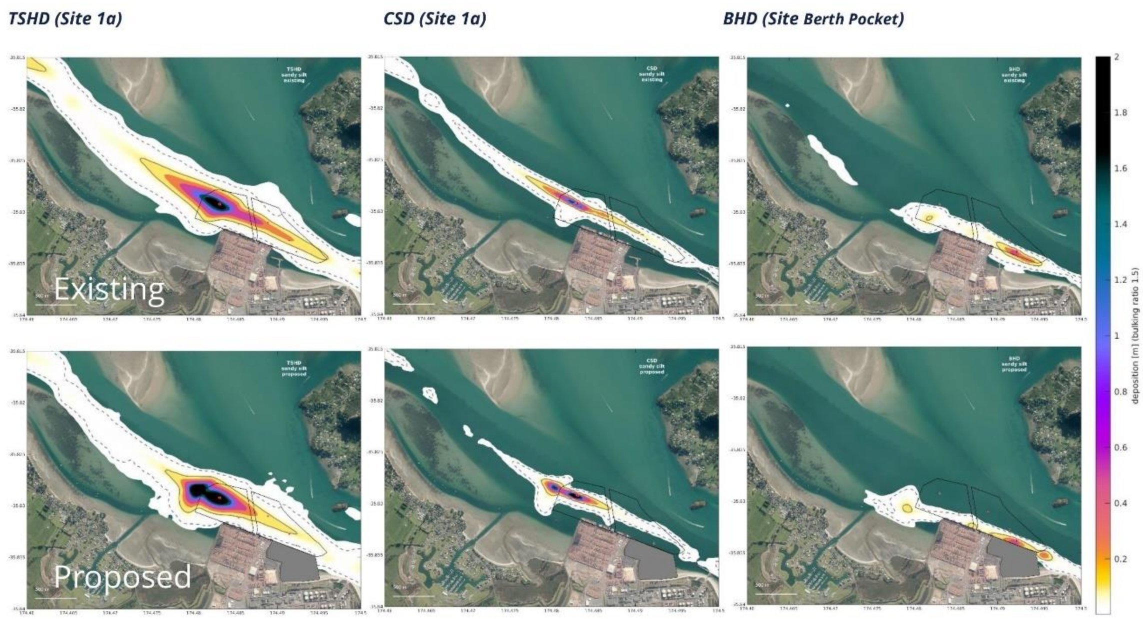
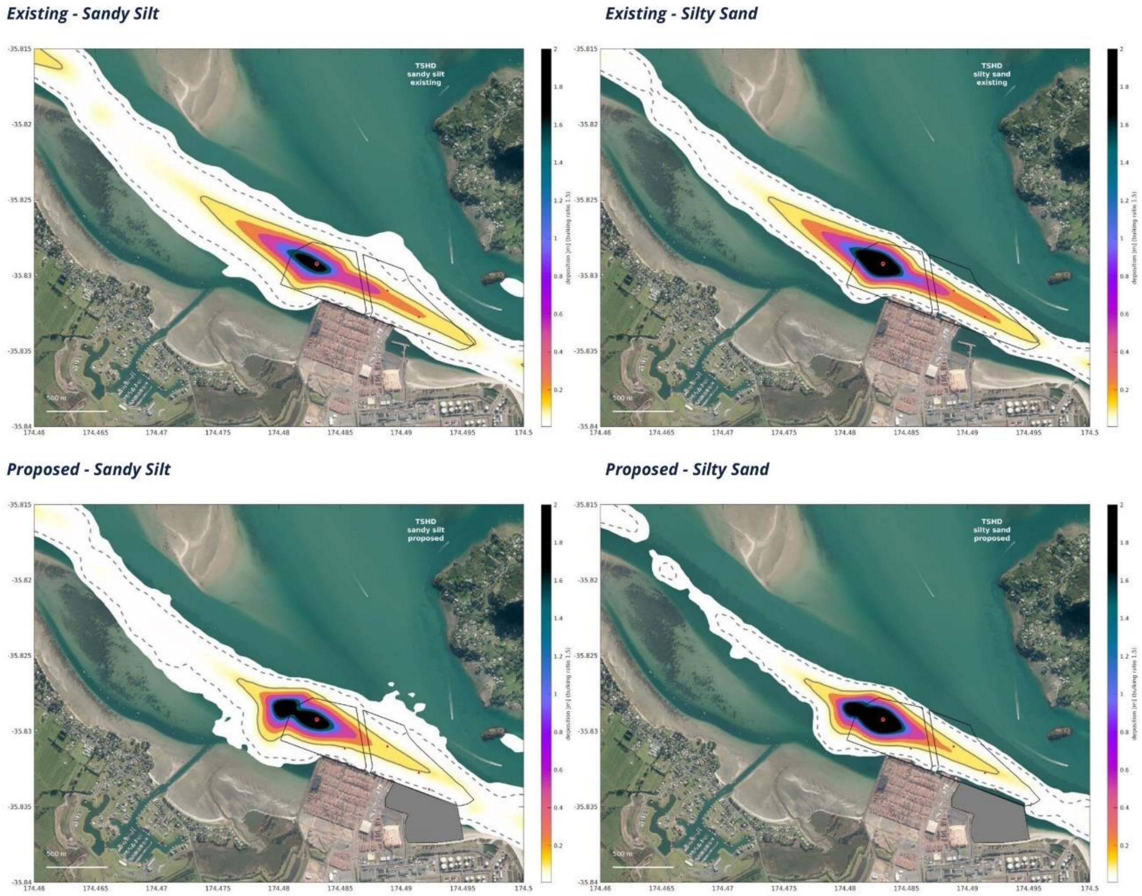


Figure 61: Final cumulative sediment deposition thickness for TSHD dredging at site 1a, over the existing and proposed bathymetry, Results are shown for the sandy silt on the left panel and silty sand on the right panel. Deposition thickness was masked below 5 mm and the 1 and 10 cm contours are shown in grey (dashed and solid lines respectively) (adapted from Cussioli *et al.*, 2022).



The adverse effects of terrigenous sediment deposits on intertidal marine biota are well known and include both lethal and sublethal effects (Gibbs and Hewitt 2004). However, the chemical and physical properties of terrigenous sediments differ from marine sediments, and ecological responses are also likely to differ. The deposition of marine sediments in intertidal areas appears to be poorly studied, but it is reasonable to assume that biota in energetic areas (such as Marsden Bay) are adapted to living in dynamic environments where marine sediments are regularly resuspended and redeposited by wave action. Such processes are known to occur in Marsden Bay where Swales et al. (2013) reported that sediments had a thin surface mixed layer, 0 to 1 cm deep, composed of laminated sands and silts consistent with wave resuspension.

In contrast to the effects of deposition in intertidal areas, there is a considerable amount of information about the effects of depositing marine sediments in subtidal areas. Available information from monitoring and assessment studies generally indicates that those effects are relatively minor and short-lived (e.g., Roberts & Forrest, 1999; Paavo, 2007). For example, disposal of muddy spoil in a high energy area off Aramoana, Otago, was found to result in a change in community composition and a decrease in abundance, but within a month the fine sediments were dispersed and the macrofaunal community recovered to the pre-existing state (Paavo, 2007). Similarly, Roberts and Forrest (1999) found that macrofaunal communities subjected to spoil disposal in Nelson recovered within six months, and no long-term, cumulative effects were discernible.

Many dredge disposal studies have not found any significant difference between disposal and control sites (e.g., West, 2010; Edhouse *et al.*, 2014), which may be due to the temporary nature of any impact and the time elapsed between deposition and monitoring. Where significant effects in the benthic community have been found, these are generally related to minor changes in community composition (Halliday *et al.*, 2008; Sneddon & Atalah, 2018), and are small in comparison to temporal changes observed across all sites (Sneddon & Atalah, 2018).

It should be noted that the studies referred to above relate to discrete, bulk deposits of dredged material, as opposed to the proposed situation, where sediment dispersed in plumes and gradually deposited. The Northport situation also differs in that the areas affected by deposition from dredge plumes contain extensive biogenic habitat, that includes large sessile filter feeders, macroalgae meadows and shell. Those features are likely to be particularly sensitive to smothering.

The following sections consider the potential for such effects at three scales:

1. The entire harbour system;
2. The OHEZ system;
3. The areas directly impacted (i.e., the reclamation or dredging footprint).

As set out above, Tables 2 and 21 identify the most relevant (and applicable) system/scale for the assessment of each key effect, along with the corresponding assessment of the level of effect.

6.3.1 EFFECTS ON INTERTIDAL SEDIMENT HABITATS AND MACROFAUNA

Whangārei Harbour contains around 6000 ha of intertidal habitat[25]. The harbour-wide assessments of Lundquist and Broekhuizen (2012) and Griffiths (2012), suggest that sandy sediments, similar to those in Marsden Bay comprise a large proportion of that area (see Figure 6).

NRC monitoring data (Griffiths, 2012) indicated that intertidal sites in Marsden Bay:

- had relatively low taxa diversity compared to other sites in Whangārei Harbour (although the number of taxa recorded in the three Marsden Bay sites (n=59) indicates that diversity was still reasonably high);
- did not contain taxa unique to the Marsden Bay sites; and,
- had similar communities to sites in other parts of the harbour.

Sampling around the port in 2020 (Knue & Poynter, 2021), indicated that benthic diversity within Marsden Bay (100 taxa reported) was greater than that obtained in the NRC survey, but both surveys obtained moderate abundances. Similar results were obtained in the 2022 survey (Section 5.4.2). Overall, the surveys indicate that benthic community composition

[25] According to Hume *et al.* (2016) the harbour has a total area of around 10,400 ha of which 58% (i.e. 6032 ha) is intertidal.

varies throughout Marsden Bay, and taxa diversity and abundance is lower on the eastern side of the port. Key differences in community composition are apparent between:

- the eastern and western sides of the port (although communities in some stations on the western side of the proposed reclamation were similar to those in stations west of the port);
- communities from western upper-mid and low shore sites; and,
- sites associated with sandy ridges.

The most comprehensive survey of Marsden Bay carried out to date (which covered the area from One Tree Point to Marsden Point – Section 5.4.2) recorded two taxa that were only obtained from the proposed reclamation area – the polychaete worm *Goniada* sp. and the horseshoe worm *Phoronus* sp. Neither of these taxa are uncommon, and both have been reported in other parts of the harbour (e.g. Knue & Poynter, 2021).

Port reclamation will remove 6.6 ha, or 1.08%, of intertidal habitat, within the outer harbour and entrance zone (OHEZ, Figure 56). The construction of the proposed bird roost on the western side of the port (for the purposes of achieving positive ecological effects for avifauna) will cover a further 0.54 ha of intertidal habitat (0.09% of intertidal habitat in the OHEZ). No at risk or threatened species of benthic macrofauna are known to occur in the area.

While the proposed reclamation will eliminate 6.6 ha of intertidal habitat, the overall abundance of common infauna will only be slightly reduced within the harbour and OHEZ, and changes to the diversity of macrofauna at those scales are not expected.

The proposed bird roost is in an area of moderate taxa diversity and abundance. The 2022 survey (Section 5.4.2) indicates that benthic communities around the feature are typical of those in found in the upper to mid intertidal zone and associated with sand ridges in Marsden Bay. Based on the small area affected the effects of the proposed roost effect on intertidal habitats and macrofaunal diversity are expected to be low.

Reclamation effects on coastal processes such as currents and sediment transport are expected to be moderate within the area bounded by the eastern extent of the port and the Channel Infrastructure wharf (Reinen-Hamill, 2022). The proposed reclamation is predicted to cause a reduction in currents that may cause sediment accretion on the channel banks between Northport and the Channel Infrastructure wharf and around the margin of the development. It is likely that the corresponding ecological effects associated with the predicted sediment changes will be low to negligible.

Dredging is not proposed in intertidal areas, and sediment plumes and deposition associated with the dredging are predicted to be largely confined to subtidal channels. Intertidal ecological effects from dredging are there expected to be negligible.

Overall, effects at the harbour and OHEZ scales on the extent of sandy intertidal habitat, the abundance and diversity of benthic macrofauna are assessed to be moderate, primarily based on the permanent loss of 6.6 ha of intertidal habitat.

6.3.2 EFFECTS ON SUBTIDAL HABITAT AND BENTHIC COMMUNITIES

Subtidal habitats in the mid to outer harbour:

- contain a variety of physical seabed habitats (Black *et al.*, 1989);
- contain macroalgae meadows, with a diverse, but low biomass, assemblage of species growing on subtidal shell and sediments (Neill & Nelson, 2016, Anderson *et al.*, 2019);
- contain a variety of biogenic habitat and habitat forming species, including horse mussels, green-lipped mussels, scallops, dog cockles, seagrass, sponges, ascidians, rhodoliths, dead shell and worm beds (Morrison, 2003, Parsons *et al.*, 2016).

