Appendix 29

Marine Ecology Fieldwork and Stormwater Monitoring Reports

4SIGHT CONSULTING

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Northport

Northport Intertidal Ecology Report

Prepared for Northport

May 2018

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

1.1 Project scope

Northport, situated at Marsden Point near the entrance to the Whangarei Harbour, is New Zealand's northernmost deep-water port. Established in 2002 the port terminal includes a reclamation covering approximately 32 Ha which projects across tidal flats and into the deep water harbour channel. 4Sight Consulting (4Sight) was engaged by Northport to characterise the ecological features in the intertidal zone within and near areas proposed for reclamation as part of future growth plans for the port. The zones proposed for reclamation comprise a 17.1 Ha area adjacent to the eastern end of the present terminal, and an area of 9.6 Ha adjacent to the western end (Figure 1).

This report details results from an ecological survey of the macroinvertebrate communities and the physicochemical status of the intertidal sandflats to the east and west of the Northport Terminal in December 2017.

1.2 Ecological setting: Whangarei Harbour

The Whangarei Harbour is a large (100 km^2) estuarine system consisting of a drowned river system (upper harbour) and a barrier-enclosed lagoon (lower harbour). This system is connected to the open ocean via an approximately 2.4 km wide opening located between Marsden Point and Home Point on the north-eastern coast of New Zealand (Griffiths, 2012; Swales et al. 2013). Through time the Harbour has been subjected to significant anthropogenic impacts including land reclamation, the deposition of 3 million m^3 of sediment fines and 2 million m^3 of channel dredge spoil since the 1920's and runoff from urban, industrial and rural sources (Morrison, 2005). Despite these impacts there is still a wide range of habitats, including deep-water channels, intertidal flats, mangroves, and saltmarsh (Morrison, 2005). Associated with these habitats is a rich diversity of marine life, from benthic invertebrates to estuarine and coastal fishes (Brook, 2002, Morrison, 2005). The harbour is also recognised for its importance for many internationally migrating bird species, New Zealand migratory bird species and resident species (Morrison, 2005).

Intertidal flats are the most common habitat type in the lower harbour, comprising 58% of the marine area. Intertidal macroinvertebrate communities generally fall into one of three community types; sheltered tidal creek communities (upper harbour), semi-exposed sandflat communities (mid-harbour), exposed sandflat communities (lower harbour). These community types are largely driven by substrate type and a clear change in community composition exists from muddy upper harbour sites, dominated by polychaete worms, to sandier lower harbour sites where bivalve species, such as cockle (*Austrovenus stuchburyii*) and nut shell (*Nucula hartvigiana*) become a key species (Griffiths, 2012). The lower harbour supports extensive cockle and pipi (*Paphies australis*) beds, both of which support commercial, recreational and customary fisheries within the harbour (Pawley and Smith, 2014; Williams and Hulme 2014).

1.2.1 Earlier Port -Related Intertidal Studies

1.2.1.1 Northport Terminal Consent Related Studies 1992-1997

A survey of intertidal habitat and edible shellfish on the sandflats on which the port reclamation was established and areas to the east and west, was reported as part of the environmental impact assessment for the establishment of the Northport facility in the late 1990s (Environmental Quality Consultants,1995). The 1995 report concluded as follows in respect of the intertidal survey, which was carried out in 1992:

'…*The intertidal zones within the proposed reclamation contain few edible sized shellfish and are reportedly utilised only occasionally for shellfish collection*…'

Further surveys were undertaken in 1997 on cockles and pipi and reported in evidence produced for the resource consent hearing on the port proposal (Environmental Quality Consultants, 1997). That work also concluded low densities of cockles within the then proposed port reclamation. Cockles were reported as '…*patchily distributed at Blacksmiths Creek but a relatively high proportion are of edible size*…'Pipi were reported as being of very low density in the Blacksmiths Creek area but reported '…*a small bed of good sized pipi about 200-400m east of the Blacksmiths Creek channel outlet (mean size 69 mm)*…'

Information on shellfish density and size reported in the consent hearing evidence are discussed in the 'Discussion' section of this report

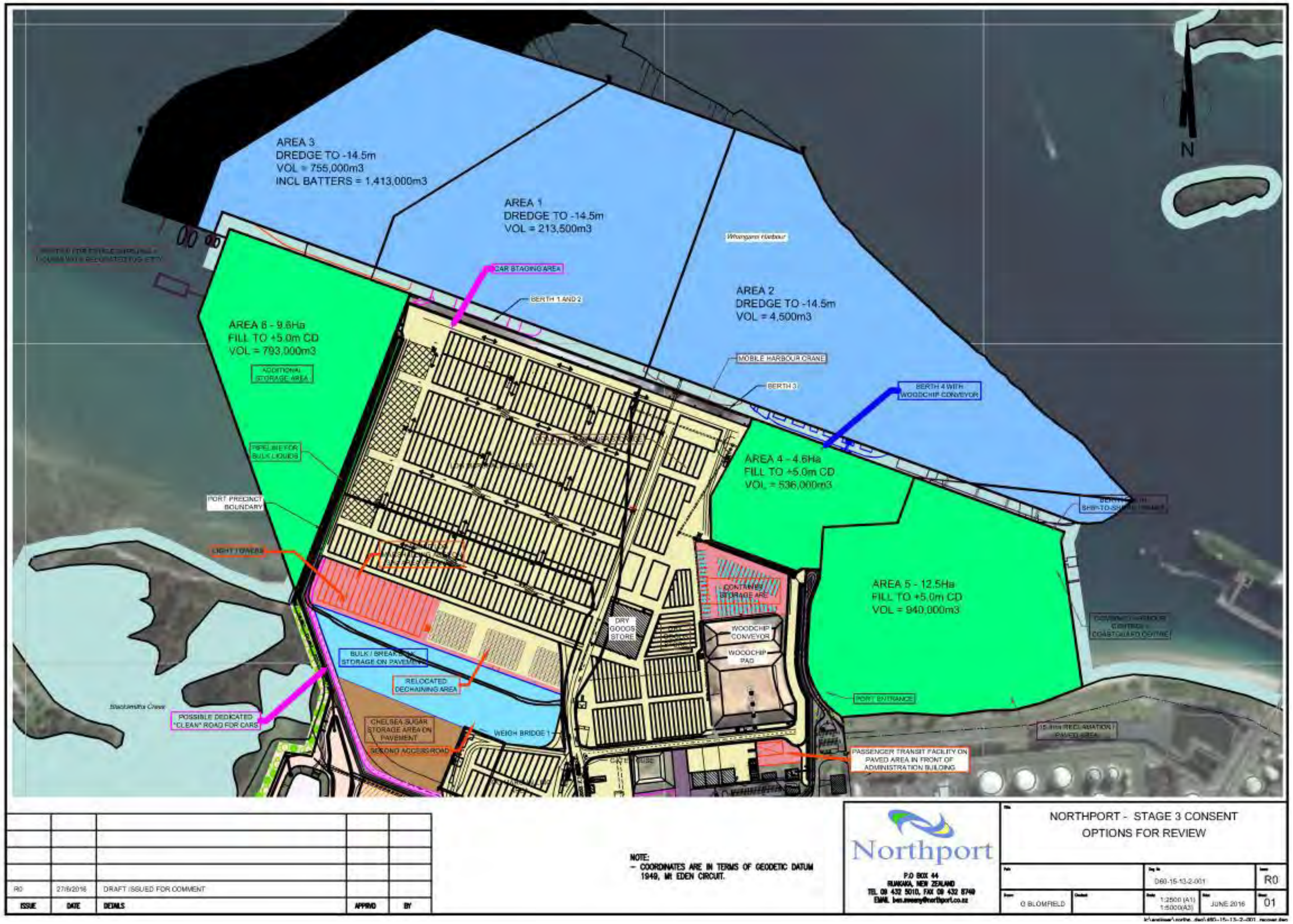

Figure 1: Existing port terminal and proposed reclamation areas (in green).

1.2.1.2 Northport Terminal Baseline Study 1997-2002

Following the granting of consents and in the period 1997-2002, low to mid tide benthic communities at eight lower harbour sites were surveyed annually in the late summer as part of the pre-development baseline studies (Poynter & Associates, 2002). Some of these sites were also surveyed as part of the 2018 work. Methodology was similar but sieve size used to screen the biological samples for small biota was different, being 1mm in the baseline work and 0.5mm in 2018. Comparisons of the current data set with the baseline survey findings are also discussed further in 'Section 4 – Discussion' in this report.

1.2.1.3 Northport Monitoring Studies 2004-2008

Following port construction, a refined survey methodology was used to monitor the low to mid tide benthic communities biennially in the years 2004, 2006 and 2008. The entire 2007-2008 data set is reviewed in Poynter & Associates, (2008). Shellfish population data in that review is compared with the 2018 study results and discussed further in 'Section 4 – Discussion' in this report.

2 METHODS

2.1 Survey rationale and site selection

An ecological assessment of the intertidal sandflats to the east and west of the Northport terminal was carried out on the 4th, 5th and 6th of December 2017. These dates were chosen due to their coincidence with the lowest astronomical tides of the month (0.4 m above datum). The ecological assessment involved the gathering of information on benthic macroinvertebrates as well as the collection of sediment samples for grain size and chemical analysis. Data was collected from nine sites (Figure 2: Sample sites). Several of these sites were at locations consistent with sites previously surveyed in the 1997-2008 survey work as identified by survey coordinates. The 2017 survey included six low water sites and three mid water sites (Figure 2: Sample sites).

Site selection to the west of the Northport Terminal is constrained by several features. The Marsden Cove Marina access channel delineates the western extent of the study area (but excluding the One Tree point background or reference site). The Blacksmiths Creek low tidal channel which crosses the tidal flat also influenced site selection. Some sampling sites were at the edge of the channel flow as previous work had shown high densities in shellfish in this vicinity. Sites were chosen to provide representative coverage of the mid to low water zone which is expected to host the widest diversity and greatest density of marine life.

Site selection to the east of the Northport Terminal is limited by the Refining NZ jetty.

The reference site at the head of the blind channel leading to One Tree Point, was located based on previous coordinates. The location is well removed from Northport, covers similar habitat type to that close to the Northport terminal and has a strong body of monitoring data collected over the 1997 to 2008 period and more recently as part of Northland Regional Council State of Environment Monitoring.

Site descriptions are as follows:

Low water

- West Low 1 (WL1) – Situated closest to the western edge of Northport (35.834089 S, 174.481099 E)
- West Low 2 (WL2) – Situated near the Blacksmith Creek outflow channel (35.832239 S, 174.476493 E)
- West Low 3 (WL3) – Situated between Blacksmith Creek and the Marsden Cove marina channel (35.831729 S, 174.474880 E)
- East Low 1 (EL1) – Situated closest to the eastern edge of Northport (35.836064 S, 174.491334 E)
- East Low 2 (EL2) – Situated between Northport and Refining NZ terminal (35.836493, 174.494294 E)
- One Tree Point (OTPL) – Background site situated approximately 5 km to the west of Northport at the end of Blind Channel (35.831822 S, 174.474596 E)

Mid water

- West Mid 1 (WM1) – Situated closest to the western edge of Northport (35.834756 S, 174.480968 E)

- West Mid 2 (WM2)– Situated near the Blacksmith Creek outflow channel (35.832697 S, 174.476187 E)
- West Mid 3 (WM3) – Situated between Blacksmith Creek and the Marsden Cove Marina channel (35.833363 S, 174.472912 E)

All western sites, including OTPL, were accessed by boat, allowing the maximum amount of time to be spent on the sandflats before incoming tides made sampling unachievable. Eastern sites were easily accessible via walkways so the boat was not used.

Low water sites were sampled within an hour either side of low tide, allowing two low water sites to be sampled each day. Mid water sites were sampled outside of the low water time frames and were sampled over the 4th and 5th.

WL2, WL3, WM2 and WM3 were approximately the same localities as the cluster of sites represented by Sites D, E, F, EZ and H in the 1997-2008 field surveys.

2.2 Macroinvertebrates

At each site a GPS point was used to fix an origin point. From this point a 50 m transect tape was laid out parallel to the water's edge, running east to west. This transect was used to establish the location of four 5 m x 5 m quadrats, from which a total of 24 macroinvertebrate samples were collected (six samples per 5 m x 5 m quadrat). These quadrats were at predetermined distances along the tape from:

- 0 m – 5 m
- 15 m – 20 m
- 30 m – 35 m
- 45 m – 50 m

At each distance a shorter tape was laid down perpendicular to the main tape so the 5 m x 5 m quadrat parameters could be established. Random xy coordinates were generated prior to sampling to determine the location of each sample within a quadrat, ensuring no sampler bias occurred. Figure 3 provides an illustration of the sampling design for each site.

Figure 2: Sample sites

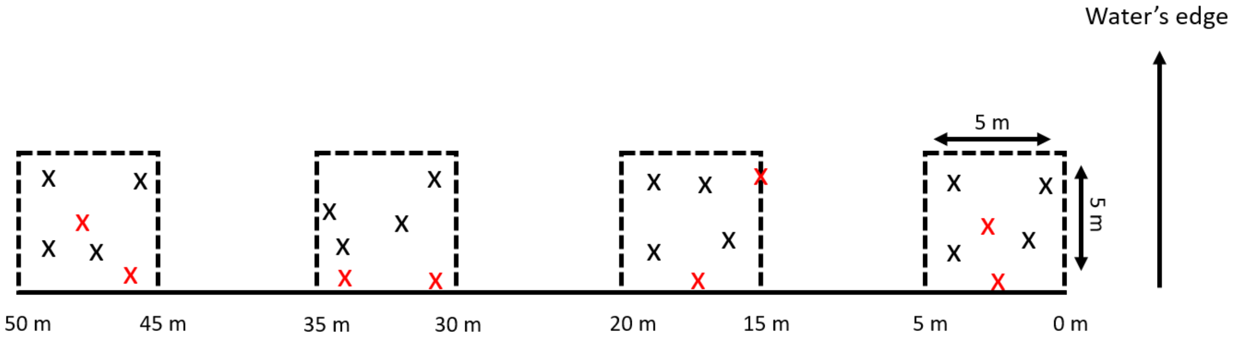

Figure 3: Schematic of macroinvertebrate sample transect. Dashed lines indicate 5 x 5 m quadrats. Black crosses indicate samples sieved through a 2 mm aperture sieve, while red crosses indicate samples sieved through a 0.5 mm aperture sock. Diagram not to scale.

A sample consisted of a single benthic core being collected using a stainless-steel corer. The corer had a diameter of 13 cm and was inserted into the benthos to a depth of 15 cm, giving a total sampling area of 133 cm^2 and sampling volume of 2651 cm^3. Once collected each sample was bagged for processing. Four samples within each quadrat (16 in total per site) were set aside for 'immediate' processing while the remaining two (eight in total per site) were set aside for subsequent processing in the laboratory.

'Immediate' processing consisted of a sample being sieved through a 2 mm stainless-steel sieve, allowing all macroinvertebrates >2 mm to be retained. Once sieved all macroinvertebrate species present were identified and their total numbers recorded. Size frequency data was also collected for key bivalve species including: cockle (*Austrovenus stuchburyi*), pipi (*Paphies australis*) and wedge shell (*Macomona liliana*). All 'immediate' samples for WL1, WL2, WM3, OTPL, EL1 and EL2 were processed in situ allowing for macroinvertebrates to be returned to the benthos alive. Tidal restrictions and poor light levels prevented complete in situ processing of 'immediate' samples from WL3, WM1 and WM2. Samples that were not processed in situ were bagged and frozen and processed later.

Samples to be laboratory processed were sieved through a 0.5 mm nylon sock, allowing all macroinvertebrates >0.5 mm to be retained. Each sample was then placed in a plastic container and preserved with 70% ethanol. Once back in the laboratory samples were stained with rose bengal dye, allowing for an easier distinction between animal tissue and other organic material. All cockle, pipi and *Macomona* sp. > 2 mm in size were removed from the samples so that size frequency data could be collected. These individuals were not returned after sizing. The remaining proportion of each sample was then sent to Gary Stephenson of Coastal Marine Ecology Consultants for faunal identification to the lowest practical taxonomic denomination.

2.3 Sediment grain size and chemistry

At each low water site sediment was collected for grain size and chemistry analysis. Both analyses required a composite sediment sample to be collected. A composite comprised sediment subsamples collected from within each 5 m x 5 m quadrat, thus four subsamples made up one composite sample. A trowel was used to collect these sediment samples. For grain size analysis a single trowel scoop, to a depth of 5 cm, was collected from each quadrat and composited into a plastic bag. For sediment chemistry two trowel scoops, to a depth of 2 cm, were collected from each quadrat and composited into an appropriate plastic and glass jar provided by Hill Laboratories.

Samples for grain size determination were sent to Geo Civil Ltd. for analysis using the wet sieving method (NZS 4402.2.8.1: 1986). Sediment samples collected for chemical analysis were sent to Hill Laboratories. Samples from all low water sites were tested for heavy metals and nutrients (nitrogen and phosphorous) using Hill Laboratories standard methodology (see Appendix C: for details

Four sites; WL1, WL2, OTPL and EL1, were also tested for polycyclic aromatic hydrocarbon concentrations using Hill Laboratories standard methodology (see Appendix C for details).

3 RESULTS

3.1 Macroinvertebrate community

Results describing the macroinvertebrate community are presented according to the sampling design in three categories:

- Macrofauna greater than 0.5 mm body size. The animals living on and within the sediment that were sampled using sediment cores and then retained by mesh with an aperture size of 0.5 mm.
- Large-bodied macrofauna greater than 2 mm body size. Large-bodied animals living within and on the sediment, that were sampled using sediment cores and then retained by mesh with an aperture size of 2 mm.
- Shellfish species, focussing on the most abundant large-bodied species (cockles, pipis and wedge shells).

3.1.1 Macrofauna (>0.5 mm)

A total of 8536 individuals from 93 different taxa were identified in the macrofaunal samples that were retained in the 0.5 mm aperture sock (Appendix A:). Within the entire intertidal zone sampled, polychaetes, crustaceans and bivalves were the dominant groups of organisms in terms of both taxonomic richness (the number of different species within that group) and abundance (number of individuals counted) (Figure 4). The mean richness per sample over all sites was 14 taxa and the mean abundance was 119 individuals.

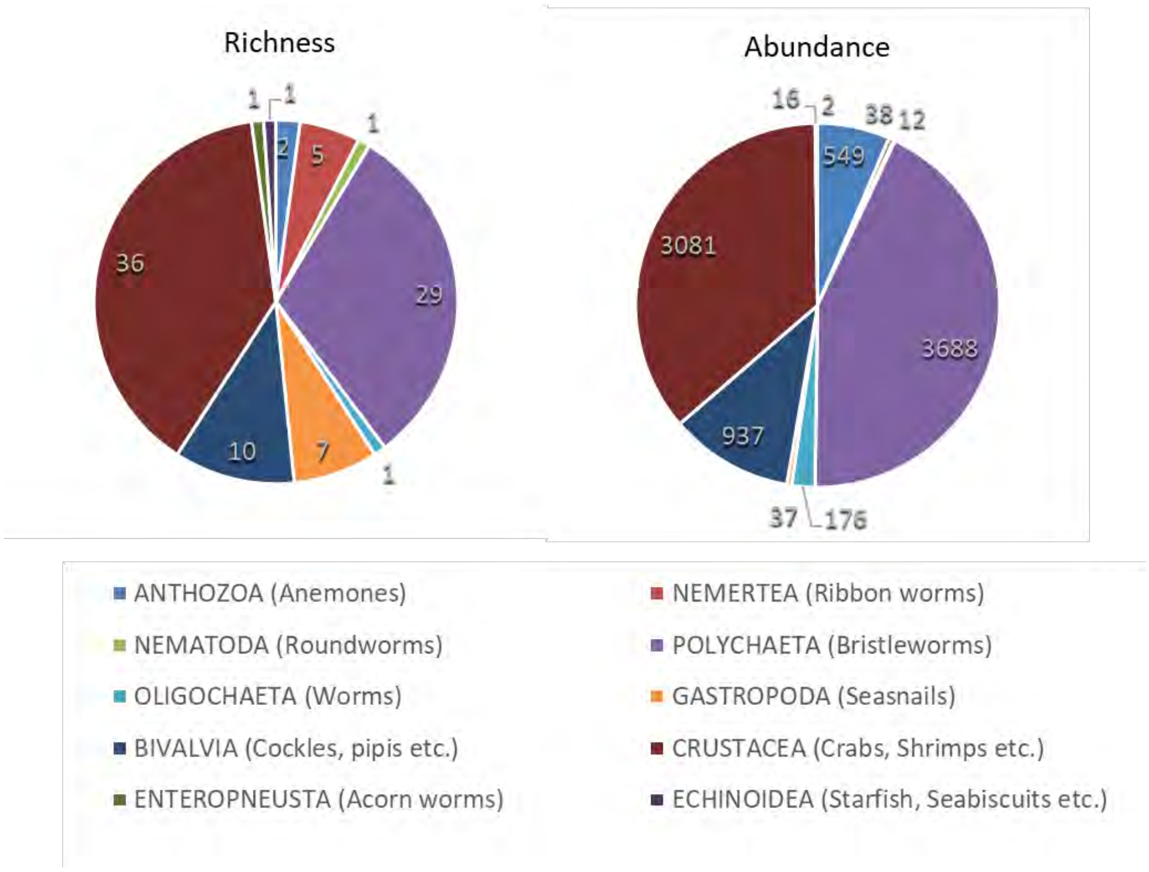

Figure 4: Total richness and abundance within broad taxonomic groups

Figure 5 shows the mean taxonomic richness (number of taxa) and relative abundance (number of individual animals) sampled at each of the sites surveyed. Site WL1 had the greatest number of taxa (21) while site EL2 supported the least (9). Fauna was most abundant at WM3 (198), and sites near the eastern reclamation (EL1, EL2) contained the lowest abundance of fauna (64 and 26 respectively).

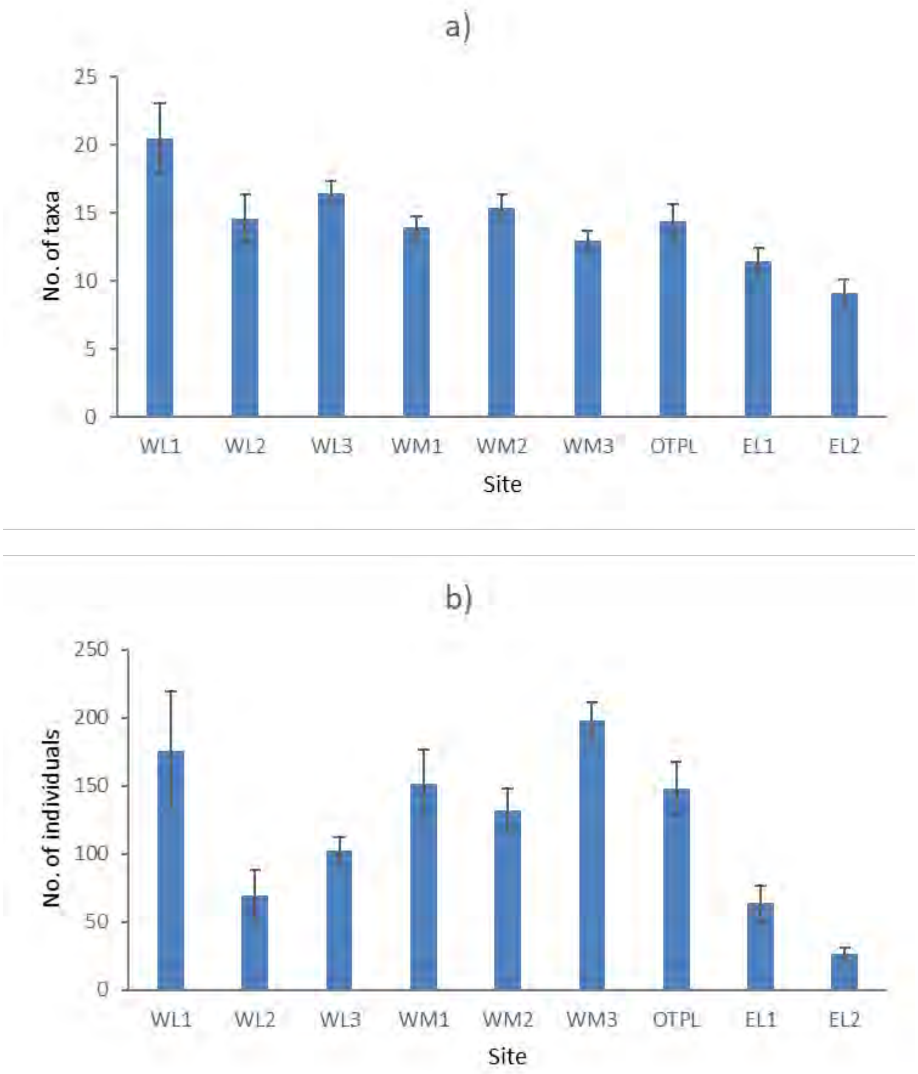

Figure 5: The mean number of taxa (taxon richness), and b) the number of individual animals (abundance) per sample at each site. Error bars represent ± 1 S.E. (n=8).

When individual taxa were allocated into broad groups (Phylum, Class) of organisms, the dominant groups in terms of abundance were polychaetes, small crustaceans, and bivalve molluscs (mainly cockles) at all sites (Figure 6). Polychaetes were the most abundant group at all sites except for WM1 where small crustaceans outnumbered all other groups. Overall, the most commonly sampled taxa were polychaetes from the families Spionidae and Syllidae, cockles (*Austrovenus stutchburyi*), and small crustaceans from the orders amphipoda and cumacea.

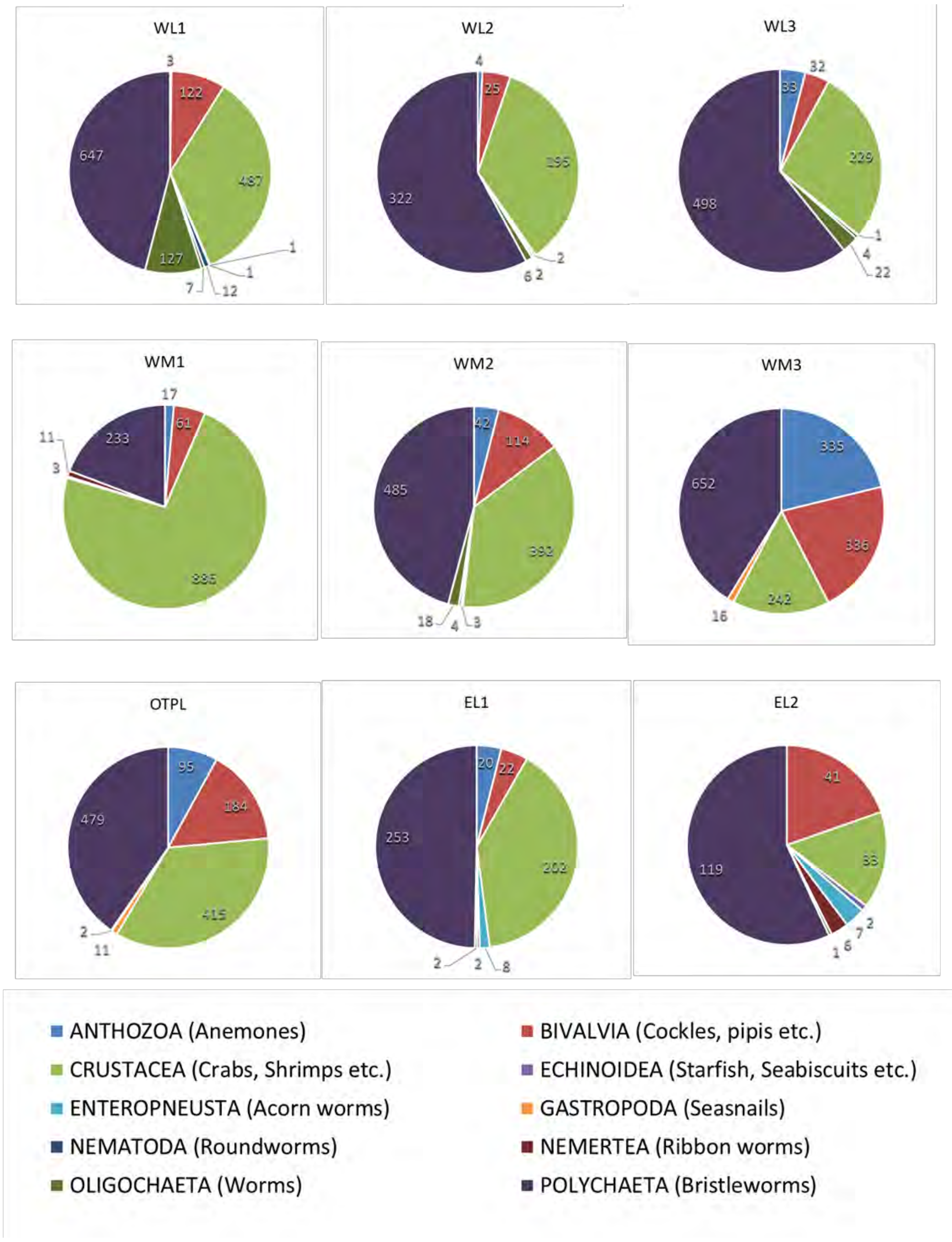

Figure 6: Pie charts showing the abundance of each taxonomic class of invertebrate sampled at each site.

A comparison of the 5 most abundant organisms found at each site shows that the spionid polychaete *Prionospio aucklandica* was abundant at all sites except the eastern low tide site EL2 (Figure 7). Small crustaceans were abundant at all sites - mainly representatives from the orders cumacea and amphipoda. In particular, the amphipod *Amphipoda phoxocephallidae* and the cumacean *Colurostylis lemurum* were abundant at 6 of the 9 sites sampled.

The western low shore sites (WL1, WL2, WL3) supported higher numbers of Tanaid crustaceans and of the spionid polychaete *Boccardia syrtis*. Site EL2, the eastern low shore site farthest (approximately 400 m) from the existing port terminal was distinct from the other sites in that macroinvertebrate abundance was low, spionid polychaetes were not abundant there, and the wedge shell *Macomona liliana* was more abundant (mean of 1.25 per sample) there than at any other site. It was the only site where the polychaetes *Magelona* sp. and *Euchone* sp. and the bivalve *Divalucina cumingi* were commonly sampled (Figure 7).

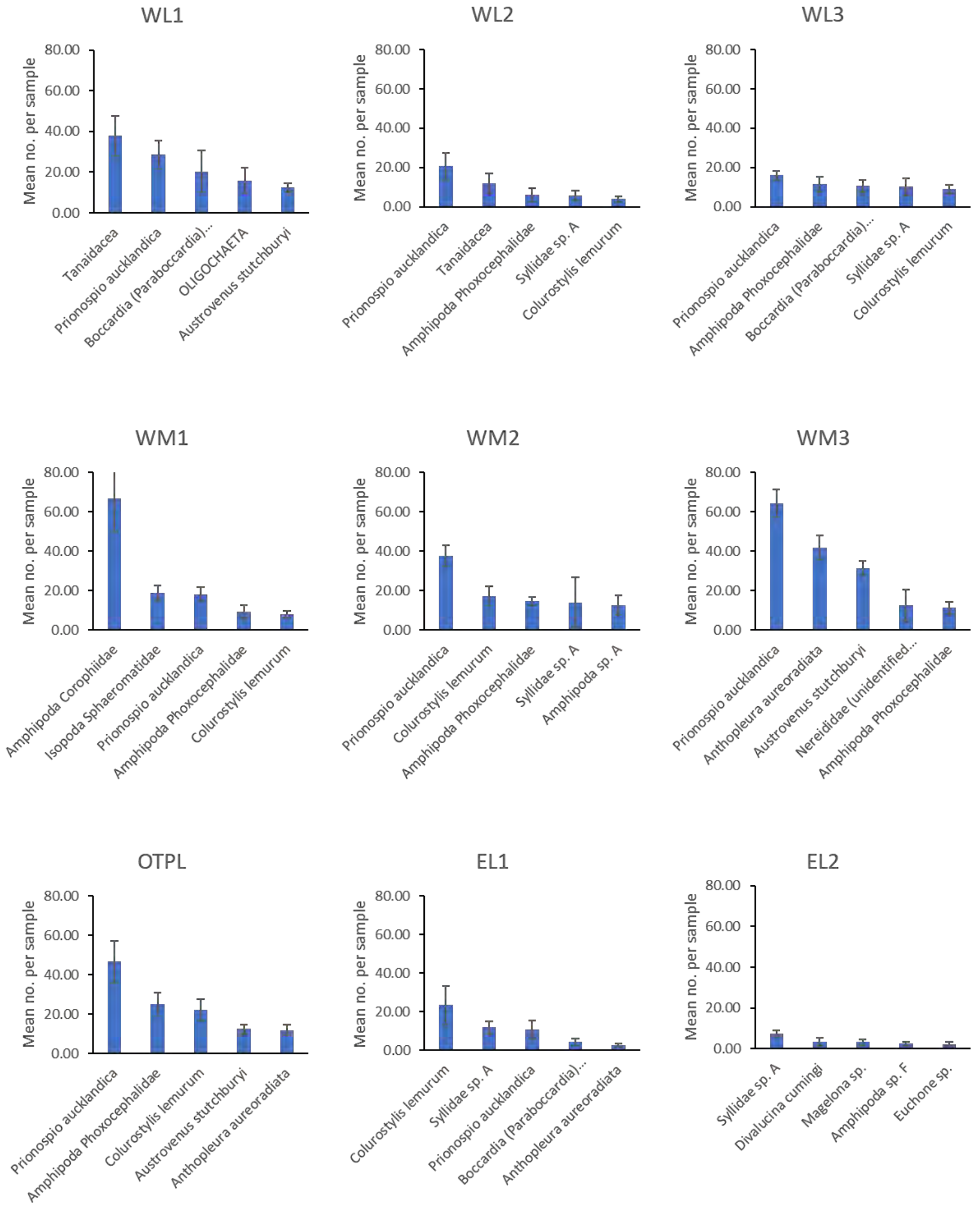

Figure 7: Mean number of the five most abundant taxa per 0.0133 m^2 core at each site (macrofauna >0.5 mm). Error bars represent 1 S.E. (n=8)

3.1.2 Large-bodied macrofauna (>2 mm)

The most abundant large-bodied (retained by the 2 mm aperture sieve) macrofaunal taxa within the entire area were cockles (*Austrovenus stutchburyi*), nutshells (*Nucula hartvigiana*), polychaetes, and the gastropods *Cominella glandiformis*, *Zeacumantus* sp. and *Diloma subrostratum* (Appendix B and Figure 8).

The sites east of the existing port terminal (EL1 and EL2) supported a lower abundance of animals than the sites to the west of the terminal (Figure 8).

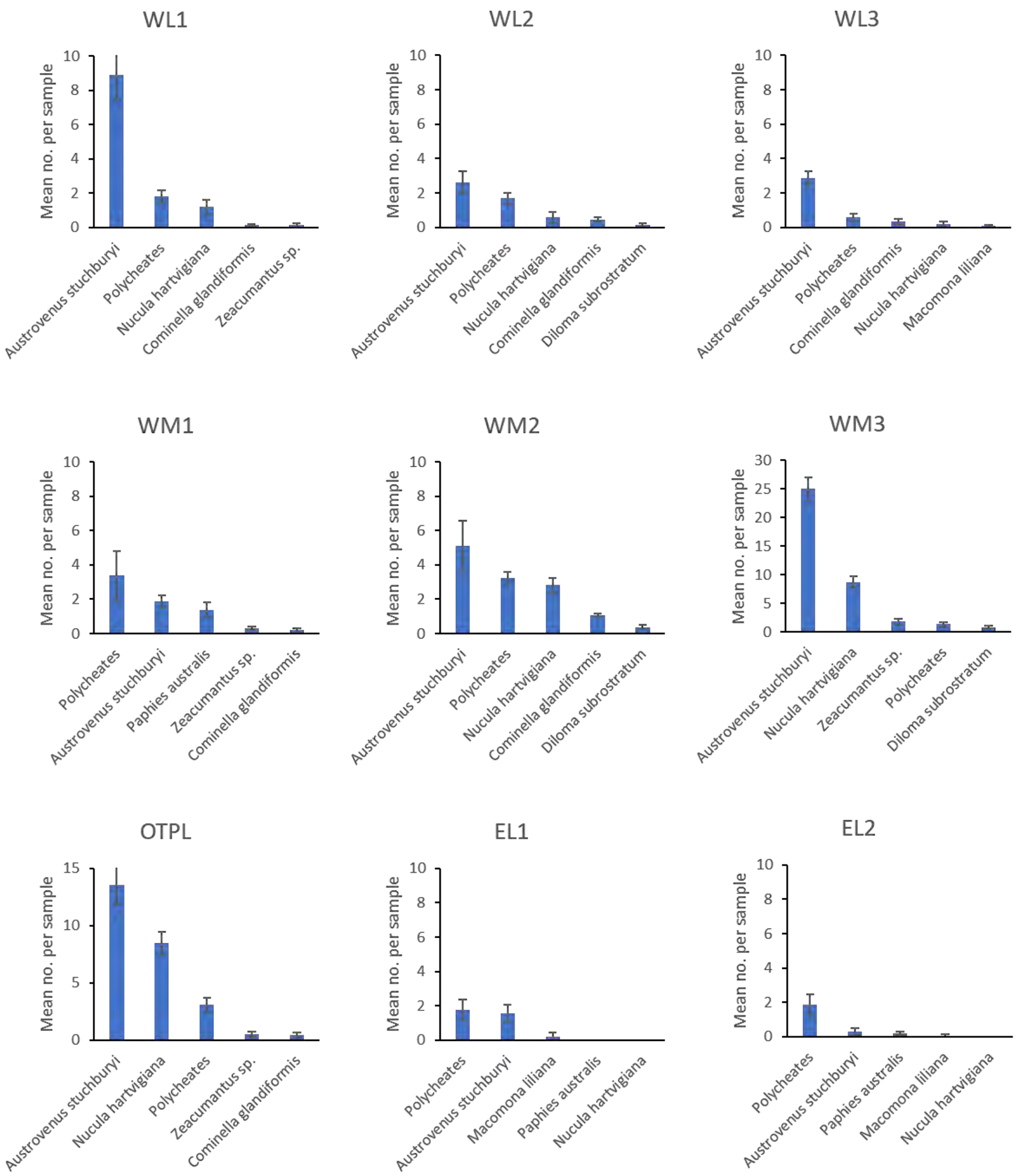

Figure 8: Mean number core of the five most abundant taxa per 0.0133 m^2 at each site (macrofauna >2 mm). Error bars represent 1 S.E. (n=16).

3.1.3 Shellfish

Cockles (*Austrovenus stutchburyi*) were the most abundant shellfish sampled overall and were especially abundant at site WM3 followed by OTPL, and WL1 (Figure 8, Figure 9). The second most commonly sampled bivalve was the nut shell *Nucula hartvigiana*. Nut shells were most abundant at sites OTPL and WM3 (Figure 8). The wedge shell *Macomona liliana* was found in relatively low abundance, and was most abundant at the eastern site EL2 in the samples sieved to 0.5 mm (Appendix A:).

In considering the edible shellfish population, there is no minimum legal size for taking cockles or pipis but the Ministry for Primary Industries has historically used a general guideline to define a harvestable shellfish population as 25 per m^2 for pipis 50 mm or greater or for cockles 30 mm or greater (e.g. Pawley and Smith, 2014). Under that definition, cockles were present in densities that would constitute a harvestable bed at site WM2, WL2 and WL3 (Figure 9, Table 1). If cockles greater than 25 mm (i.e. approaching size big enough for recreational harvest) are included, then there is a harvestable population at all sites except for WM1 and EL2 (Table 1). Cockles were very sparse at the eastern sites EL1 and EL2, and neither of those sites supported a harvestable population of the larger cockles. The size frequency data indicated that the largest cohort of cockles was in the 15 to 25 mm size range (Figure 9). That pattern was most evident at sites West Low 1 (WL1), West Mid 3 (WM3) and One Tree Point (OPTL) (Figure 9).

Pipis (*Paphies australis*) were present at low densities at sites WL1, OTPL, EL2, WM2, and WM3. At site WM1 pipis occurred at a higher mean density of 1.38 per sample that equated to 78 per m^2. Due to the low density of pipis sampled overall, size frequencies were not analysed.

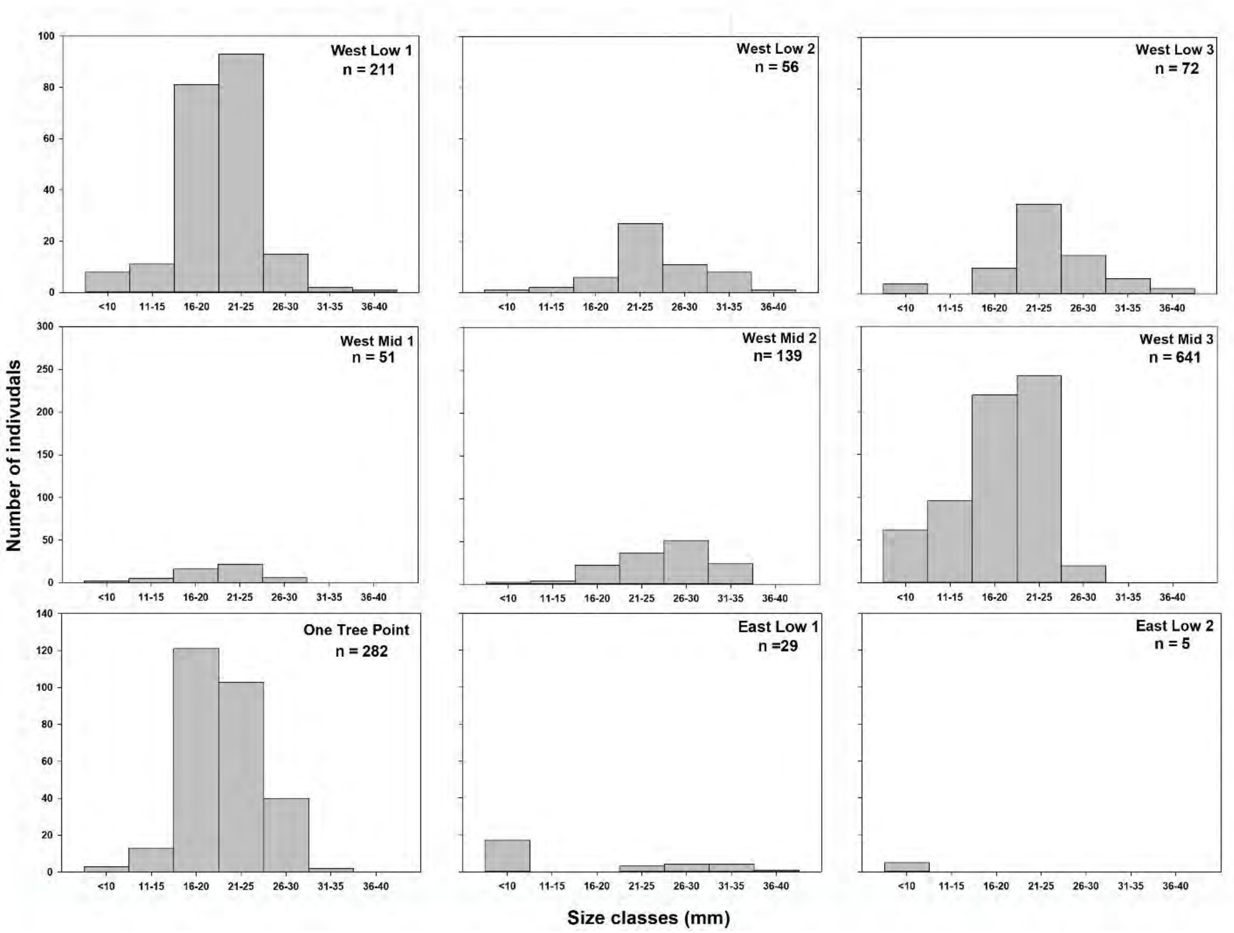

Figure 9: Size frequency of cockles sampled at each site.

Table 1: Harvestable cockle density at each site. Yellow shading denotes densities considered to be a 'harvestable population' (>25 per m^2)

	WL1	WL2	WL3	WM1	WM2	WM3	OTPL	EL1	EL2
Mean no. per m^2 (>30 mm)	9.40	28.20	25.06	0.00	75.19	0.00	6.27	15.66	0.00
Mean no. per m^2 (>25 mm)	56.39	62.66	72.06	18.80	234.96	62.66	131.58	28.20	0.00

3.2 Sediments

3.2.1 Sediment grain size

Results of the analysis of sediment grain size samples at each site is presented in Appendix D:. The substratum at all sites was predominantly composed of medium sand. Those results were consistent with data from nearby sites surveyed by Northland Regional Council as part of their State of the Environment monitoring between 2010 and 2016 (Griffiths, 2012; Bamford, 2016). In the present survey, sites WL1 and WM1 also exhibited a substantial proportion of very fine-grained sand and clay particles (which together comprise mud).

3.2.2 Sediment chemistry

The chemical analysis for sediment samples is reported in Appendix C:. Table 2 summaries the heavy metal and PAH concentration results in relation to ANZECC (2000) Interim Sediment Quality Guidelines – Low values (ANZECC ISQG – Low) and the Canadian Sediment Quality Guidelines Threshold Effect Level (TEL). Both sets of guidelines provided concentration threshold values, above which adverse biological effects are likely to occur. The Northland Regional Council (NRC) compares results from their State of the Environment (SoE) sediment monitoring programme to both guidelines, however recommends that the more conservative CCME TEL values be used as the standard set of guideline values (Griffiths, 2016).

Heavy metal and PAH concentrations were below CCME TEL, and subsequently also below ANZECC ISQG Low, with the exception of arsenic and nickel (Table 2). Arsenic was above CCME TEL at all low water sites sampled, with values at LW West 3 (the highest measured concentration) being 2.4 times higher than the CCME TEL for arsenic. No arsenic concentrations were above ANZECC ISQG Low. The relative consistency of the arsenic values and the second highest value being recorded at the OTPL reference site, suggests catchment geology rather than an anthropogenic source for the arsenic. Nickel was elevated at just one site (WL2). The 39 mg/kg concentration was well above ANZECC ISQG-Low and, given the low values at all other sites, may be explained by some inadvertent contamination of this one sample.

Table 2: Heavy metal and PAH concentrations within sediments from low water sites around the Northport terminal. Cells shaded green are below CCME TEL values, light yellow cells are above CCME TEL values and dark yellow cells are above ANZECC ISQG Low values.

Heavy Metals (mg/kg dry wt)	Sample Sites						ANZECC ISQG Low	CCME TEL
	WL1	WL2	WL3	OTPL	EL1	EL2		
Arsenic	13.20	14.70	17.20	16.40	10.3	14.60	20.00	7.24
Cadmium	0.09	0.13	0.08	0.11	0.05	0.06	1.50	0.70
Chromium	22.00	29.00	26.00	26.00	18.60	25.00	80.00	52.30
Copper	9.40	14.50	14.20	12.60	5.10	6.50	65.00	18.70
Lead	10.00	13.00	15.10	14.00	9.50	9.50	50.00	30.20

Mercury	0.03	0.05	0.05	0.05	0.03	0.03	0.15	0.13
Nickel	10.40	39.00	10.60	11.40	7.10	10.30	21.00	15.8
Zinc	64.00	77.00	67.00	67.00	55.00	63.00	200.00	124.00
Polycyclic Aromatic Hydrocarbons (PAH, µg/kg dry wt)							**ANZECC ISQG Low**	**CCME TEL**
Total PAH*	34.50	29.50	N/A	29.50	29.50	N/A	4000	-
*where individual PAHs were below detection limit, half of the detection limit values was used to calculate Total PAH								

Heavy metal concentrations reported in Table 2, were elevated in comparison to the heavy metal concentrations recorded at the two nearest NRC SoE monitoring sites in 2016 (Table 3). Concentrations were also elevated in comparison to historic SoE monitoring in 2014, 2012 and 2010 (Bamford, 2016). However, the comparison with SOE data is invalid as the discrepancy in values is likely to reflect what appears to be subtidal sampling locations identified in the SOE reports and also a grab method of sample collection which may not representatively capture fine sediment fractions.

Table 3: Heavy metal concentrations from 2016 SoE monitoring sites near the Northport terminal (Bamford, 2016). Cells shaded green are below CCME TEL values, light yellow cells are above CCME TEL values and dark yellow cells are above ANZECC ISQG Low values.

NRC Monitoring Sites	**Heavy metal concentrations (mg/kg dry wt)**					
	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Marsden Bay	<0.09	3.60	0.72	0.72	0.99	<6.80
Marsden Point	<0.09	3.80	<0.46	0.72	0.8	<6.90

There are no ANZECC default trigger values for nutrient concentrations in marine sediments, nor are there any nationally accepted guideline values. The NRC compares nutrient concentrations in marine sediments to a four level classification system developed by Robertson and Stevens (2007). This classification is shown in Table 4.

Table 5 compares the results from the 2018 survey to the nutrient classification of Robertson and Stevens (2007).

Table 4: Sediment Nutrient classification of Robertson and Stevens (2007)

Enrichment Level	**Parameter**			
		Total organic carbon	Nitrogen	Phosphorus
	Unit	%w/w	mg/kg	mg/kg
Good		<1	<500	<200
Low to moderately enriched		1-2	500-2000	200-500
Enriched		2-5	2000-4000	500-1000
Very enriched		>5	>4000	>1000

Total organic carbon, nitrogen and phosphorous were within 'good' concentration levels at all surveyed sites (Table 5). This is consistent with data from the nearby NRC SoE monitoring sites, where between 2012 and 2016 sediment nutrient concentrations have generally been in the 'good' or 'low to moderately enriched' categories (Griffiths, 2012; Bamford, 2016).

Table 5: Nutrient concentrations within sediments from low water sites around the Northport terminal. Cell shades based on Robertson and Stevens (2007) sediment nutrient classifications. Green cells indicate sediment quality in the 'good' range.

Nutrients	**Sample Sites**					
	WL1	WL2	WL3	OTPL	East 1	East 2
Total organic carbon (%w/w)	0.08	0.11	0.14	0.25	0.06	0.06
Total nitrogen (mg/kg dry wt)	<500	<500	<500	<500	<500	<500
Total recoverable phosphorous (mg/kg dry wt)	72	81	78	141	72	50

4 DISCUSSION

4.1 Macroinvertebrates

The 72 intertidal samples processed through the 0.5mm sieve, recorded a total of 93 taxa (taxonomic richness), at a mean of 14 taxa per sample and a mean abundance of 119 per sample. This is a high diversity and it confirms the biologically rich character of the intertidal flats.

The community composition was similar among all the sites on the western side of the Northport terminal. Taxonomic richness was also similar and was highest at the site closest to the Northport terminal (WL1) and was also higher than recorded at the background site (OTPL).

There was wide variability in abundance within sites and between some sites. Abundance was relatively high at the western site closest to the port (WL1) and was not significantly different to that recorded for several other western sites or the background site far to the west (OTPL). Abundances were lowest at the eastern sites.

The sites east of the terminal recorded lower taxonomic richness and abundance than those to the west. The macrofaunal community at site EL2 differed from the other sites. There, the low density of macrofauna and the increased abundance of the polychaetes *Magelona* sp. and *Euchone* sp. and the bivalve *Divalucina cumingi* relative to other sites may be due to different physical and hydrodynamic factors.

The intertidal faunal communities were very similar to those sampled previously at the Marsden Bay sites of Griffiths (2012). That survey found amphipod crustaceans and *Colurostylis lemurum* were the most abundant taxa at a site close to the western edge of the existing port terminal and that pipis *Paphies australis* and nut shells *Nucula hartvigiana* were also common there. Notably, that site was very close to site WM1 of the present survey – the only site in the present survey where pipis were commonly sampled. Also in agreement with the current survey, at two other Marsden Bay sites polychaete worms and bivalves were the most abundant taxonomic groups, the polychaete worm *Prionospio aucklandica*, the cockle *Austrovenus stutchburyi* and the anemone *Anthopleura aureoradiata* were the most common taxa, and the nut shell *Nucula hartvigiana* and crustacean Amphipoda spp. were also abundant. Those findings all closely parallel the composition of the faunal communities described in the present survey.

Several of the most abundant taxa sampled in the survey are known to be indicators of pollution by contaminants including heavy metals such as Copper, Zinc or Lead (Waikato Regional Council 2018). The polychaete *Prionospio aucklandica* was abundant at all the sites and is sensitive to copper contamination. *Euchone* sp., a polychaete that was particularly abundant at site EL2 is known to be sensitive to copper and zinc contamination. Phoxocephalid amphipods that were common at all the sites west of the port terminal are known to be sensitive to lead contamination. *Colurostylis lemurum*, a crustacean particularly abundant at eastern site EL1 and common in sandy habitats is also sensitive to lead contamination and other pollution. The bivalve *Nucula hartvigiana* prefers sandy habitats and is sensitive to organic enrichment and copper contamination. Another species that was abundant and found at all sites except for site EL2, is the anemone *Anthopleura aureoradiata* which is known to be very sensitive to copper contamination. The prevalence of these taxa is consistent with a benthic habitat which is not polluted by the heavy metals zinc, copper or lead.

4.2 Shellfish

Cockles were present at all sites at densities considered to be a 'bed' (>10 per m^2), and sites WM2, WL2 and WL3 supported a 'harvestable population' according to the definition in Pawley and Smith (2014) of cockles of sizes 30 mm or greater at a density of 25 per m^2 or more. WM3, the site farthest to the west of the terminal (except for the One Tree Point reference site that was approximately 5 km distant) held the greatest density of cockles (1420 per m^2) and cockle densities were lowest (18 per m^2) at the easternmost site EL2. Cockle densities were lower than the density (3304 per m^2) reported at a nearby site by Griffiths (2012), but at the sites west of the terminal were generally similar to densities of between 146 and 1509 cockles per m^2 reported in a survey of recreational beds in Northland, Auckland and Bay of Plenty conducted in 2011 (Pawley and Smith 2014).