Ecological values of the area are high, due to a number of factors, including:

- A consistent flux of planktonic organisms provided by strong currents, which sustain a diverse and productive assemblage of filter feeders.
- Strong currents, natural seabed armouring, relatively shallow depths, and clear coastal waters provide sufficient light, nutrients and hard substrate to sustain good macroalgae growth.
- The presence of filter feeders and benthic macroalgae as outlined above, which in turn, provide substrates, cover, food and/or other resources that attract and sustain broader species assemblages.
- The dynamic and spatially variable physical characteristics of the outer harbour, which include variation in exposure, depths, currents, natural features, and bottom types.

6.3.2.1 RECLAMATION EFFECTS

Seabed characteristics and communities vary considerably around the mid to outer harbour. Relatively few large epibiota were observed in video footage from the proposed reclamation area. The species observed included:

- dense aggregations of turret shells (possibly dead shells occupied by hermit crabs);
- scattered starfish (*A. polyacanthus*);
- scattered small sponges;
- an octopus den;
- Mediterranean fan worm (*S. spallanzanii*); and,
- cushion stars (*P. regularis*).

Worm or shellfish tubes, or crustacean burrows were also observed. All the epifaunal species observed are likely[26] to be common.

Grab sampling by 4Sight indicates that infaunal benthic macrofauna values around the port are very high, with 198 taxa being obtained from 47 grab samples. Clear variation in community composition over relatively small spatial scales was evident (Ahern, 2020; Knue, 2021b). However, counts of many taxa were patchy, with over a quarter being obtained in a single sample.

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[26] Sponges and hermit crabs (if present) could not be identified from the footage.

The subtidal portion of the proposed reclamation site contained similar assemblages to sites on the western side of Northport, and although 14 taxa obtained from the proposed reclamation area were not found in the other areas sampled, all were common taxa[27].

Overall, while subtidal habitats within the reclamation footprint appear healthy and contribute to the broader diversity and ecological values of the harbour, the proposed reclamation site does not contain unique or special ecological qualities. That, together with the small scale of reclamation area relative to the overall amount of subtidal habitat within Whangārei Harbour, suggests that, by themselves, the effects of reclamation on subtidal macrofauna will be moderate at the harbour scale.

At the OHEZ scale, reclamation will lead to the direct and permanent loss of a small proportion (0.26%) of natural subtidal habitat (see Figure 56). At the OHEZ scale, those impacts are unlikely to reduce overall biodiversity values or compromise ecological functions and processes**. Consequently, the subtidal effects of reclamation at the harbour and OHEZ scales are both assessed as moderate. However, the proposed reclamation will cause the complete loss of habitat and biota in an approximately 5.1 ha area below chart datum.**

6.3.2.2 DREDGING EFFECTS

The proposed dredging will largely be limited to an area where dredging has already occurred or is currently consented. The existing environment within that area can be broadly grouped into three zones based on past dredging activity:

- A shallow area towards the west, that is yet to be dredged, where a mix of sand and shell gravel, scattered red algae, and a variety of species including occasional starfish, sponges, anemones, and infrequent scallops and octopus were observed in the November 2021 video survey.
- The batter slope between that area and the adjoining, previously dredged area, which consisted of bare sand that gave way to a dredged seafloor completely covered with a variety of sessile organisms such as sponges, bryozoans, hydroids and macroalgae.
- Other parts of the previously dredged area which contained a mix of sand, scattered and dense shell, and biogenic species such as red algae and sponges.

The proposed dredging will:

- remove the diverse benthic community in undredged areas;
- recontour and remove substrates from the consented, but yet to be, dredged area (see Figure 62);
- remove biota and substrates that have reformed since previous dredging events;
- lead to the alteration of current velocities.

[27] *Musculus impactus*, *Ostrea chilensis*, *Solemya parkinsonii*, Bryozoa, *Ovalipes catharus*, Echinoidea, *Maoricrypta* sp., Isopoda indet., *Retusa striata*, Osteichthyes, Ampharetidae, *Aricidea* sp., *Spiophanes* sp., *Leptochiton inquinatus.*

By and large, those effects are already provided for under the current capital and maintenance dredging consent[28]. Additional effects of the proposed dredging footprint include deepening the existing dredged basin by around 2 m. If the characteristics of the seabed substrates at the proposed dredging depth are similar to those existing at the currently consented depth, a similar community of benthic macroinvertebrates is expected to reform once dredging is complete. However, macrofaunal diversity would likely be lower if areas of dense shell were permanently lost.

Modelling predicts that sediment plumes generated during dredging will also affect the surrounding habitat. Subtidal areas predominantly to the west of the port are predicted to be periodically subjected to elevated suspended sediment concentrations, which if sustained for extended periods, could adversely affect sensitive macrofaunal species by reducing their physiological condition, growth and survival. The scale, magnitude and duration of effect will depend on the type of dredging, length of time taken, and interactions between dredge operations and plume generation, tides, and the vagaries of winds and waves.

Model predictions indicate that if a TSHD is used, a relatively large area of the channel between Marsden Bay and Snake Bank may experience suspended sediment concentrations that approach levels and durations where adverse effects on subtidal habitats and communities occur. Those effects would be compounded by the impacts of sediment deposition which smothers seabed communities and habitats (particularly shell gravel). Modelling predicts that the effects of suspended and deposited sediment are likely to be much more localised for CSD and BHD operations. In all cases, the effects of suspended sediment would cease at the conclusion of dredging and, over time, sediment deposited west of the dredged area is expected to return to the dredge basin (Reinen-Hamill, 2022). We also note that:

- The percentage of time that near-bed TSS concentrations exceed 80 mg/l is predicted to dissipate with distance from the dredging site.
- Sediment will be dispersed and gradually deposited, rather than accumulating through discrete, bulk deposits.
- The models exclude real-world dynamics that will affect dispersal and deposition. For instance, the modelling does not account for any resuspension and redispersal of the sediment, and a static dredging position was used continuously for a month in the model.
- The sediments are of marine origin, which is likely to reduce their capacity to adversely affect benthic species.
- Multiple assessments have shown that effects of sediment disposal in subtidal sites tend to be relatively minor and short-lived (see Section 6.3). However, as noted earlier, this area contains extensive biogenic habitat, that includes large sessile filter feeders, macroalgae meadows and shell, which is likely to be particularly sensitive to smothering.

[28] The only change is related to the slight difference between the currently consented and proposed dredging footprints.

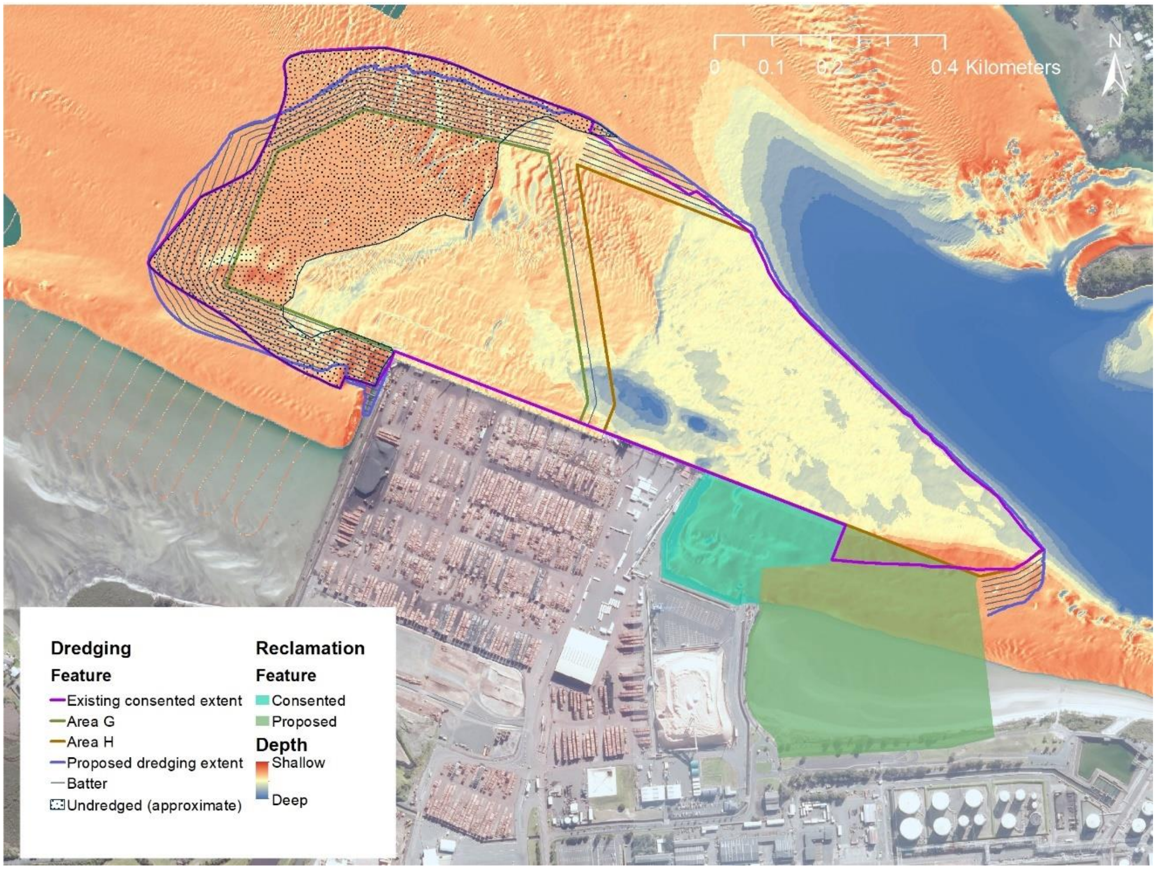
- The area has been previously dredged, but still retains high benthic ecological values.
- The modelling is conservative in several respects, as outlined in Section 6.3 above.

Consequently, while some uncertainty remains about the scale and magnitude of dredging effects, our assessment indicates that impacts of dredging in subtidal areas are likely to vary depending on the method of dredging and range from:

- **High at the OHEZ and Harbour scales if a TSHD is used; and,**
- **Moderate at those scales for CSD and BHD operations.**

Based on the high ecological values observed in and around previously dredged areas, and assuming that shell gravel habitat re-establishes, ecological recovery is expected to occur over a period of 5 or more years.[29].

Figure 62: Image of channel bathymetry (provided by Northport), consented dredging area, and proposed dredging area as modelled by MetOcean. The consented, but yet to be, dredged area is highlighted in aqua.



6.3.3 EFFECTS ON KAIMOANA SHELLFISH

Assessments by NRC and 4Sight (Lundquist & Broekhuizen, 2012 and Griffiths, 2012) indicate that juvenile cockles are widespread around much of the harbour. Marsden Bay contained relatively high densities of cockles and pipi compared to other sites in the harbour,

[29] Depending on the time taken for shell gravel habitat to recover or generate.

but their distribution was patchy (Figure 32 and Figure 33). Fisheries surveys also indicate that patchy numbers of pipi occur on Marsden and Mair Banks, with some stations having high numbers.

Benthic surveys conducted in 2021 (Section 5.4.1) and 2022 (Section 5.4.2) found moderate to very high abundances of cockles on the mid shore across the entire length of Marsden Bay, with the highest densities of larger cockles (>20 mm) found near the entrance to Marsden Cove Marina (Figure 36 and Figure 47). However, almost all the cockles found were below 'harvestable' size (>30 mm, Figure 46). Cockle densities within the proposed reclamation were representative of densities found throughout Marsden Bay, with mean densities of 75–375 cockles/m^2 (Knue & Poynter, 2021). Similar findings were obtained in the 2021 and 2022 surveys (Sections 5.4.1 and 5.4.2), with most of the cockles measured being <20 mm in size, and the majority of those being <5 mm (Figure 46). Cockles are primarily an intertidal species, and therefore, effects of dredging and the dredging plume are therefore considered to be negligible for the reasons already outlined.

Pipi appear to be patchily distributed and small within the proposed reclamation area. No pipi were recorded in the sites assessed by Knue and Poynter (2021), and none were recorded during the rapid survey carried out in 2021 (Section 5.4.1). However, moderate counts of small (<20 mm, with the majority being <5 mm) pipi were obtained from three, mid to upper intertidal stations in the proposed reclamation during the quantitative sampling survey carried out in 2022 (Figure 46 and Figure 47). Tidal eddies, created by the existing port reclamation, are likely to be a driving factor in the relatively high numbers of small pipi and cockles immediately west and east of Northport (Figure 63). Pipi were not observed in the dredging area, or in areas potentially affected by the dredging plume (Ahern 2020). The effects of dredging and the dredging plume on pipi are therefore considered to be negligible.

No live scallops were observed during the video survey of the reclamation area, but empty scallop shells were observed around an octopus den, and low numbers of patchily distributed scallops were observed in the proposed dredging and nearby areas. It is therefore possible that scallops may be present in the areas directly and indirectly affected by the proposed activities. Scallops in the reclamation area would be permanently lost, but they could recolonise dredged areas. Model predictions indicate that if a TSHD is used, a relatively large area of the channel between Marsden Bay and Snake Bank may experience suspended sediment concentrations that approach levels and durations where adverse effects on scallops occur. Those effects would be compounded by the impacts of relatively broad scale sediment deposition and could include a loss of physiological condition and/or mortality. Modelling predicts that the effects of suspended and deposited sediment is likely to be much more localised for CSD and BHD. In all cases, the effects of suspended sediment would cease at the conclusion of dredging and, over time deposited sediment west of the dredged area is expected to return to the dredge basin (Reinen-Hamill, 2022). It is therefore likely that scallops will recolonise affected areas.

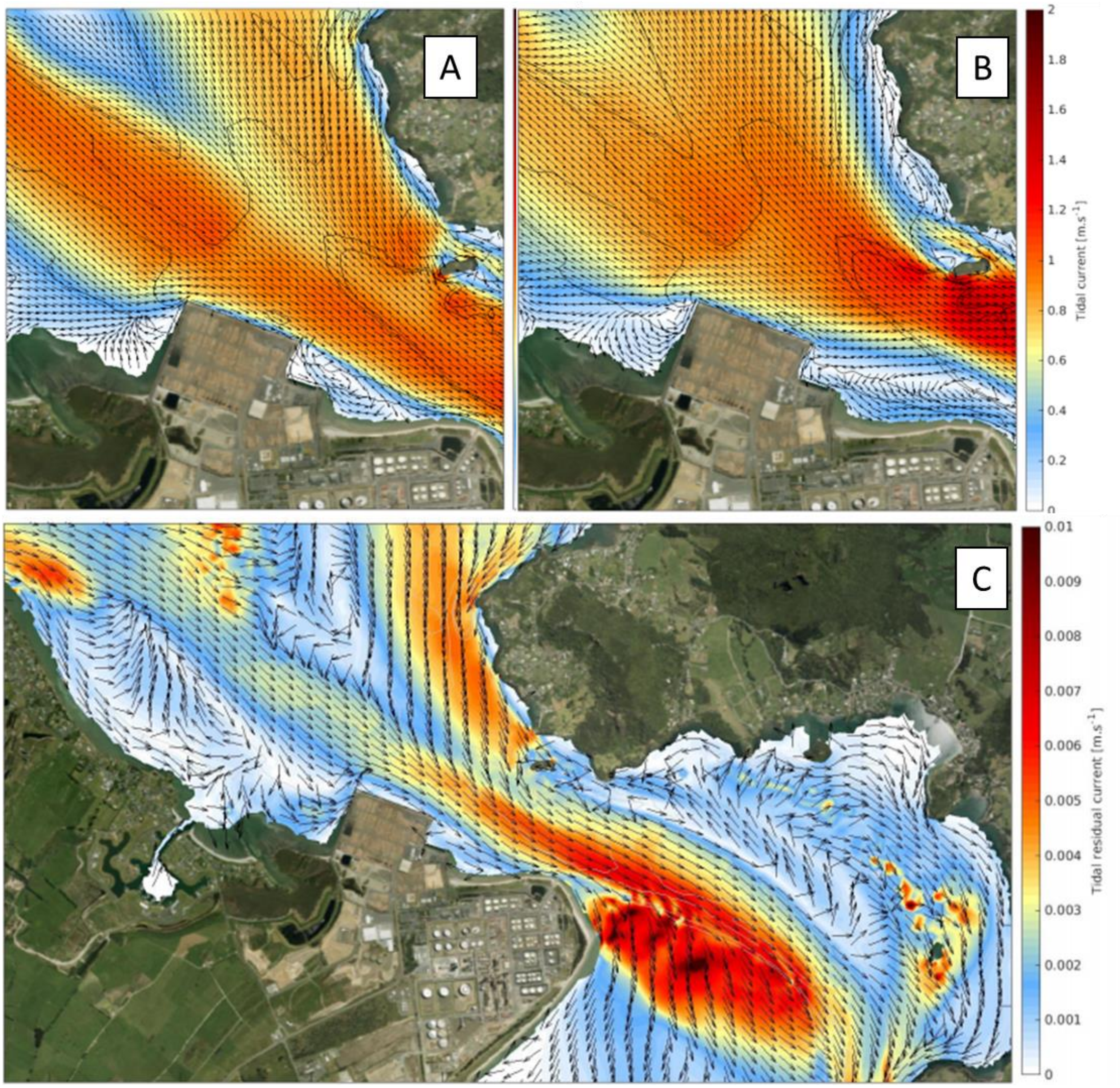
Given the widespread distribution of cockles around the harbour, and the absence of harvestable pipi in the proposed reclamation area, the **direct effects on harvestable cockles and pipi are likely to be low at the harbour and OHEZ scales. However, the proposed reclamation will cause the complete loss of cockles and small pipi within the reclamation footprint.**

Low numbers of scallops could also be lost from the reclamation area, if present. It is therefore recommended that the reclamation area be checked for scallops, and if present live scallops be moved to a nearby bed prior to reclamation occurring. Dredging effects on scallops will depend on the methods used, with TSHD having the greatest potential for adverse effects. To minimise potential effects on scallops, it is recommended that:

- A scallop monitoring and response plan be prepared, approved and implemented before dredging begins.
- Scallops are moved (if present) from high deposition areas (i.e., areas where > 10 cm of sediment is predicted to be deposited – see Figure 60) prior to dredging starting.

Overall, if the above measures are implemented effects on kaimoana shellfish are expected to be low.

Figure 63: Modelled ebb (A) and flood flows (B) during spring tides showing eddies to the east and west of the port reclamation, with the difference between tides shown in (C). A and B have the same velocity scale. C has a different velocity scale (taken from Reinen-Hamill, 2022, original source MetOcean Solutions, 2018)



6.3.4 EFFECTS ON SEAGRASS AND MACROALGAE

Seagrass meadows in Whāngārei Harbour and many other parts of New Zealand underwent a major contraction in the mid-21st century (Inlis, 2003), resulting in them being classified as "At Risk" under the New Zealand Threat Classification System (NZTCS). However, the past two decades has seen a resurgence of seagrass in Whāngārei Harbour and many other places, with its extent in the harbour increasing from a few small pockets in 1999 to around 6 km^2 in 2016 (see Section 5.1.1).

Outer parts of Whangarei Harbour contain macroalgae meadows, with a diverse, but low biomass species assemblages growing on subtidal shell and sediments (Neill & Nelson, 2016, Anderson *et al.*, 2019). Surveys carried out over the past 30+ years, indicate that the subtidal macroalgae meadows are a widespread and persistent feature (Black *et al.*, 1989, Neill & Nelson, 2016, Section 5.4.3), and that macroalgae have recolonised areas that have been dredged. Their occurrence is likely to be due to strong currents, natural seafloor armouring, relatively shallow depths, and clear coastal waters, which provide sufficient light and nutrients to sustain good macroalgal growth.

Four macroalgae species that are classified as “At Risk” have been recorded in Whāngārei Harbour, but it is not known if they are present in the proposed reclamation or dredging areas. All of these species are tagged with the qualifier “Data poor”, which is used to indicate the uncertainty about the listing due to the lack of data (Townsend *et al.*, 2008). One of those species, *Microdictyon mutabile,* is known to be endemic (Nelson, 2020) and another, *Aeodes nitidissima,* is likely to be endemic (Russell *et al.*, 2009).

Microdictyon mutabile typically grows on sheltered gently sloping rocks in the mid to low intertidal area. It has been recently described as a “common and characteristic seaweed of the eastern shores of Auckland" where it is present all year round. It has a distinct growth pattern and usually grows in open, sunny locations (Wilcox, 2018). This habitat type is not present in areas affected by the proposed reclamation or dredging, and no macroalgae resembling *M. mutabile* were observed during recent Marden Bay or underwater video surveys (see Section 5.4). Similarly, *A. nitidissima* usually occupy low intertidal and subtidal, rocky habitats on open coasts and sheltered harbours of the northern North Island (Nelson, 2020), and typically grow in intertidal runnels (Wilcox, 2018). Those habitats are not present in the areas directly affected, and absent or very limited in the areas indirectly affected by the proposed activities. It therefore seems unlikely that the proposed activities will adversely affect either of these species.

The other two “At Risk” macroalgae (*Feldmannia mitchelliae* and *Hincksia granulosa*) found in the harbour are not endemic, internationally widespread, and known to disperse long distances attached to flotsam, other floating seaweeds, and potentially through hull fouling (see Section 5.1.2.1). Note that the “At Risk” classifications of these species have the qualifier ‘Data Poor’, which indicates that there is uncertainty about the listing due to a lack of data (Townsend *et al.*, 2008). The information identified during this assessment indicates that there is sufficient information to warrant a review of their classification and suggests that their listing should be revised. Adverse effects on them are likely to be inconsequential in terms of global extinction risk, and it is also unlikely that the proposed activities will compromise the sustainability of New Zealand populations.

6.3.4.1 RECLAMATION EFFECTS

High resolution satellite images taken on 5 March 2021[30] show small patches of reasonably dense intertidal seagrass (estimated to cover a total of 0.33 ha) in the proposed reclamation area (Figure 64). Seagrass tends to be a highly dynamic feature, with aerial imagery showing substantial expansion and contraction of beds in Marsden Bay between 2015 and 2021. That variation vastly exceeded the extent of seagrass within the proposed reclamation area.

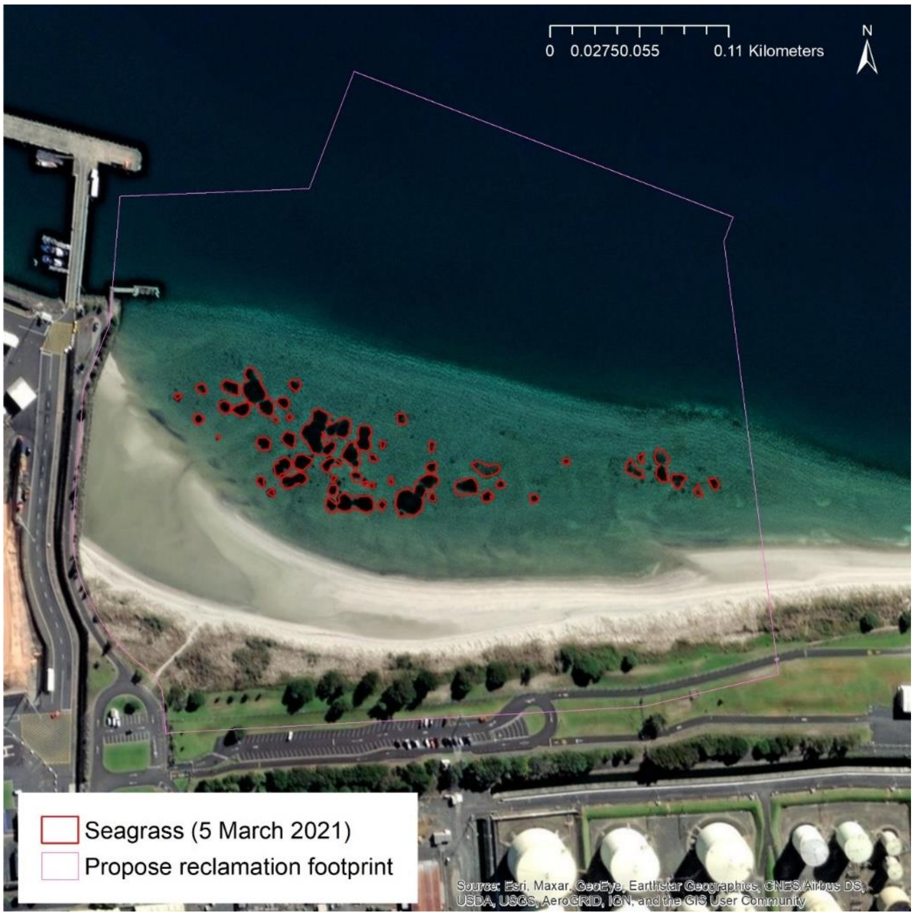
Coastal wetlands are currently regarded as natural wetlands under the National Enviromental Standards-Freshwater Management (NESFM). However, criteria for determining the presence and extent of coastal wetlands in New Zealand have not been developed. While seagrass is considered to be a coastal wetland species (Johnson & Brooke,

[30] Arc GIS “World Imagery” layer produced by Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

1989), its ephemeral nature makes classifying any particular area in the coastal marine area as a wetland based on its presence or absence, very problematic. It seems more appropriate to class the habitat within the proposed reclamation as intertidal sandflat containing a small area of seagrass. If the counterfactual, that anywhere with the potential for seagrass to grow should be classed as a wetland was applied, then most (if not all) intertidal, and shallow subtidal sandflats in Whangarei Harbour, and many (if not most) other estuaries and harbours, would be captured.