Pipi densities at all sites except for WM1 were low compared to densities reported by Griffiths (2012) who found high densities of juvenile pipis at a site near to OTPL and a high density of larger pipis at a site near WM3. At site WM1, pipis were found at a density of 78 per m^2 which is comparable to the densities reported by Griffiths (2012). Wedge shells (*Macomona liliana*) densities were similar to densities reported at nearby sites in Griffiths (2012).

4.2.1 Comparison With 1997-2008 Data

Shellfish density and size frequency data obtained in the 2018 survey can be compared with data collected at equivalent locations over the period 1997 to 2008 during which nine late summer surveys were undertaken by the same method (Poynter et al. 2008). Figure 10 provides a comparison of results from the present survey with results from those previous cockle surveys. Mean values for cockle densities at midshore sites from the present survey (sites WM2 and WM3) were within the range of values from previous surveys at midshore sites H and D reported by Poynter (2008). Cockle densities at the lowshore sites WL3, WL2, and the far west site OTPL in 2018 were within the range of values reported by Poynter (2008) at the comparable sites F, EZ and A respectively (Figure 10.)

Cockle size frequency data for these sites was generally similar in 2008 (Poynter et al. 2008) and in the present survey (Figure 9). Populations were sparse at lowshore sites and showed a peak in abundance in the middle size classes (20-30 mm) but there was a subtle shift from predominance of individuals in the 26-30 mm size class in 2008 to the 21-25 mm size class in 2018. The pattern of size frequency at the midshore site D in 2008 closely resembled that at site WM2 in 2018, but site WM3 in 2018 held a higher abundance of cockles than midshore sites did in 2008 and there were more cockles in the smaller size classes between 10 and 25 mm, and less in the 26-30 mm size range.

The very low pipi densities found at the intertidal sites in 2018 (between 0 and 10 per m^2) was consistent with results from previous surveys. An exception in 2018 was the relatively higher density found at site WM1 (mean of 78 per m^2). At site A (equivalent to OTPL in 2018), pipis were found in very high densities in 1997 (mean of 947 per m^2) and in 2008 (~1100 per m^2) but in all other years, pipi density was near zero.

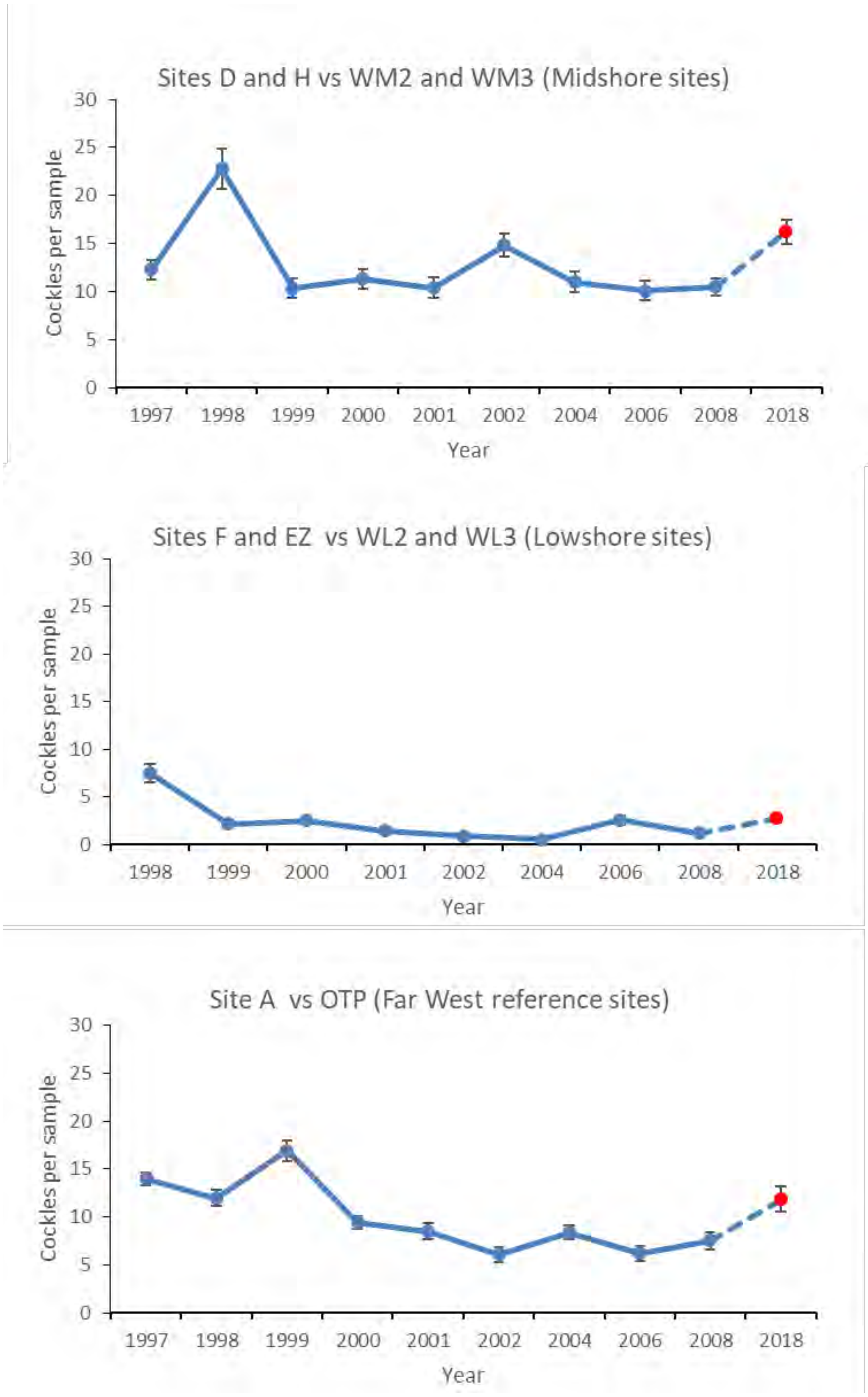

Figure 10: Mean cockle densities from previous surveys (blue markers connected by solid blue line) (Poynter et al. 2008), and from samples at equivalent locations in the present survey (red marker).

4.3 Sediment physico-chemistry

The predominance of the sandy substratum at all the sites is expected. Sites WL1 and WM1 exhibited the highest proportion of very fine-grained sand and clay particles. Those sites are closest to the western side of the existing port reclamation that alters the natural current flow in that part of the harbour and may result in increased deposition of fine sediments at those sites.

Most heavy metals and all PAH concentrations were below ANZECC (2000) Interim Sediment Quality Guidelines – Low values (ANZECC ISQG – Low) and the Canadian Sediment Quality Guidelines Threshold Effect Level (TEL). Arsenic levels which exceeded CCME TEL at all low water sites sampled is likely to be due to catchment rather than any port derived influence. A single elevated nickel value may is an outlier which may reflect sample contamination.

Nutrients in the sediment samples were all at relatively low levels considered to be 'good' quality range according to a four-level classification system developed by Robertson and Stevens (2007) in a study of Waikawa Estuary in Southland and which has been used by Northland Regional Council to describe Whangarei Harbour Sediments. The previous SoE monitoring surveys conducted by the NRC found similar nutrient levels at nearby sites that were classified as in the 'good' or 'low to moderate' according to that nutrient related classification system. The applicability of Robertson and Stevens' classification system to subtidal coarse-grained habitat or all types of estuaries (e.g. a much larger, deeper estuary system in Northland) is uncertain.

5 CONCLUSIONS

5.1 Biological Health

The biological health of the intertidal zones adjacent to the port appeared to be good as indicated by the following findings:

- Values for faunal abundance and taxonomic richness (i.e. basic measures of diversity) were generally high;
- The macroinvertebrate biota was dominated by a predictable array of taxa which are common and widely reported to occur in predominantly sandy sediment harbour habitats;
- Edible shellfish, mainly cockles, were widely distributed and occurred at densities and a size range that included beds of edible sized shellfish;
- There is no indication that targeted heavy metals or other contaminants (PAH) are elevated or occur at concentrations that would impact the habitat or the biota.

5.2 Influence of the Existing Port Terminal

There is no indication of an adverse influence from the existing terminal, in particular:

- There is no evidence of a suppressed intertidal macroinvertebrate abundance or taxonomic richness, close to the Northport facility;
- The lowshore Site WL1, which is closest to the western side of the existing terminal, showed taxonomic richness and abundance which was relatively high compared to the other lowshore sites;
- Sediment at Site WL1 exhibited a relatively high content of finer grained sediment compared to other sites. The increased finer fraction of grain sizes in the sediments may be due to the presence of or activities at the port. However, the comparatively elevated abundance and taxonomic richness at this site, suggests any such effect is not adverse;
- The observations at Site WL1 appear to be localised, as the midshore Site WM1 showed diversity measures in the middle of the range compared to the more distant midshore sites sampled;
- At site EL1, the site closest to the eastern side of the existing port terminal, values for abundance and taxonomic richness were similar to other low water sites (i.e to the west) and were higher than those values recorded at site EL2 located further from the terminal to the east;
- The abundances of cockles at the representative mid and low shore locations sampled in 2018 were similar to mean density values reported in 2002 and were greater than density values reported in 2008.

5.3 Overall Conclusion

These results indicate that the biodiversity and ecological health of the intertidal habitats is high. There is no indication that existing terminal is having a negative effect on the macrofaunal community in the intertidal zone at sites in the close vicinity.

The corollary of this conclusion is that any impact on macrofaunal communities resulting from the proposed extension of the port terminal is likely to be largely restricted to the loss of habitat and productivity beneath the extended reclamation, and not likely to extend far beyond the reclamation.

We consider the 2018 data set provides a strong technical basis to support the preparation of an assessment of environmental effects, were such to be required in the near future. The data set would lend itself to more sophisticated multivariate analysis which we have not undertaken at this stage. This would make clearer the relationships between sites in terms of community composition and the influence of physical variables. It would also provide for a stronger linkage to state of environment study findings which have carried out similar analyses.

In terms of any future monitoring strategy, this would also allow for a rationalisation of which sites produce the most useful data and would avoid the duplication of data.

We also note the potential patchiness of the invertebrate community composition in places. There may be edible shellfish beds which are quite localised and which we have not yet been able to identify. That may be a matter to explore further with local users and in particular iwi.

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Appendix A:

Invertebrate macrofauna (>0.5 mm)

	WL1								WL2								WL3								WM1								WM2							
Taxon	**77**	**78**	**79**	**82**	**85**	**87**	**91**	**94**	**27**	**28**	**31**	**32**	**38**	**41**	**44**	**45**	**97**	**100**	**105**	**106**	**111**	**112**	**115**	**117**	**145**	**147**	**153**	**155**	**159**	**161**	**163**	**166**	**2**	**3**	**4**	**10**	**14**	**15**	**23**	**24**
ANTHOZOA																																								
Anthopleura aureoradiata			1	1				1					4				5	5	1		5	8	5	3	2	3		2	2		3	5	1		2	6	8	13	7	5
Edwardsia sp.																	1																							
NEMERTEA																																								
Nemertea sp. A																																		1	1					
Nemertea sp. B																																					1			
Nemertea sp. C			2	3		1		1					1										2	1	1	4		3		2	1								1	
Nemertea sp. D																1																								
Nemertea sp. E																					1																			
NEMATODA			1	1	8	2																																		
POLYCHAETA																																								
Aonides trifida																					1		1																	
Armandia maculata			5		1	3	1												1																					1
Boccardia (Paraboccardia) syrtis		1	29	8	41	81	1	2					4	15	5	5	10	5	14	6	5	2	29	14				1					2	1	1	7	1	1	3	1
Ceratonereis sp.																																								
Dorvilleidae					2	1																																		
Euchone sp.																					1																			
Glycera lamelliformis					1				1																									1		1				
Goniadidae			1	2	1		2		1						1		1		1			1		1											1					
Hesionidae																																								
Heteromastus filiformis	1		6	4	2	7		1			4	1	1	2		2	1	3	2		16	14	4	8			1		1				2		2	1	7	7		1
Lumbrineridae														1										1																
Magelona sp.		2	1	1		1	1		3		2	2			1		4	4			1		2	1																
Macroclymenella stewartensis													1	1					1	1		2	1	2														1		
Naineris grubei australis				1			1																																	
Nereididae (unid. juveniles)													1			2		1		2					3	3			5	7	7	4	1	1			1			
Orbinia papillosa									1			1	5	1		1		1					1		1				2											
Pectinaria australis			1											1																										
Perinereis vallata																									2				1	2		1								
Prionospio aucklandica	25	31	61	40	34	32	4	2	4	18	19	10	67	21	10	16	26	18	9	16	25	11	9	14	5	8	14	30	28	25	25	9	29	20	23	46	35	52	62	35
Prionospio yuriel																														1								1		
Scoloplos cylindrifer																				1						1			12		3			1						
Spionidae sp. A		3	15	12	12	28	1						1		1	3	4	3	5	19	9	8	7	11									1		1			1		
Spionidae sp. B	1		6	3	6	1	1	1					2	5	4	2		3		1				2							1			1				2	1	
Spionidae sp. C														1																										
Spionidae sp. D																				3																				
Syllidae sp. A	14	15	9	3	23	3		1	2	1	6	3	1	10	20	3		1	9	35	4	13		20	15	2	1	2	2	4	4		1				6		1	104
Syllidae sp. B	2	1		2	10	7							2			1				2				1																
Tharyx sp.		1	4	2	9	5		1		1	1	4	5	3	3	2		4	7	6	8	11	2	2										1	4	3	4	1	3	1
Travisia olens		3									1				2	1								3																
OLIGOCHAETA	3	12	8	9	53	33	1	8		1	2	1			1	1	6	3	6	2		3		2									3		1					14
GASTROPODA																																								
Cominella adspersa								1					1																											
Cominella glandiformis										1																	1				1									
Diloma subrostratum																																								
Notoacmaea spp.																																		2				1		
Philine sp.																						1																		
Tritia burchardi																																1								
Zeacumantus lutulentus																																								

	WL1								WL2								WL3								WM1								WM2							
Taxon	**77**	**78**	**79**	**82**	**85**	**87**	**91**	**94**	**27**	**28**	**31**	**32**	**38**	**41**	**44**	**45**	**97**	**100**	**105**	**106**	**111**	**112**	**115**	**117**	**145**	**147**	**153**	**155**	**159**	**161**	**163**	**166**	**2**	**3**	**4**	**10**	**14**	**15**	**23**	**24**
BIVALVIA																																								
Arthritica sp.		2		1								1																	1	2			2							
Austrovenus stutchburyi	5	13	19	17	19	15	8	5		1	1	3	3	7	1	1	1	2	2	6	7	5	2	3	4	2		5	5	2	4	2	10	6	9	13	8	9	6	10
Divalucina cumingi				1		1								1																										
Dosinia sp.				1																																				
Felaniella zelandica														1	1				1	2																	1			2
Hiatula sp.		1																																						
Linucula hartvigiana			3	1		5		2					1	1		2				1									1		1		2	1	3	6	8	8	4	4
Macomona liliana				1																							1		3			1							1	
Myadora sp.																																								
Paphies australis			2																						2	1	4	2	3		10	5								1
CRUSTACEA																																								
Alpheus sp.	2			1						1	1	1																												
Amphipoda Corophiidae					1	1							1												111	53	37	15	39	36	83	159					1	2		
Amphipoda Phoxocephalidae	3	9	8	21	1	5			1	1	1	1	22	20		4	13	5	5	35	11	14	4	5	1	3	3	9	6	11	11	30	7	12	22	21	16	21	7	11
Amphipoda sp. A	2	2	27	11	2	4	6		1				1	2		2	4	1	3		6					3	1			1	6	49		43	14		17	11	12	3
Amphipoda sp. B																																		3			5	1	1	
Amphipoda sp. C											1	1																												
Amphipoda sp. D																																								
Amphipoda sp. E																									2	2														
Amphipoda sp. F																																								
Austrohelice crassa																																								
Colurostylis lemurum	3	2	13	5	3	5	1		5	3		4	13		1	6	14	12	12	17	9	1	3	5	1	4	5	7	8	11	13	14	6	35	33	7	7	9	5	35
Cyclaspis sp.																							1																	
Copepoda sp. A	2			1																																				
Copepoda sp. B		2																																						
Copepoda sp. C																																								
decapod megalopa/juvenile			1												1																									
Halicarcinus whitei			3	9	2	2																									1			1			1			
Hemigrapsus crenulatus																																						1		
Hemiplax hirtipes	1		1			1																																		
Isopoda Anthuridea																																								
Isopoda Sphaeromatidae																									40	25	14	8	14	25	9	14		2						
Nebaliacea																			1																					
Ostracoda sp. A					1	1							1							1			1	1																
Ostracoda sp. B													1																											
Ostracoda sp. C		2			2	2										1																								
Ostracoda sp. D														1																										
Ostracoda sp. E		2	2	2	1	4															2		1																	
Ostracoda sp. F				1																																				
Ostracoda sp. G																			1																					
Ostracoda sp. H																						1		1																
Ostracoda sp. I																																								
Palaemon affinis																																								
Philocheras australis																																								
Tanaidacea	8	32	67	47	70	64	10	5		1	3	3	34	32	12	11	18		7	7	2	1	2	2									1	1		3	8	7		
Tenagomysis sp.				1																																				
Waitangi brevirostris																														1		1								
ENTEROPNEUSTA					1																																			
Fellaster zelandiae																																								

	WM3								OTPL								EL1								EL2							
Taxon	**51**	**53**	**55**	**58**	**61**	**64**	**68**	**72**	**121**	**125**	**129**	**131**	**133**	**135**	**141**	**144**	**170**	**172**	**176**	**178**	**183**	**186**	**189**	**192**	**194**	**196**	**202**	**204**	**207**	**208**	**211**	**215**
ANTHOZOA																																
Anthopleura aureoradiata	45	19	34	17	65	46	54	55	13	23	21	9	3	6	5	15	6	3	5	3	2		1									
Edwardsia sp.																																
NEMERTEA																																
Nemertea sp. A														1																		
Nemertea sp. B																																
Nemertea sp. C																	2								1	1				2		
Nemertea sp. D												1															1			1		
Nemertea sp. E																																
NEMATODA																																
POLYCHAETA																																
Aonides trifida											1																					
Armandia maculata																																
Boccardia (Paraboccardia) syrtis																		1			4	6	8	14								
Ceratonereis sp.						2					2	1																				
Dorvilleidae																																
Euchone sp.																		1	2						3	1	2	1			2	9
Glycera lamelliformis																		1				1						1				
Goniadidae															1																	1
Hesionidae																														7	3	
Heteromastus filiformis				1	1				8	5	5	8	3	18	9	15		1						1								
Lumbrineridae		1																														
Magelona sp.				1													1	5	1		3	3			1	2	1	12	2	1	1	5
Macroclymenella stewartensis								1	1				2			1															1	
Naineris grubei australis																																
Nereididae (unid. juveniles)						1	42	57																1								
Orbinia papillosa	1									1																						
Pectinaria australis														1																		
Perinereis vallata	1	2	2	1	3	2	10	6	1	1	1				1	1																
Prionospio aucklandica	75	39	67	78	52	101	52	51	35	44	47	42	51	115	11	28	4	2	5	5	41	16	10	2		1				1	1	
Prionospio yuriel																																
Scoloplos cylindrifer			1						2							1																
Spionidae sp. A																		1			7		1									1
Spionidae sp. B											1		1		1			2			2	1										
Spionidae sp. C																			1				1									
Spionidae sp. D																																
Syllidae sp. A												1		3		1	22	14	4	10	29	9	3	3	1	11	14	6	5	9	2	11
Syllidae sp. B																			1			1										
Tharyx sp.									1			2		5				2														
Travisia olens							1																									
OLIGOCHAETA																						2			1							
GASTROPODA																																
Cominella adspersa																																
Cominella glandiformis									1			1																				
Diloma subrostratum														1																		
Notoacmaea spp.	8	4	3	1								1		1		2																
Philine sp.																																
Tritia burchardi																																
Zeacumantus lutulentus												4																				

	WM3								OTPL								EL1								EL2							
Taxon	**51**	**53**	**55**	**58**	**61**	**64**	**68**	**72**	**121**	**125**	**129**	**131**	**133**	**135**	**141**	**144**	**170**	**172**	**176**	**178**	**183**	**186**	**189**	**192**	**194**	**196**	**202**	**204**	**207**	**208**	**211**	**215**
BIVALVIA																																
Arthritica sp.												1																				
Austrovenus stutchburyi	34	22	28	11	40	37	36	44	16	23	20	5	11	10	7	8	1	1	1			1	5	4			2					
Divalucina cumingi																							1				14	10	1	1		
Dosinia sp.																																
Felaniella zelandica																																
Hiatula sp.																														1		
Linucula hartvigiana	8	13	12	7	7	13	7	7	16	8	6	18	11	11	7	5				1												
Macomona liliana	1	3	1		1		1					1					1		1	1				1		1	1		1	1	1	5
Myadora sp.																											1					1
Paphies australis			3																		3											
CRUSTACEA																																
Alpheus sp.																	1								1	1		1		2		
Amphipoda Corophiidae																																
Amphipoda Phoxocephalidae	23	8	12	23	9	12	1	1	43	31	24	30	5	10	9	49																
Amphipoda sp. A	2	3	9	25					3			1	2	17	1				2													
Amphipoda sp. B	3		4	6																												
Amphipoda sp. C																																
Amphipoda sp. D	4	6	6	10	11	16	8	19																								
Amphipoda sp. E																																
Amphipoda sp. F																		1	1						6	1	3	1		1		7
Austrohelice crassa			1																													
Colurostylis lemurum	5	1	1	2	3	4	4		16	14	12	31	6	49	12	37			8	4	25	25	83	41								1
Cyclaspis sp.																																
Copepoda sp. A												1		1																		
Copepoda sp. B																																
Copepoda sp. C																											1					
decapod megalopa/juvenile																																
Halicarcinus whitei												1			1	2																
Hemigrapsus crenulatus																																
Hemiplax hirtipes														1																		
Isopoda Anthuridea																											2	1				1
Isopoda Sphaeromatidae																	1	1	2					3							1	
Nebaliacea																																
Ostracoda sp. A												2		1												1						
Ostracoda sp. B																																
Ostracoda sp. C											2					1						1										
Ostracoda sp. D																																
Ostracoda sp. E																																
Ostracoda sp. F																																
Ostracoda sp. G																																
Ostracoda sp. H																																
Ostracoda sp. I																							1									
Palaemon affinis																											1					
Philocheras australis																		1														
Tanaidacea																																
Tenagomysis sp.																						1										
Waitangi brevirostris																																
ENTEROPNEUSTA																	2			2	3	1					3		1	3		
Fellaster zelandiae																														1	1	

Appendix B:

Invertebrate macrofauna (>2 mm)

	WL1																WL2																WL3			
Taxon	**73**	**74**	**75**	**76**	**80**	**81**	**83**	**85**	**86**	**88**	**89**	**90**	**92**	**93**	**95**	**96**	**25**	**26**	**27**	**30**	**31**	**33**	**34**	**36**	**37**	**38**	**39**	**40**	**43**	**44**	**47**	**48**	**98**	**99**	**101**	**102**
Austrovenus stuchburyii	4	8	7	2	15	3	13		15	14	9	9	20	14	6	3	2	6		2	2	1	6	8	2	2	5	5		1			4	5	2	3
Nucula hartvigiana					1		1		4		2		4	5	2				2			1				1					5			1		
POLYCHAETA		2	1	2	4	2	2		2	5		2		2	3	2		2	2	3	5	3	1	1	2	1	2	1		2		2		1	1	1
Anthopleura aureoradiata					1					1		2	1										2										1			1
Cominella glandiformis						1				1							1		1		1	1				1		1				1				
Zeacamantus sp.				2																																
Paphis australis																1																				
Diloma subrostratum																	1										1									
Macamona lilianna			1								1		1	1								1		1					1							
Cellena radians																																				
Amphipod																																				
Alpheus novaezealandiae	2																																			
Cominella adspersa													1					1														1				
Cominella sp.																																				
Austrohelice crassa							1																						1							
Helicarcinus varius											1									1																
Fellaster zelandiae																																				
Unid. Bivalve																																		1		
Unid. Gastropod																																				

	WL3												WM1																WM2							
Taxon	**103**	**104**	**107**	**108**	**109**	**110**	**113**	**114**	**116**	**118**	**119**	**120**	**146**	**148**	**149**	**150**	**151**	**152**	**154**	**156**	**157**	**158**	**160**	**162**	**164**	**165**	**167**	**168**	**1**	**5**	**6**	**7**	**8**	**9**	**11**	**12**
Austrovenus stuchburyii	3	4	3	2	2	2	4	5	3	4			2	3		2	1	2	3	1	1	2	2	3	1	4	1	2	5	2	4	7	5	12	7	5
Nucula hartvigiana							2									1	1												8	5	1	4	3	4	2	2
POLYCHAETA			3		2		1						2			4	5	3	5	1	3	2	2	3	7	14		3	2		3	3	2	6	5	3
Anthopleura aureoradiata		1					1	1		1			7	6												3	1		8				1			
Cominella glandiformis	1					1			2		1					1				2									1	1			1	4	1	
Zeacamantus sp.														1	2	1												1								
Paphis australis													1	2				1	1		1	1	3	1	3	3	1	4								
Diloma subrostratum																															1		1	2	1	
Macamona lilianna						1											1							1												
Cellena radians																																	1			
Amphipod															6					2		1		2												
Alpheus novaezealandiae																																				
Cominella adspersa						1				1				1																				1		
Cominella sp.																				3						1										
Austrohelice crassa																																	1			
Helicarcinus varius																																				
Fellaster zelandiae																																				
Unid. Bivalve									1																											
Unid. Gastropod											1																									

	WM2								WM3																OTPL											
Taxon	**13**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**49**	**50**	**52**	**54**	**56**	**57**	**59**	**60**	**62**	**63**	**65**	**66**	**67**	**69**	**70**	**71**	**122**	**123**	**124**	**126**	**127**	**128**	**130**	**132**	**134**	**136**	**137**	**138**
Austrovenus stuchburyii	7	5		1	2	7	10	3	13	27	15	25	18	16	18	23	32	26	20	30	29	28	41	39	8	9	14	18	15	6	4	20	33	12	17	15
Nucula hartvigiana	4			2	3	3	2	2	10	7	9	13	3	10	12	9	5	6	1	14	5	10	13	12	3	3	8	12	5	6	5	9	10	13	17	8
POLYCHAETA	3	4	5	4	7	3	1	1		4	2			3		2		1	1		3	1	2	2	9	7	3	5	3	4		1	3	1		1
Anthopleura aureoradiata		3						4	6			6		9		20	26	24		24	23		19								4	12	12	4	12	
Cominella glandiformis	1	3		1	1		2	1		1								1		2		3										3			2	1
Zeacamantus sp.														2		3	3	3	1	2	9	2		3							2				2	1
Paphis australis	2	1										1								1		1									1					
Diloma subrostratum	1								3	1	2	1	1		1		1				2	1						1		1			1		1	
Macamona lilianna			1									1					1	1														1	2			2
Cellena radians									3		3			3		3		2				1									4					
Amphipod																																				
Alpheus novaezealandiae															14																					
Cominella adspersa		1																																		
Cominella sp.																																				
Austrohelice crassa										1																										
Helicarcinus varius																																				
Fellaster zelandiae																																				
Unid. Bivalve																																				
Unid. Gastropod																																				

	OTPL				EL1																EL2															
Taxon	**139**	**140**	**142**	**143**	**169**	**171**	**173**	**174**	**175**	**177**	**179**	**180**	**181**	**182**	**184**	**185**	**187**	**188**	**190**	**191**	**193**	**195**	**197**	**198**	**216**	**214**	**213**	**212**	**210**	**209**	**206**	**205**	**203**	**201**	**200**	**199**
Austrovenus stuchburyii	11	14	10	11	1		1	1	1		1	1	1				3	7	5	3	1	3									1					
Nucula hartvigiana	11	10	12	3																																
POLYCHAETA	5	2	3	2	1				5	3			1	3	8	5				2		3	1	2			1		1	6		2	3	1	8	2
Anthopleura aureoradiata	14		17						2			3	1																							
Cominella glandiformis			1																																	
Zeacamantus sp.	2			1																																
Paphis australis		1																				1									1			1		
Diloma subrostratum																																				
Macamona lilianna					1															3											1					
Cellena radians																																				
Amphipod						1		1																1			1		1					1		
Alpheus novaezealandiae																																				
Cominella adspersa	1																																			
Cominella sp.					3																															
Austrohelice crassa																								1		1										
Helicarcinus varius																																				
Fellaster zelandiae					1																			1												
Unid. Bivalve																																				
Unid. Gastropod																																				

Appendix C:

Results of sediment chemistry analysis

4SIGHT CONSULTING

Hill Laboratories
TRIED, TESTED AND TRUSTED

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ANALYSIS REPORT

SUPv1

Client:	4SIGHT Consulting Limited	**Lab No:**	1895554
Contact:	Mark Poynter	**Date Received:**	14-Dec-2017
	C/- 4SIGHT Consulting Limited	**Date Reported:**	09-Jan-2018
	PO Box 402053	**Quote No:**	89166
	Tutukaka 0153	**Order No:**	AA2895
		Client Reference:	Northport
		Submitted By:	Mark Poynter

Sample Type: Sediment

Sample Name:		West Low 2 04-Dec-2017 3:45 pm	East 2 06-Dec-2017 4:45 pm	Wesst Low 3 05-Dec-2017 3:45 pm	OPTL 05-Dec-2017 4:45 pm
Lab Number:		1895554.1	1895554.2	1895554.3	1895554.4
Individual Tests					
Organic Matter*	g/100g dry wt	0.83	0.91	0.89	1.77
Dry Matter	g/100g as rcvd	79.1 ± 5.0	-	-	72.4 ± 5.0
Ash*	g/100g dry wt	99.2 ± 1.5	99.1 ± 1.5	99.1 ± 1.5	98.2 ± 1.5
Total Recoverable Phosphorus	mg/kg dry wt	72 ± 28	81 ± 28	78 ± 28	141 ± 30
Total Nitrogen*	g/100g dry wt	< 0.05 ± 0.041	< 0.05 ± 0.041	< 0.05 ± 0.041	< 0.05 ± 0.041
Total Organic Carbon*	g/100g dry wt	0.113 ± 0.042	0.061 ± 0.041	0.139 ± 0.042	0.253 ± 0.045
Polycyclic Aromatic Hydrocarbons Trace in Soil					
1-Methylnaphthalene	mg/kg dry wt	< 0.002 ± 0.0063	-	-	< 0.002 ± 0.0063
2-Methylnaphthalene	mg/kg dry wt	< 0.002 ± 0.0063	-	-	< 0.002 ± 0.0063
Acenaphthene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Acenaphthylene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Anthracene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Benzo[a]anthracene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Benzo[e]pyrene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Benzo[k]fluoranthene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Chrysene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Fluoranthene	mg/kg dry wt	0.0033 ± 0.0014	-	-	< 0.002 ± 0.0014
Fluorene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Naphthalene	mg/kg dry wt	< 0.010 ± 0.0067	-	-	< 0.010 ± 0.0067
Perylene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014
Phenanthrene	mg/kg dry wt	0.0037 ± 0.0015	-	-	< 0.002 ± 0.0014
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	< 0.005 ± 0.0020	-	-	< 0.005 ± 0.0020
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	< 0.006 ± 0.0020	-	-	< 0.006 ± 0.0020
Pyrene	mg/kg dry wt	< 0.002 ± 0.0014	-	-	< 0.002 ± 0.0014

Sample Name:	East 1 06-Dec-2017 3:45 pm	West Low 1 04-Dec-2017 2:45 pm	West Low 2 [<63um fraction]	East 2 [<63um fraction]
Lab Number:	1895554.5	1895554.6	1895554.7	1895554.8

4SIGHT CONSULTING

Sample Type: Sediment					
	Sample Name:	East 1 06-Dec-2017 3:45 pm	West Low 1 04-Dec-2017 2:45 pm	West Low 2 [<63um fraction]	East 2 [<63um fraction]
	Lab Number:	1895554.5	1895554.6	1895554.7	1895554.8
Individual Tests					
Organic Matter*	g/100g dry wt	0.97	0.92	-	-
Dry Matter	g/100g as rcvd	73.9 ± 5.0	75.7 ± 5.0	-	-
Ash*	g/100g dry wt	99.0 ± 1.5	99.1 ± 1.5	-	-
Total Recoverable Phosphorus	mg/kg dry wt	72 ± 28	50 ± 27	-	-
Total Nitrogen*	g/100g dry wt	< 0.05 ± 0.041	< 0.05 ± 0.041	-	-
Total Organic Carbon*	g/100g dry wt	0.056 ± 0.041	0.083 ± 0.041	-	-
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg					
Total Recoverable Arsenic	mg/kg dry wt	-	-	14.7 ± 1.5	14.6 ± 1.5
Total Recoverable Cadmium	mg/kg dry wt	-	-	0.127 ± 0.017	0.0642 ± 0.0098
Total Recoverable Chromium	mg/kg dry wt	-	-	28.8 ± 3.5	24.6 ± 3.0
Total Recoverable Copper	mg/kg dry wt	-	-	14.5 ± 2.1	6.52 ± 0.93
Total Recoverable Lead	mg/kg dry wt	-	-	13.0 ± 1.6	9.5 ± 1.2
Total Recoverable Mercury	mg/kg dry wt	-	-	0.0473 ± 0.0087	0.0341 ± 0.0078
Total Recoverable Nickel	mg/kg dry wt	-	-	39.3 ± 4.0	10.3 ± 1.1
Total Recoverable Zinc	mg/kg dry wt	-	-	77 ± 13	63 ± 11
Polycyclic Aromatic Hydrocarbons Trace in Soil					
1-Methylnaphthalene	mg/kg dry wt	< 0.002 ± 0.0063	< 0.002 ± 0.0063	-	-
2-Methylnaphthalene	mg/kg dry wt	< 0.002 ± 0.0063	< 0.002 ± 0.0063	-	-
Acenaphthene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Acenaphthylene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Anthracene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[a]anthracene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[a]pyrene (BAP)	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[e]pyrene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[g,h,i]perylene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[k]fluoranthene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Chrysene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Dibenzo[a,h]anthracene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Fluoranthene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Fluorene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Naphthalene	mg/kg dry wt	< 0.010 ± 0.0067	< 0.010 ± 0.0067	-	-
Perylene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Phenanthrene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-
Benzo[a]pyrene Potency Equivalency Factor (PEF) NES	mg/kg dry wt	< 0.005 ± 0.0020	< 0.005 ± 0.0020	-	-
Benzo[a]pyrene Toxic Equivalence (TEF)	mg/kg dry wt	< 0.006 ± 0.0020	< 0.006 ± 0.0020	-	-
Pyrene	mg/kg dry wt	< 0.002 ± 0.0014	< 0.002 ± 0.0014	-	-

	Sample Name:	Wesst Low 3 [<63um fraction]	OPTL [<63um fraction]	East 1 [<63um fraction]	West Low 1 [<63um fraction]
	Lab Number:	1895554.9	1895554.10	1895554.11	1895554.12
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg					
Total Recoverable Arsenic	mg/kg dry wt	17.2 ± 1.8	16.4 ± 1.7	10.3 ± 1.1	13.2 ± 1.4
Total Recoverable Cadmium	mg/kg dry wt	0.077 ± 0.012	0.110 ± 0.015	0.0477 ± 0.0083	0.090 ± 0.013
Total Recoverable Chromium	mg/kg dry wt	26.0 ± 3.2	25.6 ± 3.1	18.6 ± 2.3	22.3 ± 2.7
Total Recoverable Copper	mg/kg dry wt	14.2 ± 2.0	12.6 ± 1.8	5.08 ± 0.73	9.4 ± 1.4
Total Recoverable Lead	mg/kg dry wt	15.1 ± 1.9	14.0 ± 1.7	9.5 ± 1.2	10.0 ± 1.3
Total Recoverable Mercury	mg/kg dry wt	0.0466 ± 0.0087	0.0539 ± 0.0093	0.0307 ± 0.0076	0.0323 ± 0.0077
Total Recoverable Nickel	mg/kg dry wt	10.6 ± 1.1	11.4 ± 1.2	7.08 ± 0.73	10.4 ± 1.1
Total Recoverable Zinc	mg/kg dry wt	67 ± 11	67 ± 11	55.3 ± 8.9	64 ± 11

4SIGHT CONSULTING

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-6
Organic Matter*	Calculation: 100 - Ash (dry wt).	0.04 g/100g dry wt	1-6
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt	7-12
Polycyclic Aromatic Hydrocarbons Trace in Soil	Sonication extraction, SPE cleanup, GC-MS SIM analysis US EPA 8270C. Tested on as received sample [KBIs:5784,4273,2695]	0.002 - 0.010 mg/kg dry wt	1, 4-6
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	1, 4-6
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-12
Ash*	Ignition in muffle furnace 550°C, 6hr, gravimetric. APHA 2540 G 22nd ed. 2012.	0.04 g/100g dry wt	1-6
Sieving through 63 um sieve, no gravimetric result*	<63µm Wet Sieved with no gravimetric determination.	-	1-6
Total Recoverable Phosphorus	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-6
Total Nitrogen*	Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-6
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Kim Harrison MSc
Client Services Manager - Environmental

Appendix D:

Results of sediment grain size analysis

GEO CIVIL
TEST RIGHT • BUILD RIGHT

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E: info@geocivil.co.nz
M: 027 6565 226

TEST REPORT

Lab Job No:	8174-002
Your ref.:	-
Date of Issue:	11-04-2018
Date of Re-Issue:	-
Page:	1 of 11

Test Report.

No. 18-164

PROJECT:	**Marsden Point Sediment Grading Analysis**
CLIENT:	4Sight Consulting Office 3, Shop 10 Oceans Resort Hotel, Marina Road PO Box 402 053, Tutukaka 0153
ATTENTION:	Mark Poynter
INSTRUCTIONS:	Determination of the particle size distribution (wet sieving method)
TEST METHOD:	NZS 4402:1986 2.8.1
SAMPLING METHOD:	N/A
TEST RESULTS:	As Per Laboratory Sheets attached

G. Breckon
Laboratory Technician

D.Krissansen
Approved Signatory

IANZ ACCREDITED LABORATORY
All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-175	**Lab Job No:**	8174-002
Client Sample No:	MP East Low 1	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	26/03/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	C. Becker	**Page:**	2 of 11
History:	Natural	**Date:**	11/4/18		

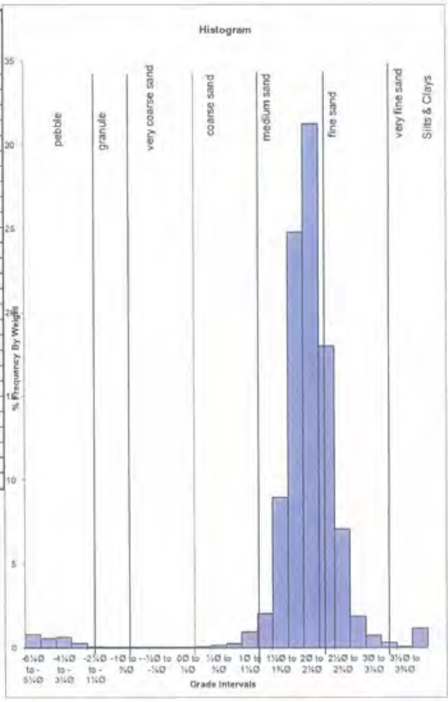
Weight of dry Sample(grams): 1026.11

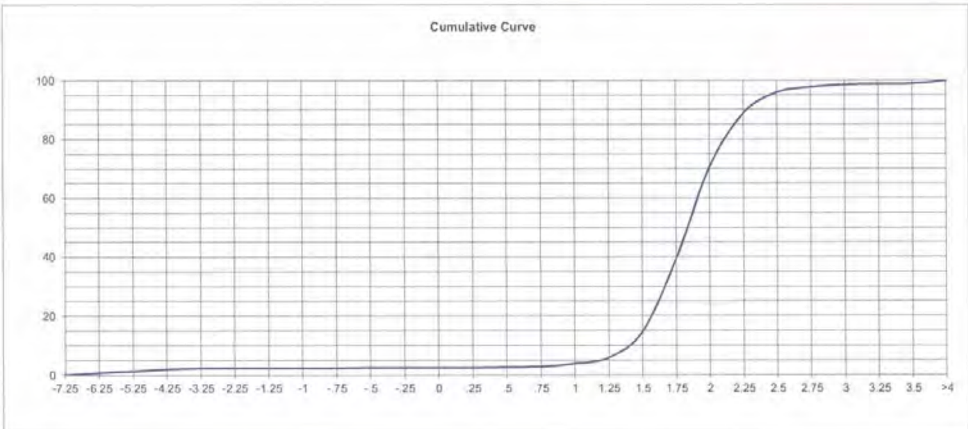
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	8.18	1	1
-4¼Ø to -3¼Ø	9.5	5.55	1	1
-3¼Ø to -2¼Ø	4.75	6.45	1	2
-2¼Ø to -1¼Ø	2.36	2.83	0	2
-1¼Ø to -1Ø	2	0.48	0	2
-1Ø to -¾Ø	1.70	0.42	0	2
-¾Ø to -½Ø	1.40	0.3	0	2
-½Ø to -¼Ø	1.18	0.28	0	2
-¼Ø to 0Ø	1.00	0.27	0	2
0Ø to ¼Ø	0.850	0.18	0	2
¼Ø to ½Ø	0.710	0.34	0	2
½Ø to ¾Ø	0.600	0.56	0	3
¾Ø to 1Ø	0.500	1.52	0	3
1Ø to 1¼Ø	0.425	2.44	0	3
1¼Ø to 1½Ø	0.355	9.77	1	4
1½Ø to 1¾Ø	0.300	20.76	2	6
1¾Ø to 2Ø	0.250	91.81	9	15
2Ø to 2¼Ø	0.212	254.27	25	40
2¼Ø to 2½Ø	0.180	320.63	31	71
2½Ø to 2¾Ø	0.150	184.64	18	89
2¾Ø to 3Ø	0.125	72.57	7	96
3Ø to 3¼Ø	0.106	19.03	2	98
3¼Ø to 3½Ø	0.090	7.52	1	99
3½Ø to 3¾Ø	0.075	3.05	0	99
3¾Ø to 4Ø	0.063	0.5	0	99
smaller than 4Ø		11.76	1	100

sum 1014.35
error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-176	**Lab Job No:**	8174-002
Client Sample No:	MP East Low 2	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	9/04/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	Checker	**Page:**	3 of 11
History:	Natural	**Date:**	11/4/18		

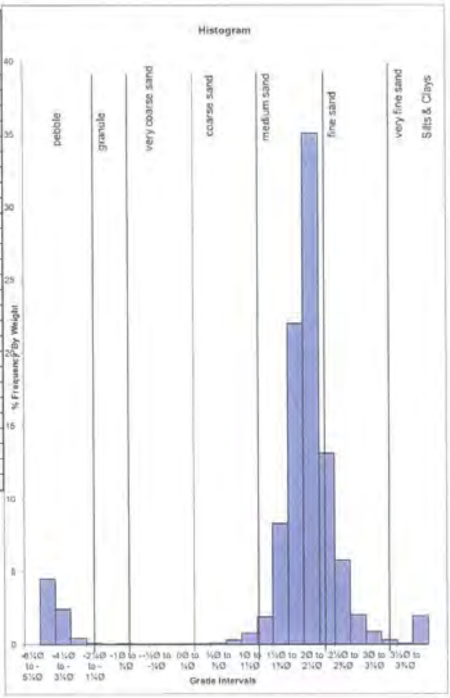
Weight of dry Sample(grams): 862.17

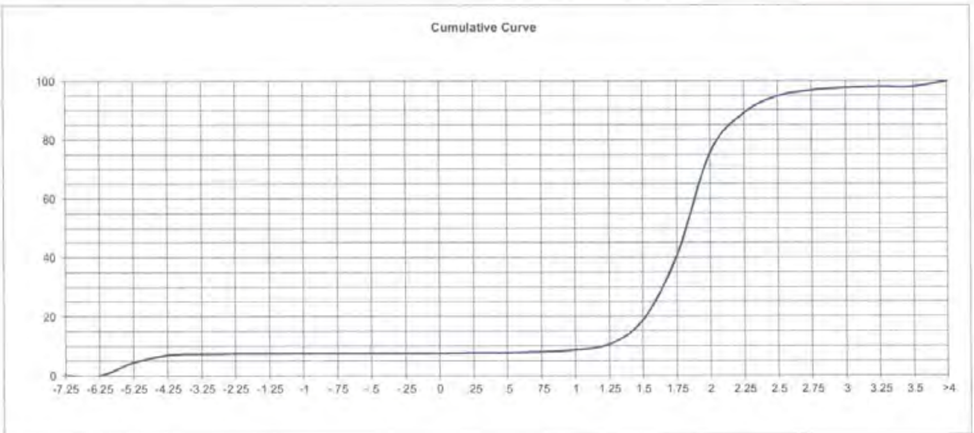
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	38.89	5	5
-3¼Ø to -2¼Ø	4.75	20.79	2	7
-2¼Ø to -1¼Ø	2.36	3.81	0	7
-1¼Ø to -1Ø	2	0.67	0	7
-1Ø to -¾Ø	1.70	0.32	0	7
-¾Ø to -½Ø	1.40	0.34	0	8
-½Ø to -¼Ø	1.18	0.22	0	8
-¼Ø to 0Ø	1.00	0.2	0	8
0Ø to ¼Ø	0.850	0.05	0	8
¼Ø to ½Ø	0.710	0.17	0	8
½Ø to ¾Ø	0.600	0.18	0	8
¾Ø to 1Ø	0.500	0.82	0	8
1Ø to 1¼Ø	0.425	2.47	0	8
1¼Ø to 1½Ø	0.355	6.57	1	9
1½Ø to 1¾Ø	0.300	16.17	2	11
1¾Ø to 2Ø	0.250	71.42	8	19
2Ø to 2¼Ø	0.212	189.62	22	41
2¼Ø to 2½Ø	0.180	302.40	35	76
2½Ø to 2¾Ø	0.150	112.77	13	89
2¾Ø to 3Ø	0.125	49.73	6	95
3Ø to 3¼Ø	0.106	17.39	2	97
3¼Ø to 3½Ø	0.090	7.59	1	98
3½Ø to 3¾Ø	0.075	2.55	0	98
3¾Ø to 4Ø	0.063	0.55	0	98
smaller than 4Ø		16.48	2	100

sum 845.69
error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

4SIGHT CONSULTING

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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-177	**Lab Job No:**	8174-002
Client Sample No:	MP West Low 1	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	28/03/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	Obrecka	**Page:**	4 of 11
History:	Natural	**Date:**	11/4/18		

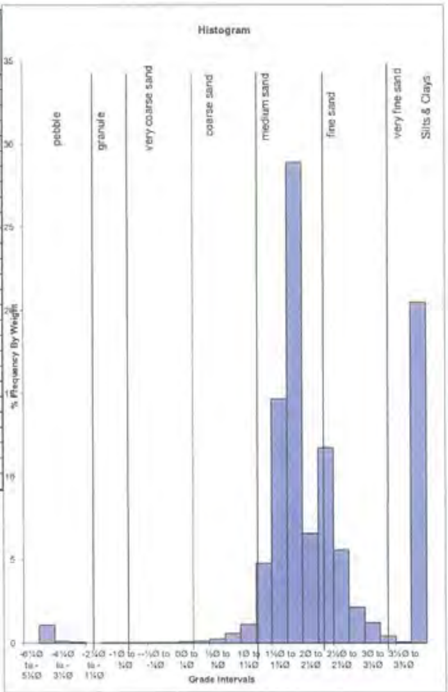
Weight of dry Sample(grams): 1132.88

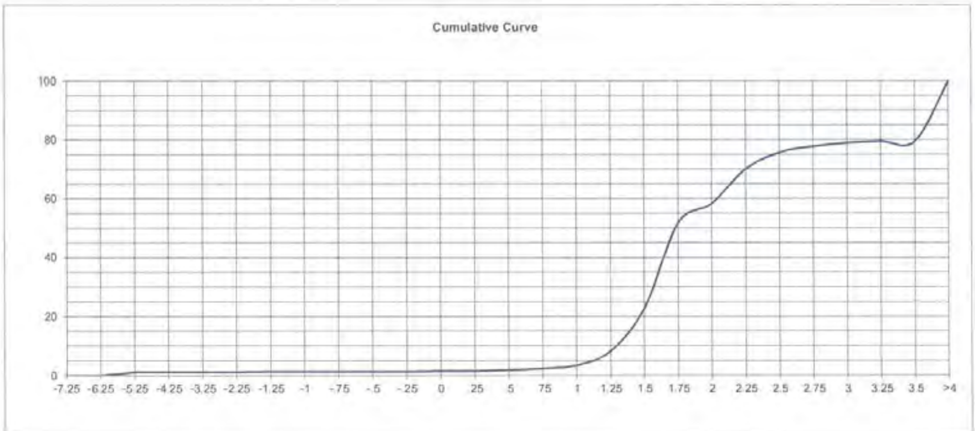
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	12.5	1	1
-3¼Ø to -2¼Ø	4.75	1.21	0	1
-2¼Ø to -1¼Ø	2.36	0.47	0	1
-1¼Ø to -1Ø	2	0	0	1
-1Ø to -¾Ø	1.70	0.2	0	1
-¾Ø to -½Ø	1.40	0.28	0	1
-½Ø to -¼Ø	1.18	0.16	0	1
-¼Ø to 0Ø	1.00	0.24	0	1
0Ø to ¼Ø	0.850	0.24	0	1
¼Ø to ½Ø	0.710	0.89	0	1
½Ø to ¾Ø	0.600	1.22	0	2
¾Ø to 1Ø	0.500	2.77	0	2
1Ø to 1¼Ø	0.425	6.57	1	2
1¼Ø to 1½Ø	0.355	12.77	1	3
1½Ø to 1¾Ø	0.300	54.45	5	8
1¾Ø to 2Ø	0.250	166.17	15	23
2Ø to 2¼Ø	0.212	327.13	29	52
2¼Ø to 2½Ø	0.180	74.40	7	58
2½Ø to 2¾Ø	0.150	132.58	12	70
2¾Ø to 3Ø	0.125	63.35	6	76
3Ø to 3¼Ø	0.106	24.36	2	78
3¼Ø to 3½Ø	0.090	13.83	1	79
3½Ø to 3¾Ø	0.075	4.61	0	79
3¾Ø to 4Ø	0.063	0.57	0	80
smaller than 4Ø		231.91	20	100

sum 900.97
error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-178	**Lab Job No:**	8174-002
Client Sample No:	MP West Low 2	**Tested by:**	N.K	**Client Ref no:**	-
Date Collected:	-	**Date:**	3/04/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	CBrecko	**Page:**	5 of 11
History:	Natural	**Date:**	11/4/18		
Weight of dry Sample(grams):	1423.88				

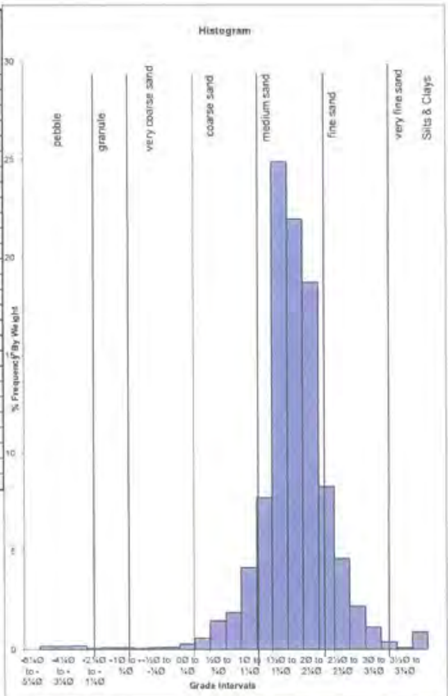
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	2.2	0	0
-3¼Ø to -2¼Ø	4.75	2.19	0	0
-2¼Ø to -1¼Ø	2.36	2.54	0	0
-1¼Ø to -1Ø	2	0.62	0	1
-1Ø to -¾Ø	1.70	0.9	0	1
-¾Ø to -½Ø	1.40	0.94	0	1
-½Ø to -¼Ø	1.18	0.79	0	1
-¼Ø to 0Ø	1.00	1.21	0	1
0Ø to ¼Ø	0.850	1.37	0	1
¼Ø to ½Ø	0.710	3.58	0	1
½Ø to ¾Ø	0.600	8.1	1	2
¾Ø to 1Ø	0.500	20.34	1	3
1Ø to 1¼Ø	0.425	26.64	2	5
1¼Ø to 1½Ø	0.355	59.33	4	9
1½Ø to 1¾Ø	0.300	109.99	8	17
1¾Ø to 2Ø	0.250	353.99	25	42
2Ø to 2¼Ø	0.212	312.78	22	64
2¼Ø to 2½Ø	0.180	266.61	19	82
2½Ø to 2¾Ø	0.150	118.04	8	91
2¾Ø to 3Ø	0.125	65.84	5	95
3Ø to 3¼Ø	0.106	31.13	2	98
3¼Ø to 3½Ø	0.090	15.95	1	99
3½Ø to 3¾Ø	0.075	5.42	0	99
3¾Ø to 4Ø	0.063	0.92	0	99
smaller than 4Ø		12.46	1	100