Irrespective of whether the area is a wetland, or not, the sizes of the seagrass patches affected are trivial compared to the current and historic extent of seagrass in Whangārei Harbour, and small compared to year-to-year variation in seagrass extent. **Based on that, the broader and local scale effects of seagrass being lost from within the proposed reclamation areas are assessed as low at all scales. This equates to a less than minor level of effect. In addition, based on the above analysis, reclamation effects on any macroalgae classified as threatened or at risk are likely to be low or negligible at all scales. This equates to a less than minor level of effect.**

Figure 64: Patches of seagrass within the proposed reclamation area mapped from high resolution satellite imagery obtained on 5 March 2021.



6.3.4.2 DREDGING EFFECTS

6.3.4.2.1 SEAGRASS

Seagrass is not present within the proposed dredging area so it will not be directly affected by dredging. However, sediment generated and dispersed during dredging has the potential to adversely affect seagrass in surounding areas. New Zealand research has found the current distribution of seagrass is limited by substrate and light levels. Seagrass is primarily found on sandy substrates with <15% mud (Zabarte-Maeztu *et al.*, 2020), with light levels determining its maximum depth (though there appears to be spatial differences in light requirements). The minimum light requirement for *Z. muelleri* in the Kaipara Harbour was found to be around 10% of the photosynthetically active radiation at the surface (Bulmer *et al.*, 2016), whereas the minimum light requirement for *Z. muelleri* in Moreton Bay, Queensland, was 30% of surface irradiation (Erftemeijer & Lewis, 2006). However, *Z. muelleri* is able to cope with short-term reductions in light intensity, and is able to survive for one month at 5% surface irradiation (Erftemeijer & Lewis, 2006). Intertidal seagrass beds in Tauranga Harbour (<2 m submerged at spring high tide) were predicted to be able to tolerate TSS concentrations of 17–20 mg/l, based on light measurements on the seabed and the relationship between turbidity and TSS (Coppede Cussioli, 2018). Seagrass beds growing higher on the shore are less affected by water turbidity due to longer emersion times.

Upper intertidal seagrass beds around Northport are unlikely to be affected by increased suspended sediment concentrations. The potential for adverse effects increases down the shore, with subtidal beds being the most sensitive. However, modelling of the sediment dispersal plumes predicts that there will be little, if any, overlap between dredging related sediment plumes or sediment deposition, and subtidal seagrass. Given that, and the ability of seagrass to tolerate short-term reductions in light, the **effect of sediment mobilisation on seagrass is assessed as low at all scales (equating to a less than minor adverse effect).**

6.3.4.2.2 MACROALGAE

Dredging could affect macroalgae through:

- direct physical removal;
- physically removing substrates that macroalgae attach to, particularly shell gravel.
- deepening, which permanently reduces the amount of light reaching the seabed;
- smothering macroalgae beneath mobilised sediment;
- smothering substrates that macroalgae attach to, particularly shell gravel;
- temporarily reducing the amount of light reaching the seabed through the suspension and dispersal of sediments.

Current velocities, and the associated flux of nutrients will also be reduced, but those changes are not expected to have a tangible effect on macroalgae.

The proposed dredging will largely be limited to an area where dredging has already occurred or is currently consented, with all macroalgae within the dredging footprint likely to be removed. By and large, those effects are already provided for under the current capital and maintenance dredging consent[31], but the proposed dredging will cause additional changes with the potential to affect macroalgae.

Deepening will increase light attenuation through the water column, reducing light levels on the seafloor. Macroalgae recolonisation could be inhibited if light levels are insufficient for photosynthesis to sustain macroalgae growth. However, predicting the magnitude of effect is difficult to determine, because light requirements vary among species, and light intensity and attenuation through the water column is affected by multiple factors that vary over time. Depth limits for macroalgae can be expressed as a percentage of the surface intensity of light. Indicative depth limits of about 0.5% of surface intensity have been proposed for upper zones of mainly leathery macroalgae, and 0.10% surface intensity for the intermediate zone of foliose and delicate algae (Markager & Sand-Jensen, 1992). Macroalgae within the proposed dredging area would likely fall into the latter category, with the depth ranges down to the indicative limit being determined by species adaptations.

Based on the above, we conclude that:

1. The proposed dredging will remove existing macroalgae and disturb or remove the substrates they attach to (shell gravel).
2. The above effects are largely provided for under the existing capital and maintenance dredging consent.
3. If shell gravel is still present at the dredged depths, or reaccumulates after dredging ceases, then recolonisation by macroalgae is expected to occur in the dredged basin. However, changes to light conditions may alter the composition of the macroalgae community within that area. Recolonisation is expected to take around five or more years depending on whether attachment substrates remain after dredging or reaccumulate after dredging.
4. Fewer macroalgae are likely to recolonise the dredged area if shell gravel is not present at the dredged depths or does not reaccumulate after dredging ceases. Macroalgae are still likely to attach to other substrates such as living shellfish (e.g., horse mussels) and other material that accumulates on the seabed.

As detailed in Section 6.3.2, in addition to direct effects, modelling predicts that sediment plumes generated during dredging will affect surrounding habitat. According to the modelling, subtidal areas predominantly to the west of the port, will be periodically subject to elevated suspended sediment concentrations, which if sustained for extended periods, could adversely affect light sensitive macroalgae. However, the scale, magnitude and duration of effect will depend on the type of dredging, length of time taken, and interactions between dredge operations and plume generation, tides, and the vagaries of winds and waves. Also note that the models exclude real-world dynamics that will affect dispersal and deposition. For instance, the modelling does not account for any resuspension and redispersal of the sediment, and a static dredging position was used continuously for a month. As further noted in Section 6.3, comparisons between the modelling results and observations from previous dredging campaigns suggests the modelling is indicative of the upper bound of potential

[31] The only change is related to the slight difference between the currently consented and proposed dredging footprints.

effects (Reinen-Hamill, 2022). However, in the absence of alternative predictions, this assessment is based on the available modelling results.

Model predictions indicate that if a TSHD is used, a relatively large area of the channel between Marsden Bay and Snake Bank may experience suspended sediment concentrations that reduce the amount of light reaching the seabed to levels. While macroalgae are able to adapt to short and long-term fluctuations in light availability (e.g., Talarico & Maranzana, 2000; Desmond *et al.*, 2019), the potential for light levels to be insufficient to sustain some species cannot be ruled out. Light related effects would also be compounded by the impacts of sediment deposition, which is likely to smother macroalgae and the substrates they attach to. Modelling predicts that the effects of suspended and deposited sediment is likely to be much more localised for CSD and BHD operations. In all cases, the effects of suspended sediment would cease at the conclusion of dredging and, over time, sediment deposited west of the dredged area is expected to return to the dredge basin (Reinen-Hamill, 2022). While that may not prevent the loss of macroalgae during dredging, it will allow them to recover. Extensive seaweed meadows remain in the OHEZ, despite earlier dredging around Northport.

Consequently, while some uncertainty remains about the scale and magnitude of indirect dredging effects, our assessment indicates that impacts of dredging in subtidal areas on macroalgae are likely to vary depending on the method of dredging and range from:

- **High at the OHEZ and Harbour scales if a TSHD is used; and,**
- **Moderate at those scales for CSD and BHD operations.**

Based on the presence of macroalgae in and around previously dredged areas, and assuming that gravel-shell lag habitat re-establishes, ecological recovery is expected to occur over a period of 5 or more years[32]. The above conclusions with respect to levels of effects is conservative, including because risks will be reduced through monitoring and management processes proposed through conditions of consent.

Note that potential effects on macroalgae species assessed as threatened or at risk are assessed separately above.

6.3.5 EFFECTS ON REEFS

Reef habitat is a relatively moderate component of the Whangārei Harbour ecosystem, but makes an important contribution to the biodiversity values of the harbour. Revetments along the western and eastern margins of Northport are narrow artificial reefs, with similar habitat and community values to naturally occurring reefs in the harbour. They contain a variety of macroalgae, sponges, echinoderms, crustaceans, and other marine invertebrates typical of north-eastern New Zealand reefs, and support a relatively diverse assemblage of fish, including obligate reef dwellers.

Reclamation will eliminate around 155 m of existing rock revetment and create around 483 m of rock revetment (Figure 65). All biota that cannot, or does not, move from existing revetment structures will be smothered. However, in the medium term (around 5 years) those losses will be offset by the colonisation and growth of reef species on Berth 5

[32] The “or more” relates to the recovery of attachment substrates.

structures. Based on communities found on similar under-wharf revetments to the ones proposed (Figure 66), shading is expected to create cool, dark conditions, and prevent intertidal areas from drying out. This will limit macroalgae growth to the outer margins of the revetments, while a diverse assemblage of sessile species is expected to grow in shaded areas. The cool, dark, and wet conditions are expected to allow a variety of (typically) subtidal species, such as subtidal sponges, ascidians, and hydroids to colonise and survive in the intertidal zone.

Reef is not present in the proposed dredging area and modelling of the sediment dispersal plumes predicts that there will be little, if any, overlap between dredging related sediment plumes or sediment deposition, and reef habitat.

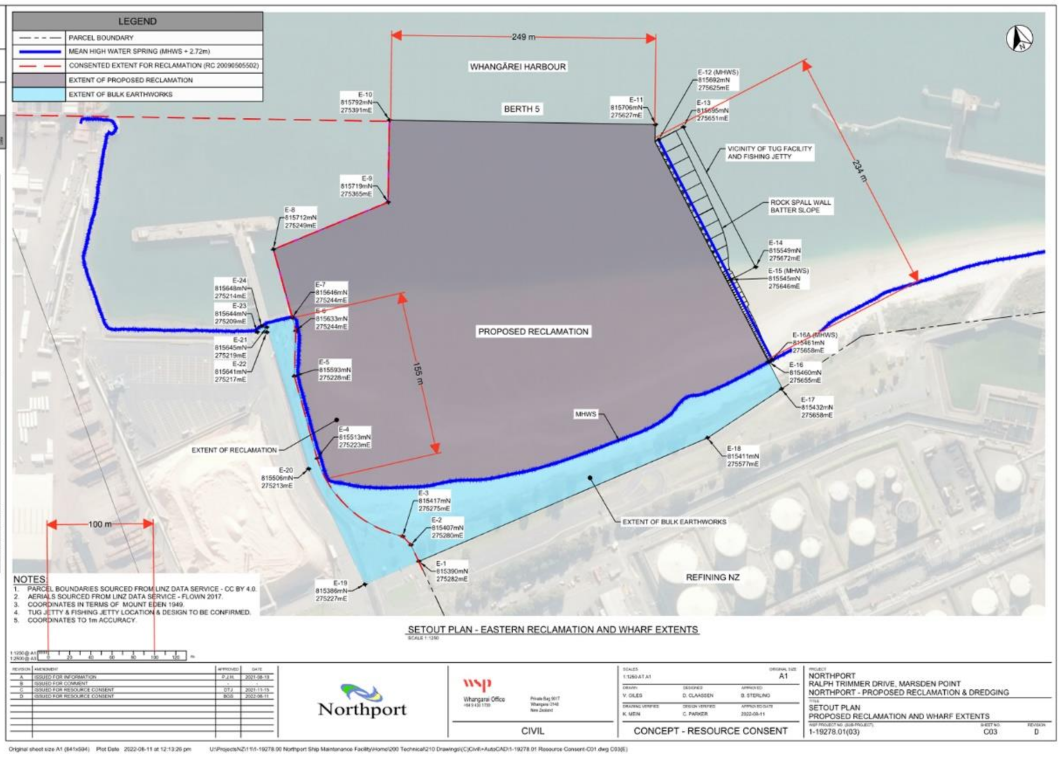
Given that:

- the existing area of revetment is an artificial construction;
- more revetment will be created than is lost;
- other natural reefs occur in the harbour;
- any adverse effects on reef species that are threatened or at risk will be low at worst (equating to a less than minor effect);
- dredging is unlikely to affect existing reefs; and,
- recovery will occur over a period of around 5 years;

the overall effect of reclamation on reef habitat and biota at all scales is considered to be low immediately, and positive in the medium to long term; and the overall effect of dredging on reef habitat and biota at all scales is considered to be negligible.