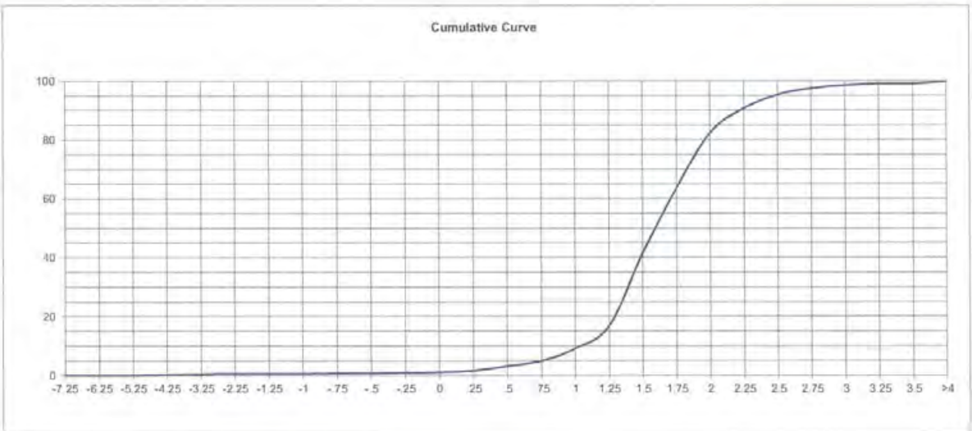
sum 1411.42

error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

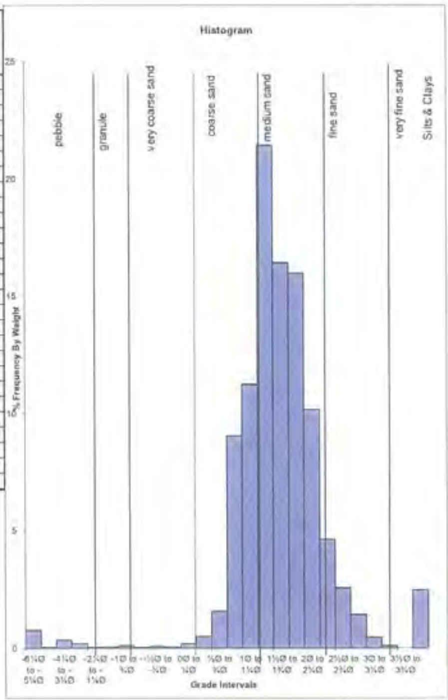
Client:	4 Sight Consulting	**Sample No.**	18-179	**Lab Job No:**	8174-002
Client Sample No:	MP West Low 3	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	29/03/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	Becko	**Page:**	6 of 11
History:	Natural	**Date:**	11/4/18		
Weight of dry Sample(grams):	956.81				

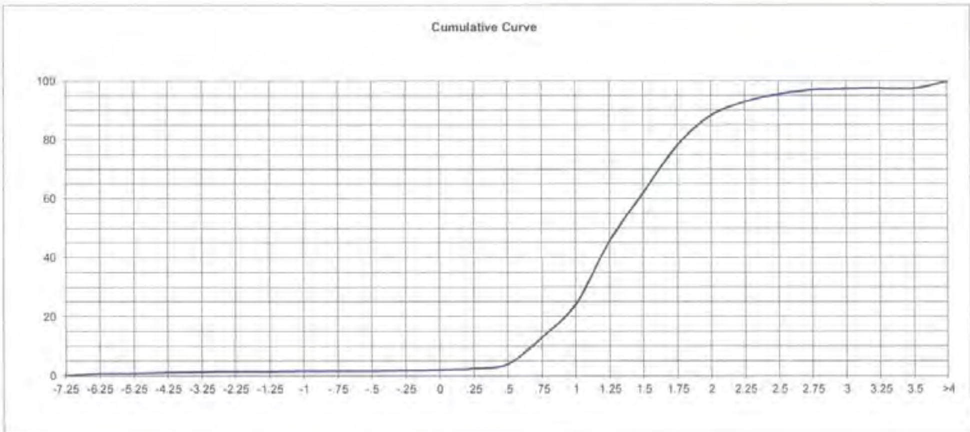
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	7.26	1	1
-4¼Ø to -3¼Ø	9.5	0.44	0	1
-3¼Ø to -2¼Ø	4.75	3.25	0	1
-2¼Ø to -1¼Ø	2.36	1.87	0	1
-1¼Ø to -1Ø	2	0.44	0	1
-1Ø to -¾Ø	1.70	0.58	0	1
-¾Ø to -½Ø	1.40	0.96	0	2
-½Ø to -¼Ø	1.18	0.4	0	2
-¼Ø to 0Ø	1.00	0.74	0	2
0Ø to ¼Ø	0.850	0.69	0	2
¼Ø to ½Ø	0.710	1.75	0	2
½Ø to ¾Ø	0.600	4.71	0	2
¾Ø to 1Ø	0.500	15.07	2	4
1Ø to 1¼Ø	0.425	86.68	9	13
1¼Ø to 1½Ø	0.355	107.55	11	24
1½Ø to 1¾Ø	0.300	205.05	21	46
1¾Ø to 2Ø	0.250	157.2	16	62
2Ø to 2¼Ø	0.212	152.87	16	78
2¼Ø to 2½Ø	0.180	97.40	10	88
2½Ø to 2¾Ø	0.150	44.28	5	93
2¾Ø to 3Ø	0.125	24.63	3	96
3Ø to 3¼Ø	0.106	13.72	1	97
3¼Ø to 3½Ø	0.090	4.51	0	97
3½Ø to 3¾Ø	0.075	0.94	0	98
3¾Ø to 4Ø	0.063	0	0	98
smaller than 4Ø		23.82	2	100

sum 932.99
error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





18-179,PSD
Date:11/04/2018
File:8174-002,4sight,marsden point,PSD,5-4-18.xlsx

D. Krissansen
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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-180	**Lab Job No:**	8174-002
Client Sample No:	West Mid 1	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	26/03/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	CBeako	**Page:**	7 of 11
History:	Natural	**Date:**	11/4/18		

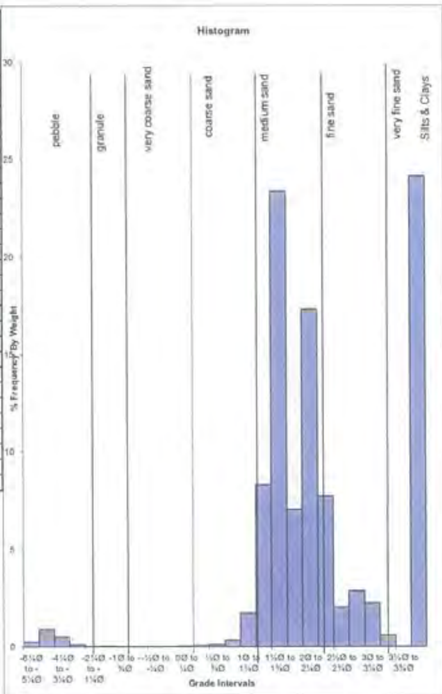
Weight of dry Sample(grams): 956.94

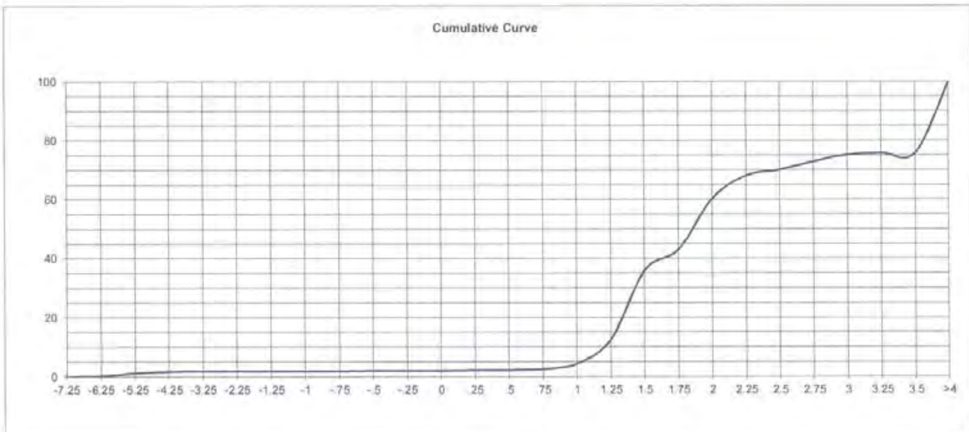
GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	2.6	0	0
-4¼Ø to -3¼Ø	9.5	8.5	1	1
-3¼Ø to -2¼Ø	4.75	4.86	1	2
-2¼Ø to -1¼Ø	2.36	1.17	0	2
-1¼Ø to -1Ø	2	0.27	0	2
-1Ø to -¾Ø	1.70	0.46	0	2
-¾Ø to -½Ø	1.40	0.3	0	2
-½Ø to -¼Ø	1.18	0.3	0	2
-¼Ø to 0Ø	1.00	0.42	0	2
0Ø to ¼Ø	0.850	0.34	0	2
¼Ø to ½Ø	0.710	0.54	0	2
½Ø to ¾Ø	0.600	0.69	0	2
¾Ø to 1Ø	0.500	1.11	0	2
1Ø to 1¼Ø	0.425	3.28	0	3
1¼Ø to 1½Ø	0.355	16.72	2	4
1½Ø to 1¾Ø	0.300	79.40	8	13
1¾Ø to 2Ø	0.250	223.45	23	36
2Ø to 2¼Ø	0.212	67.70	7	43
2¼Ø to 2½Ø	0.180	165.44	17	60
2½Ø to 2¾Ø	0.150	73.95	8	68
2¾Ø to 3Ø	0.125	19.38	2	70
3Ø to 3¼Ø	0.106	27.42	3	73
3¼Ø to 3½Ø	0.090	21.47	2	75
3½Ø to 3¾Ø	0.075	5.75	1	76
3¾Ø to 4Ø	0.063	0.42	0	76
smaller than 4Ø		231.00	24	100

sum 725.94
error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

4SIGHT CONSULTING

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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

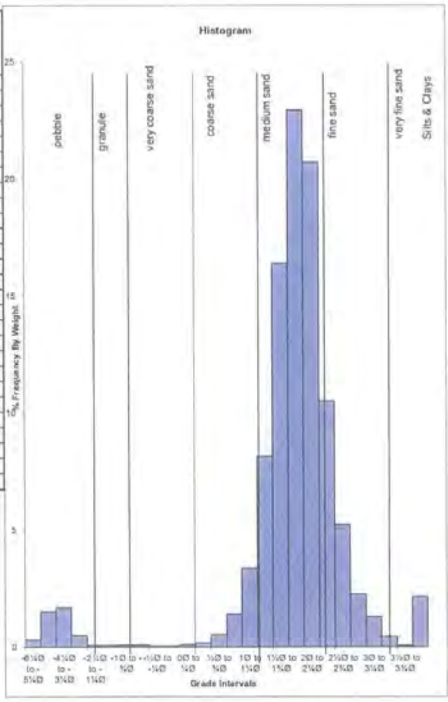
Client:	4 Sight Consulting	**Sample No.**	18-181	**Lab Job No:**	8174-002
Client Sample No:	West Mid 2 (A)	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	27/03/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	Becko	**Page:**	8 of 11
History:	Natural	**Date:**	11/4/18		
Weight of dry Sample(grams):	932.17				

GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	2.85	0	0
-4¼Ø to -3¼Ø	9.5	14.09	2	2
-3¼Ø to -2¼Ø	4.75	15.77	2	4
-2¼Ø to -1¼Ø	2.36	4.66	0	4
-1¼Ø to -1Ø	2	0.6	0	4
-1Ø to -¾Ø	1.70	0.64	0	4
-¾Ø to -½Ø	1.40	0.79	0	4
-½Ø to -¼Ø	1.18	0.76	0	4
-¼Ø to 0Ø	1.00	0.49	0	4
0Ø to ¼Ø	0.850	0.34	0	4
¼Ø to ½Ø	0.710	1.02	0	5
½Ø to ¾Ø	0.600	1.71	0	5
¾Ø to 1Ø	0.500	4.83	1	5
1Ø to 1¼Ø	0.425	13.12	1	7
1¼Ø to 1½Ø	0.355	31.30	3	10
1½Ø to 1¾Ø	0.300	75.92	8	18
1¾Ø to 2Ø	0.250	152.61	16	34
2Ø to 2¼Ø	0.212	213.70	23	57
2¼Ø to 2½Ø	0.180	192.90	21	78
2½Ø to 2¾Ø	0.150	97.99	11	89
2¾Ø to 3Ø	0.125	48.57	5	94
3Ø to 3¼Ø	0.106	20.92	2	96
3¼Ø to 3½Ø	0.090	12.02	1	97
3½Ø to 3¾Ø	0.075	3.99	0	98
3¾Ø to 4Ø	0.063	0.64	0	98
smaller than 4Ø		19.94	2	100

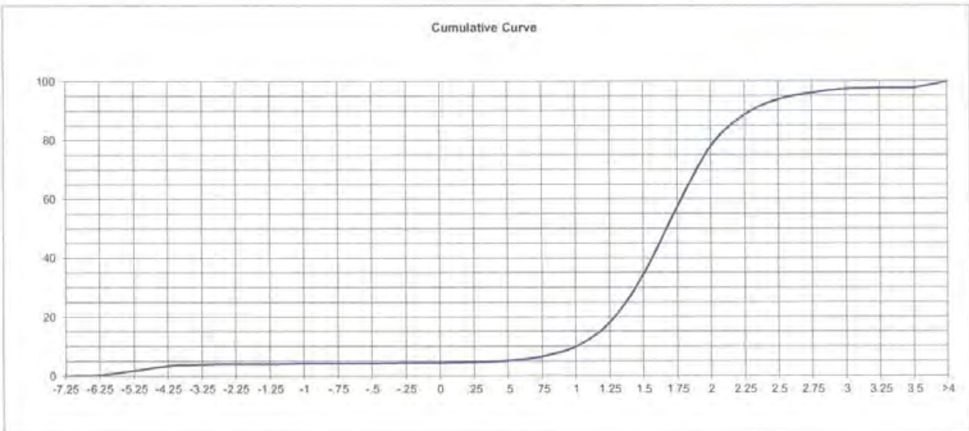
sum 912.23

error/losses %

Mean Size		-	Ø
Standard Deviation		-	Ø
Skewness		-	Ø



Note:



18-181,PSD
Date:11/04/2018
File:8174-002,4sight,marsden point,PSD,5-4-18.xlsx

D. Krissansen
Approved Signatory

4SIGHT CONSULTING

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DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-182	**Lab Job No:**	8174-002
Client Sample No:	West Mid 3	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	28/03/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	Obrecko	**Page:**	9 of 11
History:	Natural	**Date:**	11/4/18		

Weight of dry Sample(grams): 1174.17

GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
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-5¼Ø to -4¼Ø	19	12.73	1	1
-4¼Ø to -3¼Ø	9.5	109.39	9	10
-3¼Ø to -2¼Ø	4.75	16.68	1	12
-2¼Ø to -1¼Ø	2.36	10.91	1	13
-1¼Ø to -1Ø	2	0.84	0	13
-1Ø to -¾Ø	1.70	2.05	0	13
-¾Ø to -½Ø	1.40	1.89	0	13
-½Ø to -¼Ø	1.18	1.42	0	13
-¼Ø to 0Ø	1.00	1.47	0	13
0Ø to ¼Ø	0.850	1.31	0	14
¼Ø to ½Ø	0.710	2.47	0	14
½Ø to ¾Ø	0.600	4.68	0	14
¾Ø to 1Ø	0.500	11.84	1	15
1Ø to 1¼Ø	0.425	25.05	2	17
1¼Ø to 1½Ø	0.355	57.27	5	22
1½Ø to 1¾Ø	0.300	147.12	13	35
1¾Ø to 2Ø	0.250	229.45	20	54
2Ø to 2¼Ø	0.212	145.91	12	67
2¼Ø to 2½Ø	0.180	155.49	13	80
2½Ø to 2¾Ø	0.150	93.27	8	88
2¾Ø to 3Ø	0.125	56.11	5	93
3Ø to 3¼Ø	0.106	37.47	3	96
3¼Ø to 3½Ø	0.090	18.89	2	97
3½Ø to 3¾Ø	0.075	5.36	0	98
3¾Ø to 4Ø	0.063	0.1	0	98
smaller than 4Ø		25.00	2	100

sum 1149.17
error/losses %

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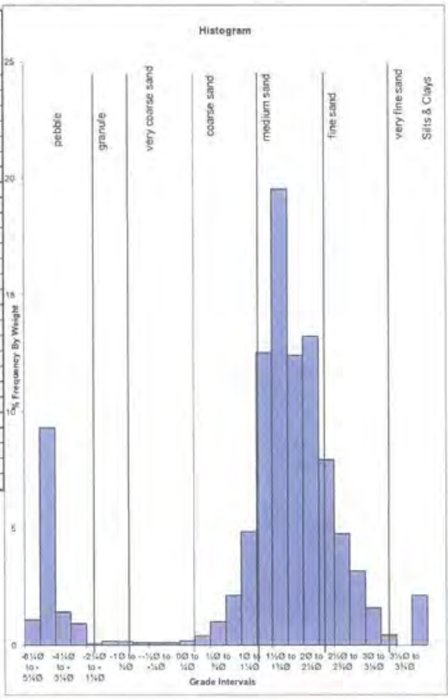
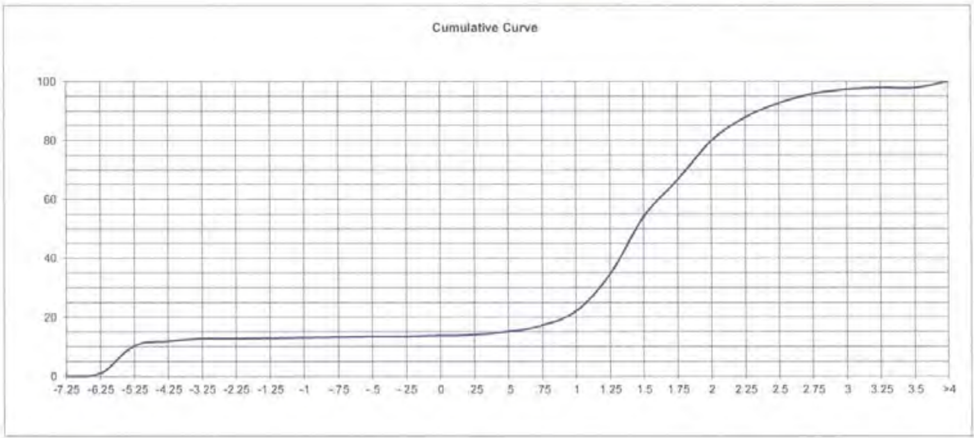
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

Whangarei Lab

DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-183	**Lab Job No:**	8174-002
Client Sample No:	Mid West 2 (B)	**Tested by:**	D.K	**Client Ref no:**	-
Date Collected:	-	**Date:**	10/04/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	CBreckon	**Page:**	10 of 11
History:	Natural	**Date:**	11/4/18		
Weight of dry Sample(grams):	649.39				

GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
-6¼Ø to -5¼Ø	37.5	0	0	0
-5¼Ø to -4¼Ø	19	0	0	0
-4¼Ø to -3¼Ø	9.5	0	0	0
-3¼Ø to -2¼Ø	4.75	2.96	0	0
-2¼Ø to -1¼Ø	2.36	1.86	0	1
-1¼Ø to -1Ø	2	0.44	0	1
-1Ø to -¾Ø	1.70	0.5	0	1
-¾Ø to -½Ø	1.40	0.5	0	1
-½Ø to -¼Ø	1.18	0.28	0	1
-¼Ø to 0Ø	1.00	0.39	0	1
0Ø to ¼Ø	0.850	0.25	0	1
¼Ø to ½Ø	0.710	0.81	0	1
½Ø to ¾Ø	0.600	1.77	0	2
¾Ø to 1Ø	0.500	4.57	1	2
1Ø to 1¼Ø	0.425	9.1	1	4
1¼Ø to 1½Ø	0.355	22.85	4	7
1½Ø to 1¾Ø	0.300	44.15	7	14
1¾Ø to 2Ø	0.250	159.64	25	39
2Ø to 2¼Ø	0.212	156.54	24	63
2¼Ø to 2½Ø	0.180	108.55	17	79
2½Ø to 2¾Ø	0.150	32.84	5	84
2¾Ø to 3Ø	0.125	23.87	4	88
3Ø to 3¼Ø	0.106	8.97	1	89
3¼Ø to 3½Ø	0.090	4.36	1	90
3½Ø to 3¾Ø	0.075	1.26	0	90
3¾Ø to 4Ø	0.063	0.16	0	90
smaller than 4Ø		62.77	10	100

sum 586.62

error/losses %

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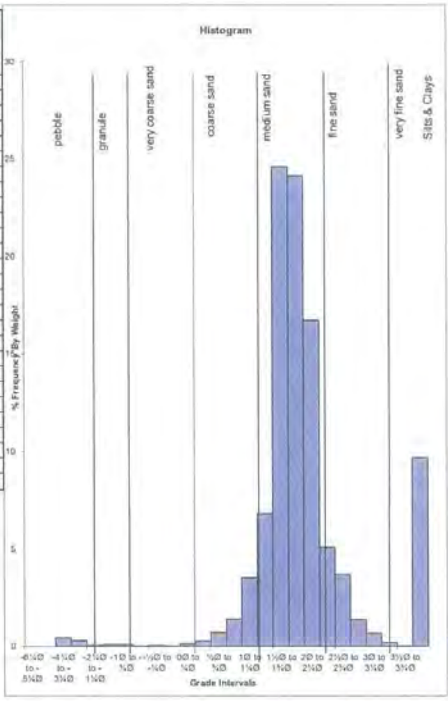
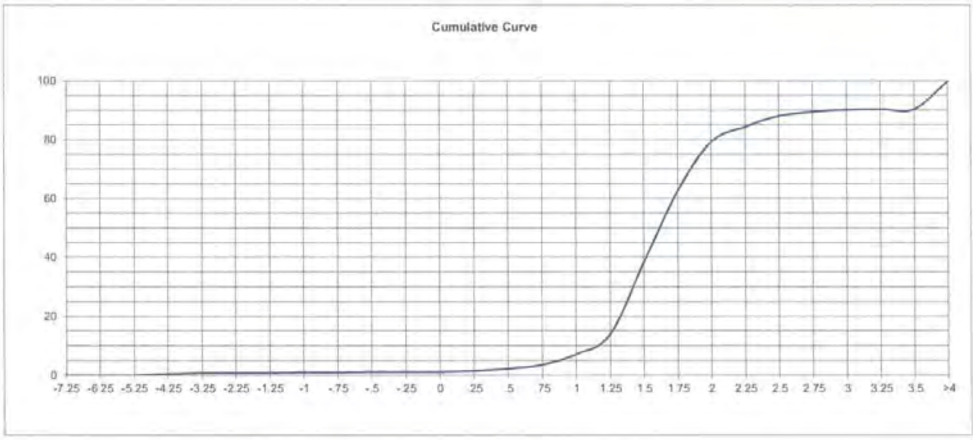
Standard Deviation		-	Ø
Skewness		-	Ø

Note:





D. Krissansen
Approved Signatory

4SIGHT CONSULTING

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TEST RIGHT | BUILD RIGHT

Whangarei Lab

DETERMINATION OF THE PARTICLE SIZE DISTRIBUTION

NZS 4402:1986 Test 2.8.1

Client:	4 Sight Consulting	**Sample No.**	18-184	**Lab Job No:**	8174-002
Client Sample No:	Olp Low	**Tested by:**	D.M	**Client Ref no:**	-
Date Collected:	-	**Date:**	11/04/2018	**Report no:**	W18-164
Test Details:	Wet sieving method	**Checked by:**	CBrecken	**Page:**	11 of 11
History:	Natural	**Date:**	11/4/18		

Weight of dry Sample(grams): 877.08

GRADE INTERVALS	BS TEST SIEVE (mm)	WEIGHT RETAINED ON SIEVE (g)	% FREQUENCY (WEIGHT)	CUMULATIVE % FREQUENCY
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-5¼Ø to -4¼Ø	19	6.38	1	1
-4¼Ø to -3¼Ø	9.5	49.71	6	6
-3¼Ø to -2¼Ø	4.75	8.81	1	7
-2¼Ø to -1¼Ø	2.36	1.62	0	8
-1¼Ø to -1Ø	2	0.52	0	8
-1Ø to -¾Ø	1.70	0.5	0	8
-¾Ø to -½Ø	1.40	0.57	0	8
-½Ø to -¼Ø	1.18	0.42	0	8
-¼Ø to 0Ø	1.00	0.36	0	8
0Ø to ¼Ø	0.850	0.36	0	8
¼Ø to ½Ø	0.710	0.56	0	8
½Ø to ¾Ø	0.600	0.82	0	8
¾Ø to 1Ø	0.500	1.77	0	8
1Ø to 1¼Ø	0.425	3.08	0	9
1¼Ø to 1½Ø	0.355	18.34	2	11
1½Ø to 1¾Ø	0.300	60.90	7	18
1¾Ø to 2Ø	0.250	208.08	24	41
2Ø to 2¼Ø	0.212	188.92	22	63
2¼Ø to 2½Ø	0.180	189.16	22	84
2½Ø to 2¾Ø	0.150	66.61	8	92
2¾Ø to 3Ø	0.125	24.83	3	95
3Ø to 3¼Ø	0.106	8.53	1	96
3¼Ø to 3½Ø	0.090	4.05	0	96
3½Ø to 3¾Ø	0.075	2	0	97
3¾Ø to 4Ø	0.063	0.03	0	97
smaller than 4Ø		30.15	3	100

sum 846.93

error/losses %

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Standard Deviation		-	Ø
Skewness		-	Ø

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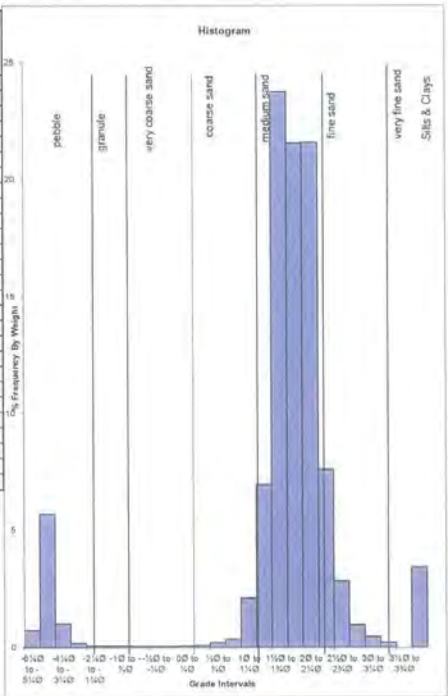

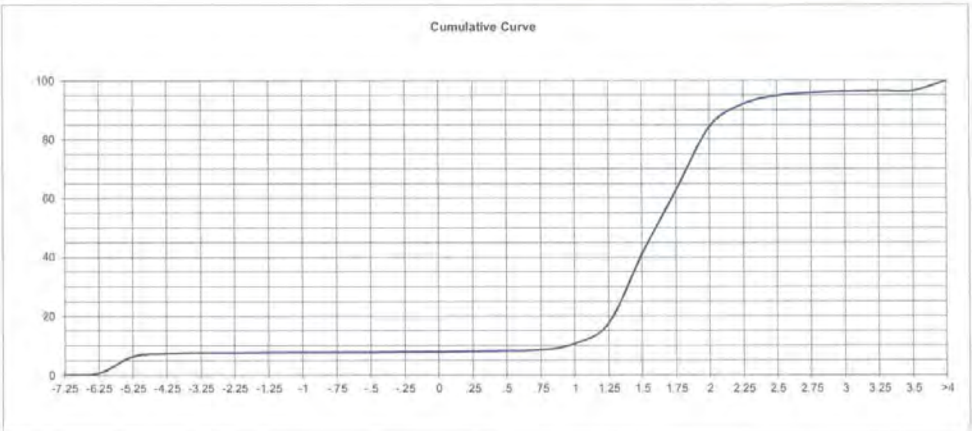

D. Krissansen
Approved Signatory

4SIGHT CONSULTING

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Northport

Northport Subtidal Ecology Report – Rock Revetments

Prepared for Northport

February 2018

REPORT INFORMATION AND QUALITY CONTROL

Prepared for:	Greg Blomfield Northport	

Author:	Arie Spyksma Ecology Consultant	
Reviewer:	Mark Poynter Principal Ecology Consultant	
Approved for Release:	Michael Lindgreen Director	

Document Name	AA2896 – Northport Subtidal Ecology Report V1.0

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	V1.0	26/02/2018

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1 INTRODUCTION

Northport, situated at Marsden Point near the entrance to the Whangarei Harbour, is New Zealand's northern most deep-water port. Established in 2002 the port terminal is a 34ha reclamation which projects across tidal flats and into the deep water harbour channel. The port terminal reclamation is protected at its eastern and western edges, by rock revetments that extend down to the seabed. The ecology of these revetments, which form a potential 'artificial' rocky reef habitat, is the subject of this report.

The Whangarei Harbour is a large (100 km^2) estuarine system that has, through time, been subjected to significant anthropogenic impacts including land reclamation, the deposition of 3 million m^3 of sediment fines and 2 million m^3 of channel dredge spoils since the 1920 and runoff from urban, industrial and rural sources (Morrison, 2005). Despite these impacts there is still a wide range of habitats, including deep-water channels, intertidal flats, mangroves, and saltmarsh (Morrison, 2005). Associated with these habitats is a rich diversity of marine life, from benthic invertebrates to estuarine and coastal fishes (Brook, 2002, Morrison, 2005). The harbour is also recognised for its importance for many internationally migrating bird species, New Zealand migratory bird species and resident species (Morrison, 2005).

Subtidal rocky reefs are one habitat type that is underrepresented with the Whangarei Harbour and much of the reef that is present occurs on the northern coastline towards the harbour entrance. The rocky reefs around Motukararo Island, within the Motukararo Marine Reserve, are the closest natural reefs to Northport. Motokararo Island is located 700m northeast, opposite Northport across the harbour channel. The revetments, while artificially created, do provide additional rocky substrate within the harbour and have now been in place for 15 years, long enough for rocky reef communities to establish. The ecology of the revetments has not been reported previously, although anecdotal information by one observer, collected shortly after their establishment, noted heavy colonisation by the invasive parchment worm (*Chaetopterus variopedatus*) (M Poynter, pers comm). In more recent times information gathered incidental to diving inspections of port structures, suggests a variety of marine life now occurs, however no formal assessment has been made.

This report details results from a subtidal survey conducted on the western and eastern revetments of the Northport Terminal to assess the subtidal communities existing on the rocky substrate.

2 METHODS

A subtidal survey was conducted on 07/11/2017. The survey was carried out by two experienced divers using SCUBA equipment. The 7th of November survey coincided with the high-water slack tide at 1040 am to optimise diving conditions and avoid the strong tidal currents that pass the port.

Data was collected from a total of three survey sites, two on the western revetment and one on the eastern revetment (Figure 1). All sites were accessed by vessel. At each site, a transect tape was laid out down the face of the revetment, from the water surface to the edge of revetment at the sea floor. Data was then collected from three depth strata along each transect – 4 m below mean low water (MLW), 6 m below MLW and 10 m below MLW. The actual depth at which these strata occurred during the time of survey were depth corrected. Data collection included a survey of key macroalgae species, turfing and encrusting algae and encrusting invertebrates, a breakdown of substrate cover composition and a fish survey

Algae, encrusting life and mobile invertebrates.

At each depth strata all species of macroalgae, turfing/encrusting algae encrusting invertebrates and mobile invertebrates within an 8 m^2 area were identified to the lowest taxonomic level. The 8m^2 area consisted of a 2 x 2 m square either side of the transect tape.

Substrate composition

Substrate composition was assessed using a photo quadrat. The quadrat consisted of a steel frame measuring 25 cm x 50 cm with an A-frame mounted over it. A Panasonic Lumix TS4 digital camera was screwed to the top of this A-frame with a wide angle wet lens attached. This enabled the full quadrat to be framed in each photo. At each depth strata eight photos of the rocky substrate were taken to allow substrate covers to be calculated. Photos were taken with the same 8 m^2 as mentioned above. Substrate covers were; macroalgae, turfing and encrusting algae, sponge, ascidian and bryozoan and sediment. The percentage (out of 100) for each substrate cover was assessed for each photo and an average taken.

Due to poor visibility at 4 m collecting photos with enough water clarity to assess substrate cover were not possible and consequently percent covers were not calculated.

Fish survey

A 10-minute fish survey was conducted at each depth strata. All new species of fish identified during this period were recorded, and in the case of schooling fish an estimate of the school number was made. The inventory included a search for cryptic fish species under boulders and ledges and within crevices

Figure 1: Site locations for the subtidal surveys

3 RESULTS

3.1 Western Revetment

3.1.1 Site description

Two sites were surveyed along the western revetment; transect one at the northern tip of the revetment and transect two, slightly south of the fishing pier (Figure 1). The revetment at both sites fell away steeply to a maximum depth of approximately 10 m below mean low water, where the boulder substrate gave way to sand.

The rocky structure along Transect One comprised large boulders. These formed a continuous substrate at 4 and 6 m, with large crevices and overhangs in the voids between boulders. At the base of the revetment, boulder cover became patchier. Patches soft substrate (silty sand) were present throughout the boulder field.

The rocky structure along Transect Two was more variable. At 4 m the substrate comprised mainly small rubble. Little biota was observed to be growing on the substrate at this depth. At 6 m a continuous substrate of large boulders existed with, large crevices and overhangs in the joints between boulders. Like with Transect One boulder cover became patchier at 10 m and soft substrate was present between boulders.

In general, the water visibility was poor (< 2 m) at 4 m. The survey was terminated at 4 m at Transect Two due to strong currents. Although the field work was timed for slack water, of note was that the 4 m survey at Transect Two experienced strong northerly current (along the direction of the revetment). This was likely to be a result of the continuing flood tide and a counter clockwise eddy on the western side of the reclamation. Visibility improved at the deeper depth and near the toe of the revetment visibility was approximately 6 - 8 m.

Sediment cover was high at both sites, and at all depth strata (Table 1). Average sediment cover on the substrate within the 6 and 10 m depth strata was 51 ± 5%. While not quantified, sediment load at 4 m appeared to be greater than at the deeper depths, and likely exceeded 50%.

Fishing debris from the nearby public access wharf was common and included various lengths of fishing line wrapped around algae and sponge along with lead from fishing weights. This debris presented a considerable hazard for diving.

Table 1: Mean substrate cover at 6 m and 10 m along each transect

Substrate cover	West				East	
	T1 6 m	T1 10 m	T2 6 m	T2 10 m	T3 6 m	T3 10 m
Kelp	2.7 ± 0.8	0.7 ± 06	1.8 ± 0.4	0.2 ± 0.1	2.8 ± 0.6	0.6 ± 0.4
Encrusting/turfing algae	29.2 ± 6.1	20 ± 6.0	25.7 ± 5.3	15.9 ± 4.7	9.4 ± 2.8	11.9 ± 3.4
Sponges	14.5 ± 6.0	36 ± 5.0	25.7 ± 9.6	13.5 ± 4.4	22.2 ± 7.6	42.8 ± 9.7
Ascidians and bryozoans	3.3 ± 0.8	1.6 ± 2.6	3.9 ± 0.8	1.3 ± 0.4	1.4 ± 0.8	7.3 ± 3.6
Sediment	50.3 ± 4.5	41.7 ± 6.1	42.9 ± 4.5	69.2 ± 4.1	64.2 ± 6.9	37.5 ± 6.1

3.1.2 Algae and encrusting life

Macroalgae composition at Transect One and Two comprised almost exclusively *Ecklonia radiata*, a large brown alga from the order Laminariales (Appendix A). At Transect one this formed a dense canopy cover at 4 m, before becoming more sporadic, but still common, as depth increased (Figure 2A). Little *Ecklonia* cover was observed within the 4 m depth strata along Transect Two, however it was common at both deeper survey depths.

Red turfing algae (both fleshy and calcareous) and crustose coralline algae (CCA) were common at all depths (Appendix A) and a major portion of substrate cover (Figure 2B). Along Transect One average turfing/encrusting algae cover was 29 ± 6% at 6 m and 20 ± 5% at 10 m (Table 1). Along Transect Two average turfing/encrusting algae cover was 26 ± 5% and 15 ± 5% respectively (Table 1).

There was a rich diversity of encrusting invertebrates on the western revetment. Thirteen species of sponge, ascidian and bryozoan were identified (Appendix A). Sponges were the dominant form of encrusting invertebrate (Figure 2B) and aside from red turfing algae were the most common substrate cover (excluding sediment). Along Transect One, sponge cover was 15 ± 6% at 6 m and 26 ± 6% at 10 m (Table 1). Along Transect Two, sponge cover was 36 ± 4% and 14 ± 5% respectively (Table 1). Ascidians and bryozoans, while common, contributed little to the overall substrate cover (Table 1).

3.1.3 Mobile invertebrates

Thirteen species of mobile invertebrates were recorded on the western revetment (Appendix B). The most commonly observed species was the turret shell (*Maoricolpus roseus*). Turret shell, a suspension feeding gastropod, was found at all depths along both transects, but was most abundant at 10 m where it formed dense aggregations on the soft substrate between boulders (Figure 2C). Other species of gastropod including the shield shell (*Scutus breviculus*) and the large predatory Trumpet shell (*Charonia lampas)* were observed in low numbers. Echinoderms including sea cucumber (*Austrastichopus molis*), were found along Transect One, and kina (*Evechinus chloroticus*), were identified within the deeper strata of both transects. No red rock lobster (*Jasus edwardsii*) were found on the western revetment, however there was suitable lobster habitat at all depths. Squid egg masses were found at 10 m, along Transect Two (Figure 2D).

The invasive Mediterranean fan worm (*Sabella* spallanzanii), was found in low numbers at 4 m along Transect One, but was not observed at any other location. Parchment tube worm (*Chaetopterus sp*) was also found in low numbers along Transect One.

3.1.4 Fish

Thirteen species of fish were counted along the western revetment (Appendix C). Common reef fish such as red moki (*Cheilodactylus spectabilis),* spotty (*Notolabrus celidotus*) and sweep (*Scorpis lineolate*), were observed along both transects as were species of triplefin (*Forsterygion varium*) and (*Forsterygion lapillum*). Small schools (5 – 10 individuals) of pelagic kingfish (*Seriola lalandi*), were observed at 6 m and 10 m, as were larger schools (50 + individuals) of bait fish jack mackerel (*Trachurus novaezelandiae*). Goatfish (*Upeneichthys lineatus*) were abundant at 10 m and were seen aggregating in loose schools on the soft substrate between boulders.

Figure 2: Photos taken along the western revetment transects. A) Dense *Ecklonia* cover at 4 m, B) typical substrate cover with red turfing algae, CCA (pink), encrusting sponges (orange), C) dense aggregation of turret shells on soft substrate between boulders and D) squid egg mass observed at 8 m along transect two.

3.2 Eastern revetment

3.2.1 Site description

One site towards the northern end of the eastern revetment was surveyed. The revetment at this location was near vertical reaching a maximum depth of approximately 10 m below mean low water, where the boulder substrate gave way to silty sand.

The revetment similarly comprised large boulders, to 10 m depth, with crevices and overhangs present between boulders. At the base of the revetment, isolated boulders were scattered over the sand creating a patchwork of hard and soft bottomed substrate.

Visibility was poor (< 3 m) at 4 m but improved at the deeper depth strata. Visibility near the bottom of the revetment was approximately 6 - 8 m. Sediment cover at all depth strata was high (Table 1). Average sediment cover at 6 m was 64 ± 7% while sediment cover dropped to 38 ± 7% at 10 m. While not quantified, sediment cover at 4 m likely exceeded 50%.

3.2.2 Algae and encrusting invertebrates

As with the western revetment, *Ecklonia* was the dominant macroalgae. However other species, including *Sargassum sinclairii* and *Carpophyllum flexuosum* were also common (Figure 3A, Appendix A). *Ecklonia* formed a dense canopy cover at 4 m, before thinning, as depth increased.

Red turfing algae (both fleshy and calcareous) and CCA were found at all depths, but were not as dominant, in terms of substrate cover, as on the western revetment (Table 1, Appendix A). Average turfing/ encrusting algae cover was 9 ± 3% at 6 m and 12 ± 3% at 10 m.

Nine species of sponge, ascidian and bryozoan were identified through the depth strata (Appendix A). Sponges were the dominant encrusting life on the eastern revetment (Figure 3B) and accounted for the largest proportion of substrate cover. Sponge cover was 22± 8% at 6 m and 43 ± 10% at 10 m (Table 1). The proportion of substrate cover attributed to sponge species was greater than that of sediment at 10 m. Ascidians and bryozoans, were common but contributed less to the substrate cover (Figure 3C, Table 1).

3.2.3 Mobile invertebrates

Twelve species of mobile invertebrates were recorded on the eastern revetment (Appendix B). As with the western revetment the turret shell was the most commonly observed species. Gastropods including Cook's turban (*Cookia sulcata*), and variable nudibranch (*Aphelodoris luctuosa*) were infrequently observed. Large *Evechinus* sea urchins (>70 mm test diameter) were recorded at all depths, while other species of echinoderm including sea cucumber and 11-arm sea star (*Coscinasterias muricata*), were found within the deeper strata. Five red rock lobster were recorded between 4 and 6 m. (Figure 3D) Three of these individuals where juveniles with a carapace width < 50 mm while the remaining two were bordering on the legal size limit of 54 - 60 mm (sex dependant).

No Mediterranean fan worm was found along the eastern transect however parchment tube worm were found in low numbers at 6 m.

3.2.4 Fish

Ten species of fish were counted along the eastern revetment (Appendix C). Common reef fish such as red moki, spotty, sweep and two spot demoiselle (*Chromis dispilus*), were observed along the transects, as were species of triplefin such as *Forsterygion varium* and *Forsterygion lapillum*. Sandager's wrasse (*Coris sandageri*) (including a large male seen at 10 m) along with butterfly perch (*Caesioperca lepidoptera*), a planktivorous species typically found where there is a good amount of current, were also observed. A large school (50+ individuals) of juvenile trevally (*Pseudocaranx dentex*) swam through the area during the 6 m survey.

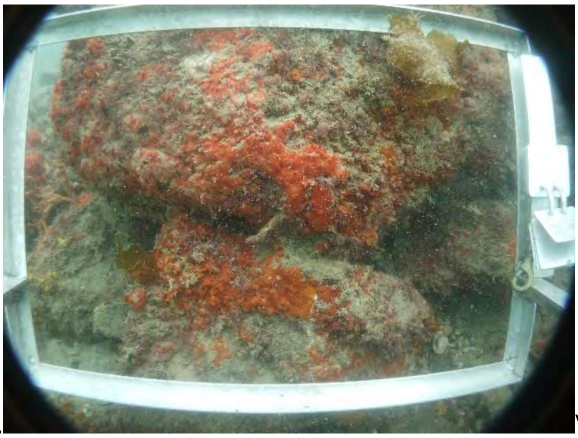
........\

Figure 3: Photo taken from the eastern revetment transect. 1A) *Ecklonia* canopy with large *Carpophyllum* present on left, B) encrusting sponges growing over the revetment, C) *Sycozoa sigillinoides*, lollipop sea squirt growing on the revetment and, D) sublegal red rock lobster.

4 DISCUSSION

A healthy and diverse subtidal community exists on the western and eastern revetments of the Northport terminal. The communities and species recorded are comparable to rocky reefs within the Motukararo Marine Reserve, on the opposite side of the harbour (Kerr and Grace, 2006; Kerr and Moretti 2012), and to reef habitat in the wider Bream Bay area (Willis, 1995; Kerr and Grace, 2016).

The pattern of macroalge described in this report is similar to that described within the Motukararo Marine Reserve where a dense stand of *Ecklonia* dominate the canopy at shallow depths before thinning as depth increases (Kerr and Grace, 2006). Limited light availability, a consequence of high water turbidity (noted as poor visibility in this report) may be a driving factor in the thinning of *Ecklonia* as depth increased.

Despite a high degree of sediment cover on much of the revetment, a rich encrusting invertebrate community existed. Encrusting invertebrate communities are likely to benefit from the canopy cover provided by *Ecklonia* as this reduces light intensity, facilitating favourable conditions for encrusting invertebrates to grow (Kerr and Grace, 2006). Similar trends, of healthy sponge communities growing under *Ecklonia* canopy have been observed within the Motukararo Marine Reserve (Kerr and Grace, 2006). Many of the sponge species identified at Northport have also been found at Three Mile Reef, an area of 'foul ground' at 27 m water depth, located approximately three miles southeast of the Whangarei Harbour entrance (Kerr and Grace, 2012).

While no red rock lobster were recorded on the western revetment there was abundant habitat for lobster. Anecdotal evidence from port staff suggests that legal sized lobster have been found on the western revetment. The recording of lobster on the eastern revetment, including two individuals of marginally legal size suggests that lobster populations can be supported on the revetment. Since establishment, the eastern revetment, has been virtually inaccessible from any form of fishing. Any large invertebrates, such as lobster are unlikely to be removed from the revetment due to fishing pressure. The habitat may provide a settlement habitat for crayfish pueruli and juveniles.

Fish species identified are largely consistent with those species likely to be found in association with reef habitat within the Whangarei Harbour, Whangarei Heads and wider Bream Bay area (Willis, 1995; Kerr and Moretti, 2012). No snapper (*Pagrus auratus*) were observed during the survey, however poor visibility and diver avoidance by snapper may explain this.

Very low numbers of the invasive Mediterranean fan worm were recorded on the Northport revetments. Mediterranean fan worm has been found in high numbers at the nearby Marsden Cove Marina. This fast growing pest can form large colonies, out-competing native species for resources. There is no evidence of this on the revetments at this stage. Only a small remnant of the previous extensive population of parchment worm appears to be present.

The Northport revetments are an artificially created habitat on what was previously a predominantly sand substrate. The marine communities that have established appear typical of nearby natural rocky reefs and those in the wider

Bream Bay area. The nature of port activities has meant that the eastern revetment has received greater protection from fishing activities than would likely be typical of a coastal reef outside the bounds of a marine reserve. This may confer some benefit to the reef itself in terms of allowing reef associated communities to develop.

5 CONCLUSION

The subtidal ecological survey of the port revetments has confirmed that a moderately rich and varied reef type ecology has developed from what was initially bare rock. The survey was not intended to be an exhaustive list of taxa at the site. Rather it was intended to enable an assessment of the ecological condition of the 'reef' habitat adjacent to the port.

The 60 taxa recorded (9 algae; 11 sponges; 4 ascidians/bryozoans; 4 crustaceans; 2 polychaetes; 6 molluscs; 5 echinoderms; and 19 fish), suggest a diversity, abundance and composition, consistent with that reported for natural rocky reefs in the vicinity, but beyond the influence of the port.

The findings would suggest that after approaching 15 years of port operations, the subtidal ecology is healthy, and furthermore, that the ecology is not adversely influenced by the adjacent port operations.

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Appendix A:

Algae and encrusting invertebrates recorded at each site

	Species	Common name	West						East		
			T1 4 m	T1 6 m	T1 10 m	T2 4 m	T2 6 m	T2 10 m	T3 4 m	T3 6 m	T3 10 m
Algae	*Ecklonia radiata*		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Sargassum sinclairii		✓						✓	✓	✓
	Carpophyllum flexuosum				✓		✓			✓	✓
	Dictyota kunthii							✓		✓	✓
	Red turfing algae (various species)		✓	✓	✓	✓	✓	✓	✓	✓	✓
	crustose coralline algae		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Hildenbrandia sp.							✓			
	Colpomenia sp.									✓	
	Ralfsia sp.								✓		
Sponges	*Tethya bergquistae*	pink golfball sponge		✓							
	Cliona cf. celata		✓	✓		✓	✓	✓	✓	✓	✓
	Ciocalypta cf. penicillus	candle sponge	✓	✓	✓	✓	✓	✓			
	Crella incrustans	orange knobby	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Raspailia arbuscula										
	Callyspongia ramosa	white finger		✓							
	Ircinia novaezealandiae	grey purple	✓			✓	✓		✓		
	Chelonaplysillia	purple enc		✓	✓					✓	✓
	Polymastia crocea				✓						✓
	Polymastia cf. massalis			✓							
	white encrusting sponge										✓
Ascidians and bryozoan	*Sycozoa sigillinoides*	lollipop sea squirt	✓	✓			✓	✓	✓	✓	✓
	pink compound ascidian		✓					✓		✓	✓
	solitary ascidians	sea squirts		✓							
	Brown encrusting bryzoan		✓						✓	✓	

Appendix B:

Mobile invertebrates recorded at each site

	Species	Common name	West						East		
			T1 4 m	T1 6 m	T1 10 m	T2 4 m	T2 6 m	T2 10 m	T3 4 m	T3 6 m	T3 10 m
Crustaceans	*Pagurus novizealandiae*	hermit crab	✓	✓				✓		✓	✓
	Guinusia chabrus	red rock crab		✓	✓		✓	✓			✓
	Jasus edwardsii	red rock lobster							✓	✓	
	Palaemon affinis	glass shrimp		✓							
Polychaetes	*Sabella spallanzanii*	Mediterranean fan worm	✓								
	Chaetopterus sp.	parchment tube worm		✓						✓	
Molluscs	*Cryptoconchus porosus*	butterfly chiton		✓			✓				
	Aphelodoris luctuosa	variable nudibranch							✓	✓	
	Scutus breviculus	shield shell		✓							
	Maoricolpus roseus	turret shell	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Charonia lampis				✓						
	Cookia sulcata	Cook's turban								✓	
Echinoderms	*Austrastichopus molis*	sea cucumber	✓	✓			✓				✓
	Evechinus chloritucs	kina			✓		✓	✓	✓	✓	✓
	Coscinasterias muricata	11-armed starfish		✓	✓			✓		✓	✓
	Pateriella regularis	cushion star	✓	✓							✓
	Ophiopsammus maculata	britle star								✓	

Appendix C:

Fish species recorded at each site

Species	Common name	West						East		
		T1 4 m	T1 6 m	T1 10 m	T2 4 m	T2 6 m	T2 10 m	T3 4 m	T3 6 m	T3 10 m
Forsterygion varium	variable triplefin	✓	✓		✓	✓	✓		✓	✓
Forsterygion lapillum	common triplefin	✓			✓		✓			✓
Forsterygion maryannae	oblique swimming triplefin							✓		
Ruanoho whero	spectacled triplefin		✓	✓			✓			
Kyphosus sydneyanus	silver drummer		✓	✓						
Girella tricuspidata	parore	✓		✓		✓	✓	✓	✓	✓
Cheilodactylus spectabilis	red moki		✓	✓	✓		✓		✓	
Scorpis lineolata	silver sweep		✓	✓		✓	✓	✓	✓	✓
Notolabrus celidotus	spotty		✓	✓		✓				
Seriola lalandi	kingfish		✓	✓		✓				
Trachurus novaezelandiae	jack mackerell		✓	✓		✓				
Pempheris adspersa	bigeye	✓	✓							
Optivus elongatus	slender roughy	✓								
Upeneichthys lineatus	goatfish			✓			✓			
Aplodactylus arctidens	marblefish		✓							
Coris sandeyeri	Sandager's wrasse					✓				✓
Caesioperca lepidoptera	butterfly perch								✓	✓
Chromis dispilus	two spot demoiselle							✓	✓	✓
Pseudocaranx dentex	trevally							✓		

4SIGHT CONSULTING

LAND. PEOPLE. WATER.

Northport Seabed Ecological Survey

For Northport

Ecological Baseline Assessment Report

Benthic Marine Ecology

August 2020

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

4Sight Consulting Ltd (4Sight) has been engaged by Northport to undertake an ecological survey of the subtidal seabed within the areas potentially to be reclaimed and capital dredged as part of the Northport Vision For Growth (VFG) port expansion.

This report on seabed ecology forms part of a suite of recent baseline studies undertaken by 4Sight for Northport. These studies have included surveys of intertidal invertebrate communities; the ecology of subtidal revetments; wading bird populations, and a review of stormwater discharge quality information.

2 METHODS

This survey targets subtidal areas within the VFG footprint for Port expansion and includes other areas nearby but beyond the VFG area. The VFG areas are the proposed western reclamation and the north western capital dredging area. These zones are shown in Figure 1.

The other areas to the east and north of the port were surveyed to establish a more complete baseline picture of the subtidal ecology around and near the entire facility port. Sampling sites are also shown in Figure 1.

The survey was undertaken over three separate days: 08; 11 and 18 November 2019. Sampling was undertaken across the different habitat types (shallow subtidal zone, the channel slope, and the near shore part of the channel) within each area to provide a comprehensive picture of the community structure and substrate type.

All samples were collected from a Northport vessel using a quantitative standard ponar grab sampler (volume 8.2L) and surface area sampled of up to 529 cm^2. On board, each sample was sorted through a 0.5mm mesh sock sieve and the contents transferred to containers and preserved in 80% ethanol in seawater. Depth was recorded at each site.

In a wet lab, each sample was subsequently stained with Rose Bengal dye to facilitate identification of biota. Biota was extracted by 4Sight technicians and preserved in 80% ethanol in seawater. Samples were sent to Cawthron Institute for taxonomic processing of biota to the lowest practicable taxonomic level.

Due to the high counts of individual organisms and the excessive time required to extract biota, a number of samples were quartered and then processed. The results of these samples were multiplied by four to provide a closer approximation to what a full sample count would have produced. It is understood this introduces a complexity to the data set, however this was unavoidable. It is acknowledged that results for these particular samples are likely to underestimate the number of taxa at the site.

In addition, grain size samples were collected to represent sediment texture from the habitats sampled. Ten such samples were collected in total. These samples were also collected with the standard ponar grab. Hill Laboratories undertook the particle size distribution analysis.

<u>Western Reclamation Footprint</u>

Benthic biota samples were collected at 13 sampling locations within the western reclamation footprint. In order to ensure samples were collected from a representative depth range, the area was stratified into 'inner', 'mid' and 'outer' zones. Sample sites were established by gridding the study site and using random selected coordinates to locate each site.

<u>Capital Dredging Area</u>

Nine samples were collected in the proposed capital dredging area, using the same sampling method and site selection process.

<u>Eastern Area</u>

Thirteen samples were collected to the east of the existing Northport terminal using the same method and site selection process.

Northern Channel Area

This deeper channel area was assessed by a different method due to its much coarser texture. Samples were collected by towing a modified scallop dredge with an internal 1cm^2 mesh. Three dredge tows were made to allow a qualitative characterisation of the substrate and community type.