Figure 65: Proposed reclamation showing a) the lengths of rocky revetment to be lost and gained, and b) concept designs for revetments along the eastern and northern margins of Berth 5.

a.



b.

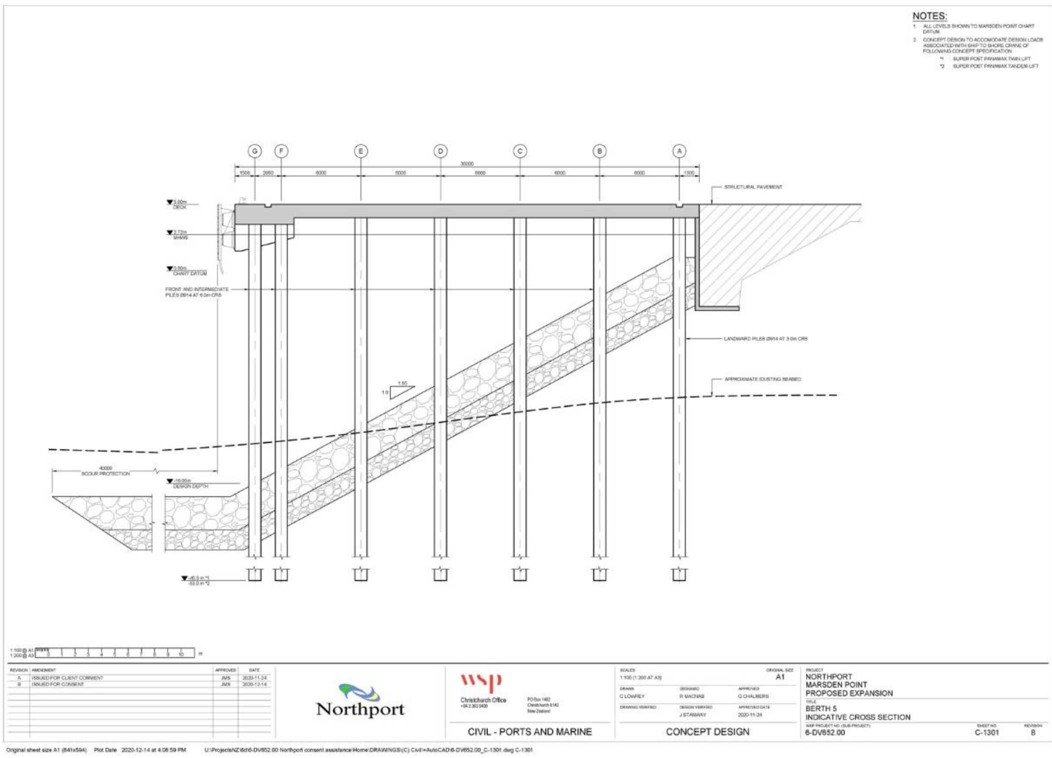
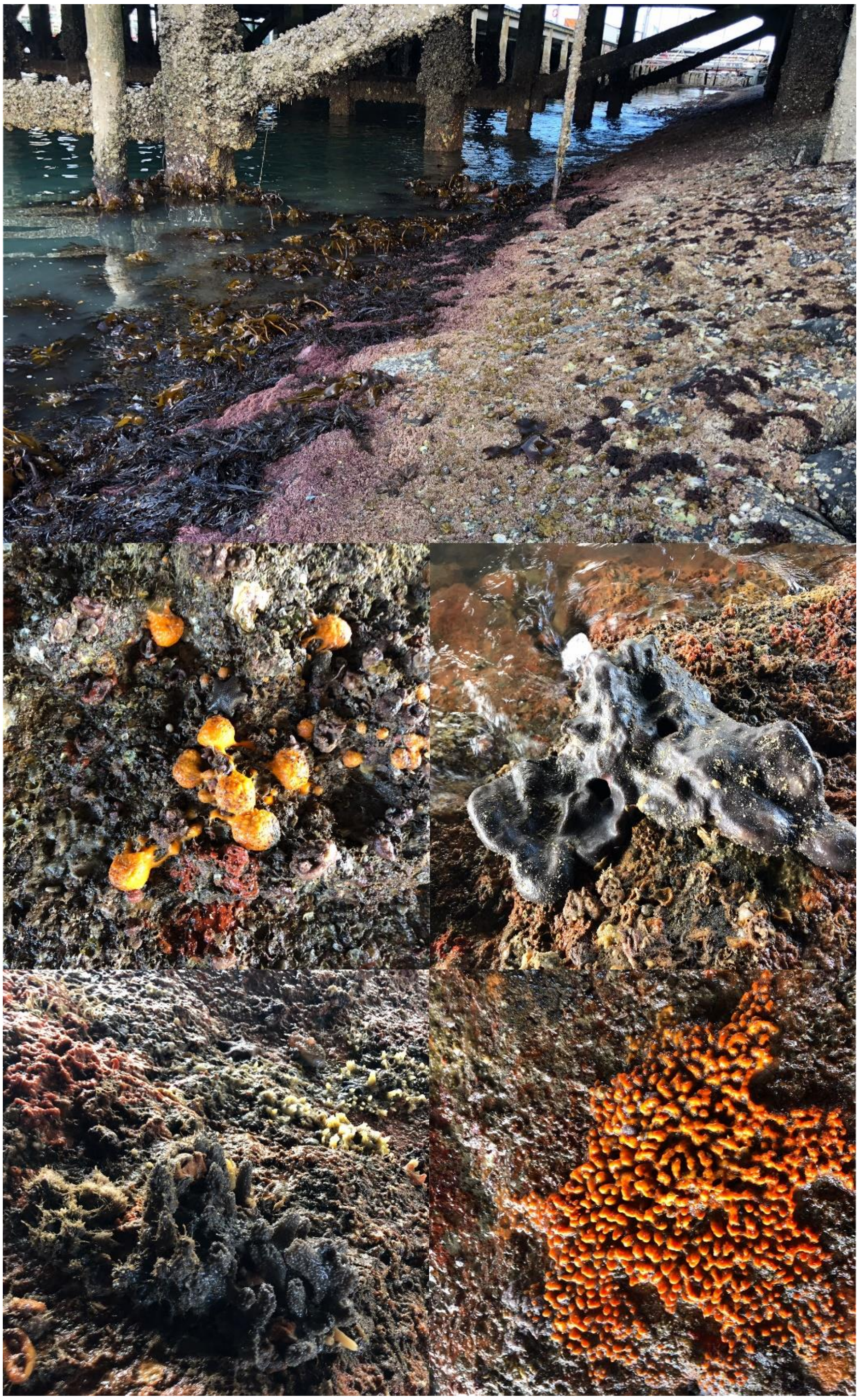


Figure 66: Photos showing examples of biota in an under-wharf community (Brighams Wharf, Auckland), which includes a variety of (typically) subtidal species growing in the intertidal zone.



6.3.6 EFFECTS ON FISH

Whangārei Habour contains a moderately diverse assemblage of fish, and biogenic habitat that may be important to some species. As noted earlier, the OHEZ contains large areas of subtidal biogenic habitat, with macroalgae meadows and other biogenic features likely to act as nursery habitats for some fish species. At the OHEZ scale, reclamation will lead to the direct and permanent loss of a small (0.12%) proportion of natural subtidal habitat with relatively little biogenic habitat. The proposed dredging will largely be limited to an area where dredging has already occurred or is currently consented. By and large, those effects are already provided for under the current capital and maintenance dredging consent. As detailed in Sections 6.3.2 and 6.3.4, in addition to direct effects, modelling predicts that sediment plumes generated during dredging and associated sediment deposition will affect surrounding habitat and benthic communities. The scale, magnitude, and duration of effect will depend on the type of dredging, length of time taken, and interactions between dredge operations and plume generation, tides, and the vagaries of winds and waves. The combined effects of dredging on benthic communities of importance to fish, including macroalgae, are expected to range from:

- high at the OHEZ and Harbour scales if a TSHD is used; and,
- moderate at those scales for CSD and BHD operations.

Ecological recovery is expected to occur over a period of 5 or more years.

The proposed activities will affect important habitat for fish (particularly juveniles), but impacts on fish, per se, are expected to be lower and temporary, because:

- The species potentially affected are able to move to other areas.
- Fish stock sizes are managed through fishing controls set under the Fisheries Management Act.
- Fish populations are unlikely to be limited by habitat or resource availability because fishing (carried out under the Fisheries Act) has reduced the populations of targeted species to levels well below those historically occurring.
- None of the fishes potentially affected are Threatened or At Risk species.

Overall, the effect of disturbing or losing important fish habitat within the dredging and reclamation footprints is assessed as low at all scales.

6.4 STORMWATER DISCHARGES

Detailed assessments of the existing Northport, and broader stormwater systems are provided in Poynter and Kane (2015) and Poynter (2021). Marsden Bay is subject to stormwater runoff from existing port facilities, as well as surrounding commercial and industrial sites, and residential areas. Poynter (2021) states that there are nine consents[33] for stormwater discharges to the Marsden Bay area that discharge from multiple outfalls along the shore (Figure 67).

Poynter and Kane (2015) state that logs are likely to have the greatest influence on the quality of stormwater from the Northport site. Other sources of contaminants include bulk cargoes transferred through the port, including phosphate rock, palm kernel, grain, coal, gypsum, sulphur, and refined fertiliser. Special provisions are made for potentially hazardous products or processes, which are bunded and or self-contained to isolate them from the stormwater system.

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[33] Stormwater discharge consents are held by Channel Infrastructure, Northport, Northland Port Corporation, Marsden Cove Ltd, Marsden Maritime Holdings Ltd and Whangārei District Council).

The quality of the stormwater discharge is currently managed through a combination of source control (containment and housekeeping) and treatment. Housekeeping practices include the removal of bark and wood debris to offsite landscape suppliers, routine sweeping, dust suppression, and the regular cleaning of cesspits.

Stormwater from the site is conveyed via open collection channels to a partitioned settlement pond of approximately 4 ha. Treatment of suspended solids occurs through trapping behind a weir at the terminal end of the collection channel system, and through settlement in two serially connected pond cells. Water is pumped from the final pond cell and discharged, along with stormwater from Marsden Maritime Holdings Ltd to the harbour via an outfall diffuser beneath the port berths. Stormwater discharges from the Northport are managed in accordance with an existing consent (CON20090505532), which includes a range of monitoring requirements, compliance standards, and indicators for assessing treatment performance ("Action Levels"). Among other things, water quality standards for the harbour currently include limits on changes to temperature, pH, dissolved oxygen, water clarity and hue, and concentrations of copper, lead and zinc, which are applied from the edge of a 300–500 m mixing zone.

Current consent conditions require a greater range of parameters (compared with the range of parameters to which water quality standards apply, as outlined above) to be monitored. Event related sampling of pond water quality (prior to discharge to the coastal environment) needs to be carried out on three occasions each year, with three samples to be collected over each of those days. Every sample must be analysed for total suspended solids, volatile suspended solids, turbidity (NTU) and pH. In addition, the first sample of the first discharge event must be analysed for aluminium, copper, lead, zinc, polycyclic aromatic hydrocarbons (PAH) and resin acids.

Conservative Action Levels are prescribed for particular contaminants to enable the early detection and investigation of issues before an environmentally harmful situation arises. Consent requirements for discharge water quality monitoring are complimented by conditions that require:

- Northport to carry out whole effluent toxicity testing (WETT) of stormwater on at least one occasion, with the need for further testing to be considered if new contaminants are introduced;
- pond influent monitoring once each year to enable treatment efficiency to be checked.