Figure 1: Benthic biota sampling locations overlain on the proposed Vision For Growth western reclamation (green highlight), capital dredging footprint (inner and outer areas), northern channel area (blue highlight) and eastern baseline sites.

3 RESULTS

3.1 Overview: All Sampling Areas

Thirty-five quantitative seabed samples were analysed for taxa and their abundances and three qualitative samples were collected from a deeper channel area. The full data set is presented in Appendix A. Depth records for each sampling site are presented in Appendix B. Grain size analysis is presented in Appendix C.

Photographs of the dredge samples collected in the northern channel are presented in Appendix D.

3.1.1 Macroinvertebrates and Fish

A total of 21,030 organisms were counted and 198 taxa identified (196 macroinvertebrate and 2 fish taxa) in the Ponar samples. The average species richness (number of taxa per sample) was 35 but richness was highly variable between samples (a range of 6 to 61 taxa per sample).

The average abundance (number of organisms per sample) was 600 and was similarly variable (a range of 36 to 3,196 per sample. It is noted that this upper value was generated from a 'quartered sample' by multiplying the actual count of 799 organisms by a factor of four). However, this 'average abundance' statistic is heavily skewed by the abundance of just two taxa that occurred in two particularly large samples. These were Sabellid polychaete worms in sample EO6 (eastern outer 6) and WO2 (western outer 2), and Amphipoda in sample WO2. Removing these high values from the data set shows a mean of 452 and range of 36 to 1,439 organisms per sample which is likely more representative of community abundance.

Overall, community diversity was wide and is considered to be high. Faunal taxonomic groupings are shown in Table 1.

Table 1: Summary of Community Composition (Ponar samples)

Taxonomic Group	Subgroup	Number of Taxa	Common Names (where applicable)
Porifera	-	1	Sponges
Cnidaria	Hydrozoa, Anthozoa	5	Hydroids, Burrowing anemone, Tube anemone, Small Brown Sea Anemones
Platyhelminthes	-	1	Flat worm
Nemertea	-	1	Proboscis worm
Nematoda	-	1	Round worm
Sipuncula	-	1	Peanut worm
Mollusca	Polyplacophora, Gastropoda, Opisthobranchia	23	Green Chiton, Snakeskin Chiton, Slipper Shell, Circular Slipper Limpet, Snails, White Slug
Bivalvia	Lasaeidae, Mactridae, Nuculidae, Ostreidae, Thraciidae, Veneridae, Psammobiidae, Hiatellidae, Semelidae, Tellinidae, Montacutidae, Mytilidae, Myochamidae, Erycinidae, Mesodesmatidae, Carditidae, Solemyidae, Ungulinidae.	43	Oyster, Cockle, Surf Clam, Nut Shell, Wedge Shell, Pipi, Morning Star, Window Shell, Golden Sunset Shell, Boring Mussel
Annelidia	Oligochaete, Polychaete	58	Bamboo Worm, Rag Worm, Fan Worm, Umbrella Worm
Crustacea	Crangonidae, Tanaidae, Mysidacea, Cumacea, Isopoda, Amphipoda, Decapoda, Ostracoda, Copepoda	46	Tanaid Shrimp, Skeleton Shrimp, Hermit Crab, Snapping Shrimp, Tunnelling Mud Crab, Pill-box Crab, Stalk-eyed Mud Crab, Hairy Red Swimming Crab, Paddle Crab, Hermit Crab, Estuarine Crab
Pycnogonida	-	1	Sea Spider
Phoronida	-	1	Horseshoe Worm
Bryozoa	Conescharellinoidea	4	-
Hemichordata	-	1	-
Echinodermata	Echinoidea, Asteroidea, Ophiuroidea, Holothuroidea,	6	Urchins, Cushion Star, Brittle Star, Sea Cucumber
Ascidiacea	Ascidiacea, Molgulidae	2	Sea Squirts
Cephalocordata	Branchiostomatidae	1	Lancelet
Osteichthyes	Osteichthyes, Creediidae	2	Fish

Overall, polychaete worms were the most diverse and abundant group followed by amphipod crustaceans and bivalves. Feeding mode in the benthic community was also broad and included infaunal and mobile predators, infaunal deposit feeders, microalgal grazers, scavengers, infaunal suspension and filter feeders, and omnivores. In short, most feeding modes were well represented in the community.

A small number of fish, predominantly from the family Creediidae (sand burrowers), were also collected from the ponar samples. These are small, sand burrowing fish that grow to 3-7cm in length.

The benthic communities were assessed based on whole community indices i.e. richness, abundance, and diversity. The average species richness, abundance, and Shannon-Weiner Diversity Index for each of the three sampling areas, as well as all the sampling areas combined, are summarised in Table 2 below.

The Shannon-Weiner index is a measure both of species' richness and evenness within a community. Specifically, a community may be diverse in terms of the number of taxa present, but it may be dominated by very few species. Where the Shannon-Wiener Diversity Index is high, the community would be expected to have high species richness with an even distribution of individuals across all species.

The average Shannon-Weiner score across all sites was 2.45 which is an indication of a species rich community that has a good distribution of individuals across most species, but also high abundances of some of the most common species.

Table 2: Average species abundance, species richness and Shannon-Weiner Diversity for each site.

	All Sites	Western Reclamation	Eastern Area	Capital Dredging
Average Abundance/sample	601	681	736	290
Average Richness/sample	35	38	37	27
Shannon Weiner Diversity Index	2.47	2.76	2.38	2.20

3.1.2 Western Reclamation Footprint

A total of 8,852 organisms were collected and 139 taxa identified. The average species richness was 38 and ranged from 22 to 51 taxa per sample. The average abundance was 681 per sample and there was a large range in density per sample: from 154 to 3,196. The Shannon Weiner Index was 2.76 which was the highest diversity index score for all three zones.

The inner, shallow sample sites were collected from an average water depth of 2.5m. There was an average of 291 organisms per sample (range 154 to 460) and 75 taxa in total. Average taxa per sample was 36 (range 27 to 45).

The mid depth sample sites were collected from an average water depth of 6.6m. There was an average 377 organisms per sample (range 180 to 713) and 105 taxa in total. Average taxa per sample was 36 (range 23 to 51).

The outer deeper sample sites were collected from an average water depth of 10.7m. There was an average of 1,807 organisms per sample (range 785 to 3196) and 74 taxa in total. Average taxa per sample was 43 (range 37 to 49).

This data suggests that, on average, diversity and abundance increases with depth within this area. The most abundant biota were Amphipod crustaceans of multiple families (and also individuals unable to be identified and thus placed in a general indeterminate category), and also polychaete worms of multiple families but particularly of Sabellidae and Spionidae. The data shows that this seabed area hosted a diverse community, albeit one numerically dominated by relatively few taxa.

For example, at the deeper sites, 56 of the total 73 taxa had a total of 20 individuals or less. Only six of the taxa recorded a total score of 100 individuals or more.

At the mid depth sites, 88 of 106 taxa scored a total 20 individuals or less and only two had a total score of 100 individuals or more.

At the inner shallower sites, 61 of 75 taxa scored a total of 20 individuals or less and none had a total score of more than 100 individuals.

3.1.3 Capital Dredging Area

At the proposed capital dredging area, a total of 2,609 individual organisms were collected and 103 taxa identified across nine core samples. The average species richness was 27 and ranged from 6 to 60 taxa per core. The average abundance was 290 and had a range from 36 to 832. The Shannon-Weiner score was 2.2 which was the lowest diversity index score for all three sites.

The inner dredge sample sites were collected from an average water depth of 10.2m. There was an average of 150 organisms per sample (range 36 to 280) and 47 taxa in total. Average taxa per sample was 20 (range 6 to 38).

The outer dredge sample sites were collected from an average water depth of 8.6m. There was an average of 464 organisms per sample (range 82 to 832) and 82 taxa in total. Average taxa per sample was 35 (range 7 to 60).

The general relationship appears to be sampling sites to the north east have lower total counts of organisms than sampling sites situated towards the south west, e.g. DI4, DI5 and DO5 had 36, 99 and 82 individuals respectively, whereas DO1, DO2 and DO3 had 456, 488, and 832.

The most abundant organisms in the capital dredging area were the polychaete worms of the family Opheliidae (specifically *Armandia maculata*), which are infaunal deposit feeders. Amphipods of the family Urothoidae were the next most common, followed by the anemone *Anthopleura hermaphroditica*, and Cumacea, which are small marine crustaceans that are typically infaunal filter feeders or deposit feeders of microorganisms and organic material.

As with the western reclamation area, the data shows that this seabed area hosted a relatively diverse community, but one numerically dominated by relatively few taxa. Of the 103 taxa identified only 19 recorded greater than 20 individuals in total and only six taxa recorded greater than a total 100 individuals. This is also reflected in the lower Shannon-Weiner Diversity Index.

3.1.4 Eastern Area Surveyed

At the eastern area, a total of 9,569 individual organisms were collected and 132 taxa identified. The average species richness was 37 and ranged from 18 to 61 taxa per core. The average abundance was 736 and mean density had a large range from 154 to 2,932. This range was due mostly to very high density of the Sabellid polychaete *Euchone* sp. which occurred at one of the deeper outer sites (EO6: *Euchone* 1,627 individuals). That particular taxon value would translate to nearly 31,000 per square metre individual worms of this species. With 2,932 total individuals counted for all taxa in the sample, the density for that particular sample is equivalent to about 56,000 animals per square metre. The Shannon Weiner score was 2.38 which was the second highest diversity index score for all three sites.

The inner shallow sample sites were collected from an average water depth of 3.2m. There was an average of 153 individual organisms per sample (range 83 to 191) and 56 taxa in total. Average taxa per sample was 25 (range 18 to 38).

The mid depth sample sites were collected from an average water depth of 6.9m. There was an average of 698 individual organisms per sample (range 288 to 992) and 78 taxa in total. Average taxa per sample was 36 (range 28 to 52).

The deeper sample sites were collected from an average water depth of 9.5m. There was an average of 1232 individual organisms per sample (range 715 to 2932) and 111 taxa in total. Average taxa per sample was 48 (range 38 to 61).

The most abundant individuals in the eastern reclamation sampling area were the polychaete worms of the families Sabellidae (genus *Euchone*) Spionidae (genus *Spio*) and Oweniidae (genus *Myriochele*). It is noted that *Myriochele* is the third most abundant taxa, whereas in the western reclamation sampling area it was only 32nd. Amphipoda are also very common with individuals of the family *Phoxocephalidae* making up the fourth most common taxa. As with the western reclamation sampling area, the eastern area is diverse but dominated by relatively few taxa.

At the deeper sites, 85 of the total 111 taxa had a total of 20 individuals or less. Only 10 of the taxa recorded a total score of 100 individuals or more and the Sabellid polychaete *Euchone* sp. had nearly three times more individuals than the next species with 2,432.

At the mid depth sites, 66 of the total 78 taxa had a total of 20 individuals or less. Only 12 of the taxa recorded a total score of 100 individuals or more.

At the inner shallower sites, of the total 56 taxa, 48 scored a total of 20 individuals or less and none had a total score of more than 100 individuals.

3.1.5 Northern Channel Area

Due to its coarse shell gravel nature, the benthic material in the northern channel area was sampled with a modified scallop dredge fitted with a 1cm internal mesh. This method provided a qualitative characterisation of the substrate and community types.

Dredge transect 1 contained the greatest amount of substrate material. It was comprised primarily of shells varying in size and species. This debris included surf clam, mussels, scallops, and dog cockles (Figure 2). These provided habitat for a variety of encrusting species such as calcareous polychaetes, anemones, coralline and filamentous algae and sponges. Live molluscs such as *Maoricolpus roseus roseus* (turret shell) and *Cominella adspersa* (spotted whelk) occurred amongst the shell.

Dredge transect 2 was similar in texture but contained more smaller bivalves such as cockles, pipis and wedge shells (Figure 3). Encrusting species were similar to transect 1. The shell remains of turret shell, *Cominella adspersa,* (*Maoricrypta costata* (slipper shell) and *Notomithrax minor* (decorator crab) were present.

Dredge transect 3 had the least amount of substrate material and was primarily large surf clam shells and an assortment of smaller mussel, pipi and cockle shells (Figure 4). The encrusting biota was similar to dredges 1 and 2. Mollusc species were absent from this sample. Two *Pycnogonida* (sea spider) were collected.

Overall, the northern channel area has a benthic substrate quite different to the other areas sampled. It is a shell gravel habitat characterised by large and assorted shelly debris that is substrate to a wide variety of sessile encrusting organisms and mobile fauna.

Figure 2: Dredge transect 1.

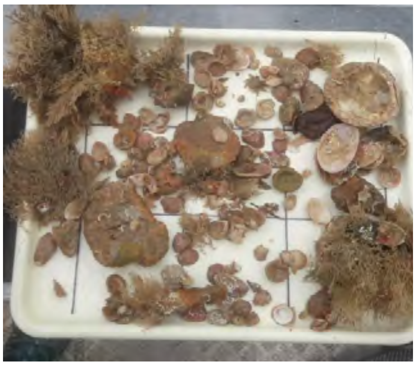

Figure 3: Dredge transect 2.

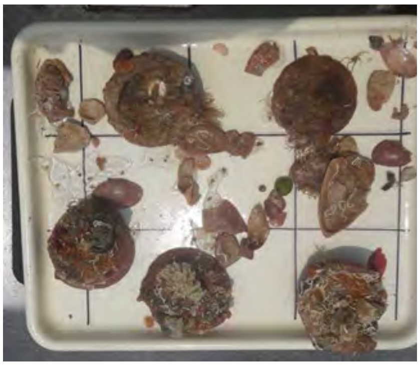

Figure 4: Dredge transect 3.

3.2 Grain Size

Sediment grain size samples collected from the three sampling areas are shown below in Figure 5. Particle size results are presented in Appendix C.

There was variation in sediment composition between the sites. The western and eastern areas were very similar in texture with the dominant fine sand fraction making up over 75% of the material. The eastern area sediment had a slightly higher proportion of medium sand, and in the west the sediment had a slightly higher proportion of mud, however these differences were minor.

The proposed capital dredging area was noticeably different with medium sand making up over 50% and coarse sand over 20%, of total sediment composition.

The likely influence of the different textures in seabed on the macroinvertebrate community, is discussed in Section 4 below.

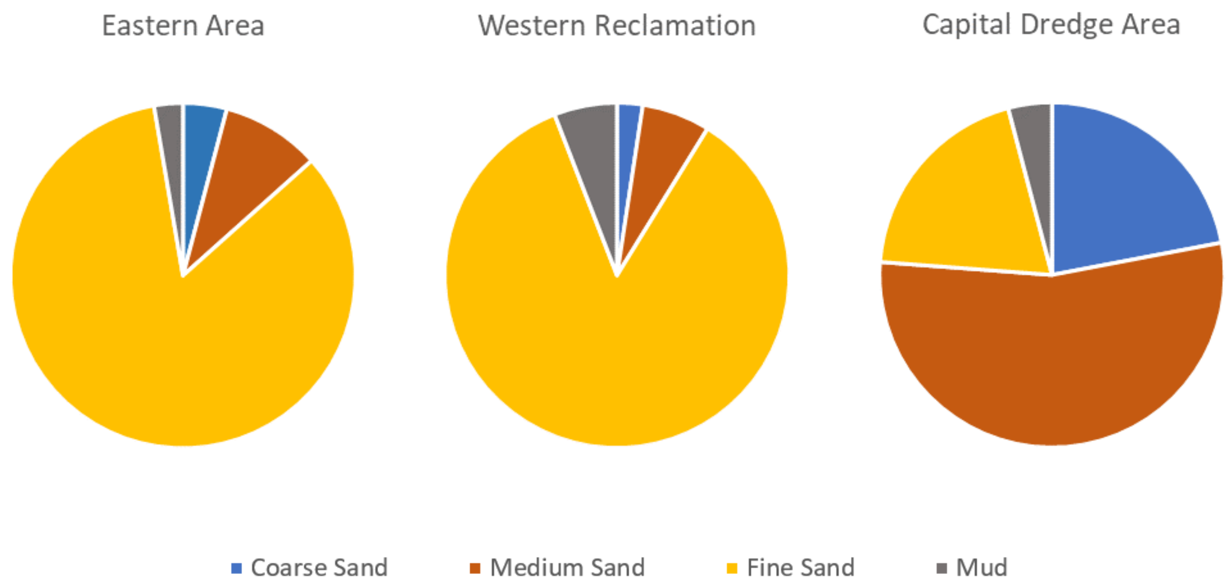

Figure 5: Pie graphs illustrating the sediment compositions from each sample area.

4 DISCUSSION

Overall, the apparent wide faunal diversity, and abundance of biota, and the wide range in life history and feeding modes in the community composition, suggests a healthy and productive benthic community.

The dominant taxa appear to be common species of polychaete worms and amphipods. Although the balance of the community is diverse and is comprised of taxa which appear to occur rather patchily and at low density, this needs to be seen within the context of the dimensions of the individual substrate samples. All abundance data for individual sites, and mean data, can be multiplied by a factor of 19 to express the data as a density per square metre of substrate. Thus, the mean abundance expressed in Table 1 for the 'West Reclamation'; 'Eastern Area'; and 'Capital Dredging' zones, translates to densities of 13,000, 14,000 and 5,500 organisms respectively per square metre. Even a density of 10 animals per sample, which at face value might seem low, translates to an indicative estimate of 190 of such animals per square metre.

Western Reclamation and Eastern Area

The results from the proposed western and eastern sampling areas, indicated the benthic fauna communities are very similar in diversity, evenness, and composition. Notwithstanding the high diversity, the dominant groups were similar with the same polychaete worm and amphipod taxa making up for a large portion of the overall abundance. Much of the diversity was represented by taxa which occurred relatively sparsely at a lower abundance.

The community composition findings for these areas are consistent with the sediment grain size information which showed habitats were of a similar texture, being mostly fine sand substrates.

Capital Dredging Area

The north western proposed capital dredging area was also relatively diverse but distinctly different from the nearer shore areas surveyed in terms of diversity, community structure, abundance and sediment texture. The benthic fauna community had lower diversity of taxa, and a different composition. The abundance of individuals was also less. The lower Shannon-Weiner Diversity Index score was reflective of these differences.

Polychaetes (in particular *Armandia maculata*) and Amphipoda were the two most abundant taxa. The next most common taxa were the small brown anemone *Anthopleura hermaphroditica* and green chiton *Chiton glaucus*. These were not seen in such densities in the nearer shore sampled areas. These organisms are normally associated with larger coarser substrate than sand, such as living shell and larger shell debris. This suggests that some shell and larger biogenic debris is present, although it was not conspicuous in the samples.

These features are consistent with expectations for a deeper channel environment at this location which is likely to experience high current velocities and transport of significant bedload. It is acknowledged that the epiphytic/encrusting biota was not assessed directly and therefore the complexity, biomass and ecological value of the substrate is likely to have been underestimated.

The Northern Channel

The results of the dredge transects in the northern channel area provided an insight into the substrate and benthic community type established there. As illustrated in Figures 2,3, and 4, it is a shell gravel habitat. The shell and other debris was heavily populated with epiphytic/encrusting biota as well as several larger mollusc species. Under a full taxonomic analysis, it would be expected that the northern channel area would also have a relatively diverse but distinctly different community to the nearer shore sampled areas. This is considered a high value habitat and assemblage.

4.1 Comparison with Other Studies

Refining NZ

The total of 198 taxa identified (which is likely an underestimate) and the overall Shannon Weiner Diversity Index score of 2.47 reported in this study, can be compared with a recent study for RNZ which investigated areas further towards the harbour entrance (Bioresearches, 2016). The RNZ assessment used the same benthic fauna sampling techniques in areas just to the east of that investigated in this study.

The RNZ study reported an average number of taxa of 29.8 per sample and an average Shannon-Wiener Diversity Index score of 2.71. These statistics compare with average richness of 34.8 and Shannon-Wiener Diversity Index score of 2.47 in this study.

Northland Regional Council

In 2012 Northland Regional Council (NRC) undertook an estuary monitoring programme of the Whangarei Harbour (Griffiths, 2012) that included sampling subtidal benthic fauna using a 150mm x 150mm core sampler. Two of the thirteen sampled sites (Snake Bank and Manganese Point) to the west of the port were broadly similar environments to those sampled by 4Sight near the port. While the methods for sampling were different between studies, the volumes collected per sample are similar and the results are broadly comparable

The average number of taxa at these sites was 20.0 per sample and the average number of individuals was 136 per sample. The Shannon-Weiner Diversity Index was 2.2.

These statistics compare with average richness of 34.8 and Shannon-Wiener Diversity Index score of 2.47 in the 4Sight study.

5 CONCLUSION

The subtidal survey carried out found a diverse and abundant seabed community around the port. There were similarities between the western and eastern sampling areas in terms of diversity, community composition, abundance, and the dominant taxa present. These similarities were predictable given the similar habitat type (texture) and similar depth range for these study areas.

The proposed capital dredging area had a different community assemblage which was also predictable based on habitat type, a greater depth and likely exposure to a greater range in tidal velocities. This community when compared to the eastern and western areas had fewer species present and lower average abundances, but the community composition was different and supported a greater proportion of epifauna.

Overall, it is concluded, that collectively, the benthic habitats around the port including those within the VFG footprint, are ecologically diverse and host an abundant fauna. The range of life history and feeding modes represented in the community suggest a well-balanced, productive and a healthy ecology. Notwithstanding the overall high biodiversity, a relatively few common taxa dominate much of the biota. This is not unexpected.

There is likely to be a wide availability of similar shallow littoral and channel edge habitats elsewhere in the lower Whangarei Harbour and harbour entrance area. These zones are likely to host comparable communities. It is concluded the habitats and communities in this study, are not per se likely to be rare. The similarities with the RNZ study results supports this.

The habitats and communities are ecologically diverse and appear to contain a high density and probably high biomass of macroinvertebrates. This macroinvertebrate assemblage is an integral part of, and contributor to, the wider harbour and local coastal ecology and marine food web.

6 REFERENCES

Griffiths, R. (2012). Whangarei Harbour Estuary Monitoring Programme 2012 (p. 70). Northland Regional Council.

West, S. A. (2016). *Existing Environment Assessment Ecology of the Dredge Area* (p. 210). Bioresearches Limited.

Appendix A:

Macroinvertebrate Raw Data Set

General Group	Family	Genus	Taxa	Common Name	Feeding	DI 2: 4S	DI 5: 4S	DO 5: 4	EI 3: 4S	EI 4: 4S	EI 5: 4S	EI 6: 4S	EM-3: 4	EM-4: 4	EM 5: 4	EM 6: 4	EO 1: 4S	EO 3: 4	EO 4: 4	EO 5: 4	EO-6: 4S	WI 1: 4	WI 2: 4	WI 3: 4	WI 4: 4	WM 1:	WM 2:	WM 3:	WM4: 4	WM 5:	WM 6 :	WO 1: 4	WO 2: 4	WO 3:
Hydrozoa			Hydrozoa (thecate)	Hydroids		1									1			1	1											1				
Anthozoa			Anthozoa	Anemones		4			1	1					1	1	4	1		8	5	2			1					3	25	2		
Anthozoa	Edwardsiidae	Edwardsia	Edwardsia sp.	Burrowing anemone																								10						13
Anthozoa			Ceriantharia	Tube anemone										4				1			3				2		4							
Platyhelminthes			Platyhelminthes	Flat Worm	Predator																									2				
Nemertea			Nemertea	Proboscis worms		5						1		4				2	1		8		1	4	2		4	1			1	1		
Nematoda			Nematoda	Roundworm		11													3	2					6			11			1	1		
Sipuncula			Sipuncula	Peanut Worm	Infaunal deposit feeder																											1		
Mollusca			Polyplacophora			3												1																
Polyplacophora	Chitonidae	Chiton	Chiton glaucus	Green Chiton	Microalgal grazer	20														1										1				
Polyplacophora	Lepidopleuridae	Leptochiton	Leptochiton inquinatus																	1														
Polyplacophora	Acanthochitonidae	Pseudotonicia (Notoplax)	Pseudotonicia (Notoplax) cuneata			1																												
Gastropoda			Gastropoda (micro snails)	Snails		1		1						4						6										2		2		
Gastropoda			Gastropoda Unid.	Snails												1			2															
Gastropoda	Pyramidellidae		Pyramidellidae																										8					
Gastropoda	Triphoridae	Bouchetriphora	Bouchetriphora pallida																										4					
Gastropoda	Buccinidae	Cominella	Cominella adspersa	Whelk	Carnivore & scavenger											2		2							1									
Gastropoda	Eatoniellidae	Eatoniella	Eatoniella sp.												3			3												1				
Gastropoda	Turritellidae	Maoricolpus	Maoricolpus roseus roseus	Turret shell													1												16					
Gastropoda	Calyptraeidae	Maoricrypta	Maoricrypta costata	Ribbed slipper shell												2		2						28										
Gastropoda	Calyptraeidae	Maoricrypta	Maoricrypta sp.	Ribbed slipper shell															3	6														
Gastropoda	Calyptraeidae	Sigapatella	Sigapatella sp.	Circular slipper limpet																											2	1		
Gastropoda	Calyptraeidae	Sigapatella	Sigapatella tenuis	Small circular slipper shell		3										1				5								1						
Opisthobranchia	Cylichnidae	Cylichna	Cylichna zealandica															1			4											1	4	1
Opisthobranchia	Retusidae	Cylichnina	Cylichnina striata													1																		
Opisthobranchia	Philinidae	Philine	Philine powelli	White Slug	Feeds on small bivalves																				1									
Bivalvia			Bivalvia indent.								1					5	2	5	2	1	2	5	4		1			7				2		1
Bivalvia			Bivalvia Unid.																												7			
Bivalvia			Bivalvia Unid. (juv)			9							4	4		1									2						8			
Bivalvia	Lasaeidae		Lasaeidae																					4			4							
Bivalvia	Mactridae		Mactridae	Bivalve (family)	Infaunal suspension feeder												8																	
Bivalvia	Nuculidae		Nuculidae										4	56				6			1	2		40		56	20			3			16	
Bivalvia	Ostreidae		Ostreidae (Juvenile)	Oyster																										1				
Bivalvia	Thraciidae		Thraciidae			1																												
Bivalvia	Veneridae		Veneridae (juv.)	Venerid Unid.		2																												3
Bivalvia	Lasaeidae	Arthritica	Arthritica bifurca	Small bivalve	Infaunal deposit feeder				1							1																		
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (<10mm)	Cockle (<10mm)	Infaunal deposit feeder																				2									
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (0-5mm)	Cockle (0-5mm)	Infaunal deposit feeder																											1		
Bivalvia	Veneridae	Dosinia	Dosinia sp.		Infaunal suspension feeder				1								1				1													
Bivalvia	Veneridae	Dosinia	Dosinia sp. (Juvenile)	Surf Clam	Infaunal suspension feeder																										1			
Bivalvia	Nuculidae	Ennucula	Ennucula strangei						1	13							45																	
Bivalvia	Psammobiidae	Gari sp.	Gari sp.									4					1				1	1						1			1		4	
Bivalvia	Hiatellidae	Hiatella	Hiatella arctica																	2	1									1				
Bivalvia	Semelidae	Leptomya	Leptomya retiaria retiaria									4																						
Bivalvia	Nuculidae	Linucula	Linucula hartvigiana	Nut Shell	Surface deposit & filter feeder					12						3	16		2			8	2		12									
Bivalvia	Tellinidae	Macomona	Macomona liliana	Wedge shell Hanikura	Infaunal suspension feeder														4												8			
Bivalvia	Montacutidae	Montacuta	Montacuta sp.																								4							
Bivalvia	Mytilidae	Musculus	Musculus impactus																		1													
Bivalvia	Myochamidae	Myadora	Myadora boltoni																		1							5						
Bivalvia	Myochamidae	Myadora	Myadora sp.																		3			4										
Bivalvia	Myochamidae	Myadora	Myadora striata			1							8			5	1	4										3		2				
Bivalvia	Myochamidae	Myadora	Myadora subrostrata																	4												1		3
Bivalvia	Erycinidae	Myllitella	Myllitella vivens vivens													2			1									1						
Bivalvia	Nuculidae	Nucula	Nucula nitidula	Nut shell	Infaunal deposit feeder								20					2			1							4				16		1
Bivalvia	Ostreidae	Ostrea	Ostrea chilensis	Flat oyster; Dredge Oyster																1														
Bivalvia	Mesodesmatidae	Paphies	Paphies australis	Pipi	Filter feeder														1					8	3									
Bivalvia	Carditidae	Pleuromeris	Pleuromeris zelandica																								4					1		
Bivalvia	Cardiidae	Pratulum	Pratulum pulchellum	Purple cockle														1																
Bivalvia	Carditidae	Purpurocardia	Purpurocardia purpurata	Purple cockle		1												1															4	
Bivalvia	Veneridae	Ruditapes	Ruditapes largillierti													4		7	7	2	11			4							1	1	12	
Bivalvia	Tellinidae	Serratina	Serratina charlottae		Infaunal suspension feeder				25	54												6			6									
Bivalvia	Solemyidae	Solemya	Solemya parkinsoni											4																				
Bivalvia	Veneridae	Tawera	Tawera spissa	Morning Star		3				2					4	7		16		9	28	1						1				2	4	
Bivalvia	Semelidae	Theora	Theora lubrica	Window Shell								1	16	4										4			12		4					
Bivalvia	Thraciidae	Thracia	Thracia vitrea																															1
Bivalvia	Ungulinidae	Zemysia	Zemysia zelandica			22				1			80	24				5		2	16	4		12	34	4	4	3				8	100	1
Oligochaeta			Oligochaeta	Oligochaete worms	Infaunal deposit feeder	2				1				8	4			3			12	1		4	1	16	4			1			72	
Polychaeta: Ampharetidae	Ampharetidae		Ampharetidae		Surface deposit feeder									4	1																			
Polychaeta: Spionidae	Spionidae		Polydorid		Surface deposit & filter feeder					4			12	20	11	1		174	20	2	164			16	8	32	44	6		1	6	3	232	
Polychaeta: Pectinariidae	Pectinariidae	Lagis	Lagis sp.						3	3			4	8	2		3	1	3			1		12		4	4							
Polychaeta:			Nereididae						1								2											1		11				
Polychaeta: Orbiniidae	Orbiniidae		Orbiniidae		Infaunal deposit feeder													3										1				1	4	1
Polychaeta: Orbiniidae	Orbiniidae	Leitoscoloplos	Leitoscoloplos sp.														1					9	1								2			
Polychaeta: Orbiniidae	Orbiniidae	Scoloplos	Scoloplos sp.																						8								4	
Polychaeta: Paraonidae	Paraonidae		Paraonidae		Infaunal deposit feeder											1						3	1	4	1	20	12							
Polychaeta: Paraonidae	Paraonidae	Aricidea	Aricidea sp.						1																									
Polychaeta: Cossuridae	Cossuridae	Cossura	Cossura consimilis		Deposit feeder																					16	16							
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio aucklandica		Surface deposit feeder				1															4	1				4					
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio multicristata		Surface deposit & filter feeder	1			3	7					3	2		2	8	9	2		1				4				3	2		
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio sp.		Surface deposit feeder	4			7	3	6			24		1		12		2	3	4		56	5	8	4	3	36	1			4	
Polychaeta: Spionidae	Spionidae	Pseudopolydora	Pseudopolydora sp.		Surface deposit feeder						11																							
Polychaeta: Spionidae	Spionidae	Spio	Spio sp.		Surface deposit & filter feeder					1	62	5			72	128		153	139	166	424	42	34		20			83		18	279	153	188	115
Polychaeta: Spionidae	Spionidae	Spiophanes	Spiophanes modestus															2			6							5				1		
Polychaeta: Spionidae	Spionidae	Spiophanes	Spiophanes sp.		Surface deposit feeder					2	1								12															
Polychaeta: Magelonidae	Magelonidae	Magelona	Magelona sp.		Surface deposit feeder				1		1	4										2	1											
Polychaeta: Capitellidae	Capitellidae		Capitellidae		Infaunal deposit feeder								4	12				10			1			76	24	4	60			2			36	
Polychaeta: Capitellidae	Capitellidae	Capitella	Capitella sp.		Infaunal deposit feeder									4	1			1							2							1	4	
Polychaeta: Capitellidae	Capitellidae	Heteromastus	Heteromastus filiformis		Infaunal deposit feeder				13	6	4	2						1				11	2	20				2			1			
Polychaeta: Capitellidae	Capitellidae	Notomastus	Notomastus sp.		Infaunal deposit feeder								8				1			1	1													
Polychaeta: Maldanidae	Maldanidae		Maldanidae	Bamboo worm	Infaunal deposit feeder	7			4	2			36	16		4	7	4	10	5	16	5		8	12	24	16	3	4	6	3	3		
Polychaeta: Opheliidae	Opheliidae	Armandia	Armandia maculata		Infaunal deposit feeder	29	3	1		2	1	1			20	67	21	7	35	45	86	5	3	4	3	4	4	3	16	67	74	60	88	25
Polychaeta: Phyllodocidae	Phyllodocidae		Phyllodocidae	Paddle worms	Carnivore & scavenger											1				2	2													
Polychaeta: Polynoidae	Polynoidae		Polynoidae	Scale worms	Infaunal carnivore									4		4														3		2		
Polychaeta: Sigalionidae	Sigalionidae		Sigalionidae		Infaunal carnivore							2		8	1			7	2		2	1						2			1	1		1
Polychaeta: Hesionidae	Hesionidae		Hesionidae		Carnivore and deposit feeder				1	1							2				5							1		3	2	1		
Polychaeta: Syllidae	Syllidae		Exogoninae						39	17			12	8	1	8	5	4	1	5	8	27	4	8	16	8		5	4	2		3	36	2
Polychaeta: Syllidae	Syllidae		Syllidae		Omnivorous	9				1	10		4	4	5	5		5	4	10	39	7	9		6			3		27	6	5	32	8
Polychaeta: Nereididae	Nereididae		Nereididae (juvenile)		Omnivorous																									11				
Polychaeta: Nereididae	Nereididae	Ceratonereis	Ceratonereis sp.	Rag worm																														1

Polychaeta: Nereididae	Nereididae	Neanthes	Neanthes cricognatha	Rag Worm	Omnivorous																		1											
Polychaeta: Nereididae	Nereididae	Perinereis	Perinereis sp.		Omnivorous																									1				
Polychaeta: Nereididae	Nereididae	Platynereis	Platynereis australis		Omnivorous																								4					
Polychaeta: Glyceridae	Glyceridae		Glyceridae		Infaunal carnivore & deposit feeder		1			2	2	1			1		1		1								4	1						
Polychaeta: Goniadidae	Goniadidae		Goniadidae		Infaunal carnivore	1								12		1		3			1			4				4		4	1				2
Polychaeta: Nephtyidae	Nephtyidae	Aglaophamus	Aglaophamus sp.		Infaunal carnivore																											3		
Polychaeta: Onuphidae	Onuphidae	Onuphis	Onuphis aucklandensis		Infaunal surface deposit feeder/omnivore																											1		
Polychaeta: Eunicidae	Eunicidae		Eunicidae		Facultative carnivore																2													
Polychaeta: Eunicidae	Eunicidae	Marphysa	Marphysa sp.		Infaunal deposit feeder																							1						
Polychaeta: Dorvilleidae	Dorvilleidae		Dorvilleidae		Facultative carnivore				5				12					9									12	32	1	4	1		1		
Polychaeta: Oweniidae	Oweniidae		Oweniidae		Infaunal deposit feeder													3			9				23									
Polychaeta: Oweniidae	Oweniidae	Myriochele	Myriochele sp.							13			416	444		1	117	22	48		6	3				20	8						4	1
Polychaeta: Oweniidae	Oweniidae	Owenia	Owenia petersenae	Polychaete worm	Infaunal deposit feeder					3			4		2											4		8			1			
Polychaeta: Cirratulidae	Cirratulidae		Cirratulidae		Deposit feeder	4			43	8			32	32	2		5	5	105	7	6	16	8	32	16	24	12	18	4	1	14	9	44	5
Polychaeta: Terebellidae	Terebellidae		Terebellidae		Infaunal deposit feeder								4					5			5		2							2			8	
Polychaeta: Sabellidae	Sabellidae	Euchone	Euchone sp.		Infaunal suspension feeder				3	3	26	1		20	29	54	152	189	186	278	1627	1	3	4	10	8	4	6	12	8	19	385	700	45
Polychaeta: Sabellidae	Sabellidae	Jasmineira	Jasmineira sp.	Fan worm													1																	
Polychaeta: Sabellidae	Sabellidae		Sabellidae	Umbrella worms	Infaunal suspension feeder	1												2			3		1				4	1					8	3
Polychaeta: Serpulidae	Serpulidae		Serpulidae		Suspension feeder											8		100																
Polychaeta: Serpulidae	Serpulidae	Hydroides	Hydroides sp.	Fan worm		1									10		33			14	2									7				
Crustacea	Crangonidae		Crangonidae	shrimps						3				4		12		5	2	1	2	4			1	8				6	5	1	4	
Crustacea	Tanaidae		Tanaidacea	Tanaid shrimp		2				1	1	3		4		1			6	1	2	2	4		2		4		4	4	3		20	6
Mysidacea	Mysidae		Mysidae indet.							2								2				2			1						1			
Cumacea			Cumacea	Cumaceans	Infaunal filter or deposit feeder	54	12	71	1	1		1	4	12	2	41		19	4	3	5	1	6		22			23		6	22	46	72	14
Isopoda	Anthuridae	Anthuridae	Anthuridae	Isopod	Epifaunal scavenger	5				1		1	12		1	6	8	17	2	6	19	4	1		3	20	8	4		10	5	8	32	5
Isopoda			Asellota	Isopod														1																
Isopoda			Isopoda indet.																	1														
Amphipoda	Atylidae		Atylidae							1						5	5					3	1									2		
Amphipoda	Caprellidae		Caprellidae	Skeleton shrimp					2	2					6	11		1	6		10		2								5		12	11
Amphipoda	Corophiidae		Corophiidae	Amphipod (family)							1					5	64		6	23	96	4	3							30	2	15	136	49
Amphipoda	Haustoriidae		Haustoriidae	Amphipod (family)		3	2				18	37			21	77	1		60	9		2	34		8			25		1	61	5	8	41
Amphipoda	Ischyroceridae		Ischyroceridae	Amphipods												8						2										90		13
Amphipoda	Liljeborgiidae		Liljeborgiidae	Amphipods				1																	1									
Amphipoda	Lysianassidae		Lysianassidae	Amphipods	Epifaunal scavenger	3							4	12		1				1								2	4	5	1	8		
Amphipoda	Melitidae		Melitidae	Amphipods																					1								4	
Amphipoda	Oedicerotidae		Oedicerotidae	Amphipods						1	6	2				4		11		1		3	4					3			5	1		4
Amphipoda	Phoxocephalidae		Phoxocephalidae	Amphipod (family)		2	3	1		2	2	10	16	100	56	135		37		37	25	7		28	24	4	48	12		5	21	17	76	12
Amphipoda	Urothoidae		Urothoidae	Amphipods			78																											
Amphipoda	Ampeliscidae	Ampelisca	Ampelisca sp.	Amphipod																		1												
Amphipoda			Amphipoda	Amphipods	Epifaunal scavenger																													
Amphipoda			Amphipoda indet.	Amphipods		4		1	1	2			8	16		17	169	26	27	9	132	3	2		3	4		11	4	33	1	432	908	317
Decapoda	Diogenidae		Diogenidae	Left-handed Hermit Crab															2	1								1			1			1
Decapoda	Paguridae		Paguridae	Hermit Crab Unid.	Epifaunal scavenger											1		2	2										8	16	1	4	8	
Decapoda	Alpheidae	Alpheus	Alpheus sp.	Snapping shrimp																								1						
Decapoda	Varunidae	Austrohelice	Austrohelice crassa	Tunnelling Mud Crab	Deposit feeder & scavenger																	1												
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus cookii	Pill-box Crab	Eats small organisms & some weed					1						6	10	2	11	4	2	4	2	4	1		4		12	4	3	15		1
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus sp.	Pill-box Crab	Eats small organisms & some weed													4			12				3								8	
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus varius	Pill-box Crab	Eats small organisms & some weed												1																	
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus whitei	Pill-box Crab	Eats small organisms & some weed										1																			
Decapoda	Macrophthalmidae	Hemiplax	Hemiplax hirtipes	Stalk-eyed Mud Crab	Deposit feeder & scavenger				3	1							1										4							
Decapoda	Portunidae	Liocarcinus	Liocarcinus corrugatus											4		1	2																	
Decapoda	Portunidae	Nectocarcinus	Nectocarcinus antarcticus	Hairy Red Swimming Crab																	2								4					
Decapoda	Majidae	Notomithrax	Notomithrax minor		Epifaunal scavenger													1																1
Decapoda	Majidae	Notomithrax	Notomithrax sp.		Epifaunal scavenger																								8					
Decapoda	Portunidae	Ovalipes	Ovalipes catharus	Common Swimming Crab; Paddle C					1																									
Decapoda	Palaemonidae	Palaemon	Palaemon affinis	Estuarine Prawn																									4					
Decapoda			Anomura	Hermit crab		1																												
Decapoda			Brachyura (juv.)																						1									
Decapoda			Decapoda (Juvenile)	Decapoda																			1											
Decapoda			Decapoda ident.	Decapoda					3	2	6	3	4	4	3	3	1	3	1	7		9	1					6			5	10	8	6
Ostracoda	Cylindroleberididae	Diasterope	Diasterope grisea	Ostracod	Omnivorous scavenger	2															1													
Ostracoda	Cylindroleberididae	Parasterope	Parasterope quadrata	Ostracod	Omnivorous scavenger																				2					1				
Ostracoda			Ostracoda	Ostracod	Omnivorous scavenger	12			11	9	2		64	104	1	14		26	12	10	29	13	14	60	18	24		28	8	9	30	108	132	22
Copepoda			Copepoda	Copepods																							4			1				
Pycnogonida			Pycnogonida	Sea spider												3														2				
Phoronida			Phoronida	Horseshoe worm									4			4		10			18				1		4			1	4		144	
Bryozoa			Bryozoa (encrusting)	Bryozoans		1										1	1	1		1								1		1		1	4	1
Bryozoa			Bryozoa (solid stalked)	Bryozoa	Filter feeder												1																	
Bryozoa	Conescharellinoidea		Bryozoa (Conical Discoidal)	Bryozoans																										1				
Bryozoa			Bryozoa	Bryozoans											1																			
Hemichordata			Hemichordata																		5													
Echinoidea			Echinoidea	Urchins									4																					
Asteroidea	Astropectenidae	Astropecten	Astropecten polycanthus														2														1			
Asteroidea	Asterinidae	Patiriella	Patiriella regularis	Cushion Star																			1											
Ophiuroidea			Ophiuroidea	Brittle stars											1	4					4									2				
Holothuroidea	Chiridotidae	Taeniogyrus	Taeniogyrus dendyi	Sea cucumber	Epifaunal deposit feeder																						4						8	
Ascidiacea			Ascidiacea	Sea Squirts																										1				
Ascidiacea	Molgulidae		Molgulidae								2		4		21	27	10	25	76	13	49							17		10	69			48
Cephalocordata	Branchiostomatidae	Epigonichthys	Epigonichthys hectori	Lancelet														1													1		4	
Osteichthyes			Osteichthyes	Fish																1														
Osteichthyes	Creediidae		Creediidae			1		6																										
					Count: No of Individuals	**237**	**99**	**82**	**176**	**191**	**163**	**83**	**804**	**992**	**288**	**709**	**715**	**973**	**818**	**725**	**2932**	**232**	**154**	**460**	**321**	**324**	**372**	**336**	**180**	**340**	**713**	**1439**	**3196**	**785**
					Count: No of Taxa	**38**	**6**	**7**	**26**	**38**	**19**	**18**	**28**	**33**	**31**	**52**	**38**	**61**	**39**	**45**	**57**	**41**	**31**	**27**	**45**	**22**	**33**	**45**	**23**	**51**	**44**	**49**	**42**	**37**

General Group	Family	Genus	Taxa	Common Name	Feeding	DI 3: 4	DI 1: 4	DI 4: 4	DO 1: 4	DO 2: 4	DO 3:
Amphipoda			Amphipoda indet.	Amphipods		20	17	8	60	76	208
Amphipoda	Eusiridae		Eusiridae	Amphipod (family)		0		0	0	46	0
Amphipoda	Phoxocephalidae		Phoxocephalidae	Amphipod (family)		8		0	8	5	20
Amphipoda	Melitidae		Melitidae	Amphipods		0		0	0	6	16
Amphipoda	Haustoriidae		Haustoriidae	Amphipod (family)		0	15	0	0		0
Amphipoda	Corophiidae		Corophiidae	Amphipod (family)		4		0	0	1	0
Amphipoda	Lysianassidae		Lysianassidae	Amphipods	Epifaunal scavenger	0		0	4	1	0
Amphipoda	Argissidae	Argissa	Argissa sp.	Amphipoda		0	4	0	0		0
Amphipoda	Ampeliscidae	Ampelisca	Ampelisca sp.	Amphipod		0		0	0	1	0
Anthozoa	Actiniidae	Anthopleura	Anthopleura hermaphroditica	Small Brown sea anemones		28	3	0	104	39	20
Anthozoa			Anthozoa	Anemones		4		0	12		0
Ascidiacea	Molgulidae		Molgulidae	Sea Squirts		0	1	0	0	45	0
Ascidiacea			Ascidian (solitary)	Sea Squirts		0		0	0	2	0
Bivalvia	Veneridae	Ruditapes	Ruditapes largillierti	Bivalve		8		0	0	1	8
Bivalvia	Ungulinidae	Zemysia	Zemysia zelandica	Globe shells		4	3	0	4		4
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (0-5mm)	Cockle (0-5mm)	Infaunal deposit feeder	0	1	0	8		0
Bivalvia	Veneridae	Tawera	Tawera spissa	Morning Star		4		0	0	1	0
Bivalvia			Mytilidae (Juvenile)	Mussel		4		0	0		0
Bivalvia	Mytilidae	Zelithophaga	Zelithophaga truncata	Boring Mussel		4		0	0		0
Bivalvia			Bivalvia Unid. (juv)	Bivalves Juvenile		0		0	0		4
Bivalvia	Mytilidae	Musculus	Musculus impactus	Mussel		0		0	0	3	0
Bivalvia			Bivalvia indent.	Bivalves broken and unidentfiable		0	1	0	0		0
Bivalvia	Ostreidae	Ostrea	Ostrea chilensis	Flat oyster; Dredge Oyster		0		0	0	1	0
Bivalvia	Psammobiidae	Soletellina	Soletellina sp. (Juvenile)	Golden sunset shell	Infaunal suspension feeder	0	1	0	0		0
Bryozoa			Bryozoa (encrusting)	Bryozoans		4		0	4	1	4
Cephalocordata	Branchiostomatidae	Epigonichthys	Epigonichthys hectori	Lancelet		0		0	4		0
Chaetopteridae			Chaetopteridae	Polychaete worm		0	2	0	0		4
Copepoda			Copepoda	Copepods		0	2	0	0	1	0
Crustacea	Tanaidae		Tanaidacea	Tanaid shrimp		4	1	4	8	5	8
Cumacea			Cumacea	Cumaceans	Infaunal filter or deposit feeder	0	9	0	4	2	4
Decapoda	Diogenidae		Diogenidae	Left-handed Hermit Crab		8		0	0	10	12
Decapoda			Anomura	Hermit crab		12		0	0	2	8
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus cookii	Pill-box Crab	Eats small organisms & some weed	0		0	0	6	12
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus sp.	Pill-box Crab	Eats small organisms & some weed	0		0	0	3	8
Decapoda	Paguridae		Paguridae	Hermit Crab Unid.	Epifaunal scavenger	4	1	0	4	1	0
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus whitei	Pill-box Crab	Eats small organisms & some weed	0		0	4		0
Decapoda	Crangonidae	Philocheras	Philocheras australis	Sand Shrimp		0		0	4		0
Decapoda	Portunidae	Liocarcinus	Liocarcinus corrugatus	Dwarf Swimming Crab		0		0	0	1	0
Decapoda			Decapoda ident.	Decapoda		0		0	0	1	0
Gastropoda	Calyptraeidae	Sigapatella	Sigapatella tenuis	Small circular slipper shell		4		0	4	5	8
Gastropoda	Eatoniellidae	Eatoniella	Eatoniella	Gastropod		0		0	4	2	4
Gastropoda	Calyptraeidae		Calyptraeidae	Slipper shells		0		0	0		8
Gastropoda			Gastropoda (micro snails)	Snails		0		0	0	2	4
Gastropoda	Calyptraeidae	Maoricrypta	Maoricrypta sodalis	Slipper shell		0		0	0		4
Gastropoda	Calyptraeidae	Sigapatella	Sigapatella sp.	Circular slipper limpet		0		0	0		4
Gastropoda	Calyptraeidae	Maoricrypta	Maoricrypta sp.	Ribbed slipper shell		0		0	0	1	0
Hydrozoa			Hydrozoa (thecate)	Hydroids		0		0	0	1	0
Hydrozoa			Hydrozoa	Hydroids		0		0	0	1	0
Isopoda	Anthuridae	Anthuridae	Anthuridae	Isopod	Epifaunal scavenger	0		0	0	1	0
Mollusca			Polyplacophora	Chiton Juvenile or Indent.		4		0	4	1	0
Nematoda			Nematoda	Roundworm		0		0	8	3	28
Nemertea			Nemertea	Proboscis worms		4	1	4	4	1	0
Oligochaeta			Oligochaeta	Oligochaete worms	Infaunal deposit feeder	0	1	0	8	2	0
Ophiuroidea			Ophiuroidea	Brittle stars		4		0	0		0
Ophiuroidea	Amphiuridae	Amphiura	Amphiura sp.	Brittle star		0		0	0		4
Osteichthyes			Osteichthyes	Fish		0		4	0	1	8
Ostracoda			Ostracoda	Ostracod	Omnivorous scavenger	0	7	0	28	2	0
Ostracoda	Cylindroleberididae	Diasterope	Diasterope grisea	Ostracod	Omnivorous scavenger	0		0	4		0
Phoronida			Phoronida	Horseshoe worm		0		0	4		0
Polychaeta:			Nereididae	Polychaete worm		0		0	0	1	0
Polychaeta: Capitellidae	Capitellidae		Capitellidae	Polychaete worm	Infaunal deposit feeder	4		0	0		0
Polychaeta: Cirratulidae	Cirratulidae		Cirratulidae	Polychaete worm	Deposit feeder	0	1	0	0	1	12
Polychaeta: Eunicidae	Eunicidae	Eunice	Eunice sp.	Polychaete worm		0		0	0	1	0
Polychaeta: Glyceridae	Glyceridae		Glyceridae	Polychaete worm	Infaunal carnivore & deposit feeder	0		0	0	1	0
Polychaeta: Lumbrineridae	Lumbrineridae		Lumbrineridae	Polychaete worm	Infaunal carnivore & deposit feeder	0		0	0	1	0
Polychaeta: Maldanidae	Maldanidae		Maldanidae	Bamboo worm	Infaunal deposit feeder	0	1	0	4	4	0
Polychaeta: Nereididae	Nereididae	Nereis	Nereis sp.	Polychaete worm	Omnivorous	4		0	0		0
Polychaeta: Nereididae	Nereididae		Nereididae (juvenile)	Polychaete worm	Omnivorous	0		0	0	1	0
Polychaeta: Nereididae	Nereididae	Platynereis	Platynereis australis	Polychaete worm	Omnivorous	0		0	0	1	0
Polychaeta: Opheliidae	Opheliidae	Armandia	Armandia maculata	Polychaete worm	Infaunal deposit feeder	88	3	4	84	96	132
Polychaeta: Opheliidae	Opheliidae	Travisia	Travisia sp.	Polychaete worm		0	1	0	0		0
Polychaeta: Orbiniidae	Orbiniidae	Scoloplos	Scoloplos sp.	Polychaete worm		0	1	0	0		0
Polychaeta: Oweniidae	Oweniidae	Owenia	Owenia petersenae	Polychaete worm	Infaunal deposit feeder	0		0	8	1	0
Polychaeta: Pisionidae	Pisionidae		Pisionidae	Polychaete worm		0		4	0		0
Polychaeta: Polynoidae	Polynoidae		Polynoidae	Scale worms	Infaunal carnivore	0		0	0	2	4
Polychaeta: Sabellidae	Sabellidae	Euchone	Euchone sp.	Umbrella worms	Infaunal suspension feeder	0		8	8	4	16
Polychaeta: Sabellidae	Sabellidae		Sabellidae	Umbrella worms	Infaunal suspension feeder	0		0	4		0
Polychaeta: Serpulidae	Serpulidae	Hydroides	Hydroides sp.	Fan worm		0		0	0	15	0
Polychaeta: Serpulidae	Serpulidae	Serpula	Serpula sp.	Fan worm	Suspension feeder	0		0	4		4
Polychaeta: Serpulidae	Serpulidae		Serpulidae	Umbrella worms	Suspension feeder	0		0	0	3	0
Polychaeta: Spionidae	Spionidae	Spio	Spio sp.	Polychaete worm	Surface deposit & filter feeder	0	1	0	12		4
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio sp.	Polychaete worm	Surface deposit feeder	0	2	0	4		4
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio multicristata	Polychaete worm	Surface deposit & filter feeder	0		0	0		8
Polychaeta: Spionidae	Spionidae		Polydorid	Polychaete worm		0		0	0	1	4
Polychaeta: Spionidae	Spionidae		Spionidae	Polychaete worm	Surface deposit feeder	0	3	0	0		0
Polychaeta: Syllidae	Syllidae		Syllidae	Polychaete worm	Omnivorous	12		0	12	47	60
Polychaeta: Syllidae	Syllidae		Exogoninae	Polychaete worm		0	4	0	12	5	32
Polychaeta: Syllidae	Syllidae		Para-syllid	Polychaete worm		0	12	0	0		0
Polychaeta: Terebellidae	Terebellidae		Terebellidae	Polychaete worm	Infaunal deposit feeder	0		0	0		4
Polyplacophora	Chitonidae	Chiton	Chiton glaucus	Green Chiton	Microalgal grazer	36		0	0	13	124
Polyplacophora	Acanthochitonidae	Acanthochitona	Acanthochitona violacea	Chiton		0		0	0	1	4
Polyplacophora	Acanthochitonidae	Pseudotonicia (Notoplax)	Pseudotonicia (Notoplax) cuneata	Chiton		0		0	4		0
Polyplacophora	Chitonidae	Sypharochiton	Sypharochiton pelliserpentis	Snakeskin Chiton		0		0	0	3	0
Polyplacophora	Chitonidae	Rhyssoplax	Rhyssoplax canaliculata	Chiton		0		0	0	1	0
Porifera			Porifera	Sponges		0		0	0	1	0
Pycnogonida			Pycnogonida	Sea spider		0		0	0		8
					Count: No of Individuals	**280**	**99**	**36**	**456**	**488**	**832**
					Count: No of Taxa	**24**	**27**	**7**	**34**	**60**	**39**

Appendix B:

Depth Records of each Sampling Site

Western Reclamation		Eastern Area		Capital Dredge Area		Channel Area	
Site	**Depth (m)**	**Site**	**Depth (m)**	**Site**	**Depth (m)**	**Site**	**Depth (m)**
WI1	2.2	EI3	4.2	DI1	9.4	Dredge 1	22.0
WI2	1.6	EI4	3.3	DI2	9.9	Dredge 2	28.0
WI3	4.8	EI5	2.5	DI3	11.7	Dredge 3	29.8
WI4	1.4	EI6	2.7	DI4	10.7	-	-
WM1	7.3	EM3	7.8	DI5	9.2	-	-
WM2	6.8	EM4	7.0	DO1	6.8	-	-
WM3	6.7	EM5	8.2	DO2	7.9	-	-
WM4	6.2	EM6	8.4	DO3	9.9	-	-
WM5	6.5	EO1	10.0	DO5	9.6	-	-
WM6	5.8	EO3	10.1	-	-	-	-
WO1	10.2	EO4	9.1	-	-	-	-
WO2	12.9	EO5	9.1	-	-	-	-
WO3	9.1	EO6	9.3	-	-	-	-

Appendix C:

Hills Laboratories Grain Size Analysis

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Certificate of Analysis

SPv1

Client:	4SIGHT Consulting Limited	**Lab No:**	2274145
Contact:	Oliver Bone	**Date Received:**	13-Nov-2019
	C/- 4SIGHT Consulting Limited	**Date Reported:**	02-Dec-2019
	PO Box 402053	**Quote No:**	102217
	Tutukaka 0153	**Order No:**	AA5255
		Client Reference:	AA5255 - Marine Sediment
		Submitted By:	Oliver Bone

Sample Type: Sediment

Sample Name:		East In 08-Nov-2019	East Mid 08-Nov-2019	East Out 08-Nov-2019	West In 11-Nov-2019	West Mid 11-Nov-2019
Lab Number:		2274145.1	2274145.2	2274145.3	2274145.4	2274145.5
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	74	72	72	67	44
Fraction >/= 2 mm	g/100g dry wt	< 0.1	5.0	5.7	4.5	1.0
Fraction < 2 mm, >/= 1 mm	g/100g dry wt	< 0.1	0.4	1.0	0.5	0.2
Fraction < 1 mm, >/= 500 µm	g/100g dry wt	< 0.1	0.4	1.6	0.3	0.4
Fraction < 500 µm, >/= 250 µm	g/100g dry wt	7.9	4.0	13.8	6.4	3.1
Fraction < 250 µm, >/= 125 µm	g/100g dry wt	87.4	84.7	69.2	56.2	60.7
Fraction < 125 µm, >/= 63 µm	g/100g dry wt	2.2	4.0	4.5	22.7	28.5
Fraction < 63 µm	g/100g dry wt	2.4	1.6	4.2	9.4	5.9

Sample Name:		West Out 11-Nov-2019				
Lab Number:		2274145.6				
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	73	-	-	-	-
Fraction >/= 2 mm	g/100g dry wt	0.6	-	-	-	-
Fraction < 2 mm, >/= 1 mm	g/100g dry wt	0.4	-	-	-	-
Fraction < 1 mm, >/= 500 µm	g/100g dry wt	0.7	-	-	-	-
Fraction < 500 µm, >/= 250 µm	g/100g dry wt	8.3	-	-	-	-
Fraction < 250 µm, >/= 125 µm	g/100g dry wt	76.1	-	-	-	-
Fraction < 125 µm, >/= 63 µm	g/100g dry wt	11.6	-	-	-	-
Fraction < 63 µm	g/100g dry wt	2.4	-	-	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-6
Fraction >/= 2 mm	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-6
Fraction < 2 mm, >/= 1 mm	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 1 mm, >/= 500 µm	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 500 µm, >/= 250 µm	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 250 µm, >/= 125 µm	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 125 µm, >/= 63 µm	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 63 µm	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This certificate of analysis must not be reproduced, except in full, without the written consent of the signatory.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

Hill Laboratories
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Certificate of Analysis

Client:	4SIGHT Consulting Limited	**Lab No:**	2277984 SPv1
Contact:	Oliver Bone	**Date Received:**	20-Nov-2019
	C/- 4SIGHT Consulting Limited	**Date Reported:**	06-Jan-2020
	PO Box 402053	**Quote No:**	102217
	Tutukaka 0153	**Order No:**	AA5255
		Client Reference:	AA5255 - Marine Sediment
		Submitted By:	Oliver Bone

Sample Type: Sediment

Sample Name:		DO 2 19-Nov-2019	DO 5 19-Nov-2019	DI 4 18-Nov-2019	DI 3 18-Nov-2019	Channel 2 19-Nov-2019
Lab Number:		2277984.1	2277984.2	2277984.3	2277984.4	2277984.5
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	74	76	76	74	67
Fraction >/= 2 mm	g/100g dry wt	35.1	1.2	19.6	15.2	69.2
Fraction < 2 mm, >/= 1 mm	g/100g dry wt	1.5	1.3	8.7	5.4	9.9
Fraction < 1 mm, >/= 500 µm	g/100g dry wt	1.0	4.6	19.5	10.7	8.5
Fraction < 500 µm, >/= 250 µm	g/100g dry wt	9.4	78.6	44.5	48.4	3.2
Fraction < 250 µm, >/= 125 µm	g/100g dry wt	45.9	9.2	3.4	19.2	4.0
Fraction < 125 µm, >/= 63 µm	g/100g dry wt	0.7	< 0.1	< 0.1	0.4	0.4
Fraction < 63 µm	g/100g dry wt	6.3	5.1	4.3	0.7	4.8

Sample Name:		Channel 5 19-Nov-2019				
Lab Number:		2277984.6				
7 Grain Sizes Profile as received						
Dry Matter of Sieved Sample	g/100g as rcvd	75	-	-	-	-
Fraction >/= 2 mm	g/100g dry wt	36.4	-	-	-	-
Fraction < 2 mm, >/= 1 mm	g/100g dry wt	10.4	-	-	-	-
Fraction < 1 mm, >/= 500 µm	g/100g dry wt	8.5	-	-	-	-
Fraction < 500 µm, >/= 250 µm	g/100g dry wt	27.6	-	-	-	-
Fraction < 250 µm, >/= 125 µm	g/100g dry wt	12.0	-	-	-	-
Fraction < 125 µm, >/= 63 µm	g/100g dry wt	0.2	-	-	-	-
Fraction < 63 µm	g/100g dry wt	4.7	-	-	-	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-6
Fraction >/= 2 mm	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-6
Fraction < 2 mm, >/= 1 mm	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 1 mm, >/= 500 µm	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 500 µm, >/= 250 µm	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 250 µm, >/= 125 µm	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6
Fraction < 125 µm, >/= 63 µm	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Fraction < 63 µm	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-6

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Dates of testing are available on request. Please contact the laboratory for more information.

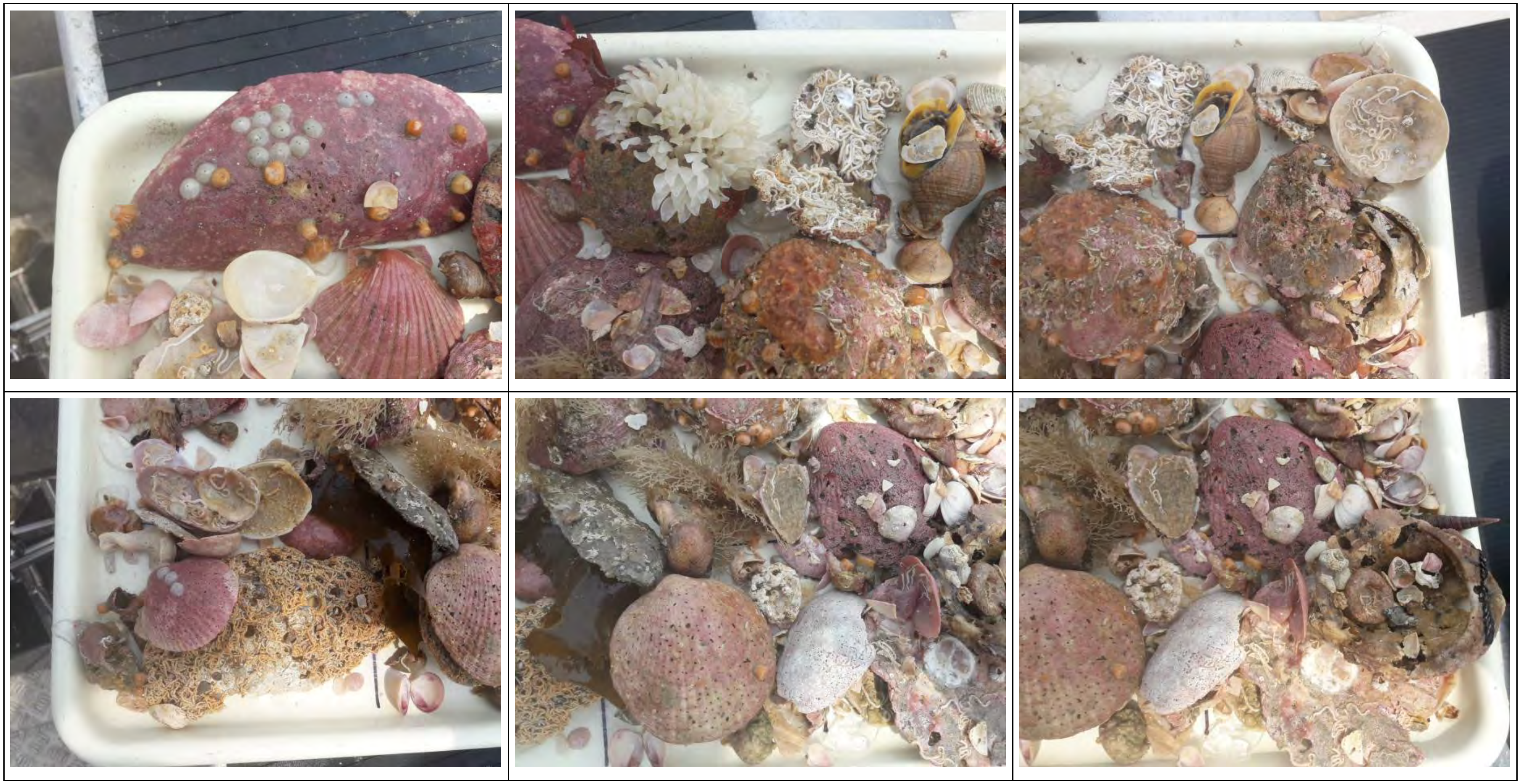
Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Kim Harrison MSc
Client Services Manager - Environmental

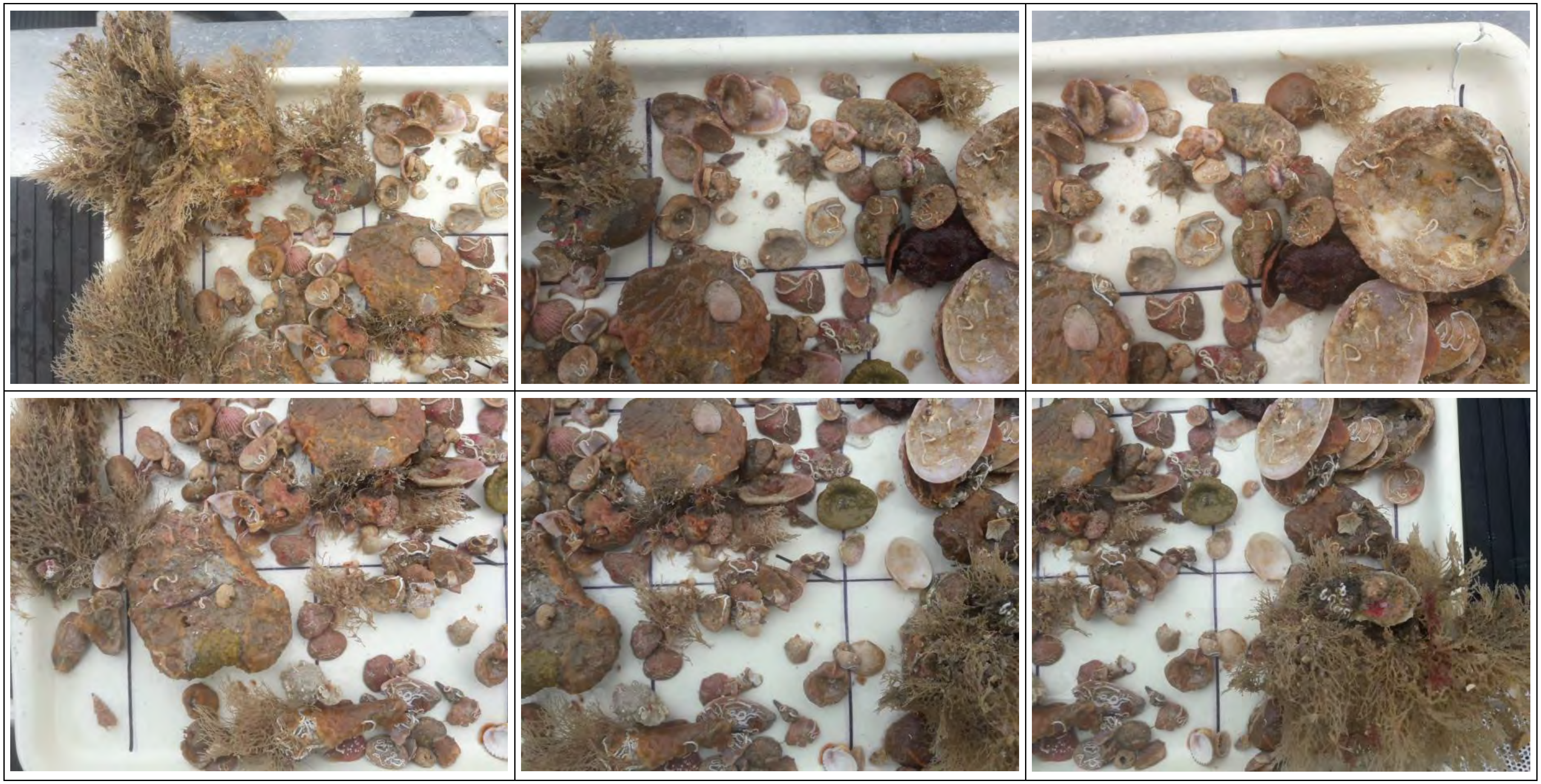
Appendix D:

Northern Channel Dredge Sample Photographs

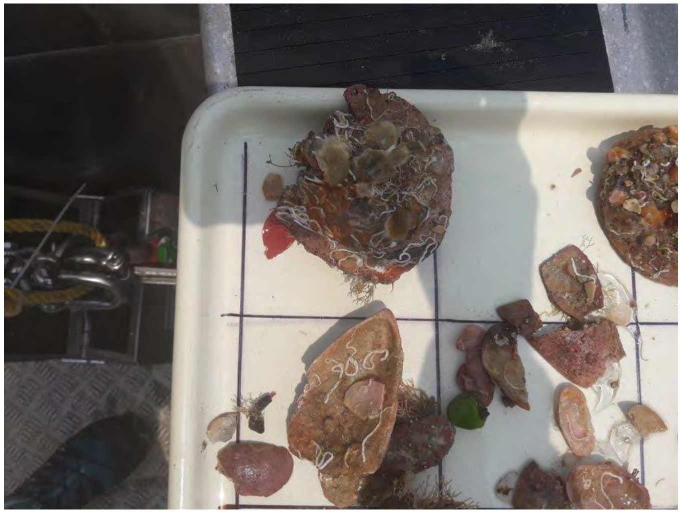
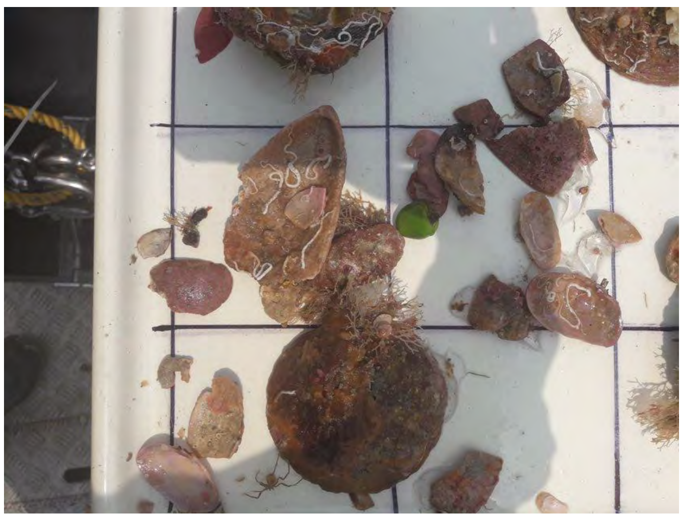
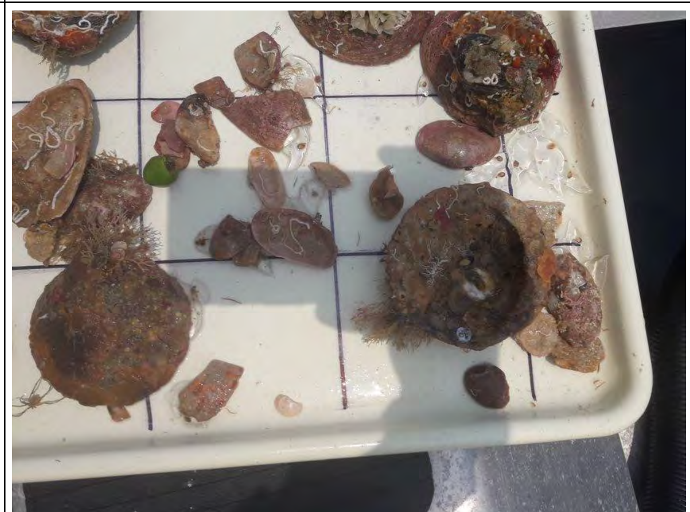
Northern Channel Dredge 1 – Contents viewed left to right, top to bottom.



Northern Channel Dredge 2 – Contents viewed left to right, top to bottom.



Northern Channel Dredge 3 – Contents viewed left to right, top to bottom.

4SIGHT CONSULTING

LAND. PEOPLE. WATER.

Northport

Northport 2020 Intertidal Macroinvertebrate Survey

Prepared for Northport

July 2021

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

1.1 Project scope

Northport, situated at Marsden Point near the entrance to the Whangārei Harbour, is New Zealand's northernmost deep-water port. Established in 2002, the port terminal includes a reclamation covering approximately 32 ha which projects across tidal flats to the deepwater harbour channel. 4Sight Consulting Limited (4Sight) was engaged by Northport to characterise the ecological features in the intertidal zone within and near areas proposed for reclamation as part of future growth plans for the port. The zones proposed for reclamation comprise a 10.5 ha area adjacent to the western end of the present terminal (Figure 1), and an area of 13 ha adjacent to the eastern end (Figure 2).

This report details results from an ecological survey of the macroinvertebrate communities of the intertidal sandflats to the west and east of the Northport Terminal between March and December 2020. Sampling events were spread across the year due to Covid-19 restrictions. This report provides the results of a follow up survey to that carried out in December 2017 and reported in 2018 (4Sight, 2018).

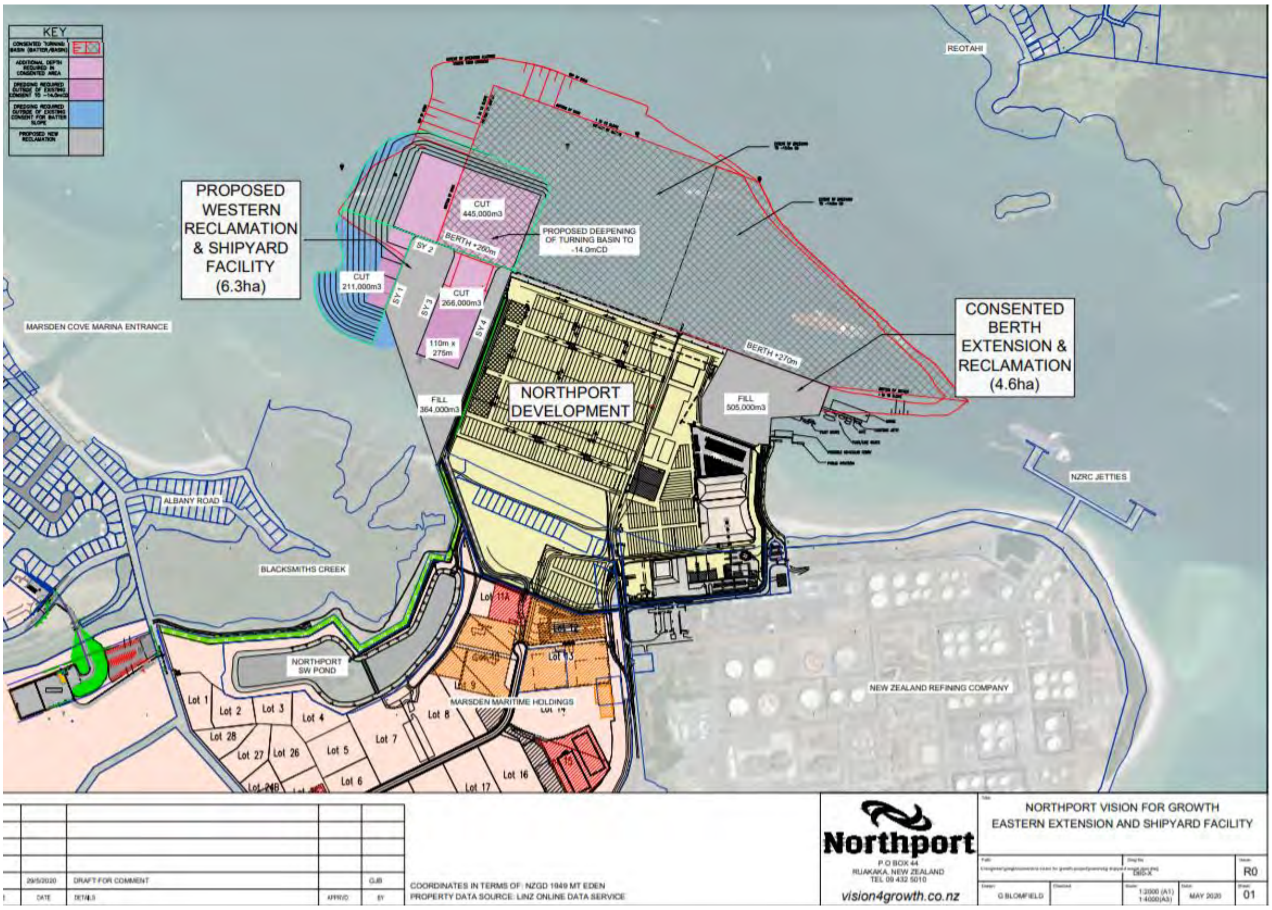


Figure 1: Existing port terminal (yellow) and proposed western reclamation area (pink).

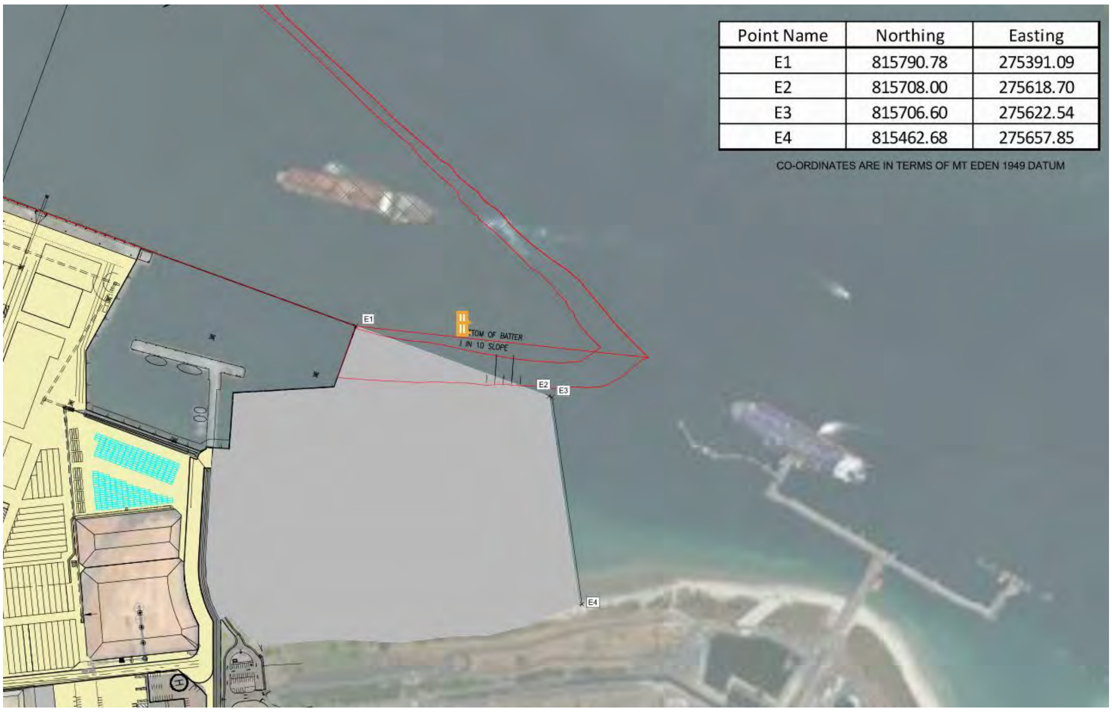


Figure 2: Existing port terminal (yellow) and proposed eastern reclamation area (grey).

1.2 Ecological Setting: Whangārei Harbour

The Whangārei Harbour is a large (100 km^2) estuary consisting of a drowned river system (upper harbour) and a barrier-enclosed lagoon (lower harbour). This system is connected to the open ocean via an approximately 2.4 km wide opening located between Marsden Point and Home Point on the north-eastern coast of New Zealand (Griffiths, 2012; Swales et al. 2013).

The Harbour has been subjected to significant anthropogenic impacts including land reclamation, the deposition of 3 million m^3 of sediment fines and 2 million m^3 of channel dredge spoil since the 1920s and runoff from urban, industrial and rural sources (Morrison, 2005). Despite these impacts there is a wide range of habitats, including deep-water channels, intertidal flats, mangroves, and saltmarsh (Morrison, 2005). Associated with these habitats is a rich diversity of marine life, including benthic invertebrates and estuarine and coastal fishes (Brook, 2002, Morrison, 2005). The harbour is also recognised for its importance for many internationally and New Zealand migratory and resident bird species (Morrison, 2005).

Intertidal flats are the most common habitat type in the lower harbour, comprising 58% of the marine area. Intertidal macroinvertebrate communities generally fall into one of three community types: sheltered tidal creek communities (upper harbour); semi-exposed sandflat communities (mid-harbour); exposed sandflat communities (lower harbour). These community types are largely driven by substrate type and a change in community composition from muddy upper harbour sites, which are dominated by polychaete worms, to sandier lower harbour sites where bivalve species, such as cockle (*Austrovenus stuchburyii*) and nut shell (*Linucula sp*) become key species (Griffiths, 2012). The lower harbour has historically supported extensive cockle and pipi (*Paphies australis*) beds, which have supported commercial, recreational and customary fisheries within the harbour (Pawley and Smith, 2014; Williams and Hulme 2014).

1.2.1 Earlier Port-Related Intertidal Studies

1.2.1.1 Intertidal Ecology Survey 2018

An ecological survey of the macroinvertebrate communities and the physicochemical status of the intertidal sandflats to the east and west of the Northport Terminal was reported in 2018. That 2018 work reported clean unpolluted, mostly coarse grained sediments and a high biodiversity and abundance of intertidal animals.

Comparisons of the 2020 data set with the 2018 survey findings are discussed.

1.2.1.2 Northport Terminal Consent Related Studies 1992-1997

A survey of intertidal habitat and edible shellfish on the sandflats on which the port reclamation was established and areas to the east and west, was reported as part of the environmental impact assessment for the establishment of the Northport facility in the late 1990s (Environmental Quality Consultants,1995). The 1995 report concluded as follows in respect of the intertidal survey, which was carried out in 1992:

'…*The intertidal zones within the proposed reclamation contain few edible sized shellfish and are reportedly utilised only occasionally for shellfish collection*…'

Further surveys were undertaken in 1997 on cockles and pipi and reported in evidence produced for the resource consent hearing on the port proposal (Environmental Quality Consultants, 1997). That work also concluded low densities of cockles within the then proposed port reclamation. Cockles were reported as '…*patchily distributed at Blacksmiths Creek but a relatively high proportion are of edible size*…'Pipi were reported as being of very low density in the Blacksmiths Creek area but '…*a small bed of good sized pipi about 200-400m east of the Blacksmiths Creek channel outlet (mean size 69 mm)*…'was reported.

Information on shellfish density and size reported in the consent hearing evidence is discussed in relation to the 2018 and 2020 surveys.

1.2.1.3 Northport Terminal Baseline Study 1997-2002

Following the granting of consents and in the period 1997-2002, low to mid tide benthic communities at eight lower harbour sites were surveyed annually in the late summer as part of the pre-development baseline studies (Poynter & Associates, 2002). Some of these sites were also surveyed as part of the 2018 and 2020 work. Methodology was similar but sieve size used to screen the biological samples for small biota was different, being 1mm in the baseline work and 0.5mm in 2018 and 2020. Comparisons of the current data set on shellfish abundance and size frequency with the baseline survey findings are discussed.

1.2.1.4 Northport Monitoring Studies 2004-2008

Following port construction, a refined survey methodology was used to monitor the low to mid tide benthic communities biennially in the years 2004, 2006 and 2008. The 2007-2008 data set is reviewed in Poynter & Associates, (2008). Shellfish population data in that review is compared with the 2018 and 2020 study results and is discussed in this report.

2 METHODS

2.1 Survey rationale and site selection

The 2020 ecological assessment of the intertidal sandflats to the west and east of the Northport terminal was interrupted due to Covid-19 restrictions and was therefore carried out in three segments. Samples were taken in March, September and December 2020 due to their coincidence with the lowest astronomical tides of the month.

The ecological assessment involved gathering information on benthic macroinvertebrates and shellfish size frequencies. Sediment samples were also collected and archived for grain size and chemical analysis if necessary. Samples were collected from eleven sites (Figure 3). Most of these sites were consistent with sites previously surveyed and reported in 2018. Two additional sites (WM1a and WL1a) were included within the footprint of the proposed western reclamation to increase sampling intensity in the mid and low shore in that area.

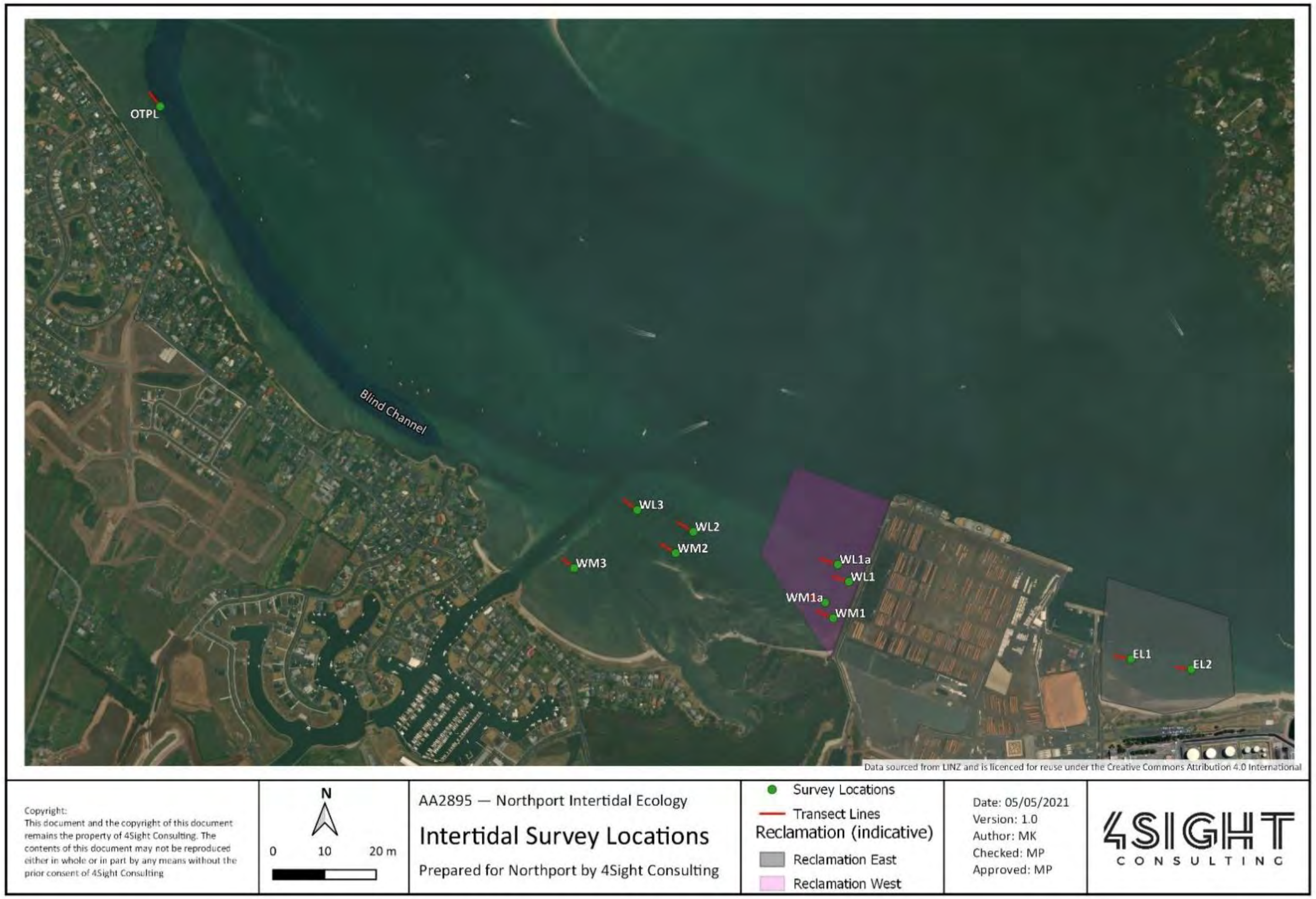


Figure 3: Intertidal Survey sites 2020.

The 2020 survey included seven low water sites (WL1, WL1a, WL2, WL3, EL1, EL2 and OTP) and four mid water sites WM1, WM1a, WM2 and WM3). Four sites (WM1, WM1a, WL1 and WL1a) fall within the indicative western reclamation footprint and two within the proposed eastern reclamation (EL1 and EL2).

Site selection to the west of the Northport Terminal is constrained by several features. The Marsden Cove Marina access channel delineates the western extent of the study area (but excluding the One Tree Point background reference site). The Blacksmiths Creek low tidal channel which crosses the tidal flat, also influenced site selection. Some sampling sites were at the edge of the channel flow as previous work had shown high densities in shellfish in this vicinity. Sites were chosen to provide representative coverage of the mid to low water zone which is expected to host the widest diversity and greatest density of marine life.

Site selection to the east of the Northport Terminal is limited by the Refining NZ jetty.

The reference site at the head (western end) of the One Tree Point (OTP) blind channel, was located based on previous coordinates. The location is well removed from Northport, covers similar habitat type to that close to the Northport terminal and has a strong body of monitoring data collected over the 1997 to 2008 period and more recently as part of Northland Regional Council State of Environment Monitoring.

The OTP site was sampled at two slightly different locations. This was because eelgrass sward had increased in this area. An initial survey at the site of previous sampling which is now within the eelgrass bed, produced very few shellfish. This site was used for the analysis of macroinvertebrates but to better document shellfish abundance and size, the area immediately adjacent to the eelgrass was subsequently resurveyed for shellfish

All sites were accessed by foot. Low water sites were sampled within an hour either side of low tide.

WL2, WL3, WM2 and WM3 were approximately the same localities as the cluster of sites represented by Sites D, E, F, EZ and H in the 1997-2008 field surveys.

2.2 Macroinvertebrates

The sites were located based on GPS point taken during the 2018 survey. From this point a 50 m transect tape was laid out parallel to the water's edge, running east to west. This transect was used to establish the location of four 5 m × 5 m quadrats, from which a total of 24 macroinvertebrate samples were collected (six samples per 5 m × 5 m quadrat). These quadrats were at predetermined distances along the tape from:

- 0 m – 5 m
- 15 m – 20 m
- 30 m – 35 m
- 45 m – 50 m

At 0m, 15m, 30m and 45m, a further tape was laid down perpendicular to the main tape so the 5 m × 5 m quadrat parameters could be established. Random xy coordinates were generated prior to sampling to determine the location of each sample within each quadrat, ensuring no sampler bias occurred. Figure 4 provides an illustration of the sampling design for each site.

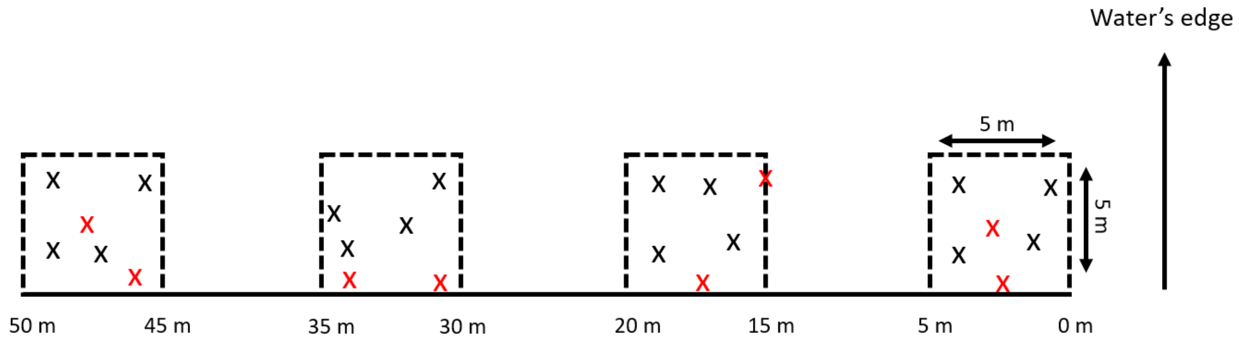


Figure 4: Schematic of macroinvertebrate sample transect. Dashed lines indicate 5 × 5 m quadrats. Black crosses indicate samples sieved through a 2 mm aperture sieve to assess key bivalve species, while red crosses indicate samples sieved through a 0.5 mm aperture sock for thorough taxonomic idenfication. Diagram not to scale.

The same core size was used in 2020 as was used in 2018. A sample consisted of a single benthic core being collected using a stainless-steel corer. The corer had a diameter of 13 cm and was inserted into the substrate to a maximum depth of 15 cm, giving a total sampling area of 133 cm^2 and sampling volume of up to 2651 cm^3. Once collected each sample was bagged for processing. Four samples within each quadrat (16 in total per transect) were set aside for 'immediate' processing while the remaining two per quadrat (eight in total per transect) were set aside for subsequent processing in the laboratory.

'Immediate' processing consisted of a sample being sieved through a 2 mm stainless-steel sieve to record size frequency data for key bivalve species including: cockle (*Austrovenus stuchburyi*), pipi (*Paphies australis*) and wedge shell (*Macomona liliana*). All such samples were bagged and refrigerated to be processed for size frequency.

Samples to be laboratory processed were sieved through a 0.5 mm nylon sock, allowing all macroinvertebrates >0.5 mm to be retained. Each sample was then placed in a plastic container and preserved with 70% ethanol. Once back in the laboratory samples were stained with rose bengal dye, allowing for an easier distinction between animal tissue and other material. The sorted samples were then sent to Cawthron for faunal identification to the lowest practical taxonomic denomination.

2.3 Sediment grain size

At each site, sediment was collected and archived for grain size analysis if required. It is considered that the 2018 work adequately describes the broad physical substrate in terms of texture.

Each archived sediment sample is a composite collected from a subsample within each 5 m x 5 m quadrat, thus four subsamples made up one composite sample. Sediment samples were collected to a depth of 5 cm.

Observations of broad habitat type and substrate texture were made.

3 RESULTS

3.1 Macroinvertebrate Community

Results describing the macroinvertebrate community are presented according to the sampling design in two categories:

- Macrofauna retained by mesh with an aperture size of 0.5 mm.
- Shellfish species, focussing on the most abundant large-bodied species (cockles, pipis and wedge shells) retained by a mesh of 2mm.

3.1.1 Overview

A total of 15,205 *(8,332 in 2018)* organisms from 113 different taxa (*90 taxa 2018*) were identified in the macrofaunal samples (Appendix A:). Polychaetes and crustaceans (a collective of Decapoda, Tanaiidae; Cumacea; Amphipoda, Ostracoda, Isopoda, Mysidacea) were the diverse (number of different species within that group) and most abundant groups (number of individual counts) (Figure 5). The mean richness per sample was 19 taxa (*14 taxa 2018*) and the mean abundance was 175 individuals per core sample (*116 individuals 2018*).

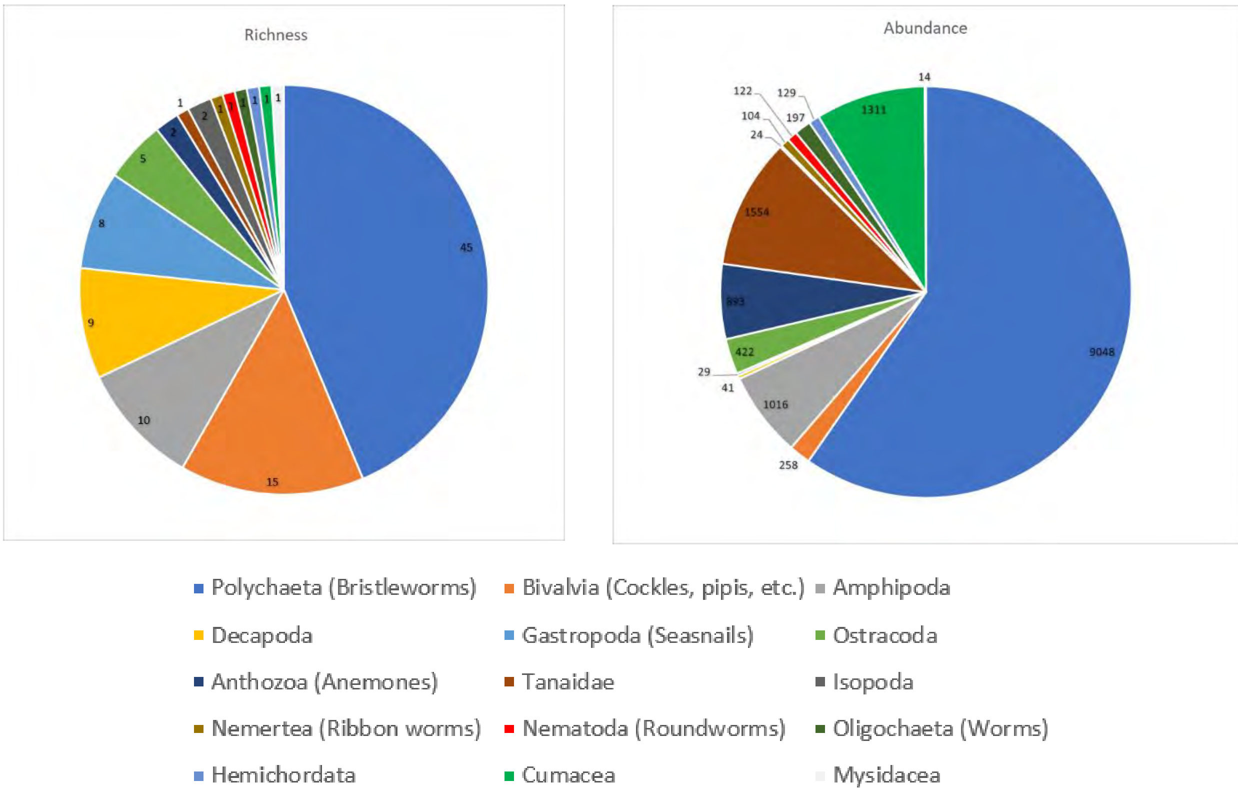


Figure 5: Total richness and abundance within top 15 broad taxonomic groups.

A broad breakdown of the composition of the community at each site is shown in Figure 6. Overall, the most commonly sampled taxa were polychaetes from the families Spionidae and Syllidae. Spionid polychaetes *Prionospio aucklandica* and/or *Prionospio sp*. were abundant at all sites except for sites WL1a and EL1. Small crustaceans were abundant at all sites except for WM1a and WM1. Nereid polychaetes (adults and juveniles) dominated WM1a.

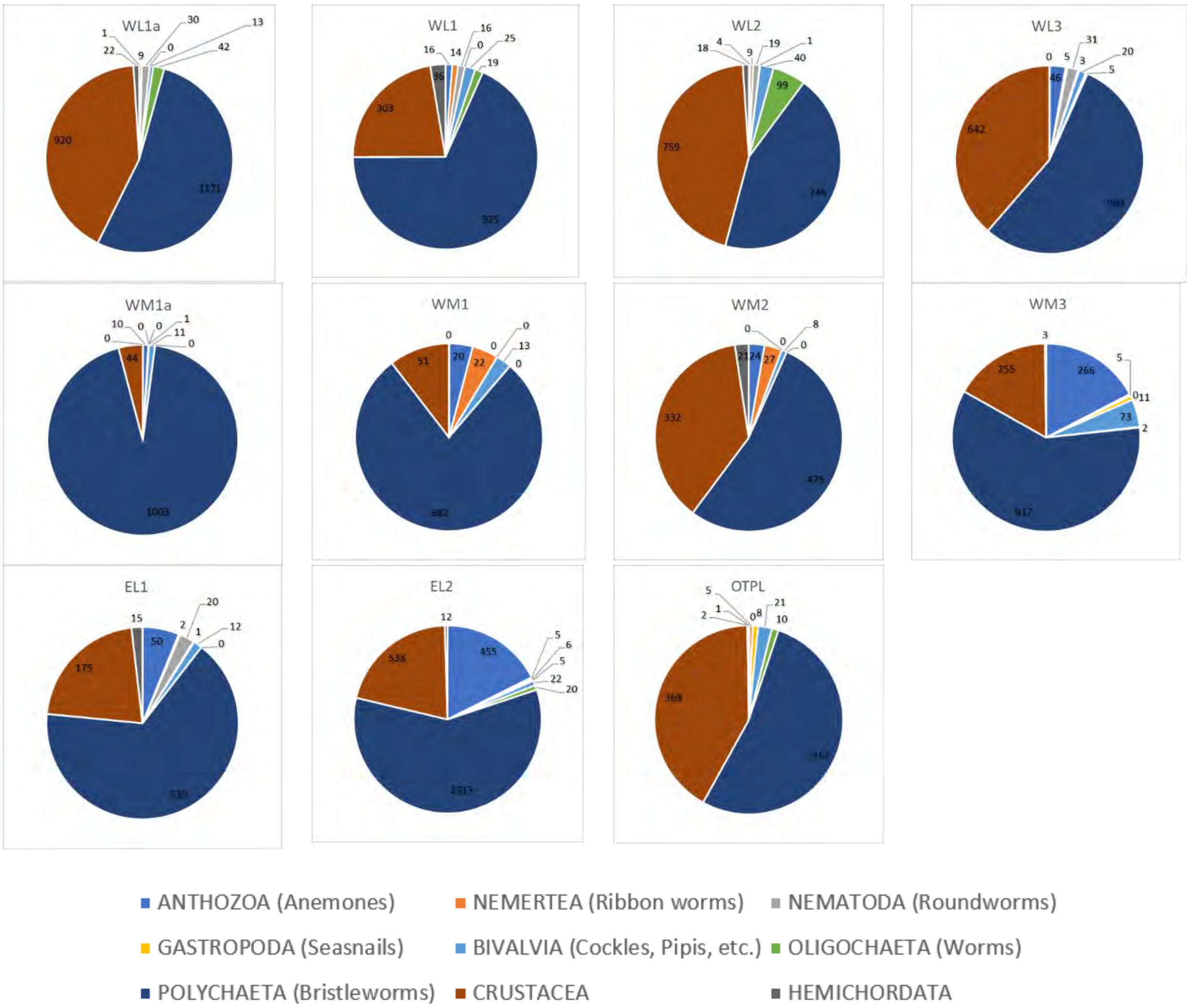


Figure 6: Pie charts showing the abundance of each taxonomic Class of invertebrate sampled at each site.

Figure 7 shows the taxonomic richness (mean number of taxa), abundance (mean number of individual animals) and Shannon-Weiner Diversity Index for each of the sites surveyed in 2018 and 2020.

Six of the 11 sites sampled in both years had near equivalent or higher mean abundances in 2020 but only three sites showed a statistically significant increase. Eight sites had similar or greater diversity and six of these were statistically significant. Sites which showed statistically significant increases in both abundance and diversity in 2020 were WL2, WL3 and EL2. One site (WL1) showed a ststistically significant decrease in these metrics.

Overall, the diversity index (Shannon-Weiner index) was similar for both sampling years at sites, excluding WM3, where the mean diversity index was lower in 2020 (2.22) than it was in 2018 (2.36). The statistical significance of differences in diversity index for each site between years is shown in Table 1. This was conducted using a Wilcoxon rank sum, which is a non-parameteric method similar to that of a student's t-test.

Table 1: Comparison of Shannon-Weiner diversity between sampling years (2020 and 2018) for each site. A p value <0.05 indicates a statistically significant difference.

Site	Wilcoxon rank sum test (p value)
OTPL	0.44
WL1	0.57
WL2	0.16
WL3	0.10
WM1	0.27
WM2	0.72
WM3	**0.02**
EL1	0.13
EL2	0.19

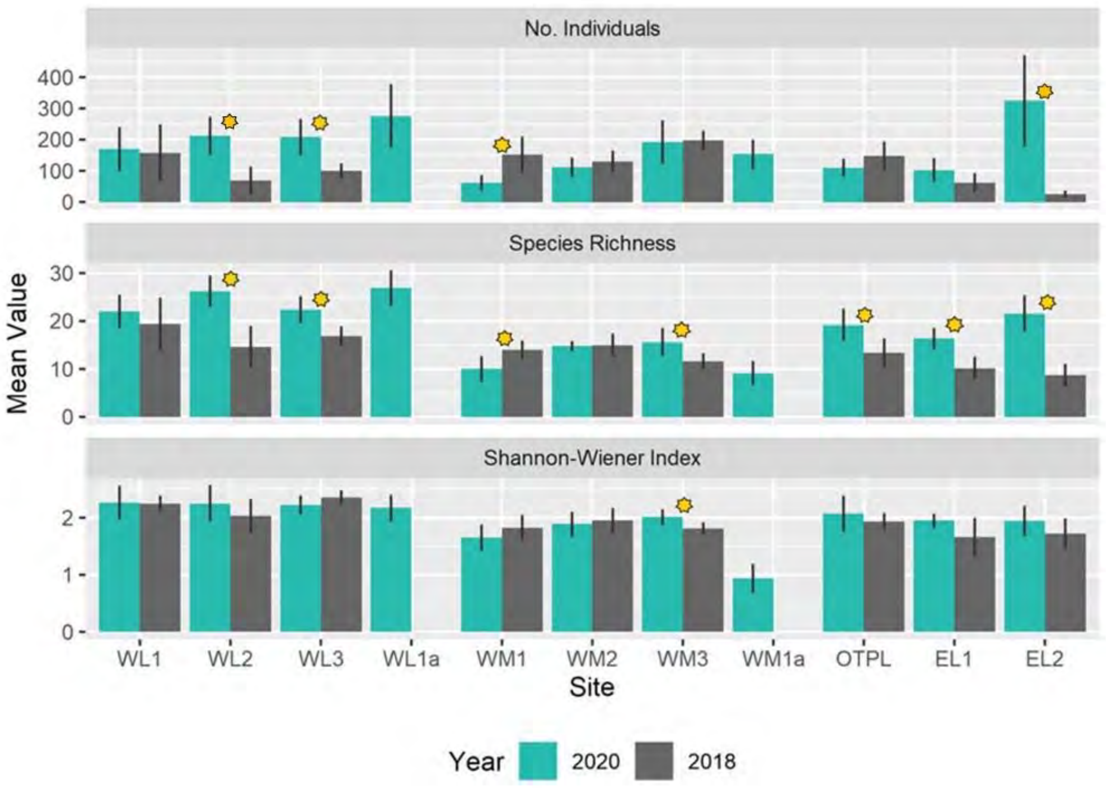


Figure 7: Mean Number of Individuals, Species Richness and Shannon-Wiener Index per site (including 95% CI bars, n = 8). * indicating significant statistical difference between years.

Broadly, richness and abundance at individual sites varied over time but was greatest at the low shore sites.

Sites within the indicative reclamation footprints did not show consistent differences to sites elsewhere. For example:

- WL1 had similar abundance and diversity between years and these metrics were within the ranges for the other low shore sites;
- Site WL1a had the highest diversity (mean taxa 27) in 2020 but site EL2 while most abundant (mean 324) in 2020 had the lowest diversity and abndance in 2018;
- In contrast, WM1 had a significantly lower richness and abundance in 2020 than recorded in 2018 and compared to other mid shore sites beyond the reclamation footprint. However, the additional mid shore site sampled in 2020 (WM1a) showed abundance within the range reported for the other mid shore sites while diversity was very similar to WM1a.
- Low shores sites close to the port (WL1 and WL1a) showed abundance and diversity either greater than or similar to the background site (OTP).