Results from the monitoring indicate that Northport has displayed a high level of compliance with its conditions of consent, and that the quality of discharged stormwater is reasonably good. Little, if any, need for dilution in the mixing zone was required to achieve compliance, or reduce concentrations to levels below ANZG (2018) 95% protection guideline values (Poynter, 2021). For instance:

- All of the prescribed metals presented in Poynter (2021) were well below consented concentration limits for the receiving environment (based on ANZG (2018) 95% guideline values), after providing for 200 times dilution within the mixing zone. In most cases, metal concentrations were below the receiving environment limit before they left the pond. The exception was copper, but that only had pond concentrations of around two times the receiving environment limit. Based on expected dilution rates (Poynter and Kane (2015)), copper concentrations will be well below consent standards and guideline values after reasonable mixing.

- Poynter and Kane (2015) indicated that polycyclic aromatic hydrocarbons (PAH) concentrations in eleven samples collected between November 2013 and December 2014 had concentrations below levels of detection.
- Continuous pond monitoring between 2019 and 2020, and spot sampling between September 2018 and September 2019, has shown that pond water is reasonably aerated (average DO concentration at the discharge was 7.24 mg/L), turbidity and total suspended solids (TSS) concentrations were low (particularly given the nature of port runoff) with an average of 9.53 NTU and a TSS maximum of 15 mg/l), and that the average pH of 7.47 was within consent limits.

Overall, the available information suggests that the current discharge poses little ecological risk. This conclusion is supported by toxicity testing (WETT) carried out by NIWA in 2003 and 2005, which showed no significant toxicity at 200 times dilution, and even under the highest concentrations tested (32% and 63.5% for a marine algae and the wedge shell *M. liliana*, respectively), there were no adverse effects on the test organisms relative to the control (see Poynter & Kane, 2015).

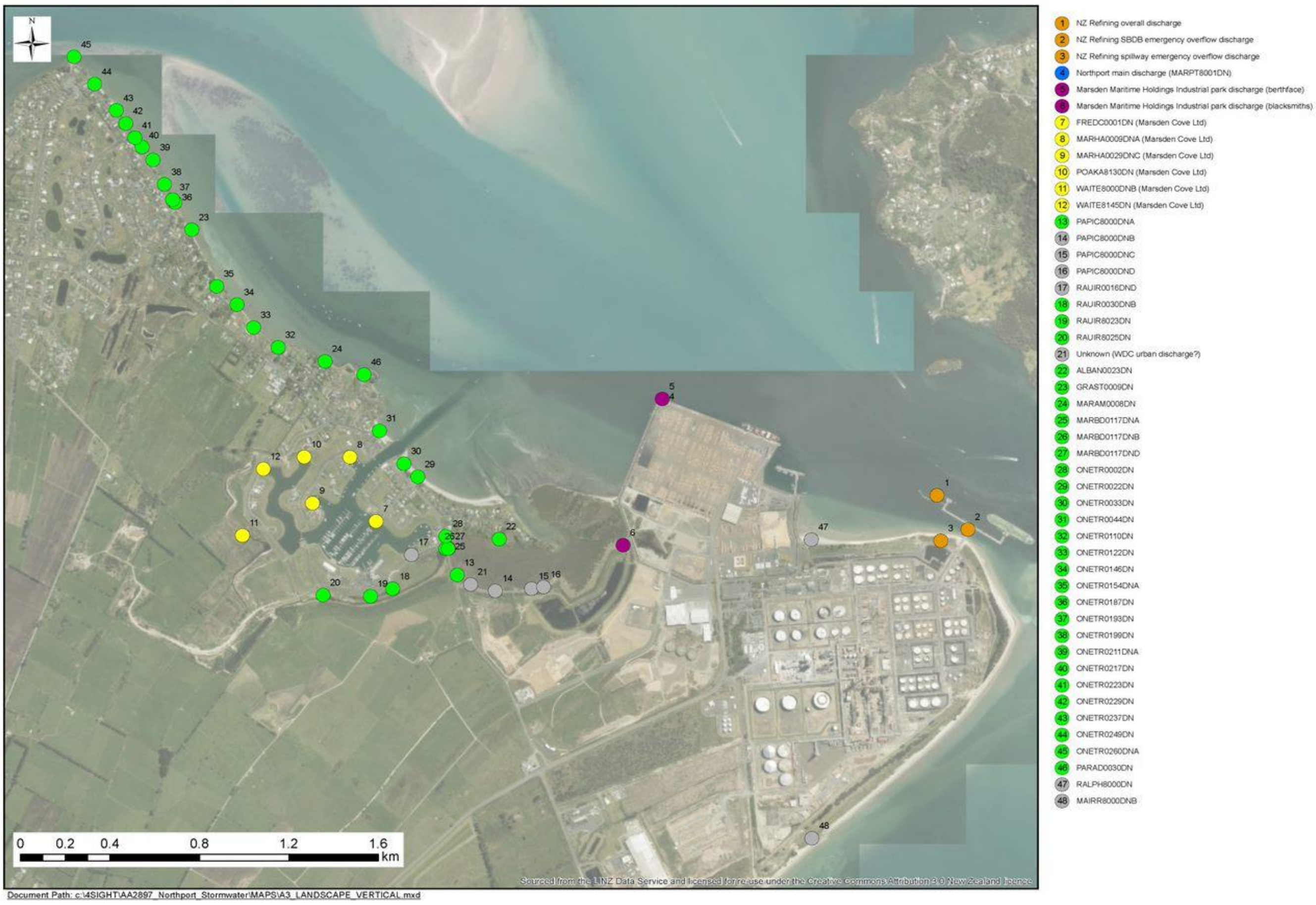
The existing stormwater system will be upgraded to accommodate runoff from the proposed reclamation areas. Importantly, no logs or other bulk freight will be stored on the proposed reclamation areas. Consequently, stormwater contaminant loads from the proposed reclamation are expected to be relatively low. Discharge water quality is therefore expected to be similar to, or better than, that provided by the existing system (due to inputs of cleaner stormwater water), but discharge loads may increase slightly. Overall, the proposed reclamation is expected to have a low effect on sediment and water quality, given:

- past monitoring and assessments indicate that key contaminant concentrations are well below toxicity guidelines after reasonable mixing;
- the outfall discharges to a high flushing area;
- contaminants are unlikely to permanently settle and accumulate in the local receiving environment.

Assuming that past monitoring results are representative of existing discharge quality, and that a similar discharge quality will be maintained, the addition of the proposed reclamation area **is not expected to cause any additional adverse ecological effects.** However, it is recommended that stormwater monitoring requirements be reviewed to ensure:

- they remain aligned with port operations (e.g., the addition of total organic carbon is recommended); and,
- they provide a timely warning for management intervention if unanticipated changes in the discharge occur.

Figure 67: Consented stormwater discharges on the southern side of the lower harbour (from Poynter, 2021).



6.5 CUMULATIVE EFFECTS

6.5.1 BACKGROUND

When considering cumulative effects, context is important. Whangārei Harbour has been modified by decades of industrial, rural, urban, and coastal activities, which among other things include:

- the disposal of millions of cubic metres of sediment produced from cement production and channel dredging;
- dredging effects associated with maintaining navigable channel depths around the outer harbour and Marsden Cove, through to Whangārei;
- the construction of existing developments in the CMA including Northport, Channel Infrastructure, Port Whangārei, and various marinas; and,
- fishing and shellfish harvesting.

Activities for which consents have been granted, but are yet to be actioned, have also been considered - where relevant. They include:

- Port Nikau marina extension (upper harbour);

- Whangārei Marina Management Trust's new marina (upper harbour);
- dredging to deepen and realign the commercial shipping channel by Channel Infrastructure; and,
- the Ruakaka (Bream Bay) wastewater discharge held by Whangārei District Council.

Importantly, however, a number of effects associated with Northport's current proposal are already provided for under the current berth 4 capital and maintenance dredging consent.[34] It is difficult to be precise about differences between the adverse effects of the existing berth 4 consents and those of the current proposal. Therefore, a variety of effects that are already authorised, have simply been absorbed into the effects assessment in this report. As a result, the assessments of cumulative effects are conservative.

6.5.2 ACTIVITIES TO BE CONSIDERED

The potential effects of the proposed reclamation, dredging and stormwater discharges outlined above are:

- loss of marine habitat and biota living within the dredging and reclamation footprints;
- displacement of species that utilise the reclamation area, but do not permanently live within it;
- effects of sediment suspension, dispersal and deposition beyond the dredging zone;
- indirect effects arising from alteration to currents, wave and/or sedimentation patterns;
- effects on reef habitat;
- ecological effects associated with potential changes to water quality from stormwater discharges.

Of these, the cumulative disturbance or loss of habitat and biota through the combined impacts of dredging and reclamation appears to be the main issue with the potential to act in a cumulative fashion and increase the magnitude of effects beyond those already described.

6.5.3 CUMULATIVE LOSS OF MARINE HABITAT

Subtidal video surveys show that the harbour entrance contains highly diverse biogenic habitats and species. The two dominant biogenic habitats present were dense shell and macroalgae meadows. These habitats are known to provide important ecosystem services and habitats for a wide variety of organisms, as summarised below.

1. Dense shell habitats:
    a. provide a hard substrate for a diverse range of epifauna to attach to, and may form the basis of the development of other biogenic habitats e.g., sponge gardens, bryozoan thickets;
    b. stabilise the sediment;

[34] The only changes are related to the slight difference between the currently consented and proposed dredging footprints and the different dredge depths involved.

c. can alter the flow dynamics across the seabed;

d. often support a significantly higher infaunal diversity that surrounding fine sediment habitats;

e. may act as a nursery habitat for post-settlement snapper, which have been shown to aggregate around sediment structures such as mounds, pits and burrows (Compton *et al.*, 2012; Morrison *et al.*, 2014; Anderson *et al.*, 2019).

2. Macroalgae meadows:

    a. are important primary producers and act as a carbon sink;

    b. can modify water flows and sediment regimes;

    c. provide biogenic habitat, food and refuge to a wide range of fishes and invertebrates;

    d. may act as a nursery area for juvenile snapper (< 10 cm) and other fish species;

    e. comprising filamentous species provide a primary settlement substrate for mussel and scallop larvae;

    f. get washed ashore where they provide habitat and food for beach invertebrates and birds (Morrison *et al.*, 2014; Anderson *et al.*, 2019).

Other biogenic habitat forming species, such as sponges, bryozoans, and horse mussels, were also observed in the subtidal video survey conducted for Northport, which collectively formed a mixed species biogenic habitat, but they did not reach sufficient densities to be defined as their own, separate biogenic habitats. It is also possible that other biogenic habitats were present in the area that could not be verified in the video survey. For example, large areas of dense holes could have been made by buried shellfish.

Overall, consents have been obtained (or are sought by Northport) for around 70 ha of dredging and reclamation in the OHEZ. Northport already have consent to carry out new dredging of around 13.2 ha of subtidal habitat, and reclamation of around 4.5 ha of mostly subtidal habitat on the eastern side of the port, which is yet to be actioned (Berth 4). Northport are seeking to reclaim an additional 6.6 ha of intertidal and 5.1 ha of subtidal habitat as part of their proposed reclamation project. The total area of outer-harbour, marine habitat that will be lost, or disturbed, by the combined proposed Northport activities is therefore around 29.4 ha.

Channel Infrastructure have also gained consent to dredge around 144 ha from the approach and entrance channel to Whangārei Harbour (Kemble *et al.*, 2017; NRC, 2018b; Figure 68), but are yet to exercise it. Georectified images indicate that around 40 ha will be dredged from the OHEZ (Figure 69). Drop camera, dredge and grab sampling in and around areas that Chanel Infrastructure have consent to dredge were carried out by West and Don (2016) (Figure 70). In summary, they found:

- the overall diversity of infaunal taxa was very high;
- seabed habitats in the dredging areas consisted of sand and shell gravel;
- the only kaimoana shellfish species present were green-lipped mussels, which were obtained from stations C23 MN, C26 N, and C27 MN (see Figure 70);

- macroalgae meadows, sponge gardens, scallops, horse mussels or other living biogenic features are not apparent in photographs obtained from any stations in the dredging areas.

Breakdowns of the combined areas of intertidal and subtidal habitat affected by consented and proposed reclamation and dredging are provided in Table 8–Table 10, and the combined significance of effects are considered in the following section.

Figure 68: Map showing Channel Infrastructure consented dredging areas (from NRC, 2018b).