A comparison of the five most abundant organisms per site is presented in Figure 8. This shows that the Spionid polychaetes *Prionospio aucklandica* and/or *Prionospio sp*. were abundant at all sites except for WL1a and EL1. Small crustaceans were abundant at all sites except for WM1a, which was dominated by nereid poylchaetes (adults and juveniles). The western low shore sites (WL1a, WL2 and to a lesser extent WL1) supported high numbers of Tanaid crustaceans.

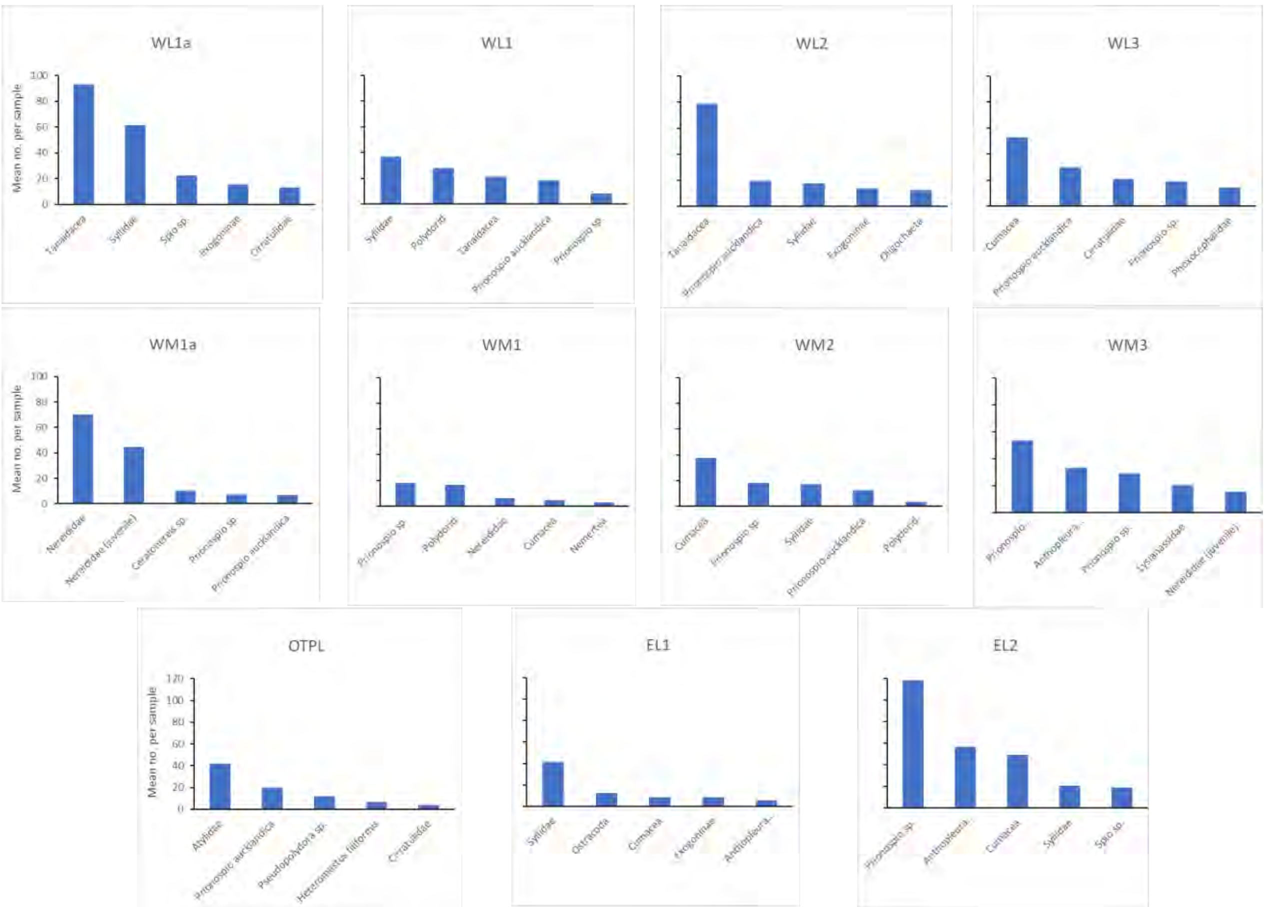


Figure 8: Mean number of 5 most abundant taxa per site.

3.1.2 Western sites: Macrofauna (>0.5 mm)

A total of 12,157 individuals from 101 different taxa (*79 taxa 2018*) were identified in the macrofaunal samples (Appendix A:). Polychaetes and crustaceans were the most abundant groups (number of individual counts) and polychaetes and bivalves were the dominant groups with the highest taxonomic richness (number of different species within that group) (Figure 9). The mean richness per sample was 19 taxa (*15 taxa 2018*) and the mean abundance was 171 individuals per core sample *(136 individuals 2018).*

Of the 101 taxa recorded to the west of the existing port (between One Tree Point and the port), 76 taxa (75%) were recorded at sites within the proposed western reclamation (*55 taxa or 70% in 2018*). That is, taking both surveys into account, between 70-75% of the taxa recorded in the western reclamation footprint were recorded elsewhere on the western shore.

Taking both the western and eastern site biodiversity into account, 10 taxa or about 9% of the total biodiversity was found only in the western reclamation footprint and similarly 13 taxa or 11.5% were found only in the eastern reclamation footprint. The numbers of individuals of these taxa which were found only in the western or eastern reclamation footprints respectively, was small.

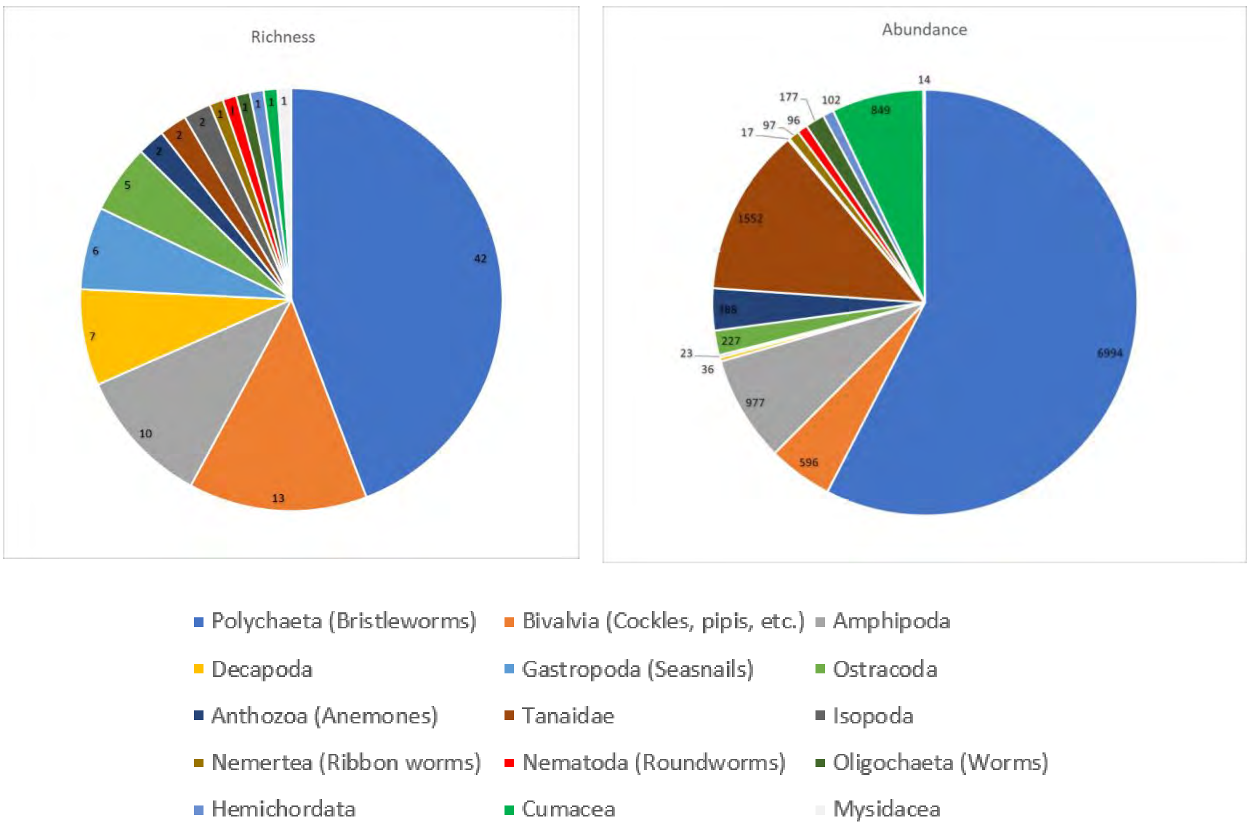


Figure 9: Total richness and abundance within broad taxonomic groups at western sites.

3.1.3 Eastern sites: Macrofauna (>0.5 mm)

A total of 3,420 individuals from 68 different taxa (*40 taxa 2018*) were identified in the eastern macrofaunal samples (Appendix A). Polychaetes were both the richest (number of different species within that group) and most abundant (number of individuals) of the broad taxonomic groups at the eastern sites (Figure 10). The same observation was made for the western sites. Bivalves and small crustaceans were other relatively diverse groups and small crustaceans (tanaids, amphipods and ostracods) were also abundant. The mean richness per sample was 19 taxa (10 taxa 2018) and the mean abundance was 214 individuals per core sample (*44 individuals 2018*). As previously noted only 13 taxa were not recorded in the wider sampling to the west of the port but numbers were small.

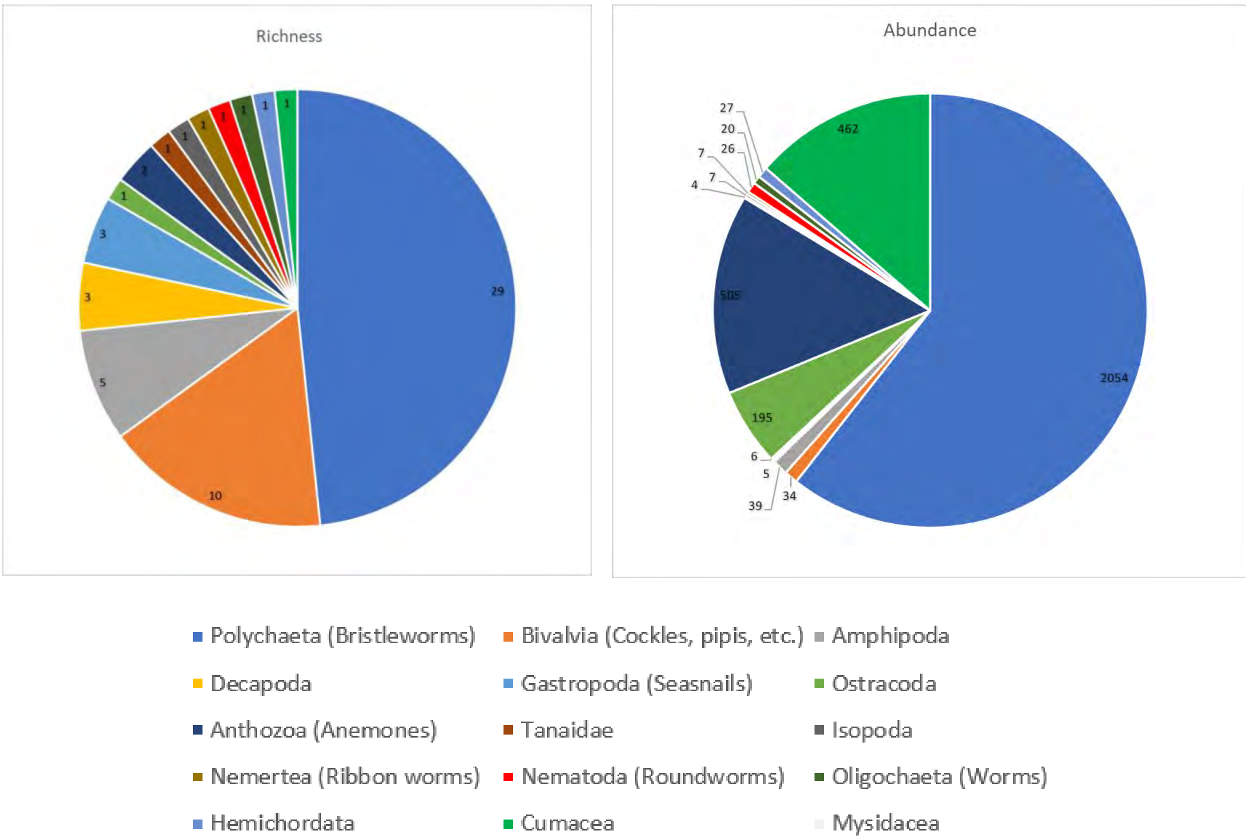


Figure 10: Total richness and abundance within broad taxonomic groups at eastern sites.

Although both the eastern sites showed an increase in mean abundance and mean diversity for 2020 relative to 2018, the increase at EL2 is noteworthy and due to greater densities of most taxa recorded but particularly spionid polychaetes.

3.1.4 Shellfish (>2mm)

Cockles (*Austrovenus stutchburyi*) were present at most sites at densities considered to be a 'bed' (>10 per m^2). They were the most abundant shellfish recorded (total of all samples n=2025) and were most abundant at site OTP followed by WM3, and WL3 (Figure 11). Relative to these sites, although cockles were present at the sites sampled within the respective western and eastern reclamation footprints, density was comparatively low.

Pipis (*Paphies australis*) were present at low densities at sites WM1, WM2, WM3, WL1 and OTP. At site WM1a pipis occurred at a comparatively higher mean density of 12 per sample that equated to 892 per m^2, most of which occurred in the 11-25mm size classes. Due to the low density and small size of pipis, size frequencies are not presented.

The wedge shell *Macomona liliana* was found in relatively low abundance (total of all samples n=85) and was most abundant at WM3.

In considering the proportion of an edible shellfish population that is harvestable, there is no minimum legal size for taking cockles or pipis. The Ministry for Primary Industries has historically used a general guideline to define a harvestable shellfish population as 25 per m^2 for pipis 50 mm or greater, or for cockles 30 mm or greater (e.g. Pawley and Smith, 2014).

Under that definition, cockles were present in densities that would constitute a harvestable bed at site WL3 and EL1 (Figure 11 and Table 2). If cockles greater than 25 mm (i.e. approaching size big enough for recreational harvest) are included, then there is a potentially harvestable population at sites WM2, OTP, WL3 and EL1.

Cockles were very sparse at sites WL1a, WL2, WM1 and WM1a and those sites did not support a harvestable population of larger cockles. The size frequency data indicated that the largest cohort of cockles was in the 15 to 25 mm size range (Figure 11). That pattern was most evident at sites WL1, WL3, EL1 and OPTL .

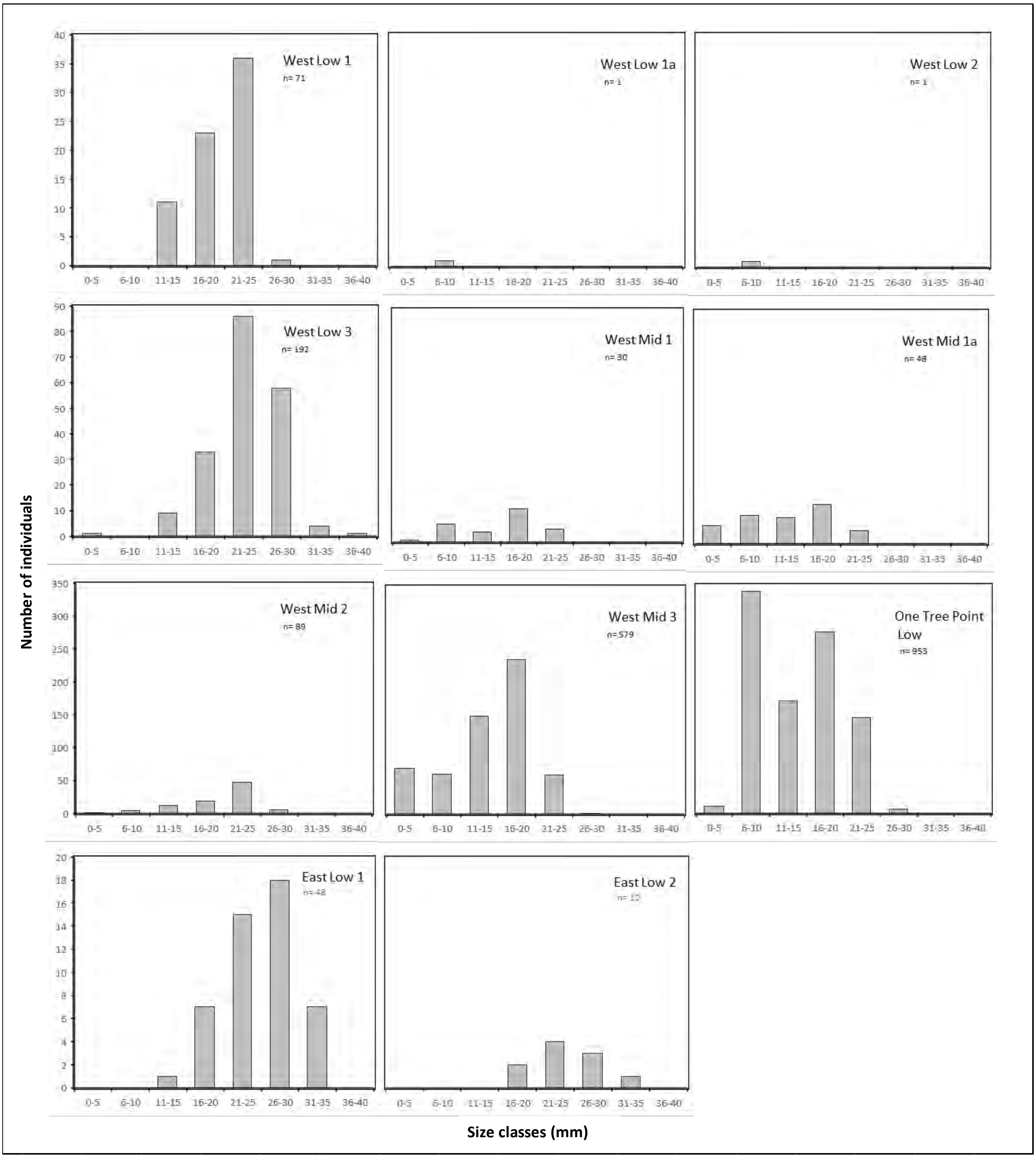


Figure 11: Size frequency of cockles sampled at each site.

Table 2: Harvestable cockle density at each site. Yellow shading denotes densities considered to be a 'harvestable population' (>25 per m²) or approaching harvestable size (>25mm)

	WL1	WL1a	WL2	WL3	WM1	WM1a	WM2	WM3	OTP	EL1	EL2
Mean no. per m^2 (>30 mm)	0	0	0	38	0	0	0	0	0	33	5
Mean no. per m^2 (>25 mm)	5	0	0	273	0	0	28	5	33	85	14

3.1.4.1 Comparison With 1997-2008 Data

Shellfish density and size frequency data obtained in the 2018 and 2020 surveys can be compared with data collected at equivalent locations over the period 1997 to 2008 (Appendix B) during which nine late summer surveys were undertaken by the same method (Poynter et al. 2008).

Figure 12 provides a comparison of results from the present survey with results from those previous cockle surveys.

Mean values for cockle densities at midshore sites WM2 and WM3 were within the range of values from previous surveys at similar midshore sites H and D reported by Poynter (2008). Cockle densities were comparatively high and were higher in 2020 than at any time since the 1998 pre-port survey which showed a similar value.

Although cockle densities in the low shore were generally low, sites WL3 and WL2 were within the range of values reported by Poynter (2008) at the comparable sites F and EZ (Figure 12). The 2020 value was higher than all results over 1999 to 2018 and was similar (sightly lower) than the 1998 value.

Cockle densities at the OTP site were considerably higher than reported densities between 1997 and 2008 at comparable site A. The 2020 density was also well above the 2018 OTP value. The high 2020 OTP density is in large part due to a very strong 6-10mm size class, likely reflecting a recent recruitment event but which was not observd at any other site. As noted, the situation at OTP is somewhat unclear as substrate conditions may have changed at this site due to the eelgrass expansion.

The generally low pipi densities found at the intertidal sites in 2020 (between 0 and 30 per m^2) were consistent with results from previous surveys. One sample with a higher pipi density was found at site WM1a (892 per m^2). WM1 also had relatively higher density in 2018 (mean of 78 per m^2). WM3 had similar densities in 2020 (94 per m^2). At Site A (equivalent to OTP in 2018 and 2020), pipis were found in high densities in 1997 (mean of 947 per m^2) and in 2008 (~1100 per m^2) but in all other years, pipi density was near zero.

Overall, cockles remain widely distributed but are generally small. Pipi have a limited presence on the shore and are small.

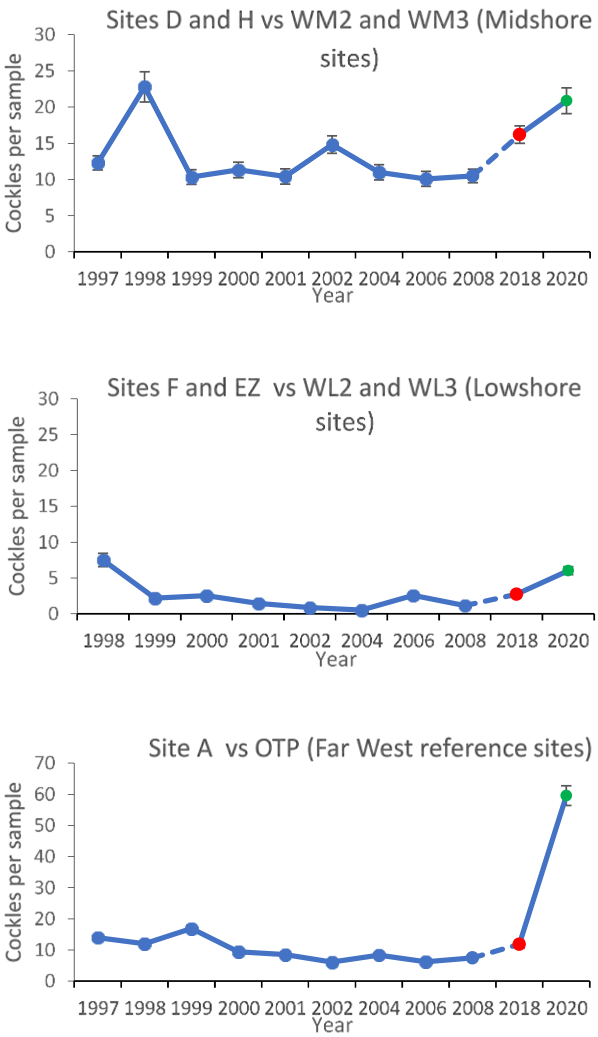


Figure 12: Mean cockle densities from previous surveys (blue markers connected by solid blue line) (Poynter et al. 2008), from a 2018 survey (red marker) and samples at equivalent locations in the present survey (green marker).

3.1.5 Comparison Between Sites

3.1.5.1 Similarity Between Sites

Non-metric multidimensional scaling and ordination plots (nMDS) were used to assess similarities (or differences) in community composition. nMDS assembles the data to reflect the order of least dissimilarity between sampling points (in this case replicates). Ordination effectively summarizes community data from which similar species and samples plot closer together, and dissimilar species and samples plot further apart. Data points that overlap between site clusters indicate that those individual core samples from one site are similar in species composition and representation, to results from the other sites. This ordination technique is used to describe relationships between species compositions and any intrinsic patterns that the data may have. It displays information in a visual manner that makes complex data easier to interpret. Statistical significance cannot be inferred from the plots but is discussed below (see section 3.1.5.2).

The ordination plots in Figure 13 below allow the relationships between replicates to be visualised in terms of clusters (sites), and dissimilarity between sites, for both the 2020 and 2018 data sets. The circles around the data cluster for each site represents a 95 percentile distribution. The bigger the circle, the more heterogeneous (dissimilar) the community for the site cluster.

2020 (a)   2018 (b)

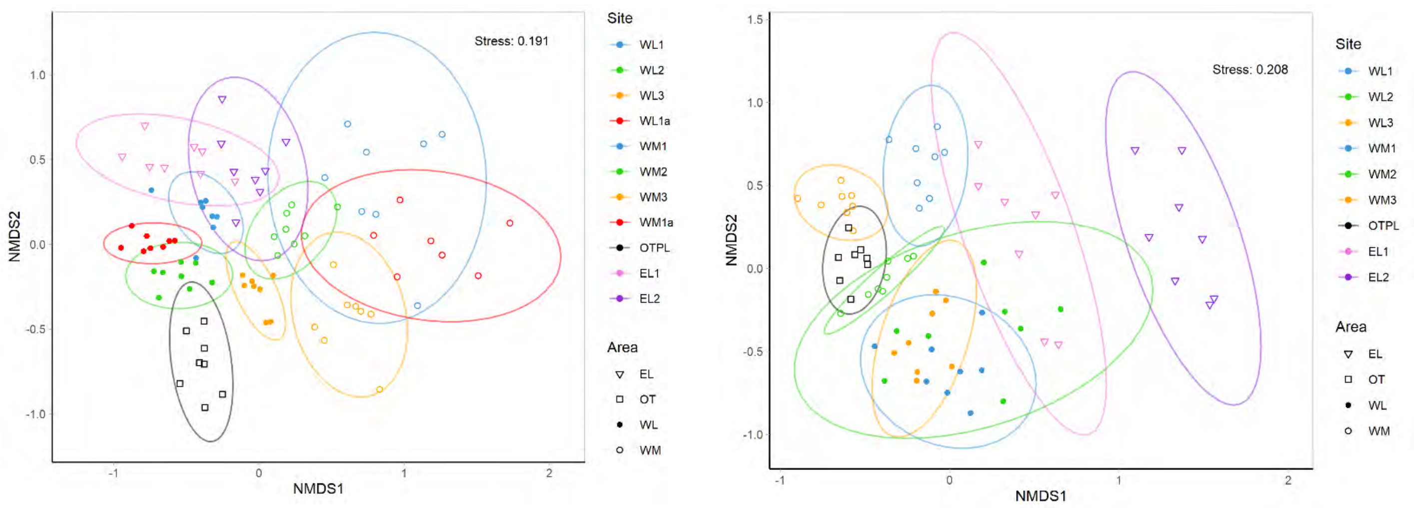


Figure 13: 2-dimensional ordination plots of benthic communities sampled at each site in 2020(a) and 2018(b).

<u>2018</u>

- At the western low tide sites, the data points are clustered closely around their centre points and there is a large amount of overlap between clusters. This suggests that overall, the benthic community composition at these three sites is similar.
- The eastern low tide sites are distinctly different from one another. Within each site the species found in each core sample are relatively different (wide spread) and the community can be considered heterogeneous. The EL1 cluster is closer to and overlaps the western sites indicating EL1 has a more similar community composition to those on the western side of the port than does EL2.
- The community within each of the western mid shore sites is relatively homogenous but the sites are distinctly different.
- The OTP site has a homogenous community composition as illustrated by the tight cluster of data points. Community composition at this site is more similar to the mid tide communities than the low tides communities.

<u>2020</u>

- The plot shows the community at each western low tide site is dissimilar (little overlap between circles) and the community in each site appears relatively homogeneous. There was more similarity between these sites in 2018 although the communities within each were similarly homogeneous.
- A different pattern was evident in 2020 for the eastern sites than in 2018. In 2020 these showed strong overlap with each other and generally with the communities surveyed at other sites. In 2018 the eastern sites were relative discrete and showed a relatively low degree of similarity with other sites.
- In 2020 the western mid shore sites showed a strongly overlapping community structure. The WM1 site showed a broader and more heterogeneous biota that in the previous sampling. The larger extent of the circle around the WM1 and WM1a samples suggests a more heterogenous community composition.
- The OTP site is more distinctly different from the other sites, but has a relatively homogenous community composition based on the smaller extent of the circle around the data points.

Overall, the ordination analysis suggests broad and overlapping distribution in similarity between many sites. There is general consistency with the expectation that sites at a particular level on the shore (ie mid shore or low shore) will tend to be more similar. Notwithstanding this, a permutational multivariate analysis of variance (Permanova) on the data confirms a statistically significant difference amongst the clusters (sites) ($F= 9.8915$, $R^2= 0.5575$, and $p=0.001$).

3.1.5.2 Statistical Comparison Among Reclamation and Other Sites

Western reclamation

Figure 14 presets a comparison between western reclamation sites (REC) and the remaining western sites, excluding OTLP (WEST) separately for the 2020 and 2018 years. PERMANOVA between groups was statistically significantly different for both years. However, the MDS plot does reveal some overlap in the points between the reclamation and western sites suggesting some commonality in benthic community composition. Note that 2020 includes additional sites to 2018 (WL1a and WM1a)

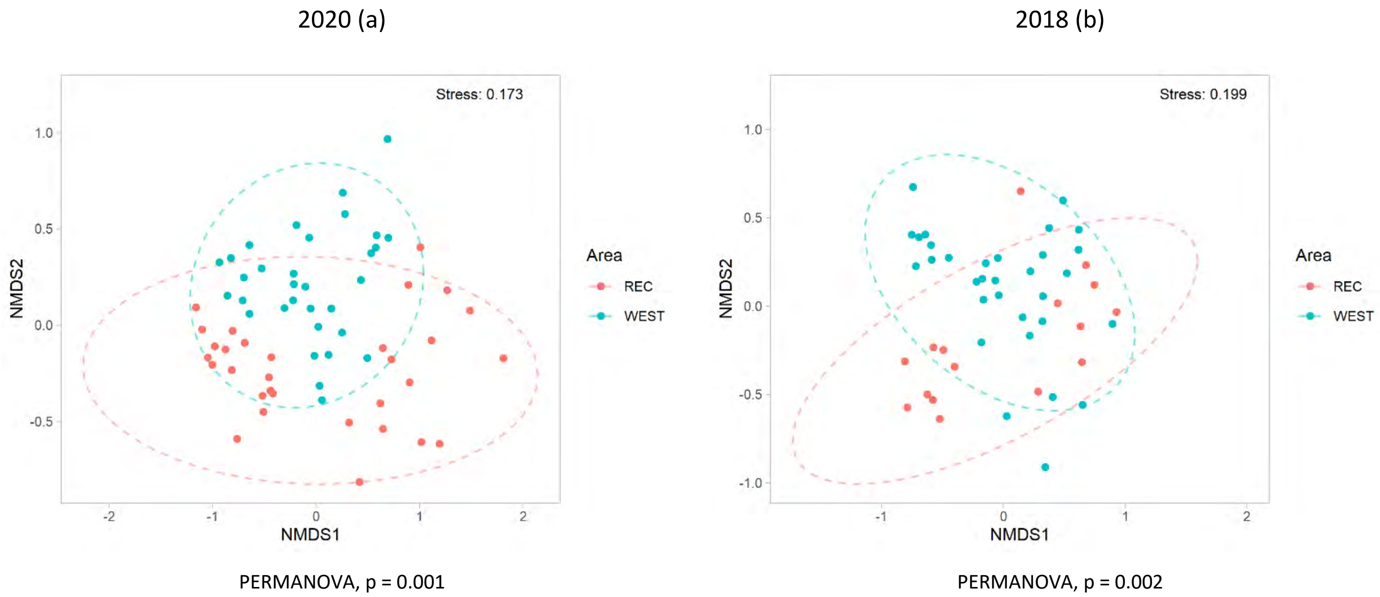
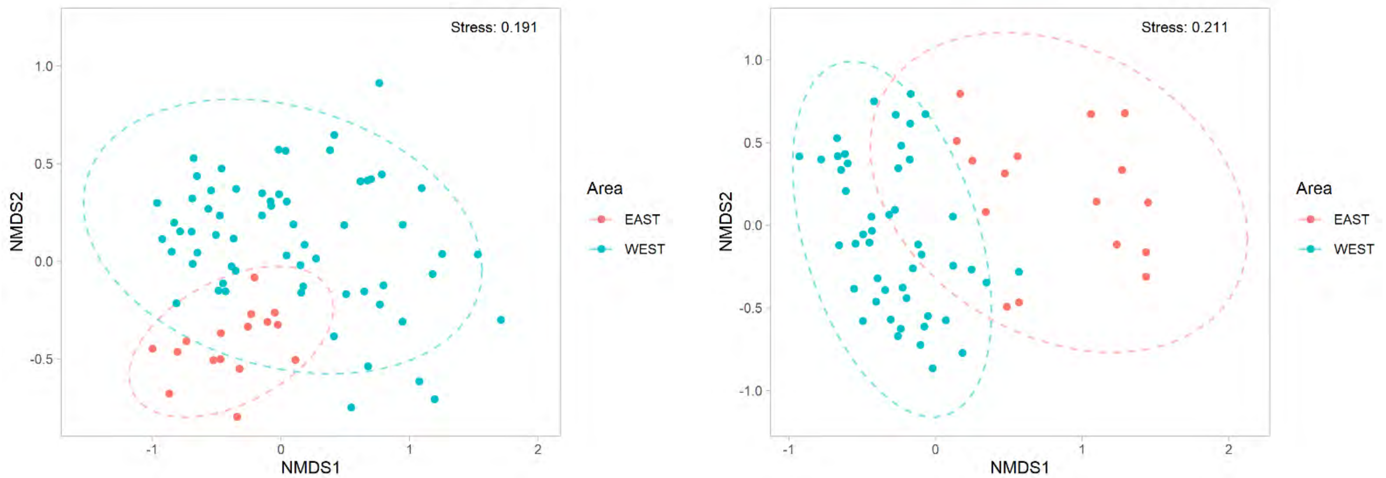


Figure 14: 2-dimensional ordination plots of benthic communities sampled in 2020 (a) and 2018 (b). Sites are grouped based on being located within the western reclamation zone (REC) or the western sampling sites outside of the reclamation zone (WEST).

Eastern Reclamation

Comparison between eastern reclamation sites (EAST) and all western sites, including those within the western reclamation (but excluding OTLP) separately for the 2020 and 2018 years is presented in (Figure 15). PERMANOVA between groups was statistically significantly different for both years. There is a relatively clear distinction between the points in the MDS plot for the 2018 data, however, there is some overlap in 2020, potentially due to some benthic community changes and the addition of the additional sampling sites, WL1a and WM1a in 2020.

2020 (a) 2018 (b)



PERMANOVA, p = 0.001 PERMANOVA, p = 0.001

Figure 15: 2-dimensional ordination plots of benthic communities sampled in 2020 (a) and 2018 (b). Sites are grouped based on being located within the eastern reclamation zone (EAST) or the western sampling sites within and outside of the reclamation zone (WEST).

<u>Overview</u>

The diversity data previously discussed showed a high percentage of the biota within the indicative reclamation areas is common to the broader tidal flat. Notwithstanding this and the degree of similarity as shown in the ordination plots, there are statistically significant differences in the community data for the reclamations compared to the other areas.

3.1.5.3 Note on Other Species Recorded

It is noted that incidental to the low shore 2020 sampling, several other species of interest were observed in the low shore, beyond the survey sites.

During the March 2020 survey there was a significant presence of the Comb starfish (*Astropecten polycanthus*) and the woolly or ragged seahare *Bursatella leachii* in the very low interidal shore. *Astropecten* feeds on detritus and small molluscs and invertebrates and while common, density at the survey appeared high. *Bursatella* is a common opisthobranch mollusc in the low shore and shallow subtidal soft shore habitats. It is herbivorous detritovore and typically grazes on microalgae such as diatom films but is also found in eelgrass beds. There were high numbers of *Bursatella* in the shore at the time of survey perhaps reflecting the availability of seasonal diatom ‘bloom’ that has been recorded on the shore.

An extensive presence of the invasive Asian date mussel (*Musculista senhousia*) was observed in parts of the low shore closer to the Blacksmiths Creek low tidal channel. This bivalve had formed extensive mats which appeared to have smothered and dominated the substrate in parts of the low shore.

4 DISCUSSION

4.1 Macroinvertebrates

The results confirm the high diversity and abundance and the biologically rich character of the intertidal flats.

Higher abundances and species richness were measured in 2020 than in 2018. This could in part be due to the extended period of the surveys in 2020. It is also likely due largely to natural variablility through time. An exception to this was at the OTP site, where lower abundances were measured. However, this is likely to reflect the presence of eelgrass at the site in 2020. There is no indication that (other than the OTP) substrate conditions have changed generally. At a local sampling scale, small shifts in the pattern of texture on the shore may also account for site specific changes in the associated community over time.

The intertidal faunal communities in 2020 were similar to those sampled in 2018. In both years the broad taxonomic group with the highest richness were polychaetes followed by crustaceans.

Overall abundance and richness in 2020 were higher at the western low shore sites and the eastern sites but lower at the western mid shore sites. At the background site OTP richness has slightly increased while abundance decreased.

Benthic communities within the reclamation footprints were generally similar to those outside. Most of the species present within the reclamation areas are found on the tidal flats to the west. Assuming this situation holds into the future, the potential loss of this habitat should not reduce biodiversity in the lower harbour.

There are statistically significant differences in the community data for the reclamation areas and the wider community but these differences do not reflect a lesser ecological value or that the benthic communities adjacent to the existing port terminal are, or are likely to be, any less diverse or abundant than those beyond.

4.2 Shellfish

Cockles were present at all sites at densities considered to be a 'bed' (>10 per m^2). Sites WL3 and EL1 supported a 'harvestable population' according to the definition in Pawley and Smith (2014) of cockles of sizes 30 mm or greater at a density of 25 per m^2 or more.

The OTP reference site held the greatest density of cockles (equivalent of ~4500 per m^2) and cockle densities were lowest (5 per m^2) at WL2. Excluding the OTP site, cockle densities were lower than the density (3304 per m^2) reported at a nearby site by Griffiths (2012). The sites west of the terminal were generally similar to densities of between 146 and 1509 cockles per m^2 reported in a survey of recreational beds in Northland, Auckland and Bay of Plenty conducted in 2011 (Pawley and Smith 2014).

Cockle size frequency data was generally similar in 2018 and 2020, except for the OTP site where a strong recruitment event is likely to have occurred . Lowshore sites showed a peak in abundance in the middle size classes (21-25 mm). Midshore sites showed a similar peak in small size classes. EL1 and EL2 showed abundance in the middle to larger size class (16-35mm) while cockles at OTP were most represented in the small to middle size classes (6-25mm).

Pipi densities at all sites except for WM1 and WM3 were low compared to densities reported by Griffiths (2012) who found high densities of juvenile pipis at a site near to OTP and a high density of larger pipis at a site near WM3. This latter record is consistent with an earlier finding (refer section 1.2.1.2 of this report). At site WM1, small pipis were found at a comparatively high density of 892 per m^2 and at site WM3 at a density of 94 per m^2. The low pipi abundance is consistent with the reduced population densities and distribution that have been a feature of the lower Whangarei Harbour in recent times. Overall, edible sized shellfish are sparse and have not been recorded within the indicative reclamation footprints in either survey.

5 CONCLUSIONS

5.1 Ecological Health

The biological health of the intertidal zones adjacent to the port appears to be good as indicated by the following 2020 macroinvertebrate survey findings:

- Faunal abundance and taxonomic richness were generally high and at most sites weresimilar or higher than reported for the 2018 survey;
- The macroinvertebrate biota was dominated by a predictable array of taxa which are common and widely reported to occur in predominantly clean sandy sediment harbour habitats;
- The habitat continues to be a mixture of coarse sandy and shelly substrate with noticeable finer texture in parts of the low shore and within the area close to the port on its western side.
- Most taxa, including those within the indicative western and eastern reclamation footprints, occur widely on the shore although distribution and abundance is variable;
- Cockles, were widely distributed and generally small. There were limited areas where edible sized cockles (>30mm) occurred at densities that constitute a 'harvestable bed' (>25/m^2). Harvestable beds did not occur in the substrates close to the port.
- In 2020, cockle densities were higher than recorded in similar parts of the shore surveyed nine times in the period 1997 to 2008, and were also higher than mean densities recorded in 2018.
- Pipi had a limited distribution and low abundance which included the mid shore on the on the western side close to the port, but all pipi were small.
- Although similar in structure, there are ststisticaly significant differences in the communities on different parts of the shore. These differences are likely to reflect natural spatial patterns, variations in substrate and settlement patterns.
- The ecological health of the benthic habitats and associated communities is high.

5.2 Influence of the Existing Port Terminal

- There is no evidence of a markedly different habitat or suppressed intertidal macroinvertebrate abundance or taxonomic richness, close to the Northport facility;
- The near ubiquitous presence of cockles and their similar or greater abundance compared to the the mean density values reported prior to the port development at the representative mid and low shore locations sampled in 2020, suggests cockle populations are not adversely influenced by the existing terminal.

5.3 Overall Conclusion

The results of this second comprehensive survey indicate that the abundance, biodiversity and ecological health of the intertidal habitat is and remains high.

The analysis, and the high proportion of taxa that are common to all sites, suggests that, while intrinsically variable in space and time at a local spatial scale, the community type reflects the intertidal flats at large as a single contiguous habitat type.

The nMDS and PERMANOVA analysis clarified the relationships between sites and showed a moderate level of similarity of community composition but also statistically significant differences between the communities within the reclamations compared to the wider tidal flat. There is no suggestion that the community close to the port is any less biodiverse, healthy or has a reduced ecological value.

Relative to the sites further away and the background site, there is no indication that existing terminal is having a negative shadow effect on the macrofaunal community abundance, biodiversity or ecological function, in the intertidal zone in the vicinity.

There may be edible shellfish beds or patches which are quite localised and which have not been identified.

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Appendix A:

Invertebrate macrofauna (>0.5 mm)

						OTPL								WL1								WL1a								WL2								WL3								WM1a							WM2								WM3								WM1								EL1								EL2							
General Group	Family	Genus	Taxa	Common Name	Feeding	149	150	155	156	161	162	167	168	5	6	11	12	17	18	23	24	29	30	35	36	41	42	47	48	101	102	107	108	113	114	119	120	125	126	131	132	137	138	143	144	Q1-05	Q1-06	Q2-5	Q3-5	Q3-6	Q$-5	Q4-6	53	54	59	60	65	66	71	72	77	78	83	84	89	90	95	96	Q1-5	Q1-6	Q2-5	Q2-6	Q3-5	Q3-6	Q4-5	Q4-6	173	174	179	180	185	186	191	192	197	198	203	204	209	210	215	216
Anthozoa			Anthozoa	Anemones									1	3	3	4		4	1		1								1			1	1																														1																					1	2		2						
Anthozoa	Actiniidae	Anthopleura	Anthopleura hermaphroditica								1																					1								5	6	4	3	7	12	6	3	2	2		1		2	3	3	1		4	3	5	5	3	60	6	29	46	28	49	26	21	7			5		2	6		15	7	3	19	1			2	26	6	56	100	89	43	77	56
Nemertea			Nemertea	Proboscis worms		1	2		2					2	5	2	1	3		1			1	2	1	2	3		1	2					5	1		2	1			1	1							1		12	1	2		3		2	7	1			1		3			3	1		1	6	8	3				1				1				1	2				2
Nematoda			Nematoda	Roundworm										1	7	3	1	2		1	1	25	3	1		1				1	3	1	5	2	1	6		3	17		2	3	1	5																																		1	3	13				3					3	2	1		
Gastropoda	Bullidae	Bulla	Bulla quoyii	Brown bubble shell			2						1																																																																																						
Gastropoda	Buccinidae	Cominella	Cominella adspersa	Whelk	Carnivore & scavenger																									1																																																														
Gastropoda	Buccinidae	Cominella	Cominella glandiformis	Mud Flat Whelk	Carnivore & scavenger																																																																	1			1																								
Gastropoda	Trochidae	Diloma	Diloma subrostratum		Microalgal & detrital grazer																																																													1																															
Gastropoda	Lottiidae	Notoacmea	Notoacmea sp.	Limpet	Microalgal & detrital grazer				1	2																																																							2				1		1	4																			1				1	1
Gastropoda	Nassariidae	Tritia	Tritia burchardi						1			1																										1	1		1																																																						
Gastropoda	Trochidae	Cantharidus	Cantharidus sp.																																																																																1														
Gastropoda	Trochidae	Zethalia	Zethalia zelandica	Sundial shell																																																																																								1	1						
Opisthobranchia			Opisthobranchia Unid.																																																															1																															
Opisthobranchia	Philinidae	Philine	Philine angasi	White slug																										1																																																													1	
Heterobranchia	Limapontiidae	Ercolania	Ercolania felina	Black slug																																																																																												1				
Bivalvia			Bivalvia indent.																																																																1											1																	1				
Bivalvia			Bivalvia Unid. (juv)																																																																																														1			
Bivalvia	Lasaeidae		Lasaeidae													1																																																																															
Bivalvia	Lasaeidae	Arthritica	Arthritica sp.	Small bivalve	Infaunal deposit feeder																																																																																		1												
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (0-5mm)	Cockle (0-5mm)	Infaunal deposit feeder									3	1			2	1																									1	2					2	1	1	1					2					2			1	1				1	1	1	2									2	2	4	1		2		
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (10-15mm)	Cockle (10-15mm)	Infaunal deposit feeder																																														2															1																			1		1				1	
Bivalvia	Veneridae	Dosinia	Dosinia sp. (juvenile)	Surf Clam	Infaunal suspension feeder																				1																																																																								
Bivalvia	Veneridae	Ruditapes	Ruditapes largillierti																																																																																										1					
Bivalvia	Nuculidae	Linucula	Linucula sp.	Nut Shell	Surface deposit & filter feeder	4	1	1	4	4	1	2	2		1				5		3						1	1	2	6	7	2	8	5	1	5	4	5	6	1	2		1	2	1	1	2								1						16		5	5	3	10	19	9			1		1		3		1	1		1	1							1		1			
Bivalvia	Lasaeidae	Myllita	Myllita vivens														3		2													1																						1	1																											1				5	1						1	
Bivalvia	Mesodesmatidae	Paphies	Paphies australis	Pipi	Filter feeder																																											1																												1																		
Bivalvia	Galeommatidae	Scintillona	Scintillona zelandica															1																																																																																
Bivalvia	Tellinidae	Serratina	Serratina charlottae		Infaunal suspension feeder	1						1						1																																							1							1																																
Bivalvia	Tellinidae		Tellinidae (juvenile)																																																																																												1						
Bivalvia	Ungulinidae	Zemysia	Zemysia zelandica															1				3	2		1		1		1		1															1																																							1												
Oligochaeta			Oligochaeta	Oligochaete worms	Infaunal deposit feeder	3	6			1					11		2		1	3	2	33	4	1	2			1	1	5	14	8	18	2	24	17	11	3	1			1																												2																				1			3	5	10	1	
Polychaeta:			Polychaeta indet.	Bristle worms																																																																																															1						
Polychaeta: Spionidae	Spionidae		Polydorid			2	1				1		1	32	64	63	17	4	18	3	21								27	13	8	2				2	2	20	59	14	1	1			1				1	1			17				1	6															30	40	61	3		14	3	1	2					2	15	15	67	5	27	8	
Polychaeta: Sphaerodoridae	Sphaerodoridae		Sphaerodoridae	Polychaete family																																					2																																																												
Polychaeta: Pectinariidae	Pectinariidae	Lagis	Lagis sp.																						1																																							1																					1											
Polychaeta:			Polychaete larvae	Bristle worms																																																																																																			3		
Polychaeta: Nereididae	Nereididae	Platynereis	Platynereis sp.	Rag worm																					2									1				2																																																											
Polychaeta:			Nereididae																			1							2	1								1									127	45	55	152	111																						4	7	2	10	1	3	8	12																
Polychaeta: Orbiniidae	Orbiniidae		Orbiniidae		Infaunal deposit feeder																															1			1		2	7	1	1		1	3																									1	2		1	1		2															1		
Polychaeta: Orbiniidae	Orbiniidae	Orbinia	Orbinia papillosa		Infaunal deposit feeder																											1																	2																																																	
Polychaeta: Orbiniidae	Orbiniidae	Scoloplos	Scoloplos sp.				1					2	1																2	4		2									3	2				4	2					2	10	3				1	1		1				2	3	1	2			6		1	1			3		1															
Polychaeta: Paraonidae	Paraonidae		Paraonidae		Infaunal deposit feeder				2			2													1																																																																													
Polychaeta: Paraonidae	Paraonidae	Aricidea	Aricidea sp.																					1																																																																											
Polychaeta: Spionidae	Spionidae		Spionidae		Surface deposit feeder																											3																																																															1						
Polychaeta: Spionidae	Spionidae	Aonides	Aonides sp.		Surface deposit feeder		1																							6			1									1		1																				6			7			25	1																								
Polychaeta: Spionidae	Spionidae	Paraprionospio	Paraprionospio sp.		Surface deposit feeder																																																																																													1	2				
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio aucklandica		Surface deposit feeder	21	38	6	29	3	19	27	15	28	46	31	7	14	12	5	5	11	3	1	3			8		67	26	3	9	2	30	12	7	5	50	29	1	33	42	63	14	2	26	1	6		3	8	4	7	8	29	25	3	6	16	66	9	42	44	2	60	139	67						5	2		1			2														
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio sp.		Surface deposit feeder	1	5	7		6	2	1		16	24	10	8	4	3	1		2	1	2				1	5	1	2	1	1	1		5	17	64	2	1	19		25		39	22	16	1			8	5	6	3	6	6	24	27	46	28	9	3	54	59	16	7	24	61	29	23	1	13	10	28	23	16	18	1	3	4	1	1		1			68	93	231	127	279	147
Polychaeta: Spionidae	Spionidae	Pseudopolydora	Pseudopolydora sp.		Surface deposit feeder	29	9	5	18	9		8	17	1	3	2	2		2	1	10	1	1	2	6	3	4	1	2	17	2	8	5		4				3	2	1		1	6	1								4	1	1			4			1																												2					1
Polychaeta: Spionidae	Spionidae	Spio	Spio sp.		Surface deposit & filter feeder							2		5	13	8	6	2	10	1	9	28	22	32	18	17	19	13	31	17	6	33	13	1	3	1	1	4	8	5		5	3	8	1								1			1		2																				13	4	2	1					6	19	22	68	14	2	11	8
Polychaeta: Magelonidae	Magelonidae	Magelona	Magelona sp.		Surface deposit feeder	3	6		2	6	1		1	1	5	2	1					4			10	3	1	6	2							1	1																																												2	2	1	3	1	3	4	1			2	2		1	
Polychaeta: Capitellidae	Capitellidae		Capitellidae		Infaunal deposit feeder											2							7	9	1	4	7	14		3		2			2	2		3			1					1													2				5																1															
Polychaeta: Capitellidae	Capitellidae	Capitella	Capitella sp.		Infaunal deposit feeder		1																							2	5	1	1	2	1												1					1									1			1	6									6																					
Polychaeta: Capitellidae	Capitellidae	Heteromastus	Heteromastus filiformis		Infaunal deposit feeder	12	17	6	2	1	7	3	6	1		1	1				1							2	2	3	1				2			4	2			3														1		1		1		1							1																1	1		1	3					2				
Polychaeta: Capitellidae	Capitellidae	Notomastus	Notomastus sp.		Infaunal deposit feeder																									2	3	4			2	1				2	2		7	1	5																																										1									
Polychaeta: Maldanidae	Maldanidae		Maldanidae	Bamboo worm	Infaunal deposit feeder	2		1	1	2			1										1	2	3	12	3	3	5				2	1	2	1																																	1											1					1	1		1						1	
Polychaeta: Opheliidae	Opheliidae	Armandia	Armandia maculata		Infaunal deposit feeder	1				1		1				2		1		2	7	2	1		2	1	2		3	3	1	1			2	3	6	4	2	1	1	5	1		1								1																																									4	1	3		1	
Polychaeta: Hesionidae	Hesionidae		Hesionidae		Carnivore and deposit feeder		1		1		1		2		1				1	1	1			2	1	1	2						1						1	2		1	1								1						1											1																					1						2		1	
Polychaeta: Syllidae	Syllidae		Exogoninae					2	1	3	2		1		7	5	6	4	1	12	3	7	108							14	9	12	5	18	22	12	10	23	9			1		1																																							12	4	14	6	6	12	7	6	3	1	1	4	5	9		2
Polychaeta: Syllidae	Syllidae		Syllidae		Omnivorous	1	1	4		1				28	34	22	37	17	60	61	35	120	50	35	52	82	78	42	32	11	19	7	7	22	29	18	30	12	26	32	2	1		4	7	1	1				1		6	12	33	37	7	27	6	8	3								4			1	1	1			64	36	55	54	45	19	30	29	29	29	22	32	29	9	9	8
Polychaeta: Nereididae	Nereididae		Nereididae (juvenile)		Omnivorous	1		1																					2			1	4	1	1	1	1	6	2	5		5	1						171	142	5	1	1		6	1	2	3	14	3	51	41	9			5											1	1							3	3	1		2	
Polychaeta: Nereididae	Nereididae	Ceratonereis	Ceratonereis sp.	Rag worm																																					4	1	5						3	1	3	11	28	15	10				1										2	3																								
Polychaeta: Nereididae	Nereididae	Neanthes	Neanthes cricognatha	Rag Worm	Omnivorous									1									1	1			1		2	1	1		1	2	3	1	1	1																																																	1				1	1
Polychaeta: Nereididae	Nereididae	Perinereis	Perinereis sp.		Omnivorous																																									2		1			1	2	2					1	1		4	1	5	17	2	5	6	11	4	5	2	2	4	1				1	10																
Polychaeta: Glyceridae	Glyceridae		Glyceridae		Infaunal carnivore & deposit feeder										1		1					1	1											1			1		1						1	1																																1		1											
Polychaeta: Goniadidae	Goniadidae		Goniadidae		Infaunal carnivore	2	2	2	1			1	1				1					3		2	5	6		5	3	2	7				1	3				1		1	1																																					4	4	1	1	1	3	1							
Polychaeta: Nephtyidae	Nephtyidae	Aglaophamus	Aglaophamus sp.		Infaunal carnivore		1	1																																																																																					1						
Polychaeta: Onuphidae	Onuphidae		Onuphidae		Omnivorous								2																																																																																														
Polychaeta: Eunicidae	Eunicidae		Eunicidae		Facultative carnivore							3																																																																																																
Polychaeta: Eunicidae	Eunicidae	Lysidice	Lysidice sp.		Facultative carnivore		1																																																																																																
Polychaeta: Lumbrineridae	Lumbrineridae		Lumbrineridae		Infaunal carnivore & deposit feeder																																																																																																	
Polychaeta: Dorvilleidae	Dorvilleidae		Dorvilleidae		Facultative carnivore							2	3			1													2			1						1																																													2						1								
Polychaeta: Cirratulidae	Cirratulidae		Cirratulidae		Deposit feeder	2	2	3	3	4	12	4	1	3		7		2	2	6	15	4	3	12	18	13	17	23	15	1	2	1	1	7	3	14	15	25	24	23	13	21	18	29	11								1		3	1	1	4		2			1	2	2		1						1			1	1		3	3		1		3	1	12	7	7		3	2
Polychaeta: Terebellidae	Terebellidae		Terebellidae		Infaunal deposit feeder					1	3	4	3																																																																																											
Polychaeta: Sabellidae	Sabellidae	Euchone	Euchone sp.		Infaunal suspension feeder		1									2									1	4	1		2	1		3					3	1																					1		1																					2								3		1				
Polychaeta: Sabellidae	Sabellidae		Sabellidae	Umbrella worms	Infaunal suspension feeder						2	1	1								1			1				6	4								1																																													1			1		2	2		1		1	
Crustacea	Nebaliacea		Nebaliacea	Small crustacean	Epifaunal deposit feeder							2																																																																																																
Crustacea	Tanaidae		Tanaidacea	Tanaid shrimp			1								3			10	152	3	2	177	138	29	50	75	68	109	99	18	70	5	31	170	79	90	166		1														2	1																					1			1								1		1		1			
Mysidacea			Mysida																				7	4			1	1				1																																																																		
Cumacea			Cumacea	Cumaceans	Infaunal filter or deposit feeder				1					2	1	5		1	4	3		3	1	2	3	1	3		2				1		1	1		45	15	127	60	31	82	13	48		2		2		2		8	38	11	48	86	47	41	22	6	2	4	1	12	7	14	4	11	9	6	6	1		1	2	23	23	11	9	1		1		11	12	13	9	24	19	175	131
Isopoda	Anthuridae	Anthuridae	Anthuridae	Isopod	Epifaunal scavenger																	1																																																													1										
Isopoda	Sphaeromatidae	Exosphaeroma	Exosphaeroma chilense																																					1							1	6		3														1			1		3										1									1		1	3		
Amphipoda	Atylidae		Atylidae			31	12	3	91	51	71	48	26		2	1		1	1		1			6	3		4	1					1	4	3	36	11	8	7	24	10	4	10	5	3										1	1		3				1				1	2																									2		1	
Amphipoda	Caprellidae		Caprellidae	Skeleton shrimp												6	2			1			1		2																																																																											
Amphipoda	Corophiidae		Corophiidae	Amphipod (family)											2		5																																			1	1	23		2																																									1		
Amphipoda	Haustoriidae		Haustoriidae	Amphipod (family)																				1																																																																							2	2						
Amphipoda	Lysianassidae		Lysianassidae	Amphipods	Epifaunal scavenger																	1																	2																			1			15	2	18	18	19	40	28	22	1																						
Amphipoda	Oedicerotidae		Oedicerotidae	Amphipods												1							3		2	3		2	1																																																																				
Amphipoda	Photidae		Photidae																									1																												1																																								
Amphipoda	Phoxocephalidae		Phoxocephalidae	Amphipod (family)		1	3	3					2								3	1		1	2	2	2	2	1	1			3		2	4	5	33	10	27	23	4	13	1	3						1		1	2	1	2		5	2	1	1		1	1	5	7	10	4	3				2	1													1		2	1	12	10
Amphipoda	Phoxocephalidae	Waitangi	Waitangi brevirostris						1		3	4	1																									8	1	4	1	1	1	5																																																				
Amphipoda			Amphipoda indet.	Amphipods			1		2							1						1	2		2	2	2			1				1			1	1	2		2					1								1		3												1					1			1							1	1					1		2			
Decapoda	Varunidae	Austrohelice	Austrohelice crassa	Tunnelling Mud Crab	Deposit feeder & scavenger																													1																																																																	
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus sp.	Pill-box Crab	Eats small organisms & some weed											1										2																																																																										
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus varius	Pill-box Crab	Eats small organisms & some weed	1		2	1		1		2								1		1			1						1																																																																			
Decapoda	Diogenidae		Diogenidae	Left-handed Hermit Crab																																																																																		1															
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus sp. (juvenile)	Pill-box Crab	Eats small organisms & some weed																																																																																														1	2	
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus whitei	Pill-box Crab	Eats small organisms & some weed																																																																													2													1			
Decapoda	Macrophthalmidae	Hemiplax	Hemiplax hirtipes	Stalk-eyed Mud Crab	Deposit feeder & scavenger																			1																																											1																											
Decapoda	Crangonidae	Philocheras	Philocheras australis	Sand Shrimp		1							1				1					3	1	1		1	2		2		1	1					1																																																												
Decapoda			Decapoda ident.	Decapoda																						1																																																																						
Ostracoda	Cylindroleberididae	Diasterope	Diasterope grisea	Ostracod	Omnivorous scavenger			1						2		6		3	1		2	2	2	2	4	2		1	1		17	1		3	2	1	2																																																															
Ostracoda	Sarsielloidea	Euphilomedes	Euphilomedes sp.																												1			2			2	2																						2		1	1			2																									
Ostracoda	Cylindroleberididae	Parasterope	Parasterope quadrata	Ostracod	Omnivorous scavenger													1			3	1				2		1																																																																					
Ostracoda	Philomedidae	Scleroconcha	Scleroconcha sp.	Ostracod	Omnivorous scavenger									5	14	15	5		4															3	2	2	5																																																														
Ostracoda			Ostracoda	Ostracod	Omnivorous scavenger									2	16	2	3				2	10	14	17	6	6	2	3	3		2						1		3			1	1														1		1																					12	5	5	39	8	15	7	9	4	4	16	29	17	10	5	10
Copepoda			Copepoda	Copepods																																						1																1																																							
Cirripedia	Balanidae	Austrominius	Austrominius modestus	Estuarine Barnacle	Filter feeder																																																																																			1									1				1	6
Insecta			Insecta	Insects																																																																																													1					
Phoronida			Phoronida	Horseshoe worm																										3								1																																												1	6	3	1	1	1	1	1				1				1
Hemichordata			Hemichordata			1	1							5	7	4	4	5	2	4	5	1		3	1	4	8	4	1	1	4	2	2	1	4	2	2																		2	5	2	1	10		1	1				1		1												1	3	1	1	3	4		2	1	3	1	2	2	1	1	1
Holothuroidea	Chiridotidae	Taeniogyrus	Taeniogyrus dendyi	Sea cucumber	Epifaunal deposit feeder													2																																																																																		
Osteichthyes	Gobiidae		Gobiidae			1																																																																										1																			
			Count: No of Individuals			122	119	47	166	94	125	120	90	143	276	211	115	69	302	100	140	567	262	169	210	246	236	247	274	197	226	89	135	257	220	249	323	270	261	315	156	127	229	156	147	164	98	69	176	168	220	174	72	73	76	138	166	148	115	99	229	31	214	242	115	195	305	202	76	46	13	74	66	113	57	44	182	102	124	152	78	59	61	67	97	105	255	434	450	270	597	387
			Count: No of Taxa			22	26	16	19	15	14	21	21	19	26	27	24	16	22	17	25	31	20	31	28	25	21	28	31	26	32	21	24	22	26	30	29	25	28	25	20	20	22	18	21	10	11	7	8	6	14	8	15	15	15	15	16	16	12	14	21	11	13	16	17	14	20	13	14	6	7	10	12	12	13	6	19	16	19	20	16	13	14	14	19	18	29	23	25	18	25	16

Appendix B:

Map of 1997 – 2002 Sampling Sites from Marsden Point Deepwater Port Marine Intertidal Benthos Sampling 1997 – 2002 Summary Baseline Report

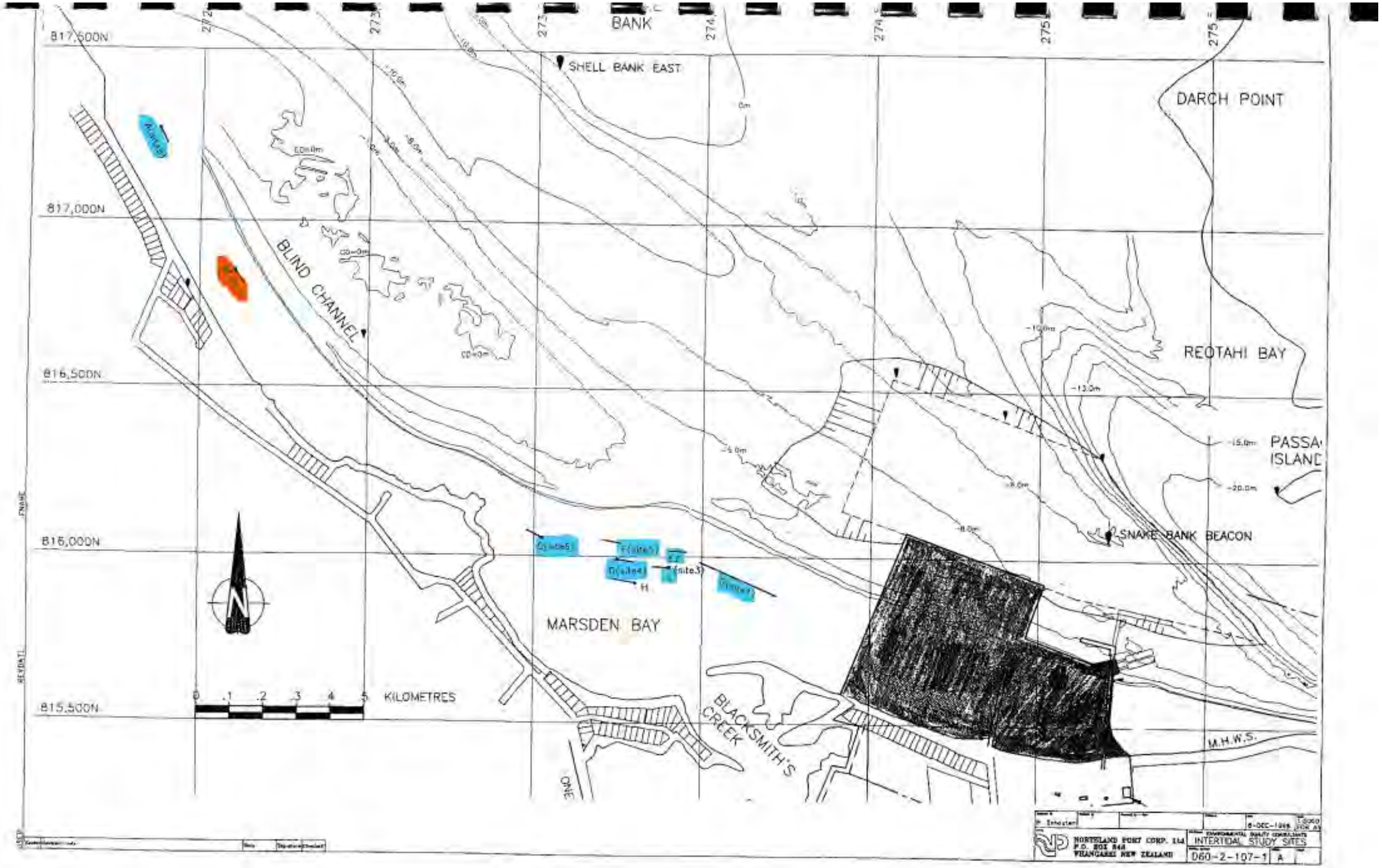

FIGURE 1: Intertidal Benthic Monitoring Transect Locations

*Sites marked in blue continued, sites marked in red discontinued.

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Northport Subtidal Survey
Vision for Growth Project

For Northport

Proposed Western Dredging-Subtidal Ecology Report

July 2021

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

1.1 Project scope

Northport, situated at Marsden Point near the entrance to the Whangarei Harbour, is New Zealand's northernmost deep-water port. Established in 2002 the port terminal includes a reclamation covering approximately 32 ha which projects across tidal flats to the deepwater harbour channel.

In 2019, 4Sight Consulting Ltd (4Sight) undertook a subtidal survey of the seabed within the proposed area to be dredged as part of the Northport Vision For Growth (VFG) port expansion (4Sight, August 2020), as it was then conceived. At the time it was not apparent that there would be dredging to the west of the proposed western reclamation. Subsequently a further survey was conducted in 2021 to the west of the proposed western reclamation. This area is shown in Figure 1.

1.2 Ecological setting

The Whangarei Harbour is a large (100 km2) estuarine system consisting of a drowned river system (upper harbour) and a barrier-enclosed lagoon (lower harbour). This system is connected to the open ocean via an approximately 2.4 km wide opening located between Marsden Point and Home Point on the north-eastern coast of New Zealand (Griffiths, 2012; Swales et al. 2013). The Harbour has been subjected to significant anthropogenic impacts including land reclamation, the deposition of 3 million cubic metres of sediment fines and 2 million cubic metres of channel dredge spoil since the 1920's and runoff from urban, industrial and rural sources (Morrison, 2005). Despite these impacts there is still a wide range of habitats, including deep-water channels, intertidal flats, mangroves, and saltmarsh (Morrison, 2005). Associated with these habitats is a rich diversity of marine life, from benthic invertebrates to estuarine and coastal fishes (Brook, 2002, Morrison, 2005). The harbour is also recognised for its importance for many internationally and New Zealand migratory bird species, and resident species (Morrison, 2005).

2 METHODS

The survey was undertaken on 19 February 2021.

12 samples were collected to assess community structure within this area; four from each of three transects identified as Inner, Mid and Outer shore (Figure 2).

Sampling was undertaken from a Northport vessel using a quantitative standard ponar grab sampler (volume 8.2L) with a surface area sampled of up to 529 cm^2. Each sample was sorted through a 0.5mm mesh sock sieve and the contents transferred to containers and preserved in 80% ethanol in seawater.

In a wet lab, each sample was subsequently stained with Rose Bengal dye to facilitate identification of biota. Biota was extracted by a 4Sight technician and preserved in 70% ethanol in freshwater. Samples were sent to Cawthron Institute for taxonomic processing of biota to the lowest practicable taxonomic level.

Three sediment samples were collected and archived in case grainsize analysis would be required. Each sediment sample is a composite collected from a subsample along each transect.

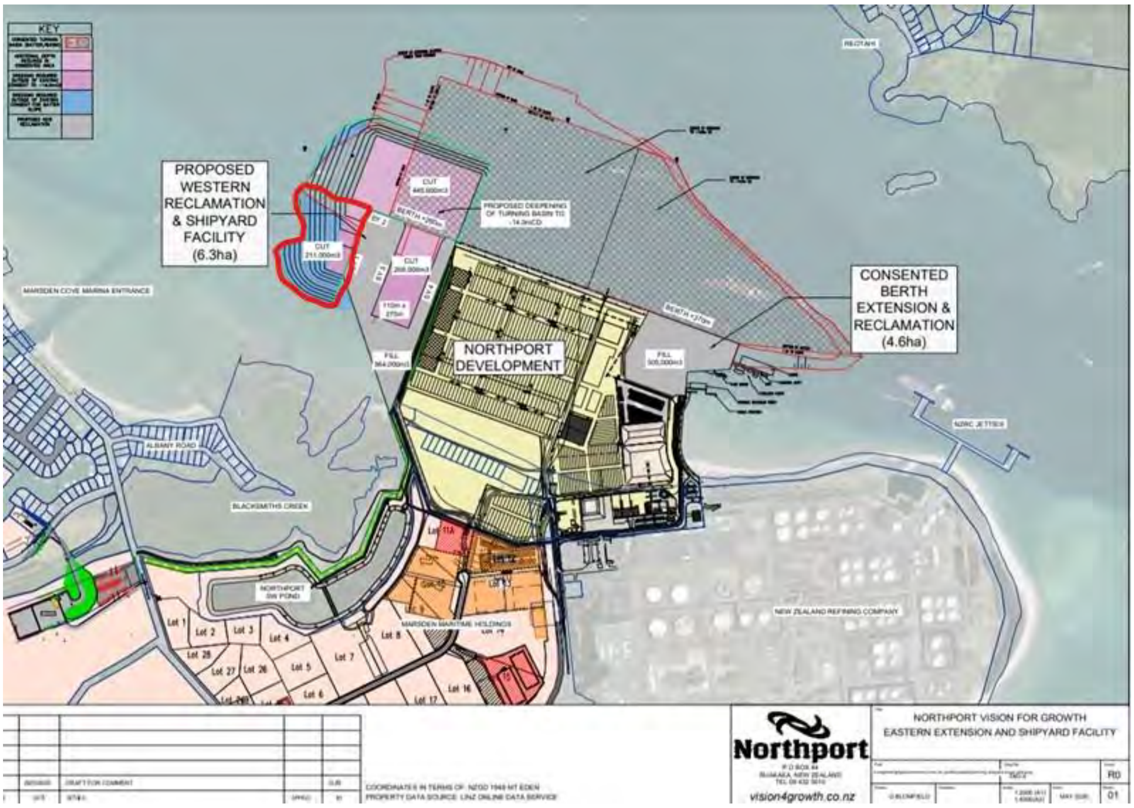

Figure 1: Existing port terminal and proposed western reclamation area. Subtidal Survey are marked in red.

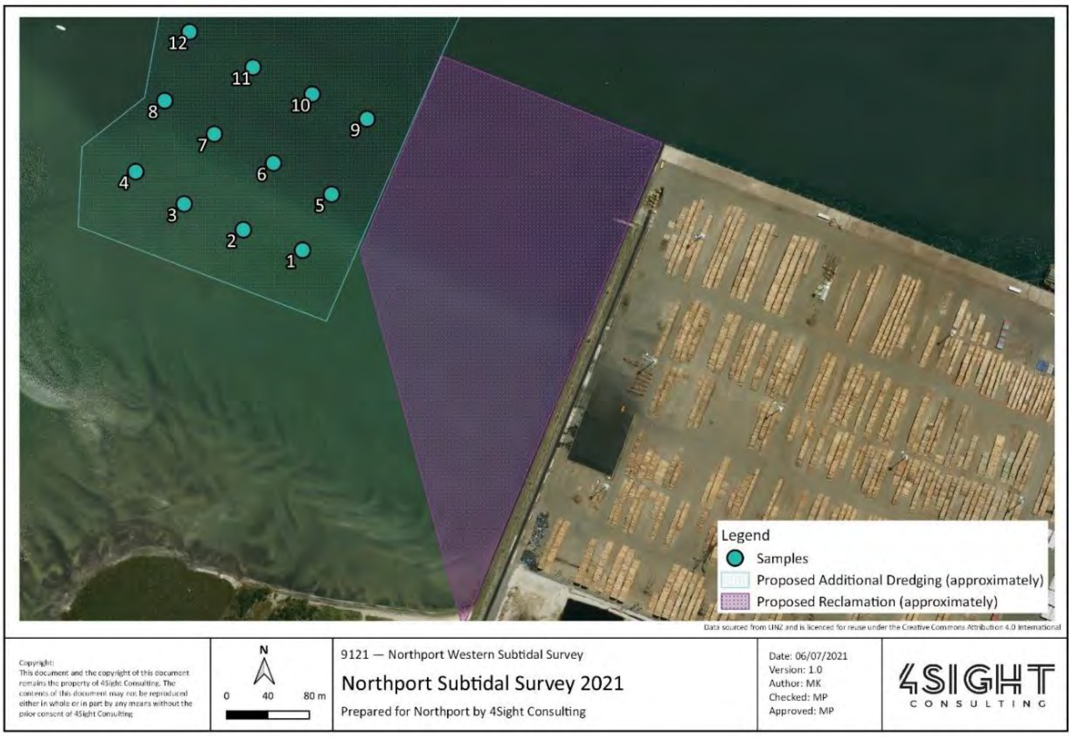

Figure 2: Sampling sites laid over proposed additional dredging area (blue), adjacent to proposed reclamation area (purple); (polygons roughly based on map supplied by Northport).

3 RESULTS

3.1 Biota

A total of 4275 organisms from 100 different taxa were identified in the macrofaunal samples (Appendix A:). Polychaetes were the most diverse (number of different species within that group) and by far the most abundant group (number of individual counts) (Figure 3). Tanaid shrimps, which are part of the general group of crustaceans, were the second most abundant taxa, while Bivalves were the second most diverse group. The mean richness per sample was 38 taxa and the mean abundance was 356 individuals per sample.

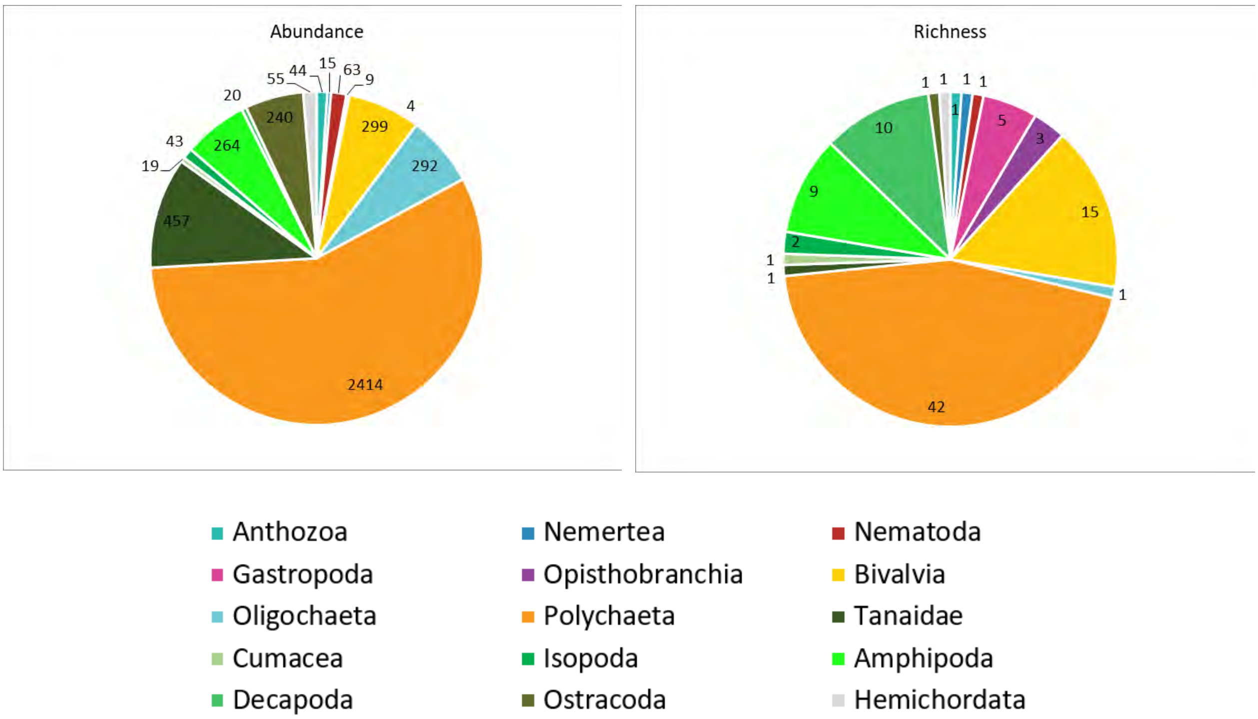

Figure 3: Pie charts showing total abundance and richness within the top 15 broad taxonomic groups (groups in green shading can be combined into the broad taxonomic group of crustaceans).

A broad breakdown of the composition of the community at each transect is shown in Figure 4.

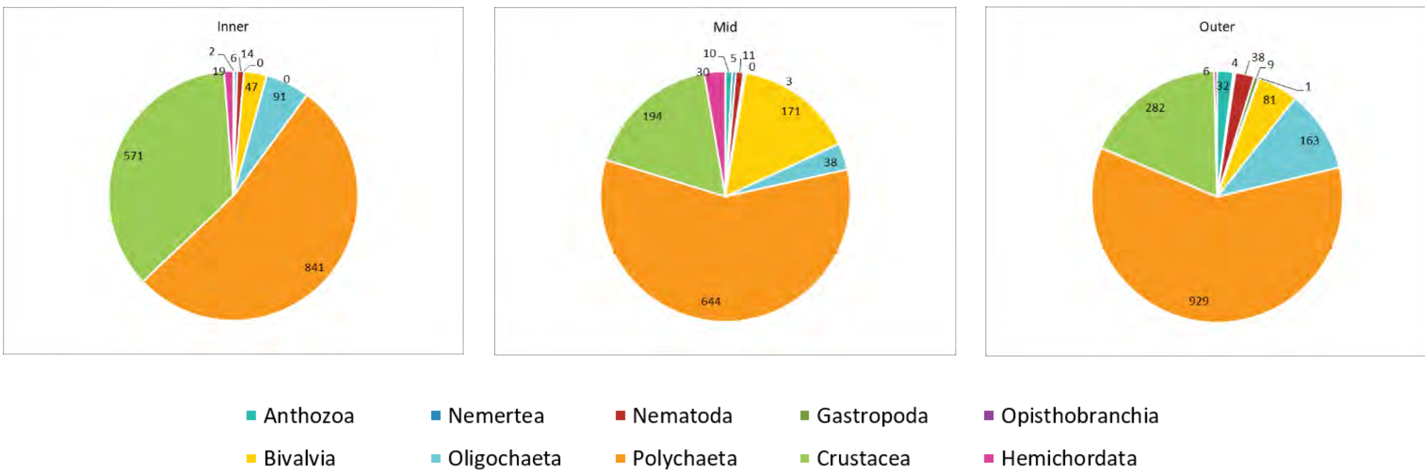

Figure 4: Pie charts showing the abundance of each taxonomic class of invertebrates at Inner, Mid and Outer transect.

Overall, the most commonly sampled taxa were polychaetes predominantly represented by the families Spionidae, Syllidae and Sabellidae. Crustaceans were overall the second most abundant group with Tanaid shrimps mostly represented at the inner transect. Bivalves at the mid transect were dominated by *Linucula sp.* (nut shell).

It is also noted that the Inner Transect sites were in the shallow subtidal zone. These recorded a few small cockles and only one small pipi.

Figure 5 shows the taxonomic richness (mean number of taxa), abundance (mean number of individuals) and Shannon-Wiener Diversity Index for each transect.

- Abundance was variable and mean abundance was not significantly different between transects.
- Mean species richness increased from the Inner, to the Outer transect but was also variable within sites.
- The Shannon-Wiener Diversity Index across all transects is high: 2.9 at the Mid and Outer transects and 2.4 at the Inner transect.

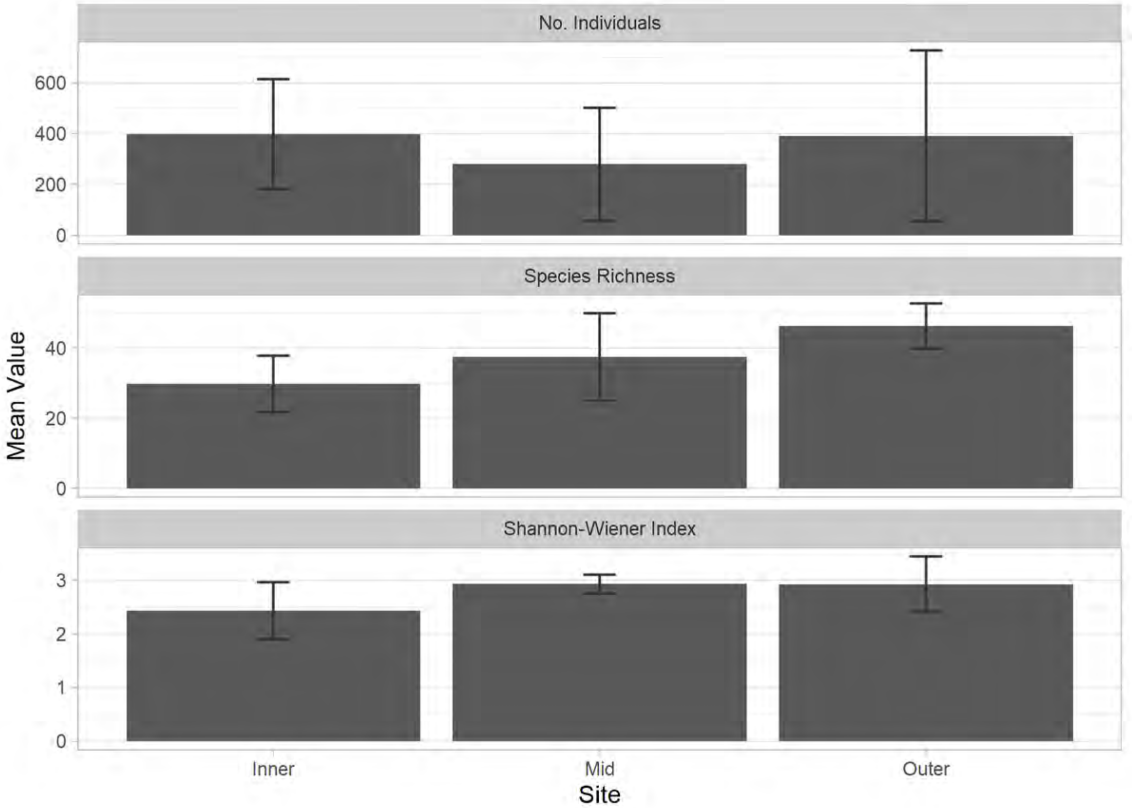

Figure 5: Mean abundance, richness and Shannon-Wiener Index per transect (incl. 95% CI bars).

The non-metric multidimensional scaling and ordination plot (nMDS) in Figure 6 shows the similarities and differences in community composition between the three transects. Each cluster represents one transect and the circle around the data cluster represents a 95-percentile distribution. The larger the circle, the more heterogeneous (dissimilar) the community for the transect.

The Inner and Outer transect are similarly homogenous and distinctly different in community composition. The Mid transect is more heterogenous and, as would be expected, overlaps with both the Inner and Outer transect in terms of community composition.

Overall, the data suggests a changing community with increasing depth.

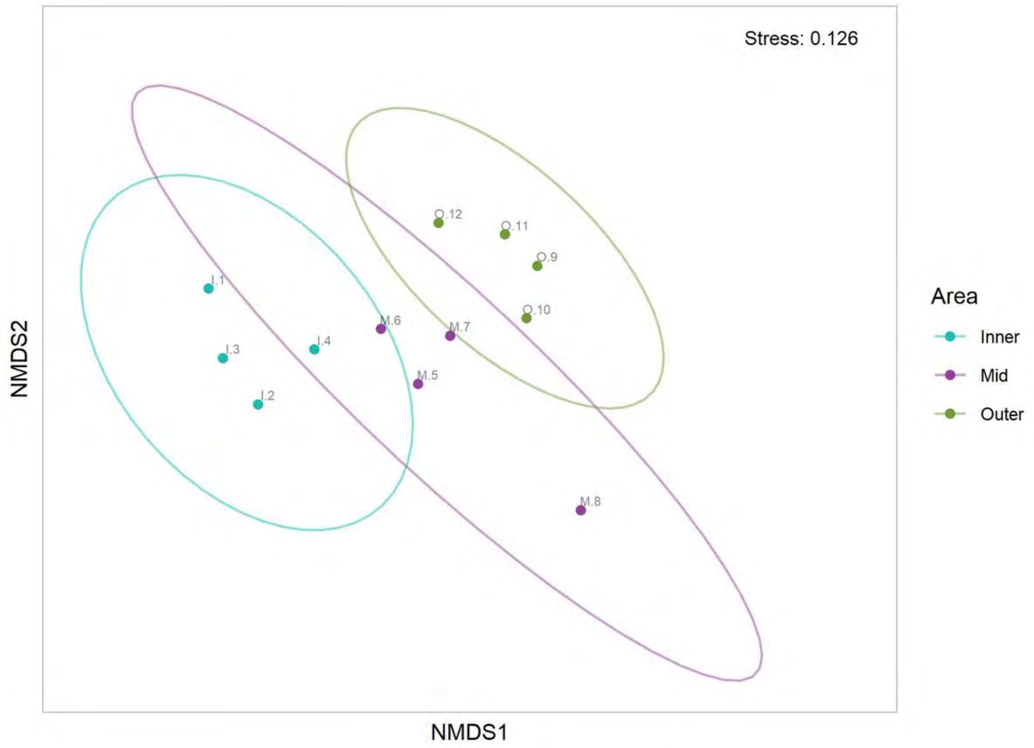

Figure 6: nMDS ordination plot of benthic communities.

3.2 Substrate Texture

Although the sediment samples collected during the survey have not been formally analysed for grain size fraction, sediment type was recorded at the time of sampling. Those observations confirm that samples were sandy with no shell armouring. Often the sand surface was made relatively cohesive by meadows of protruding tube dwelling polychaetes which constituted a dense biomass within the sediment. At the Outer sites there was shell debris within the sand matrix. Representative photos of the sample types and above features are shown in Appendix B:.

4 DISCUSSION

Overall, the apparent wide faunal diversity and abundance of biota suggest a healthy and productive community.

The dominant taxa appear to be common species of polychaetes and crustaceans (particularly decapods and amphipods). The balance of the community is diverse and is comprised of taxa which occur rather patchily and at low density.

All abundance data for individual transects, and mean data, can be multiplied by a factor of 24 (based on a Ponar sampling area of 530cm^2 and a grab efficiency of 80% equates to an effective sampling area of 423cm^2) to express the data as a density per square metre of substrate. On this basis abundance per site ranged from 1750 to 16,500 per m^2, the highest density being recorded at an Outer site where the sabellid polychaete *Euchone* sp recorded over 6700 per m^2 and where biodiversity was also greatest (51 taxa).

Overall mean abundance translates to in the order of 9500 individuals per m^2 at the Inner and Outer Sites and 6700 per m^2 at the mid site.

4.1 Comparison with 2019 Survey

The community abundance and richness of the 2021 survey can be compared with the findings of the shallow littoral to channel edge sampling that was undertaken in the 2019 survey. For reference, those sampling sites are shown in Figure 7 below.

Figure 7: Benthic biota sampling locations overlain on the proposed Vision For Growth western reclamation (green highlight), capital dredging footprint (inner and outer areas), northern channel area (blue highlight) and eastern baseline sites. (Source-4Sight, August 2020)

Although the 2019 sampling included a slightly greater depth range in the West ('W') and East ('E') series of samples, abundance and richness were very similar to that recorded for the additional proposed dredging area investigated in the 2021 survey. Comparative statistics are reviewed in Figure 8.

The ordination plot (nMDS) in Figure 9 allows the relationship between replicates to be visualised in terms of clusters (sites), and dissimilarities between sites and years for the areas surveyed in 2019 and 2021. The 2021 data suggests a community more homogeneous and discrete than those characterised in 2019.

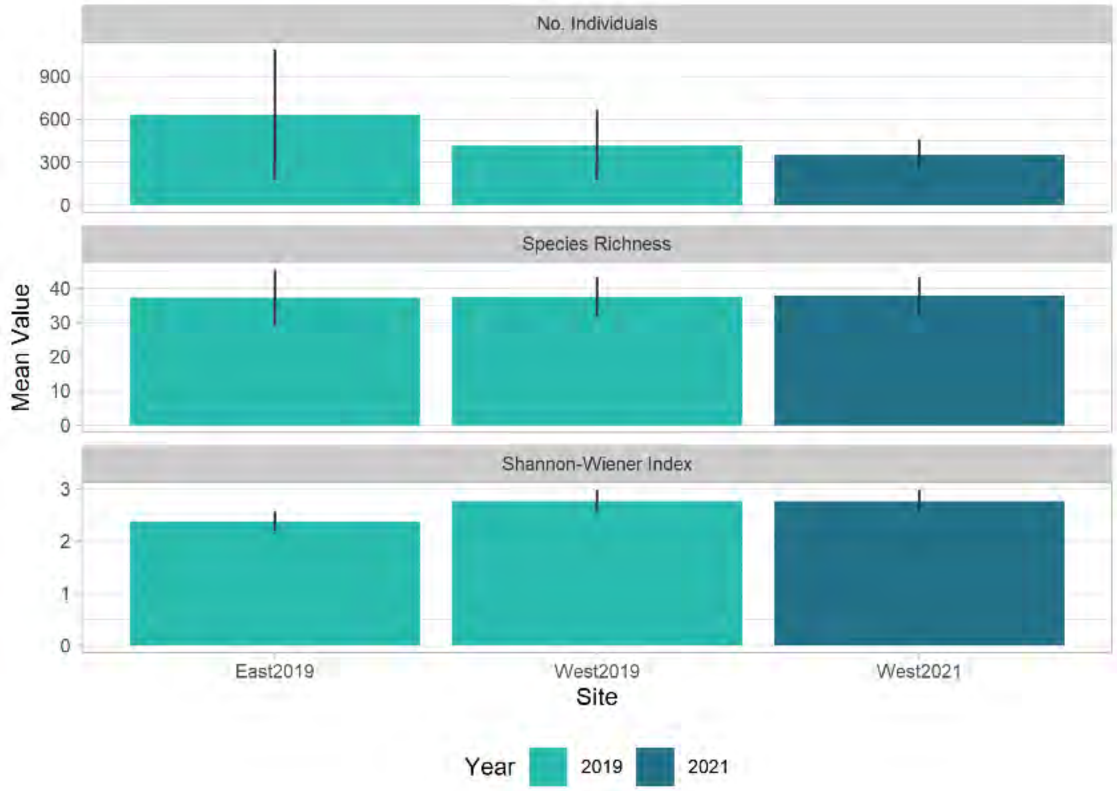

Figure 8: Comparison of mean abundance, richness and Shannon-Wiener Diversity Index of the 2019 and 2021 surveys.

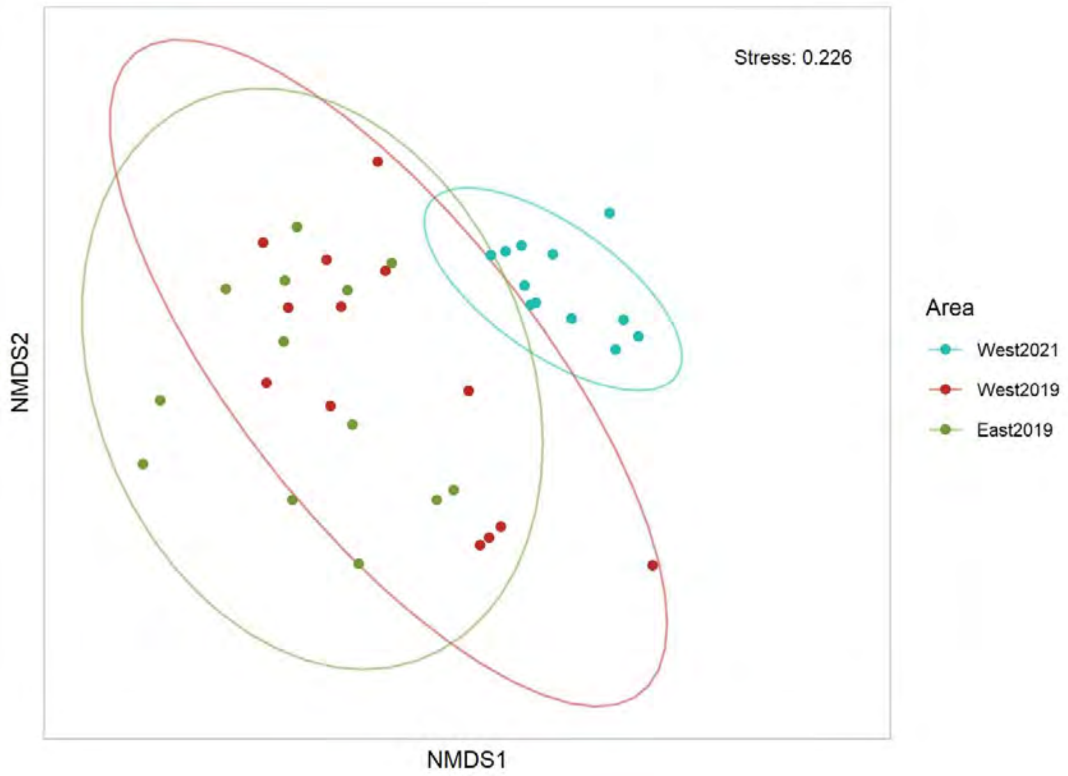

Figure 9: nMDS ordination plot comparing communities of the Eastern and Western reclamation area from 2019 survey to Western additional dredging area from 2021 survey.

4.2 Comparison with other studies

Refining NZ

The total of 100 taxa, the average richness of 37.8 and Shannon-Wiener Diversity Index score of 2.76 in this study, can be compared with a RNZ study which investigated areas further towards the harbour entrance (Bioresearches, 2016). The RNZ assessment used the same benthic fauna sampling techniques in areas just to the east of that investigated in this study.

The RNZ study reported an average number of taxa of 29.8 per sample and an average Shannon-Wiener Diversity Index score of 2.71.

Northland Regional Council

In 2012 Northland Regional Council (NRC) undertook an estuary monitoring programme of the Whangarei Harbour (Griffiths, 2012) that included sampling subtidal benthic fauna using a 150mm x 150mm core sampler. Two of the thirteen sampled sites (Snake Bank and Manganese Point) to the west of the port were broadly similar environments to those sampled by 4Sight near the port. While the methods for sampling were different between studies, the volumes collected per sample are similar and the results are broadly comparable.

The average number of taxa at these sites was 20.0 per sample and the average number of individuals was 136 per sample. The Shannon-Weiner Diversity Index was 2.2.

These metrics are below the values recorded in the 4Sight 2021 study, that is, the benthic communities identified in the NRC study were less abundant, rich, and diverse.

5 CONCLUSION

The 2021 subtidal survey recorded a diverse and abundant seabed community. Although diversity tended to increase from the Inner (shallower) to Outer (deeper) transects, and the communities were somewhat different, overall the community was relatively homogenous.

2021 results were comparable with and support the findings of the earlier 2019 surveys of the shallow sublittoral and channel edge environment in this vicinity. These environments are biodiverse and hold a high biomass of invertebrates. Community composition appears to be taxa that are common and probably widely represented in similar habitats in the harbour. It is noted that other than a few small cockles and one pipi at the Inner transect, no beds of edible shellfish were located. Also, no subtidal seagrass was recorded.

Substrate type in the 2021 survey was sandy. Often the sand surface was made relatively cohesive by meadows of protruding tube dwelling polychaetes. No shell-armoured habitat was encountered.

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Appendix A:

Invertebrate macrofauna (>0.5mm)

GenGroup	Family	Genus	Taxa	Common Name	Feeding	I.1	I.2	I.3	I.4	M.5	M.6	M.7	M.8	O.9	O.10	O.11	O.12
Anthozoa			Anthozoa	Anemones		1			1	1	1	5	3	4	11	4	13
Nemertea			Nemertea	Proboscis worms				2	4	2	2	1				2	2
Nematoda			Nematoda	Roundworm		6	7		1	3		3	5	3	25	2	8
Gastropoda			Gastropoda indeterminable	Snails													1
Gastropoda			Heterobranchia	slug											1		
Gastropoda	Turritellidae		Turritellidae	screw shells													1
Gastropoda	Lottiidae	Notoacmea	Notoacmea spp.	Limpet	Microalgal & detrital grazer										1		
Gastropoda	Calyptraeidae	Sigapatella	Sigapatella tenuis	Small circular slipper shell										2	1	1	1
Opisthobranchia	Cylichnidae	Cylichna	Cylichna zealandica														1
Opisthobranchia	Limapontiidae	Ercolania	Ercolania felina										2				
Opisthobranchia	Philinidae	Philine	Philine sp.	White Slug								1					
Bivalvia			Bivalvia Unid. (juv)			1			1								
Bivalvia	Mytilidae	Arcuatula	Arcuatula senhousia								1						
Bivalvia	Lasaeidae	Arthritica	Arthritica sp.	Small bivalve	Infaunal deposit feeder												1
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (0-5mm)	Cockle (0-5mm)	Infaunal deposit feeder		1	1	2	1			1				
Bivalvia	Veneridae	Austrovenus	Austrovenus stutchburyi (06-10mm)	Cockle (6-10mm)	Infaunal deposit feeder	1			3								
Bivalvia	Semelidae	Leptomya	Leptomya retiaria retiaria					1									
Bivalvia	Nuculidae	Linucula	Linucula sp.	Nut Shell	Surface deposit & filter feeder	1	14	5	15	63	53	26		9	2	13	7
Bivalvia	Myochamidae	Myadora	Myadora striata									2			2		2
Bivalvia	Lasaeidae	Myllita	Myllita vivens									1					
Bivalvia	Nuculidae	Nucula	Nucula nitidula	Nut shell	Infaunal deposit feeder								1				
Bivalvia	Tellinidae	Serratina	Serratina charlottae		Infaunal suspension feeder								2		1	1	
Bivalvia	Veneridae	Tawera	Tawera spissa	Morning Star													19
Bivalvia	Ungulinidae	Zemysia	Zemysia zelandica						1	3	7	6	3	2	16	2	2
Bivalvia	Mesodesmatidae	Paphies	Paphies australis	Pipi	Filter feeder					1							
Bivalvia	Tellinidae	Macomona	Macomona liliana	Wedge shell Hanikura	Infaunal suspension feeder									2			
Oligochaeta			Oligochaeta	Oligochaete worms	Infaunal deposit feeder	41	7	40	3	7	17	12	2	47	39	23	54
Polychaeta: Spionidae	Spionidae		Polydorid			47	12	47	30	74	19	64		6	23	2	101
Polychaeta: Pectinariidae	Pectinariidae	Lagis	Lagis sp.			1											
Polychaeta:			Nereididae							1		1		2		6	
Polychaeta: Orbiniidae	Orbiniidae		Orbiniidae		Infaunal deposit feeder					1	1	1				2	1
Polychaeta: Orbiniidae	Orbiniidae	Naineris	Naineris sp.		Infaunal deposit feeder										1		
Polychaeta: Orbiniidae	Orbiniidae	Scoloplos	Scoloplos sp.						4	2	1	6	2	2	4	1	
Polychaeta: Paraonidae	Paraonidae		Paraonidae		Infaunal deposit feeder									2			
Polychaeta: Spionidae	Spionidae	Aonides	Aonides sp.		Surface deposit feeder											1	
Polychaeta: Spionidae	Spionidae	Paraprionospio	Paraprionospio sp.		Surface deposit feeder	1											
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio aucklandica		Surface deposit feeder	1	15	47	25	4	4	2	2			29	3
Polychaeta: Spionidae	Spionidae	Prionospio	Prionospio sp.		Surface deposit feeder	65	20			5			1		1	4	1
Polychaeta: Spionidae	Spionidae	Pseudopolydora	Pseudopolydora sp.		Surface deposit feeder	1	1	2	4		2	2		3	6	1	1
Polychaeta: Spionidae	Spionidae	Spio	Spio sp.		Surface deposit & filter feeder	15	12	12	24	18	18	12			14	1	16
Polychaeta: Spionidae	Spionidae	Spiophanes	Spiophanes modestus							1		1	2		3		3
Polychaeta: Magelonidae	Magelonidae	Magelona	Magelona sp.		Surface deposit feeder	7	1	3	6		8	2					
Polychaeta: Capitellidae	Capitellidae		Capitellidae		Infaunal deposit feeder							1					
Polychaeta: Capitellidae	Capitellidae	Barantolla	Barantolla lepte					2								1	
Polychaeta: Capitellidae	Capitellidae	Capitella	Capitella spp.		Infaunal deposit feeder	12				1	2		1	1	3	2	1
Polychaeta: Capitellidae	Capitellidae	Heteromastus	Heteromastus filiformis		Infaunal deposit feeder		1		1	1	1			1			
Polychaeta: Capitellidae	Capitellidae	Notomastus	Notomastus sp.		Infaunal deposit feeder	11	5	10	6	33	53	33		17	30	15	12
Polychaeta: Maldanidae	Maldanidae		Maldanidae	Bamboo worm	Infaunal deposit feeder		3		2	11	2	3	2	2	5		5
Polychaeta: Opheliidae	Opheliidae	Armandia	Armandia maculata		Infaunal deposit feeder				3	6	17	8		16	18	9	9
Polychaeta: Phyllodocidae	Phyllodocidae		Phyllodocidae	Paddle worms	Carnivore & scavenger		3					2		6	1	1	8
Polychaeta: Aphroditidae	Aphroditidae		Aphroditidae	Sea Mouse	Infaunal carnivore							1					
Polychaeta: Polynoidae	Polynoidae		Polynoidae	Scale worms	Infaunal carnivore											1	
Polychaeta: Sigalionidae	Sigalionidae		Sigalionidae		Infaunal carnivore												1
Polychaeta: Hesionidae	Hesionidae		Hesionidae		Carnivore and deposit feeder					3	3	1		2	1		
Polychaeta: Syllidae	Syllidae		Exogoninae			90	58	30	39	8	7	11	1	1	4	2	6
Polychaeta: Syllidae	Syllidae		Syllidae		Omnivorous	17	30	7	25	11	16	6		2	8	3	15
Polychaeta: Nereididae	Nereididae		Nereididae (juvenile)		Omnivorous	2	1		1					8	6	6	6
Polychaeta: Nereididae	Nereididae	Neanthes	Neanthes cricognatha	Rag Worm	Omnivorous	3	5	4	1	6	17	5	2	8	6	42	13
Polychaeta: Glyceridae	Glyceridae		Glyceridae		Infaunal carnivore & deposit feeder			1	1		1	1					
Polychaeta: Goniadidae	Goniadidae		Goniadidae		Infaunal carnivore	1			1	1	4					1	4
Polychaeta: Eunicidae	Eunicidae		Eunicidae		Facultative carnivore						1						1
Polychaeta: Eunicidae	Eunicidae	Eunice	Eunice sp.								2				1		
Polychaeta: Dorvilleidae	Dorvilleidae		Dorvilleidae		Facultative carnivore	2	1	2		1	1	2			1	2	
Polychaeta: Oweniidae	Oweniidae	Owenia	Owenia petersenae	Polychaete worm	Infaunal deposit feeder							5	1	1	2	1	1
Polychaeta: Cirratulidae	Cirratulidae		Cirratulidae		Deposit feeder	2	25	4	2	7	11	2	9	3	5	1	2
Polychaeta: Terebellidae	Terebellidae		Terebellidae		Infaunal deposit feeder	1								1			
Polychaeta: Sabellidae	Sabellidae	Euchone	Euchone sp.		Infaunal suspension feeder	4	14	2	3	7	11	43		10	43	24	280
Polychaeta: Sabellidae	Sabellidae		Sabellidae	Umbrella worms	Infaunal suspension feeder						1	1					
Polychaeta: Serpulidae	Serpulidae	Serpula	Serpula sp.		Suspension feeder									1			
Crustacea	Tanaidae		Tanaidacea	Tanaid shrimp		162	243	25	15					5	2		5
Cumacea			Cumacea	Cumaceans	Infaunal filter or deposit feeder	1		1	1	1					6		9
Isopoda	Anthuridae	Anthuridae	Anthuridae	Isopod	Epifaunal scavenger						2	2	1	2	27	1	6
Isopoda	Sphaeromatidae	Exosphaeroma	Exosphaeroma sp.			1											1
Amphipoda	Caprellidae		Caprellidae	Skeleton shrimp							1	1					2
Amphipoda	Corophiidae		Corophiidae	Amphipod (family)					1	11	14	7	3				
Amphipoda	Dexaminidae		Dexaminidae	Amphipods					38	45	20	3			2	3	4
Amphipoda	Haustoriidae		Haustoriidae	Amphipod (family)											2		2
Amphipoda	Lysianassidae		Lysianassidae	Amphipods	Epifaunal scavenger									1	1	7	1
Amphipoda	Oedicerotidae		Oedicerotidae	Amphipods									3	1	1		
Amphipoda	Phoxocephalidae		Phoxocephalidae	Amphipod (family)					1	1	4			7	20	4	10
Amphipoda	Ampeliscidae	Ampelisca	Ampelisca sp.	Amphipod											1		
Amphipoda			Amphipoda indet.	Amphipods		5		3	1	7	6		1	6	1	3	9
Decapoda	Diogenidae		Diogenidae	Left-handed Hermit Crab											1	2	
Decapoda	Paguridae		Paguridae	Hermit Crab Unid.	Epifaunal scavenger									1		4	
Decapoda	Alpheidae	Alpheus	Alpheus sp.	Snapping shrimp							1						
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus cookii	Pill-box Crab	Eats small organisms & some weed					1						1	
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus sp. (juvenile)	Pill-box Crab	Eats small organisms & some weed						1						
Decapoda	Hymenosomatidae	Halicarcinus	Halicarcinus whitei	Pill-box Crab	Eats small organisms & some weed					1			1				
Decapoda	Macrophthalmidae	Hemiplax	Hemiplax hirtipes	Stalk-eyed Mud Crab	Deposit feeder & scavenger		1					1					
Decapoda	Majidae	Notomithrax	Notomithrax minor		Epifaunal scavenger					1							
Decapoda	Palaemonidae	Palaemon	Palaemon affinis	Estuarine Prawn													1
Decapoda	Crangonidae	Philocheras	Philocheras australis	Sand Shrimp			2										
Ostracoda			Ostracoda	Ostracod	Omnivorous scavenger	11	32	15	11	14	10	15	13	11	28	47	33
Copepoda			Copepoda	Copepods			1				2			1			
Phoronida			Phoronida	Horseshoe worm					1	5		5	1	2	6		1
Hemichordata			Hemichordata			1	1	5	12	3	13	6	8	2	2	1	1
Ophiuroidea			Ophiuroidea	Brittle stars										2	1	4	
Ophiuroidea	Amphiuridae		Amphiuridae	Amphiuridae								1					1
Holothuroidea	Chiridotidae	Taeniogyrus	Taeniogyrus dendyi	Sea cucumber	Epifaunal deposit feeder		1							1	1	1	1
Ascidiacea			Ascidian (solitary)	Sea Squirts										1			
			Count: No of Individuals			515	517	271	290	372	358	314	73	205	387	284	689
			Count: No of Taxa			31	28	24	36	39	41	43	26	41	48	44	51

Appendix B:

Representative Sample Photos


Photo 1: Inner sample (in field)

Photo 2: Inner sample (in lab)


Photo 3: Mid sample (in field)


Photo 4: Mid sample (in lab)


Photo 5: Outer sample (in field)

Photo 6: Outer sample (in lab)

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Northport

STORMWATER DISCHARGE REVIEW

For Northport Ltd

Ecological and Water Quality Report
Final

August 2015

REPORT INFORMATION AND QUALITY CONTROL

Prepared for:	Northport Ltd

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4SIGHT CONSULTING

EXECUTIVE SUMMARY

The report prepared by 4Sight Consulting covers two key areas of focus: 1) the performance and effectiveness of the Northport Ltd Marsden Point port stormwater system operation in relation to the initial design and the current resource consent requirements intended to protect environmental quality; and 2) how this stormwater system interacts with other areas of the lower Whangarei Harbour and in particular the Mair Bank.