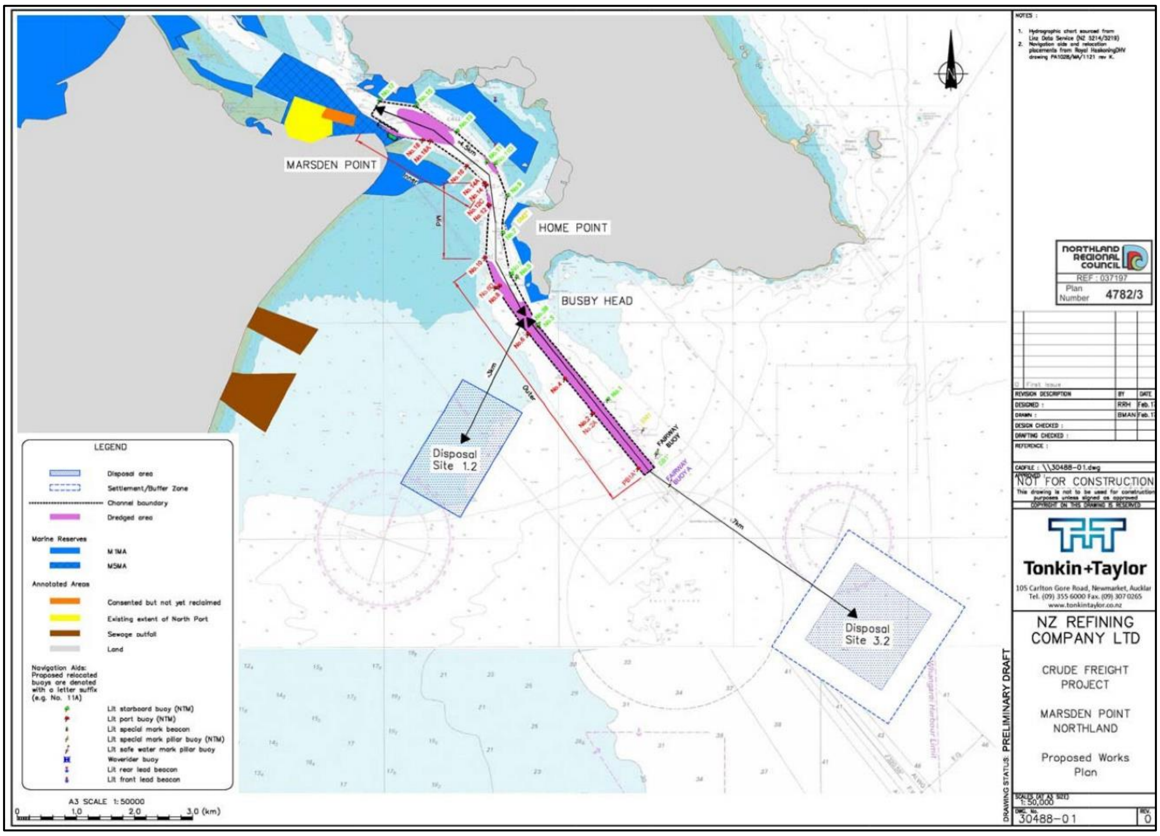
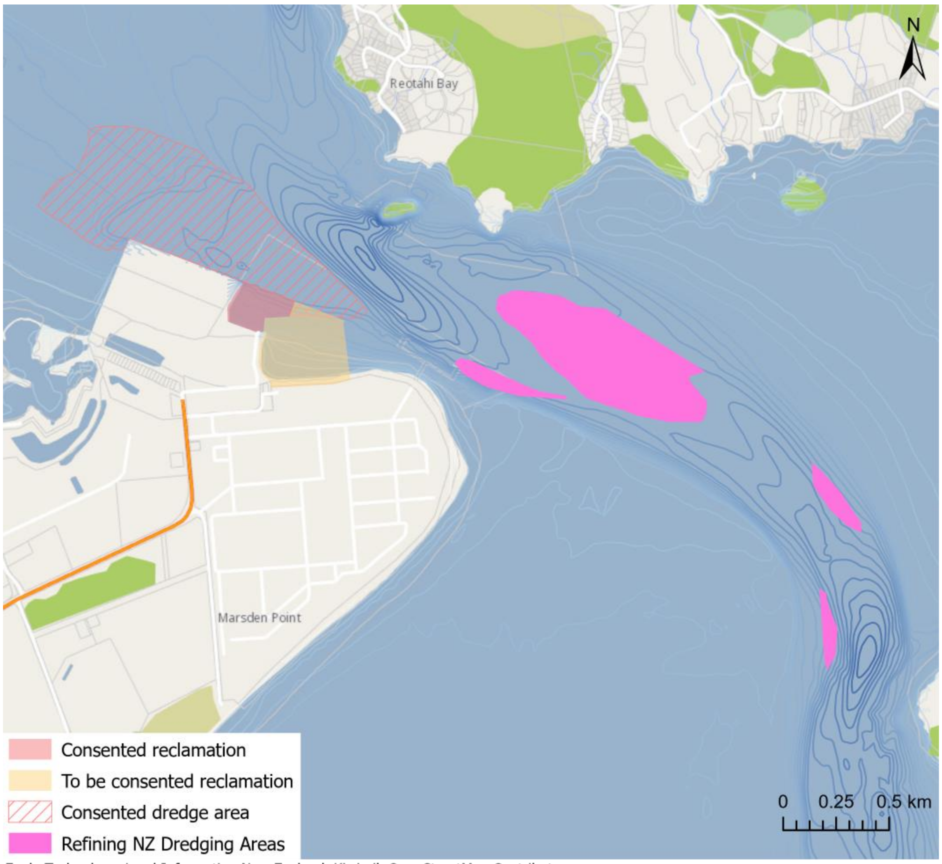


Figure 69: Consented, but not implemented, and to be consented, reclamation and dredging footprints in Whangārei Harbour entrance. Channel Infrastructure footprints are approximate.



Eagle Technology, Land Information New Zealand, Kiwirail, OpenStreetMap Contributors

Figure 70: Stations sampled by West and Don (2016) showing station codes and substrate types.

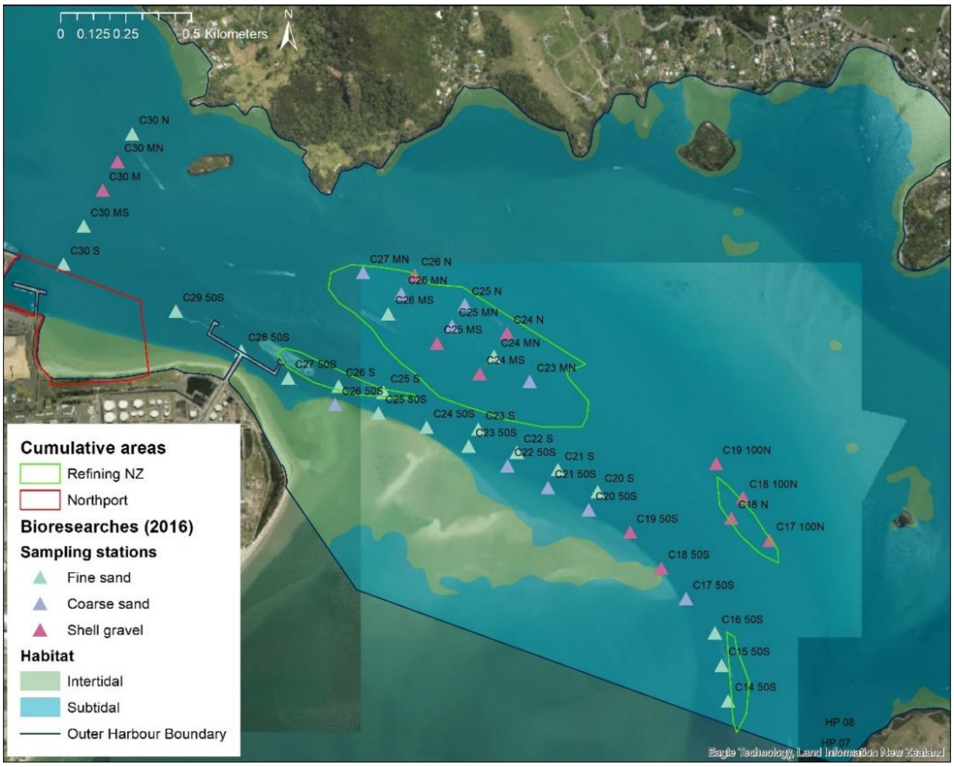


Table 8: Areas in hectares (ha) of proposed and consented reclamation and dredging areas.

	Intertidal	Subtidal	
Development Area	Reclamation footprint (ha)	Reclamation footprint (ha)	Dredging footprint (ha)
Proposed (excl. bird roost)	6.56	5.13	61[35]
Proposed (bird roost)	0.54	0	0
Northport consented	0.14	4.35	60[35]
Channel Infrastructure	0	0	40
Total	**6.33**	**9.86**	**101[36]**

Table 9. Approximate size of the OHEZ and Harbour ecological systems.

Ecological System	Intertidal (ha)	Subtidal (ha)	Total (ha)
OHEZ	606	1,970	2,576
Harbour	6,032	4,368	10,400

Table 10: Extents of proposed and consented reclamation and dredging areas expressed as percentages of the intertidal and subtidal area within the OHEZ ecological system. Note that areas affected by dredging sediment plumes have not been included.

Activity	Reclamation Intertidal (% of OHEZ intertidal)	Reclamation subtidal (% of OHEZ subtidal)	Dredging subtidal (% of OHEZ subtidal	Intertidal total (% of OHEZ intertidal)	Subtidal total (% of OHEZ subtidal)	Reclamation total (% of total OHEZ area)	Dredging total (% of total OHEZ area)	Total loss and disturbance (% of total OHEZ area)
Proposed (excl. bird roost)	1.08	0.26	3.1[35]	1.08	3.36[35]	0.45	2.37	2.82
Proposed (bird roost)	0.09	0	0	0.09	0	0.09	0	0.02
Northport consented	0.02	0.22	3.05[35]	0.02	3.27[35]	0.17	2.33	2.5
Channel Infrastructure	0	0	2.03	0	2.03	0	1.55	1.55
Proposed and consented	1.2	0.48	3.1[35]	1.2	3.58[35]	0.65	2.37	3.02
Channel Infrastructure, proposed and consented	1.2	0.48	5.13[35]	1.2	5.61[36]	0.65	3.92	4.57

[35] Consented and proposed dredging areas largely overlap.

[36] Sum of proposed and Channel Infrastructure areas.

6.5.4 SIGNIFICANCE OF CUMULATIVE EFFECTS

Reclamation will result in a permanent reduction in the extent of physical and biological features that increase diversity values and support important ecosystem services. Dredging will physically alter (deepen) habitats and disturb such features. However, observations from around Northport indicate that similar, high value habitats and ecological features do reform once dredging ceases.

The significance of ecological effects associated with reclamation and dredging were individually assessed for the proposed reclamation and dredging and for combinations of those developments and other dredging and reclamation projects that have already been consented. Individual assessments were produced for major habitats and features, and for activities of particular significance. For each of these, an assessment was made against, what was considered to be, the most ecologically relevant system (Table 11 to Table 19). Key factors considered in the assessments where the:

- scale of effect relative to the size of the relevant ecological system;
- values of the habitats, communities and biota likely to be affected;
- extent, abundance and/or occurrence of features within the relevant ecological systems; and,
- potential for recovery.

Key results from the assessment are:

- individual and cumulative effects of the developments on intertidal habitats were assessed as being moderate;
- individual and cumulative effects on kaimoana shellfish (cockles, pipi, scallops, and mussels) were assessed as being low;
- individual and cumulative reclamation effects on subtidal habitats and communities were assessed as being moderate;
- individual and cumulative effects dredging effects on subtidal habitats and communities were assessed as moderate to High, but;
- individual and cumulative effects on seagrass were assessed as being low;
- individual and cumulative effects on seaweeds were assessed as being moderate to high;
- individual and cumulative effects on rocky reef habitat and communities (i.e., the revetment) were assessed as positive in the medium to long term;
- individual and cumulative effects on fish habitat were assessed as low;
- individual and cumulative effects from stormwater discharges were assessed as low.

Table 11: Assessment of cumulative effects on intertidal benthic habitats and macrofauna, relative to the harbour system.

Development	Effects on sandy intertidal habitat and ecology.	Rationale	Notes
This project	Moderate	High values, permanent loss, but relatively small area affected.	Around 0.12% of harbour's intertidal habitat will be lost and the overall abundance of common infaunal taxa will be slightly reduced, but changes to infaunal biodiversity are not expected.
This project and Northport consented	Moderate	High values, permanent loss, but relatively small area affected.	There is no sandy intertidal habitat in the currently consented Northport areas, so there are no additional effects.
Channel Infrastructure, this project and Northport consented	Moderate	High values, permanent loss, but relatively small area affected.	There is no sandy intertidal habitat in the currently consented Northport or the Channel Infrastructure areas, so there are no additional effects.

Table 12: Assessment of cumulative effects on kaimoana shellfish relative to the harbour system.

Development	Effects on kaimoana shellfish	Rationale	Notes
This project	Low	Cockles are ubiquitous in the harbour. No harvestable pipi in the detected in the reclamation area or in areas affected by dredging. Few live scallops observed, and measures proposed to minimise effects on them.	Cockles, pipi and scallops potentially affected.
This project and Northport consented	Low	Same as above	Same as above.
Channel Infrastructure, this project and Northport consented	Low	Past records of mussels, same as above for other kaimoana shellfish.	Assumed that mussels reported in 2016 are still there. Same as above for other kaimoana shellfish.

Table 13: Assessment of cumulative reclamation effects on subtidal habitat and benthic macrofauna relative to the OHEZ system.

Development	Reclamation effects on subtidal benthic habitats and communities.	Rationale	Notes
This project	Moderate	Small area, high value features in the proposed reclamation limited in extent	Only a small proportion of OHEZ subtidal habitat affected (0.26%) and high value features within the proposed reclamation are very limited in extent.
This project and Northport consented	Moderate	Small area, high values	Combined reclamation areas comprise a small proportion of the OHEZ subtidal habitats (0.48%) with varying occurrence of high value features.
Channel Infrastructure, this project and Northport consented	Same as above.	Same as above.	Same as above (no additional reclamation).

Table 14: Assessment of cumulative dredging effects on subtidal habitat and benthic macrofauna relative to the OHEZ system.

Development	Dredging effects on subtidal benthic habitats and communities	Rationale	Notes
This project	CSD and BHD - Moderate TSHD –High Temporary if similar seabed substrates are present or re-establish after dredging ceases. Permanently diminished ecological values if similar seabed substrates are not	Relatively large area effected. Some effects already provided for under existing consent. Effects depend on the method used to dredge and on seabed substrates after dredging ceases.	Relatively large area with high ecological values directly affected (3.1% of the OHEZ subtidal). Those effects are already largely provided for under the current capital and maintenance dredging consent. The scale and magnitude of indirect effects (particularly sediment plumes and deposition) depends on the method of dredging. Recovery to levels existing inside and outside of previously dredged area is expected if similar seabed substrates are present after dredging ceases. Diminished ecological values are anticipated if that does not occur. Risks of indirect effects will be reduced through monitoring and management regimes.

Development	Dredging effects on subtidal benthic habitats and communities	Rationale	Notes
	present or do not re-establish after dredging ceases. Risks of indirect effects will be reduced through monitoring and management regimes.		
This project and Northport consented	Same as above.	Same as above.	Same as above.
Channel Infrastructure, this project and Northport consented	CSD and BHD - Moderate TSHD – High Temporary if similar seabed substrates are present or re-establish after dredging ceases. Permanently diminished ecological values if similar seabed substrates are not present or do not re-establish after dredging ceases.	Moderate area, high values, recovery expected.	The Channel Infrastructure dredging area comprises around 2 % of subtidal habitat in the OHEZ. In general, subtidal habitats of the OHEZ have very high infaunal diversity. Known habitats in the area include sand and shell hash, with scattered green lipped mussels present in 2016. It does not appear to contain seaweed meadows or other living biogenic habitats. Combined Northport and Channel Infrastructure dredging directly affects 5.1% of the subtidal area on the OHEZ. The scale and magnitude of indirect effects (particularly sediment plumes and deposition) depends on the method of dredging and could also be substantial. Recovery to levels existing inside and outside of dredged areas is expected if similar seabed substrates are present after dredging ceases. Diminished ecological values anticipated if that does not occur. Effects could be diminished by using sequencing to allow recovery (or partial recovery) in one area before moving to the next.

Table 15: Assessment of cumulative effects on seagrass relative to the Harbour system.

Development	Effects on seagrass	Rationale	Notes
This project	Low	Small amount affected, but high value, At Risk species.	Small patches of seagrass will be lost. Extensive beds occur throughout the harbour. Significant recovery in seagrass extent has occurred over the past two decades. Species displays large fluctuation in extent.
This project and Northport consented	Same as above.	Same as above.	Seagrass is not affected by previously consented activities that are yet to be implemented.
Channel Infrastructure, this project and Northport consented	Same as above.	Same as above.	Same as above. The Channel Infrastructure dredging area does not appear to contain seagrass.

Table 16: Assessment of cumulative effects on macroalgae (seaweeds) relative to the OHEZ system.

Development	Effects on macroalgae (seaweeds)	Rationale	Notes
This project	CSD and BHD - Moderate TSHD – High Temporary if similar seabed substrates are present or re-establish after dredging ceases. Some uncertainty about the effects of increased light attenuation. Risks will be reduced through monitoring and management regimes.	High values. Level of effect depends on dredging method used. Mix of clear and uncertain impacts. Key dredging effects already provided for by existing consents. Macroalgae particularly susceptible to physical removal, smothering, and changes in the quality and quantity of light.	Outer harbour contains soft sediment macroalgae meadows with diverse, but low biomass species assemblages. Around 3.36% of the OHEZ directly affected by dredging and reclamation, with the scale and magnitude of indirect effects varying widely depending on the method of dredging. Macroalgae meadows are not present throughout the entire OHEZ. Little macroalgae present in the proposed reclamation area, but it is common throughout areas directly and indirectly affected by the proposed (and currently consented) dredging. Key dredging effects are already provided for by existing consents. Recovery expected, but values may be permanently diminished if similar seabed substrates are not present or do not re-establish after dredging ceases.

Development	Effects on macroalgae (seaweeds)	Rationale	Notes
			Some uncertainty about the effects of increased light attenuation. Changes to light conditions may alter the composition of the macroalgae community within the dredged area. At Risk species are potentially present, but adverse effects on those are likely to be low. Potential for risks will be reduced through monitoring and management regimes.
This project and Northport consented	Same as above.	Same as above.	Same as above, with the additional loss of 0.22% of subtidal habitat in the OHEZ related to reclamation that has already been consented but yet to be implemented.
Channel Infrastructure, this project and Northport consented	Same as above	Same as above.	Same as above. The Channel Infrastructure area does not appear to contain macroalgae meadows.

Table 17: Assessment of cumulative effects on reef habitat and biota relative to the Harbour system.

Development	Effects on reef habitat and biota	Rationale	Notes
This project	Low, but temporary and positive in the medium to long term.	Man-made features. Support high value ecological community. Losses will be more than offset by newly created habitat. Recovery expected.	The extent of rocky reef is limited in the harbour. Community associated with existing rocky revetments will be lost, but they will reform on new revetments. The length of revetment created will be greater than the length lost.
This project and Northport consented	Same as above.	Same as above.	Same as above.
Channel Infrastructure, this project and Northport consented	Same as above.	Same as above.	No reef in Channel Infrastructure area. Same as above.

Table 18: Assessment of cumulative effects on fish relative to the Harbour system.

Development	Effects on fish habitat	Rationale	Notes
This project	Low	Permanent displacement from very small portion of available habitat. Temporary displacement from areas affected by dredging.	Affected species mobile and able to utilise other locations
This project and Northport consented	Same as above	Same as above	Same as above
Channel Infrastructure, this project and Northport consented	Same as above	Same as above	Same as above

Table 19: Assessment of cumulative ecological effects of stormwater discharges relative to areas beyond the mixing zone.

Development	Effects of stormwater discharges	Rationale	Notes
This project	Low	Past performance and set standards.	Adverse ecological effects beyond the mixing zone managed through site controls, monitoring and discharge standards.
This project and Northport consented	Low	Same as above.	Same as above.
Channel Infrastructure, this project and Northport consented	Low	Same as above.	Same as above.

7 CONCLUSIONS

The entrance to Whangārei Harbour entrance supports a diverse marine ecological community including seagrass beds, cockle and pipi beds, a high diversity of macrofaunal taxa, diverse subtidal habitats with large areas of biogenic habitat, and numerous fish species. An assessment of potential marine ecological effects (excluding biosecurity issues, and effects on birds and mammals) of the proposed development was conducted on three different scales: the harbour, OHEZ, and the proposed development footprint. Those effects are summarised in Table 20 below, along with a summary of overall cumulative effects at the most appropriate system in Table 21.

The proposed reclamation will lead to the loss of around 6.2 ha of intertidal and 5.5 ha of subtidal habitat beneath the proposed reclamation (excluding already consented areas), while around 61 ha of subtidal habitat will be directly impacted by dredging, with surrounding areas also being indirectly affected by dredging. By and large, the direct effects of dredging are already provided for under the current capital and maintenance dredging consent[37]. Construction of a 0.54 ha bird roost in the intertidal zone on the western side of Northport is also proposed.

Surveys carried out for Northport indicated that those habitats contain:

- intertidal habitat and infaunal communities;
- subtidal habitats that are physically and ecologically diverse with extensive areas of biogenic habitat (including extensive shell gravel beds, seaweed meadows, seagrass beds, sponges, horse mussels and significant shellfish beds);
- kaimoana shellfish species including cockles, small pipi and scallops;
- small patches of intertidal seagrass within the proposed reclamation area.

The proposed activities will cause a variety of effects that include: the loss of intertidal habitat beneath the reclaimed and bird roost areas; the removal of substrates and communities through proposed dredging; effects related to suspended and deposited sediments; and effects related to deepening the seabed. Levels of effect have been assessed for the individual activities and in combination with other relevant activities. Potential effects vary among the key ecological receptors — ranging from positive in terms of effects on reef habitat, to potentially highly adverse in relation to effects on subtidal habitats, macroalgae and benthic macrofauna. Potential effects are summarised in Tables 20 and 21 below, which represent conservative assessments for the reasons outlined.

Most effects within the reclamation and dredging footprints are unavoidable. However, actions can be taken (including through conditions of consent) to reduce the overall level of effects. Possibilities include:

- minimising sediment suspension and dispersal through the selection of dredging methods;

[37] The only changes are related to the slight difference between the currently consented and proposed dredging footprints and the different dredge depths involved.

- using best practice methods such as real time turbidity monitoring and triggers to maintain the effects of dredging plumes within acceptable limits (e.g. Napier Port 2019);
- removing key species (e.g., scallops) from affected sites prior to starting reclamation or dredging.
- monitoring recovery after dredging is complete and reseeding dredged areas with shell, if shell/gravel is not present at the dredged depth, or it does not re-establish naturally.

Finally, the ecological effects of the proposal on threatened or at risk species (seagrass and macroalgae), or the Significant Ecological Areas (SEAs) identified in the Proposed Regional Plan (Figure 13) will be in the range of negligible to less than minor (and in some cases temporary). Noting that, most of proposed dredging area is already subject to dredging — if best practice methods for managing dredging effects are applied (e.g. Napier Port 2019), then the ecological effects on any other potential areas of significant indigenous vegetation and habitats of indigenous fauna under Appendix 5 of the Regional Policy Statement (RPS) could also be kept within minor and/or transitory levels.

Table 20. Summary of individual effects of the proposed development at the scale of the: harbour; outer harbour and entrance zone (OHEZ); and development footprint.

Potential effects	System		
	Harbour	OHEZ	Footprint
Effects on intertidal sediment habitats and macrofauna	Moderate	Moderate	Very high
Effects on kai moana shellfish	Low	Low	High
Effects on subtidal habitat and benthic macrofauna - Reclamation	Moderate	Moderate	Very high
Effects on subtidal habitat and benthic macrofauna - Dredging	Moderate to High	Moderate to High	Moderate to High
Effects on seagrass	Low	Low	Very High
Effects on macroalgae	Moderate to High	Moderate to High	Moderate to High
Effects on fish	Low	Low	Low
Effects on reef habitat	Low and positive in medium to long term	Low and positive in medium to long term	Low and positive in medium to long term
Effects of stormwater discharges	Low	Low	Low

Table 21. Summary of total cumulative effects of the proposed development assessed against the most relevant system.

Potential effects	Most relevant system	Level of Effect
Effects on intertidal benthic habitats and macrofauna	Harbour	Moderate
Effects on kaimoana shellfish	Harbour	Low
Effects on subtidal habitat and benthic macrofauna - Reclamation	OHEZ	Moderate
Effects on subtidal habitat and benthic macrofauna - Dredging	OHEZ	Moderate to High
Effects on seagrass	Harbour	Low
Effects on macroalgae	OHEZ	Moderate to High
Effects on fish	Harbour	Low
Effects on reef habitat	Harbour	Positive in medium to long term
Effects of stormwater discharges	Beyond the mixing zone	Low

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