1) Performance and Effectiveness of the Stormwater System

Since the beginning of port operations 13 years ago, stormwater has been transported via the collection canals inland to a large detention pond for treatment through natural processes. In addition to coarse screens which remove larger debris, this treatment of contaminants is achieved by further dilution within the pond system, settling of a high proportion of solid particulates and microbial action. The detention pond has also developed a strong wetland character which will provide further treatment of water quality through filtering and uptake of dissolved contaminants such as nutrients.

Stormwater is then intermittently discharged from the pond into the harbour from a diffuser on the seabed (approx. 11 m depth) at the wharf. Discharge into the harbour in the port's early years (2003 – 2007) was small, infrequent and in some years no discharge occurred. This situation was due to the port being in early stages of operation and development, combined with high seepage and evaporation rates in the detention pond. In more recent years (2008 – 2015) discharge volume has remained low and has occurred in short periods with long periods of little to no discharge. The discharge is pumped into the high volume highly dispersive local harbour water environment.

There is some uncertainty around the actual volume of stormwater discharged based on current pumping rates and pump capacity. Northport is presently carrying out investigations to more accurately quantify this aspect as accurate records of pumping hours and volume are a requirement of section 1.2 of Schedule 1 of the resource consent (CON20090505532).

After stormwater has resided in the detention pond it is intermittently discharged into the harbour where it undergoes mixing in a designated mixing zone (an area within 300 to 350 m of the outlet diffuser). A previous study estimated a minimum dilution potential in a zone within 250 m of the outlet to be at least 200 times, and generally significantly more. Thus dilution potential within the actual larger consented mixing zone will be greater. Environmental limits on contaminant concentrations are set at the edge of the consented mixing zone. These limits are intended to protect the biota and ecology of the harbour waters and its aesthetic qualities which will ensure that the CA Water Classification for this part of the harbour is met.

The monitoring approach for the water quality of the detention pond is conservative. The water is regularly monitored for parameters including total suspended solids, heavy metals and polycyclic aromatic hydrocarbons. However logs are the main product stored and exported at the port and therefore stormwater collected in the detention pond has characteristics that are associated with log storage. This stormwater is not a significant source of toxic, bio-accumulative or persistent compounds and there are no processing industries or other heavy industries that generate potential toxicants. Previous antisapstain activities located within the port were fully enclosed and bunded. Such industry as may occasionally occur has not added toxic compounds to the stormwater and is managed as a separate entity within the stormwater management system to avoid contamination.

The water quality monitoring data and other testing which has been undertaken such as Whole Effluent Toxicity Tests, suggests that the stormwater in the detention pond is of a consistently high quality. This provides a large degree of certainty that the pond discharge is meeting environmental protection standards. Median contaminant concentrations in the discharge adjusted to allow for the probable minimum dilution in the harbour mixing zone, show concentrations are much less than 1% of the receiving environment limit required to protect marine biota. The similarly derived 95 percentile values are only between 0.4% and 4% of the receiving environment.

Water quality targets expressed as concentrations of contaminants intended to protect aquatic life in the harbour are generally met in the raw stormwater prior to the discharge entering the harbour. In addition to this, the consented mixing zone boundary is at least 1 km away in any direction from potentially sensitive ecological areas such as Mair Bank and other local marine features including the Marsden Bay and One Tree Point areas and Snake

Bank. Additional mixing and dispersion potential over this distance is likely to result in actual dilution of at least three orders of magnitude or more.

High water quality performance confirms that the stormwater system is working efficiently and effectively. This reflects the fact that the stormwater system was designed to protect the high ecological and water quality values of the adjacent harbour areas and to ensure that these values are not adversely affected or threatened by the discharge. Reviewing the information received, there is no basis for speculation that the Northport Ltd discharge has affected harbour water quality, or based on the same or similar product mix, will do so in the future.

4Sight consider that to maintain detention pond performance, capacity and ongoing function, a management plan should be prepared to provide for an appropriate mix of open water areas and wetland habitat.

2) The relationship of stormwater discharge to Mair Bank

Mair Bank has been considered in this review as a special and topical case. The bank is located at the entrance to Whangarei Harbour and is a prominent sandbank which plays an important role in natural protection of the harbour entrance and the navigable channel for the deep-water port. Mair Bank previously supported an important pipi fishery, which was highly valued by commercial, recreational and customary harvesters. The shellfish population which is integral to the physical integrity of the bank, has in the past decade collapsed and is now estimated at approximately 1% of its recent historical biomass. There needs to be multi sector effort toward an understanding of the potential causes of that decline and 4Sight have considered this in relation to the Northport stormwater discharge. In terms of any potential 'hydraulic' connection to Mair Bank, the ebb tide is most relevant and is therefore emphasized in the review.

Discharge from the stormwater detention pond was analysed over the last 21 months, as this best represents the current state of the port development. Over the 21 months, discharge occurred 11% of the time; 4% during ebb tide and 7% during flood and slack water periods. Over the total period of ebb tide, discharge occurred 11% of the time.

As a potential influence on harbour waters flowing past Mair Bank, wind speed and direction were also reviewed during this 21 month period. Winds of sufficient strength were considered as a potential influence on the behaviour of the discharge. Wind speed was less than 10 knots 85% of the time and at this low velocity range can be discounted as influential on the behaviour of near-surface water. Such conditions which also coincided with a period of stormwater discharge were rare. Therefore wind speed and direction can be set aside as an influential factor when considering the discharge and its relationship with Mair Bank.

Analysis of rainfall data over the 21 month period, confirms the strong correlation between rainfall and stormwater discharge volume. The months of greatest stormwater discharge were November and December and July to September. Little or no discharge occurred in January and February.

The month of highest stormwater discharge occurred in August 2014. This data was reviewed to understand pattern and intensity of discharge to the harbour waters during a month of high rainfall. During this month, discharge occurred 33% of the time on the available ebb tide, 35% of the time on the available flood and slack tide and there was no discharge about 32% of the time. Small rainfall events did not initiate a discharge, however large rainfall events were followed by a period of discharge, which occurred several days after the rainfall. This confirms that even during high rainfall there is a significant period of attenuation of stormwater through the port canal and pond system. Thus under high rainfall there continues to be significant 'treatment' of stormwater through the system prior to discharge. This part of the review confirms that the majority of the time even in a wet month (in this case 67%), there is either no discharge or the direction of the discharge during mixing with the harbour water will be away from the Mair Bank.

Based on this review the Authors see no basis for a view that the Northport discharge might in some way be linked to the fate of the Mair Bank pipi.

4Sight have also reviewed current information (from the Ministry of Primary Industries and other sources) on the collapse of the Mair Bank pipi population and note there are presently (and have been historically) a number of areas around the Northland coast where bivalve shellfish die off has occurred. This would suggest other factors are involved. We do not review and discuss the information we have assembled on this wider environmental phenomenon as it would seem to be unnecessary given the findings of the port stormwater system review.

4SIGHT CONSULTING

1 INTRODUCTION

4Sight Consulting, formerly known as Andrew Stewart Ltd, has been contracted by Northport Ltd to provide this report reviewing their stormwater discharge system. In commissioning this report, Northport Ltd has given 4Sight an open brief and have provided all file information.

The review draws on a range of information sources which assist in interpretations about the actual and potential effects of the port stormwater discharges on harbour water quality. The report has been commissioned by Northport Ltd as a timely overview of their stormwater discharge system after more than a decade of port operations. A particular aim of the report, is to understand what if any linkage there might be between the port discharges and the collapse of the Mair Bank pipi bed, and also more generally the health of shellfish in the lower harbour. The report is in the first instance intended to inform Northport Ltd.

For completeness, the report briefly tracks the history of the port in relation to stormwater. The intended design and management of the stormwater system, as originally proposed and consented at the establishment of the port, is briefly reviewed.

The chemical characteristics of the stormwater generated on the site are reviewed and the port discharge monitoring programme is described, with findings to date overviewed. Integral to an understanding of the fate of the stormwater discharge and to an understanding of the effect of the discharge on harbour water quality, is the hydrodynamic setting at this location of the lower Whangarei Harbour. This is briefly discussed.

Critical to an understanding of the port discharge in relation to lower harbour water quality, is information on the volume of discharge; the frequency, duration and timing of discharge during both ebb and flood tidal periods; and the relationship of the discharge to rainfall and wind direction and strength. This information is reviewed in detail.

2 BACKGROUND

2.1 The Stormwater System

Consent was granted in 1997, on the basis that an open channel collection system to collect all stormwater and achieve primary settlement followed by a large settlement pond, represented the most effective form of treatment for the type of stormwater likely to be produced by the port. The system in use since mid-2002 consists of:

- Approximately 2000 lineal metres of collection channels (the first treatment stage), where the primary settlement of suspended solids occurs as the stormwater is retained in channels by a weir at the entry to the settlement pond.
- A settlement pond of approximately 4 ha subdivided with a cross partition which divides the second and third treatment stages. The rock partition allows stormwater to flow into the third treatment stage when the necessary pond level is reached.
- A pumping station in the third stage area has two pumps with a combined capacity of up to 133 litres per second or 72 litres per second when a single pump is operating. Actual pumping rate will be variable depending on factors such as the head of water and also the age of the pump. The 4Sight assessment has been based on the conservative pumping capacity provided by Northport. Pumps are triggered automatically by water level sensors.
- Pumped water is discharged to the harbour through a diffuser at approximately Reduced Level (RL)-11.0 below Chart Datum (CD) under the port berths.

The pond has a general base level of RL 2.7 above CD. One pump will commence operation at RL 3.24 and two pumps will operate when the pond level reaches RL 3.44, which is when the pond has 0.54 m depth and 0.74 m depth respectively. Once started, the pump(s) draw the pond level down to RL 2.84, so a residual level in the pond of 0.14 m is maintained.

Prior to discharge, the Northport Ltd stormwater flow is potentially joined by stormwater discharging from the Marsden Maritime Holdings Ltd (MMH-formerly Northland Port Corporation) Industrial Park. The MMH discharge is a gravity rather than pumped discharge and is typically a much smaller flow. There is no maximum rate of flow specified in the MMH consent. The consent conditions covering that discharge are separate from those governing the

Northport Ltd discharge and are detailed in resource consent CON20081072304. Thus the diffuser beneath the port berths is the outlet for a combined discharge where these stormwater discharges may occur concurrently. It is noted that MMH has commissioned 4Sight to undertake an independent review of the stormwater discharge from the MMH Industrial Park.

A schematic of the Northport Ltd stormwater system configuration is presented in Appendix A.

2.2 Stormwater Discharges 2003 to 2015

Pond performance reported for the first four years (2003 to 2008) (J Palmer, January 2008)[1] stated '*...the settlement pond has been dry or well below pump initiation levels for several months over summer. Observation has shown that there has to be significant rainfall for runoff to even reach the pond through the collection channel system and over the pond entry weir...*' The Palmer report further noted that '*...although there is only a 200 mm difference between the starting levels of the two pumps, the second pump has in fact only operated in the very large storm in March 2007...*'

The Palmer report presented a review of the actual port discharge volumes in the period between 2003 and 2007. This information is presented in Table 1 below. The information shows that between 2003 and 2007 actual spill volumes were very much below the predicted volumes. In two of these years (2004 and 2006), there was in fact no discharge from the pond system. The Palmer report concluded that losses due to seepage and evapotranspiration over this period were very much higher than originally anticipated (in this case 'evapotranspiration is the process by which water is transferred to the atmosphere by evaporation from the pond surface and by transpiration from the emergent plants within the pond).

Table 1: Actual Pond Discharge 2003 to 2015 (2003 – 2007 from Palmer, 2008)[1]

Year	Actual port area	Actual annual rainfall mm*	Calculated annual volume to spill (m^3)	Actual annual spill (m^3)	Actual Spill Source Data
2003	15	1596	234,000	114,000	Pump records
2004	17	1029	168,000	0	Pump records
2005	17	1039	170,000	11,000	Pump records
2006	17	1246	205,000	0	Pump records
2007	18	1290	230,000	54,000	Pump records
2008	18	1207		No data	
2009	18	768		No data	
2010	18	913		165,829	Pump Station Monthly Reports
2011	18	1454		288,511	Pump Station Monthly Reports
2012	22	1269		268,757	Pump Station Monthly Reports
2013**	26	1211		194,160	Pump Station Monthly Reports
2014*	26	1420		278,882	'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records'
2015***	26	225		13,604	'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records'

*Annual rainfall is calculated from information provided by Northport Ltd, except for April 2008-2010 and 2014 which was provided by Northland Regional Council.
**2013 represents January 2013 to February 2014, due to no other data available in the reports to calculate only a year.
***2015 is from January 2015 to 11 May 2015 and calculated from 'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records'.

[1] North Port Development, Review of Storm Water Collection and Treatment System' prepared by John Palmer, 23 January 2008

As might be expected, there is a relationship between the annual volume of stormwater discharged and the annual rainfall. Figure 1 below plots 'Annual Rainfall' (blue) versus 'Actual Annual Spill' (purple) over the period 2003 to May 2015. This confirms the close relationship between annual rainfall and annual spill.

Incidental to this 4Sight have checked the accuracy of the Northport Ltd rainfall record against the nearest reliable record (NRC at 'Fosters'). That relationship is discussed in Appendix F and shows the Northport Ltd record is accurate and reliable.

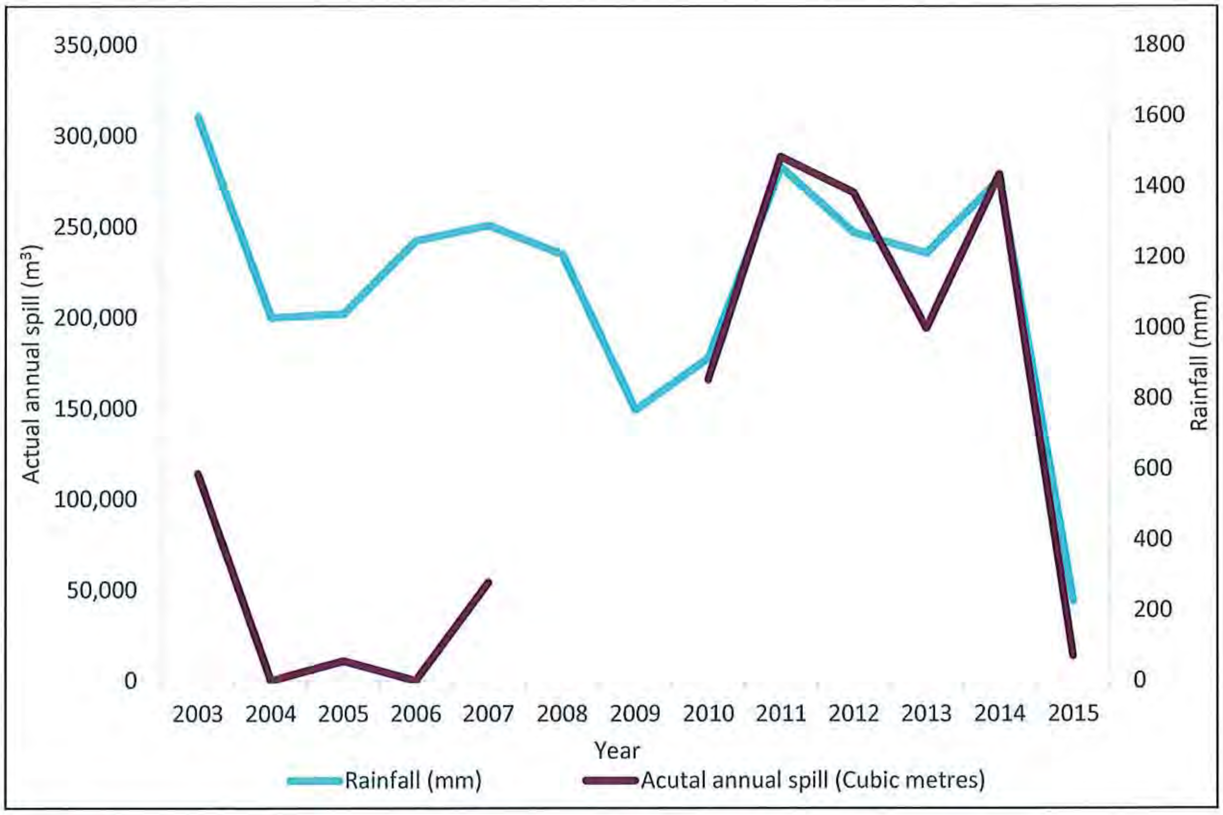

Figure 1: Annual Rainfall versus 'Actual Annual Spill' over the period 2003 to May 2015.

2.3 Stormwater Quality

Monitoring of stormwater has been required since the discharge began in March 2003. The resource consent granted by NRC in April 2010 (CON20090505532) details the monitoring requirements as they currently stand. This consent expires in December 2034. Key aspects in terms of discharge quality are discussed below.

The quality of the stormwater discharged to the harbour is a function of the particular product mix at the port; the onsite management; and the design and capability of the stormwater management system. The design and capability has been discussed earlier in this report (section 2.1) but in short the system provides for effectively all stormwater being moved to land and treated via natural physical and biological processes (sedimentation; biological action and chemical transformation including photolysis). Product mix and on site management are briefly considered below.

2.3.1 The Source of Contaminants

Logs are the dominant volume of the port's trade and are likely to remain so. They will continue to be the principal influence on stormwater. Bulk cargoes are mostly loaded directly to trucks via hoppers (these products include fertiliser/phosphate rock, palm kernel, grain and coal) and are then moved to covered storage other than for coal. Coal is stockpiled on site and is a potential source of dissolved and particulate contaminants entering the stormwater system. The expected chemistry of coal runoff has been recently reviewed by Golden Bay Cement and is discussed later in this report.

A few bulk cargoes (gypsum, sulphur and refined fertiliser) are moved directly to the wharf for subsequent handling. There is a potential for small amounts of spillage to occur between the vessel and berth face during product offloading and around the hoppers and from fertilizer dust. 'Save-alls' are used between the ship and berth face to deflect spillage. Some of this spillage will enter the slot drains near the berth face as well as being blown or conveyed into the perimeter drains. All material entering the slot drains and perimeter drains is ultimately moved inland toward the detention pond. Spillage around the hoppers is removed in clean-up operations during loading and when loading is complete. The risk of exposure of this material to rainfall and entrainment in the stormwater flow is small.

There is no expectation that the future development of the port will generate a different or poorer quality of stormwater relative to that which has been characterised to date. Rather, it is likely that runoff will be cleaner and dilution within the detention pond greater as a consequence of the continued port expansion and the use of the new sealed areas for containers. Stormwater generated from that new area will be clean.

Any potentially hazardous products or processes that require particular consideration in terms of runoff management are dealt with accordingly and where necessary are bunded and or self-contained so that they are effectively isolated from the stormwater system at large. An example of this was the debarker and antisapstain operation that was present on site for several years. There are presently no such special activities within the catchment of the Northport pond.

2.3.2 On Site Management

The site is routinely swept as an integral part of the log handling operations. Bark and other wood debris are gathered into small piles and moved offsite to landscape suppliers. There is also dust suppression using a water truck when required. Inevitably some of this larger material as well as clay and dust enters the perimeter drains. This material accumulates at various grate points in the drainage system and is periodically removed by a small excavator for disposal elsewhere on the Northport Ltd site (also subject to a resource consent). These operations keep the site relatively clean of macro material and limit the accumulation of debris and aggrading of particles.

2.3.3 Discharge from the Pond System to the Harbour

The resource consent requires the following monitoring:

- Samples collected from the detention pond, before discharge to the marine area.
- Three discharge events are required to be monitored each year.
- For each discharge event, 3 samples are required to be collected over each day of the discharge event.
- Each sample must be analysed for total suspended solids, volatile suspended solids (an indication of the organic non mineral portion of the suspended sediment load); Nephelometric Turbidity Units (NTU-broadly an indicator and proxy for visual clarity of the discharge) and pH.
- The first sample of the first discharge event needs also to be analysed for aluminium, copper, lead, zinc; polycyclic aromatic hydrocarbons (PAH - which include compounds considered likely to be carcinogenic) and resin acids (natural wood leachates considered to have some toxicological effects on aquatic life at sustained high concentration).
- Conservative 'Action Levels' for particular contaminants are prescribed for the discharge prior to release so that any elevations are detected early and investigated as to source and management intervention where required. Action Levels are not to be confused with compliance limits. 'Action Levels' are part of an alert system for monitoring trends in stormwater quality before discharge. Compliance limits, apart from Total Suspended Solids, all relate to receiving environment concentrations after reasonable mixing.
- Since 2014, Northport Ltd has monitored the discharge more frequently than is required by the consent. For example there were 13 days on which monitoring was carried out in 2014 and a similar intensity of sampling has been maintained into 2015.

2.3.4 Discharge from the Port into the Pond System (Pond Influent)

To understand the performance of the pond in reducing and retaining contaminants, the inflow to the pond during the first discharge event in a calendar year is also tested for most of the parameters cited above.

This influent information has not been reviewed as part of this report.

2.3.5 Stormwater Canals within the Port

- Sediment samples are collected from representative sites within the canal system and tested for copper, lead, zinc and PAH. This is done to provide an indication of concentrations closer to the source of potential contaminants and to alert Northport where particular attention should be given to a product or area of the port which may have the potential to influence the pond discharge quality.
- Representative samples of the canal water are also required to be tested for pH, copper, lead, zinc, resin acids, phenols and PAH. Again there are no specific limits imposed on this material but the concentration data is intended to establish trend information as to what is typical within the port and to assist as an early warning system should elevations in any particular contaminant be detected.

This information has not been reviewed as part of this report.

2.3.6 Receiving Environment and Water Quality

The waters near to the port are identified in a number of ways in relation to harbour water quality management.

The Northland Regional Council's Regional Coastal Plan for Northland (RCP) identifies the Northport Ltd (and Refining NZ) port area as Marine 5 (Port) Management Area. This zone is shown in Map C13 from the RCP which is presented as Appendix B. The RCP identifies areas being managed primarily for port related purposes as Marine 5. The zone defines the extent of the harbour area required for berthing and turning large ships and the maintenance of gazetted depths required for that purpose as well as the safety margins applied to such operations. The waters within the zone are still subject to the requirements of the RCP around the management of adverse effects but those requirements are not as stringent as for areas beyond the port zone.

Immediately beyond the Marine 5 port zone the waters of the harbour are identified as Marine 2 (Conservation) Management Area. This zone is also shown in the RCP. Marine 2 covers most of the harbour waters and is a catch-all management zone where the waters are not identified for other purposes. The RCP states in respect of Marine 2 that it is an area '*without precluding the provision for appropriate subdivision, use and development to manage those remaining areas in such a way as to protect, and where practicable, enhance natural, cultural and amenity values...*' Thus the area just beyond the port zone has a high expectation in terms of the management of environmental values.

The RCP also identifies areas close to the port to the north (Motukaroro Island and Marine Reserve), northeast (Calliope Bank), southeast (Mair Bank) and west (Snake Bank and One Tree Point) as Marine 1 (Protection) Management area. The RCP identifies these areas as having important conservation values which must be protected. Thus the port area is 'hemmed in' by marine habitats afforded the highest conservation importance within the RCP framework.

Supporting these Management Areas for the Whangarei Harbour is a specific water quality classification. This is shown in Appendix D. The waters of the lower harbour excluding the area immediately adjacent the Refining NZ wharf terminal are classified as CA in Appendix 4 of the RCP. The purpose of the CA classification is stated as *'Provides for virtually all uses and protection of marine ecosystems...'* It is noted that this is not the highest classification under the standards available. A 'CN' classification is available and has the purpose of '*...Protection of Waters in their Natural State...*' There are no waters identified as CN in Whangarei Harbour.

In applying the CA water standards the RCP and the Coastal Permit issued to Northport Ltd, relies on the ANZECC 2000 water quality guidelines[2]. These Guidelines provide toxicological limits for a wide range of parameters to achieve specified levels of protection of marine biota. For the waters beyond the mixing zone in the lower harbour entrance area, the target ANZECC parameters are effectively intended to achieve protection of 95% of the marine biota.

The port stormwater system was designed specifically to ensure that these areas of ecological and water quality value and importance are not adversely affected by the port operation.

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[2] *Australian and NZ Guidelines for Fresh and Marine Water Quality 2000, Volume 1. The Guidelines/* Australian and NZ Environment and Conservation Council. Agriculture and Resource Management Council of Australia and NZ.

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2.3.7 Mixing Zone and Dilution

It is important to understand the concept of a mixing zone and its statutory basis.

The discharge of stormwater from the port stormwater system occurs within the Marine 5 Management Area. The discharge is mixed and diluted once it enters the marine water via the diffuser at approximately 11 m depth at the berth face. A very high volume of sea water flows past the diffuser most of the time, other than for brief periods during slack water. On the flood tide the discharge will be carried up the harbour and on the ebb tide it will be carried down the harbour. It is noted that ebb tides reach higher velocities than flood tides. Being freshwater, the discharge is buoyant relative to seawater such that it rises to the surface. The overall effect is for a highly complex mixing dynamic involving horizontal and vertical mixing as the discharge is carried away from the diffuser.

The behaviour of the discharge was investigated in detail by physical modelling at the time of the original consent hearings (Barnett, undated)[3]. It was predicted that under conservative assumptions, dilution 250 m distance from the outlet would be 200 times. The hydraulic analysis indicated that this was to be taken as the lower end of potential dilution. The Barnett evidence stated that '*...modelling gave the result that during 80% of the tide the total dilution 250 m from the outfall is expected to exceed 300:1 for the stormwater discharge, often by some margin. During periods of slack water to total dilution 250 m from the outfall is predicted to exceed 150:1. Again by a considerable margin...*'

Even taking account of the assumptions built into the hydraulic modelling at the time (for example a peak discharge during a 1 in 20 year event of 100 litres/sec), and dilution calculated for more or less the least dilution scenario at the mixing zone edge, a further conservative element lies in the fact that the actual discharge which occurs most of the time (as evidence by pump hour records) is about 70 l/s.

Looking beyond the mixing zone, the distance between the eastern end of the mixing zone and the nearest point of the Mair Bank is about 1500 m. Dilution estimates were not modelled for that reach as part of the Barnett work but they are likely to be a further several orders of magnitude relative to that achieved within the mixing zone.

The boundary of the mixing zone is prescribed in the resource consent and is shown in Appendix C. This mixing zone extends around the port but is of smaller dimensions than the Marine 5 Management area. The resource consent specifies water quality that must be achieved at the boundary of the mixing zone, beyond which the CA water quality classification standards apply. The corollary of this is that water quality within the mixing zone need not comply with CA requirements. However, while there is effectively some relaxation of water quality targets within this mixing zone, acute or other significant adverse effects are not anticipated or allowed.

The statutory basis of the mixing zone concept is contained in section 107(1) of the Resource Management Act (RMA) which to paraphrase, does not allow the consent authority to issue a coastal permit '*...if, **after reasonable mixing**, the contaminant or water discharged (either by itself or in combination with the same, similar or other contaminants or water), is likely to give rise to all or any of the following effects on receiving waters...*' [Emphasis added]. The section goes on to identify a number of effects which are not allowed, one of which is '*any significant adverse effects on aquatic life...*'

In reality there is difficulty in sampling at the mixing zone edge meaningfully and representatively. The probability of intercepting the diluted stormwater discharge field in this complex hydrodynamic environment is low if not remote. Additionally there are practical problems with sampling within the commercial port zone. NRC initially undertook the sampling at the mixing zone edge but dropped this in favour of relying on the testing described below.

The alternative approach used for monitoring the Northport Ltd discharge has been to sample the discharge before it is released to the harbour. This option has the benefit of easy accessibility to the sampling point during discharge events as well as getting reliable measurements of a range of parameters 'at source'. These measurements can then be directly interpreted in relation to the anticipated dilution that would be achieved within the port mixing zone and those derived values can then then be assessed against the known thresholds of concentration required to protect the marine biota from adverse effects; namely the CA water classification.

[3] Statement of Evidence of Alistair Gordon Barnett before the Northland Regional Council and Whangarei District Council, undated

3 RESULTS

The results are based on information provided by Northport Ltd. The following sections consider:

- Stormwater discharge occurrence for ebb, flood and slack tide periods based on pump records.
- Wind speed and direction as a potential influence on the behaviour of ebb phase discharge.
- Quality of stormwater discharged.

3.1 Overall Stormwater Discharge

Two Excel files 'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records' were received from Northport Ltd, with running times of the two storm water discharge pumps ('Papich Road'). These files contained running time and date, and stopping time and date of storm water flow for each of the two pumps. Data that could be analysed and reliably interpreted was from 10 August 2013 at 16:39 to 11 May 2015 at 13:49, a period of approximately 21 months.

Analysis has been partitioned on the following basis: two tides per day, with approximately 5 hours of flood tide (incoming), 5 hours of ebb tide (outgoing) and two hours of slack tide (30 minutes before and after each high and low tide respectively). On this basis 41.7% of the record was flood tide, 41.7% was ebb tide and 16.7% was slack tide.

Based on the pump data, the analysis depicted graphically below shows the percentage of time stormwater was discharged on the ebb tide and non-ebb tide (in this case flood and slack times combined). During the 21 month period, there was approximately 6391 hours of ebb tide potentially 'available' for discharge. Of this maximum potential period, discharge occurred on only 682.92 hours (or 10.7% of the time), which equates to 4.5% of the total time (Figure 2).

Of the approximately 8948 hours (58.4% of the total time) during which the tide was in flood or at slack (not ebbing), discharge occurred on 998.33 hours (11.2% of the time), which equates to 6.5% of the total time.

In terms of a consideration of the Northport discharge in relation to the Mair Bank, the primary focus is the ebb tide and as the data shows discharge occurs only 11% of the time.

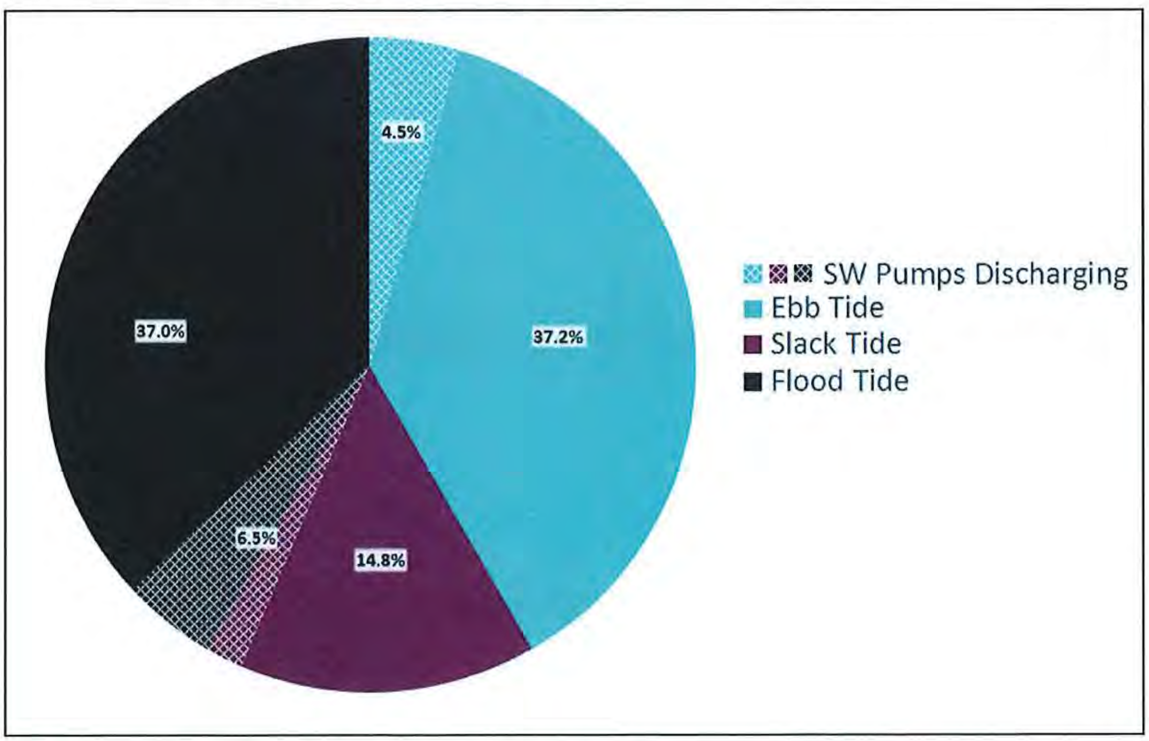

Figure 2: Stormwater discharged by pumps from 10 August 2013 to 11 May 2015, on the ebb and non-ebb tides.

3.2 Wind Speed and Direction

Putting aside all matters around dilution of the stormwater discharge within and beyond the mixing zone, a factor to consider as a potential influence on the 'behaviour' of any near-surface water is wind speed and direction The proportion of the time that wind reached speeds greater than 10 knots has been considered as a potential influence on the behaviour of the discharge.

The wind speed and direction data is recorded every 5 minutes. This data was used to provide an average speed and direction each day. Figure 3 displays the distribution over the same 21 month period (10 August 2013 to 11 May 2015). This is for the entire period not specific to ebb tides.

Wind speed was less than 10 knots 85% of the time and at this low velocity range can be discounted as influential on the behaviour of near-surface water. The maximum wind speed was NE 49.63 knots, during a cyclone that occurred on the morning of 17 April 2014.

This information suggests that wind speed and direction can be discounted in terms of it being a significant influence on the behaviour of the Northport discharge generally and in relation to Mair Bank in particular.

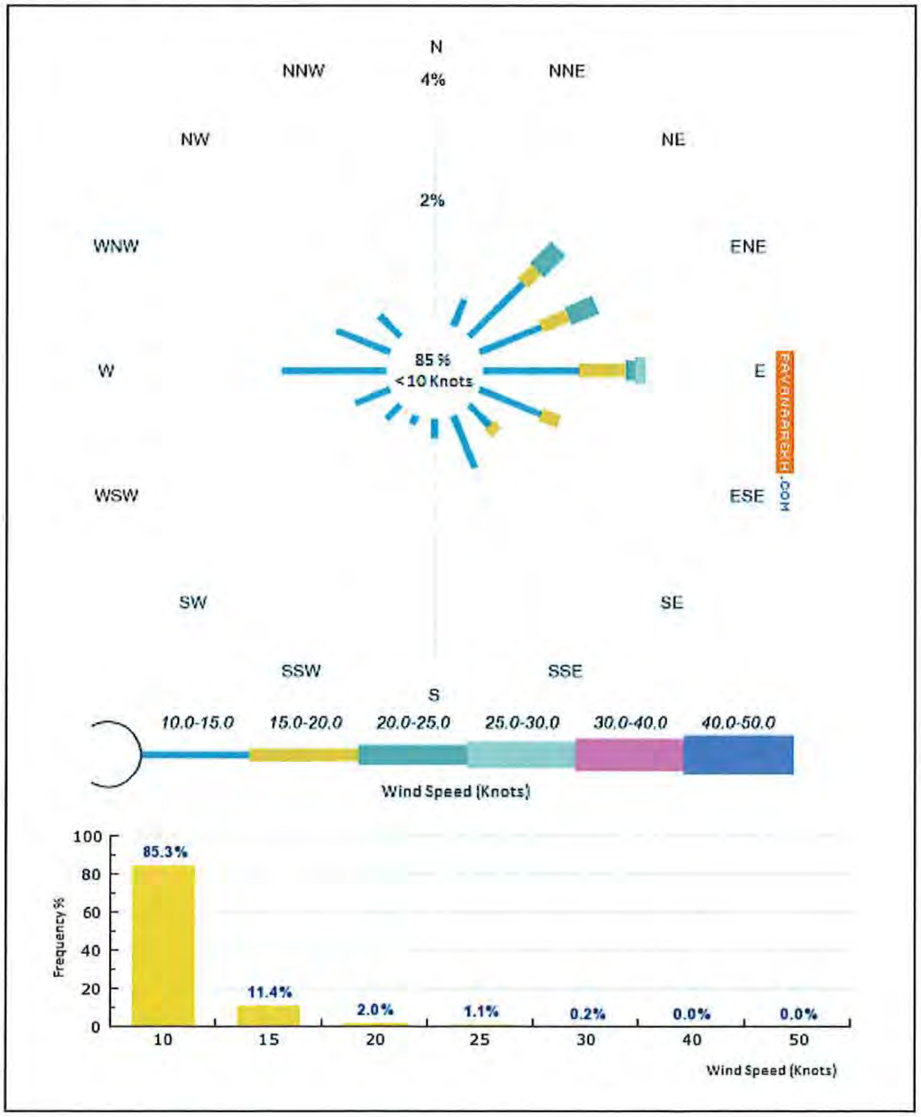

Figure 3: Wind rose and frequency of wind speeds for 10 August 2013 to 11 May 2015.

3.3 Rainfall and Stormwater Discharge

Rainfall data, provided by Northport Ltd was analysed for the period August 2013 to May 2015. Figure 4 shows rainfall along with the total number of hours the stormwater pumps were discharging each month, and the number of hours this discharge occurred on the ebb tide. It is to be noted that for April 2014, the rainfall data provided produced an anomalous peak, thought to be incorrect (699 mm), and has therefore been replaced with rainfall data received from the Northland Regional Council, for rainfall at Whangarei Harbour at Marsden Point.

Figure 4 confirms the correlation (as expected) between stormwater discharge periods and rainfall. It also indicates that highest discharge occurred November/December and July to September. Little or no discharge occurred over January and February of both 2014 and 2015 and little or no ebb tide discharge also extended into the months of March 2014 and March to May 2015. This reinforces the view that there are periods of a number of months, sometimes consecutively when there is little or no discharge over the ebb tide.

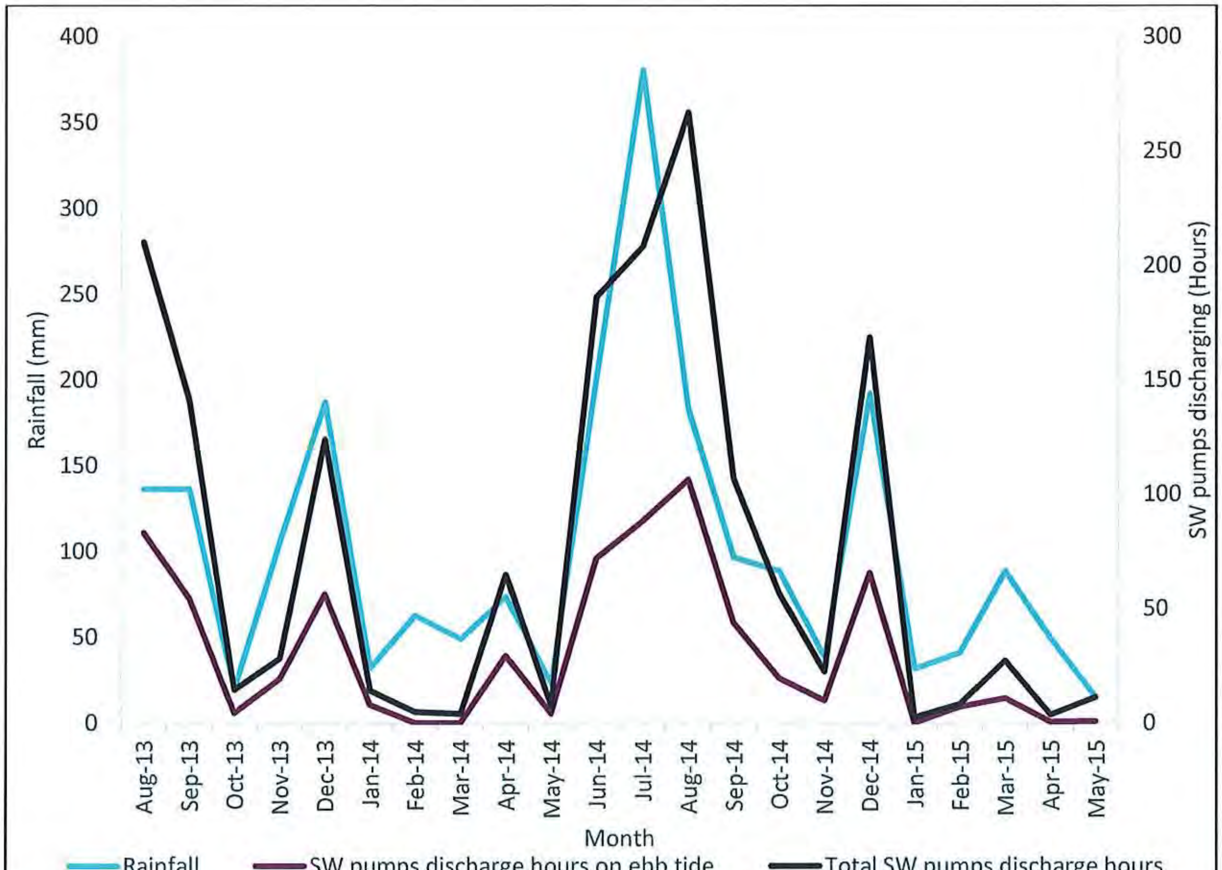

Figure 4: Rainfall, total number of hours the stormwater pumps were discharging, and the number of hours this discharge occurred on the ebb tide each month, from 10 August 2013 to 11 May 2015 (note August 2013 and May 2015 are not complete months).

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3.4 Highest Month of Discharge Example – August 2014

A 'worst case' discharge month has been analysed from 01 August 2014 to 02 September 2014, being the greatest month of discharge compared to other months during the 21 month period.

3.4.1 Overall Stormwater Discharge

During August 2014, total run time hours for the pumps was calculated, along with the amount of time this occurred on the ebb tide and non-ebb tide. Of the total available 325.4 hours of ebb tide in the month, stormwater discharge occurred for 106.35 hours (32.7% of the time), which equates to 13.6% of the total time. Of the total available 455.6 hours of non-ebbing tide (i.e. flood and slack tide), stormwater discharge occurred for 160.60 hours (35.3% of the time), which equates to 20.6% of the total time (Figure 5). Thus even in the month of greatest discharge, this occurred only 34% of the time and there was no stormwater discharged 66% of the time.

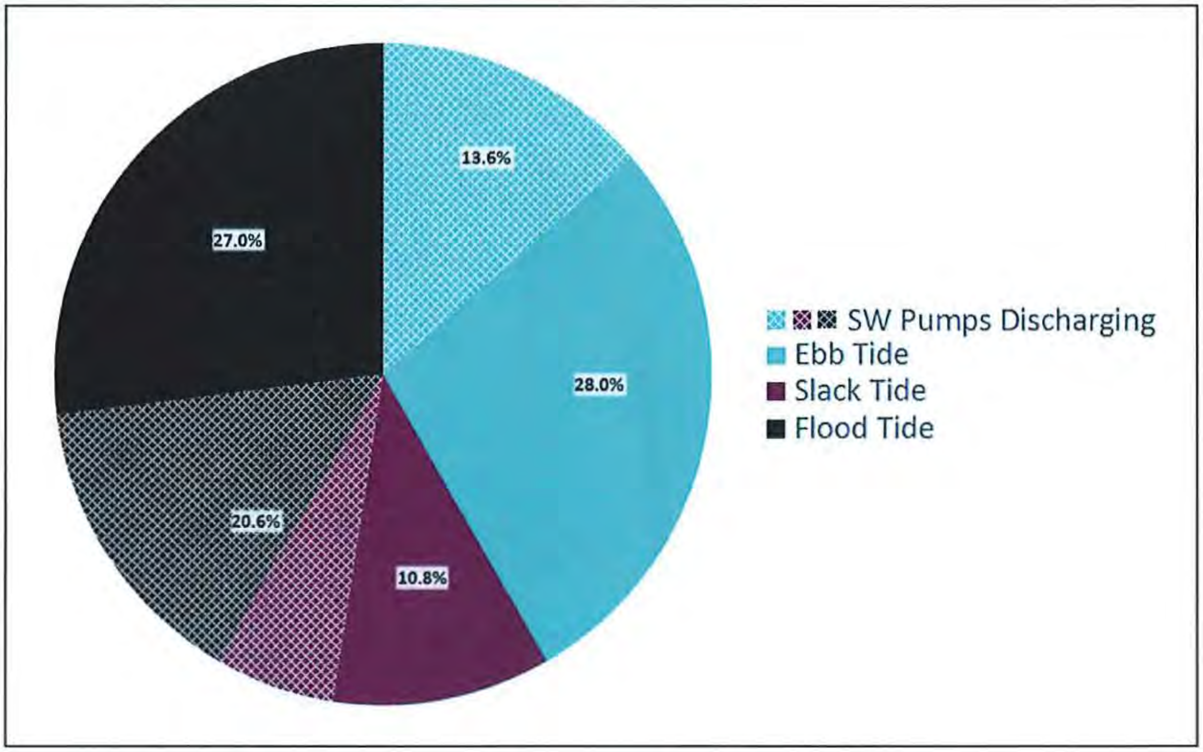

Figure 5: Stormwater discharged by pumps during August 2014, on the ebb and non-ebb tides.

Total storm water discharge hours and the volume of discharge (cubic metres) for the months ranked from greatest (August 2014) to least discharge (January 2015) are shown in Table 2. The bold sections highlight the percent of stormwater flow occurring on the ebb and non-ebb tides.

The data confirms that during the month of highest discharge there is still 32% of the time when there is no discharge, and also often on consecutive months, there is little to no discharge. For example for 11 of the 22 months, discharge occurred less than 10% of the time.

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Table 2: Total stormwater pump discharge hours and volume of discharge (m^3) ranked from highest to lowest for the period from August 2013 to May 2015 (note August 2013 and May 2015 are not complete months). Bold columns show percent of storm water flow occurring on the ebb and non-ebb tides.

Month	Overall		Ebb Tide			Non Ebb Tide		
	Total Discharge Hours	Cubic Metres (m^3)	Total Hours	Total Discharge Hours	**Discharge as % of total ebb hours**	Total Hours	Total Discharge Hours	**Discharge as % of total non-ebb hours**
Aug-14	266.9	66120	325	106.3	**32.7%**	456	160.6	**35.2%**
Aug-13	210.2	54616	216	83.2	**38.5%**	302	127.0	**42.1%**
Jul-14	208.3	53392	310	88.3	**28.5%**	434	120.0	**27.6%**
Jun-14	186.1	45651	300	72.0	**24.0%**	420	114.2	**27.2%**
Dec-14	168.5	41697	310	65.5	**21.1%**	434	103.0	**23.7%**
Sep-13	141.4	34639	300	54.4	**18.1%**	420	87.0	**20.7%**
Dec-13	124.0	31146	310	56.2	**18.1%**	434	67.8	**15.6%**
Sep-14	106.8	27732	300	43.8	**14.6%**	420	63.0	**15.0%**
Apr-14	64.8	15885	300	29.2	**9.7%**	420	35.5	**8.5%**
Oct-14	56.8	14759	310	19.6	**6.3%**	434	37.2	**8.6%**
Nov-13	28.2	7330	300	19.3	**6.4%**	420	8.9	**2.1%**
Mar-15	27.3	7087	310	10.8	**3.5%**	434	16.4	**3.8%**
Nov-14	22.3	5809	300	9.7	**3.2%**	420	12.6	**3.0%**
Oct-13	14.5	3760	310	4.3	**1.4%**	434	10.1	**2.3%**
Jan-14	14.1	3665	310	7.9	**2.5%**	434	6.2	**1.4%**
May-15	11.2	2907	106	0.7	**0.7%**	148	10.5	**7.1%**
Feb-15	8.17	2097	280	7.0	**2.5%**	392	1.3	**0.3%**
May-14	7.4	1915	310	4.1	**1.3%**	434	3.3	**0.8%**
Feb-14	4.78	1243	280	0.00	**0.00%**	392	4.8	**1.22%**
Mar-14	3.90	1014	310	0.00	**0.00%**	434	3.9	**0.90%**
Apr-15	3.53	918	300	0.43	**0.14%**	420	3.1	**0.74%**
Jan-15	2.30	595	310	0.00	**0.00%**	434	2.3	**0.53%**

3.4.2 Wind Speed and Direction During August 2014

Following on from the earlier consideration of the influence and potential significance of wind speed direction, data was looked at for this month. Winds greater than 10 knots occurred 33% of the time (Figure 6).

4Sight conclude that during the month of highest rainfall, wind speed and direction is also not a significant influence on the behaviour of the discharge during its mixing with the harbour waters.

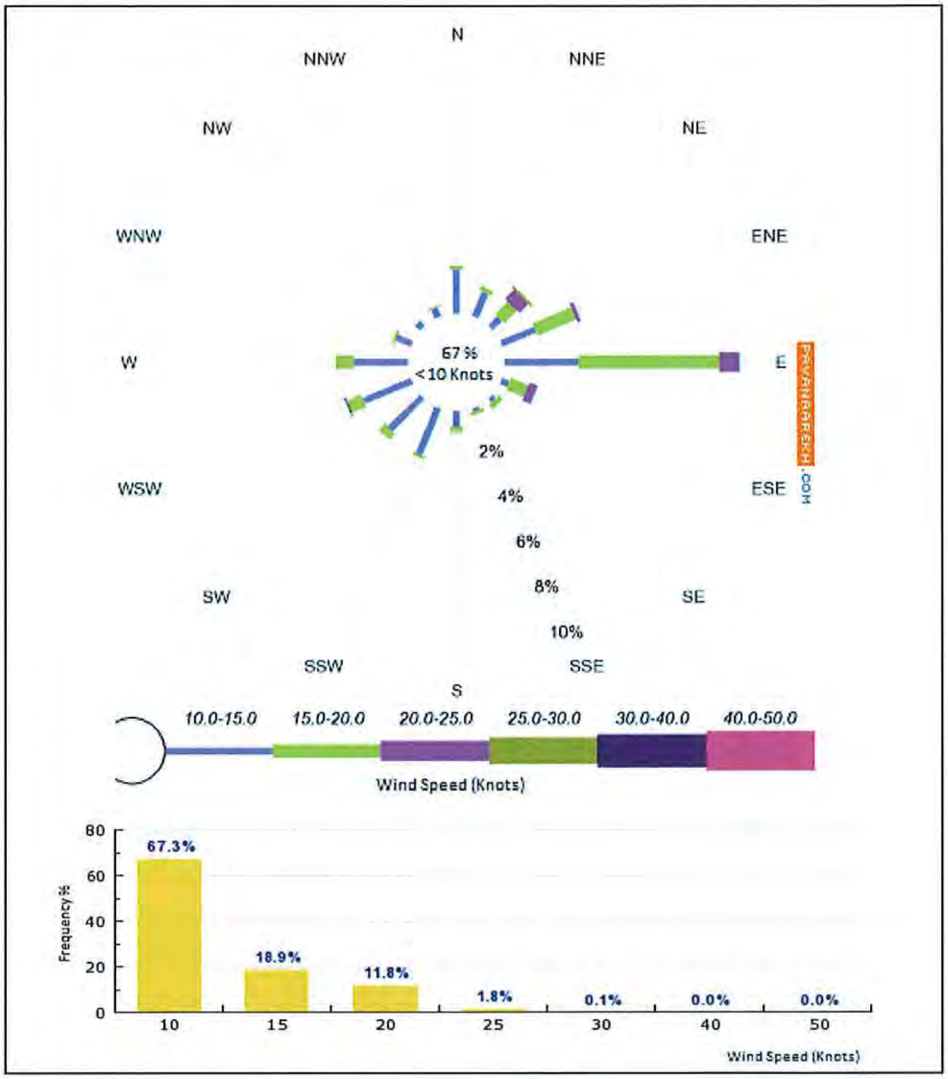

Figure 6: Wind rose and frequency of wind speeds for August 2014.

3.4.3 Rainfall and Stormwater Discharge

Of interest is also the relationship between rainfall and stormwater discharge during this month of highest discharge. Figure 7 shows the tidal cycle for August 2014, combined with storm water discharge from one or two pumps and rain fall per day. It indicates that typically small pulses of rainfall do not result in a discharge. Repeated smaller rainfall episodes and or high rainfall appear to result in a discharge but there is generally a significant lag (days) between the rainfall event and the discharge other than following very high rainfall. The pumping period can last from less than a day to several days.

Figure 8 further amplifies the findings that periods of discharge during ebb tide is relatively infrequent even during a month of high rainfall and that there is a significant delay between rainfall and pond discharge unless there have been sustained days of high rainfall.

It is noted that typically the sequence is for one pump to be triggered and then subsequently the second pump is activated by the level sensor as required. The data in Figures 7 and 8 indicate a period 22-23 August when both pumps were activated at the outset. Records show that due to a switch fault, both pumps were manually turned off and on.

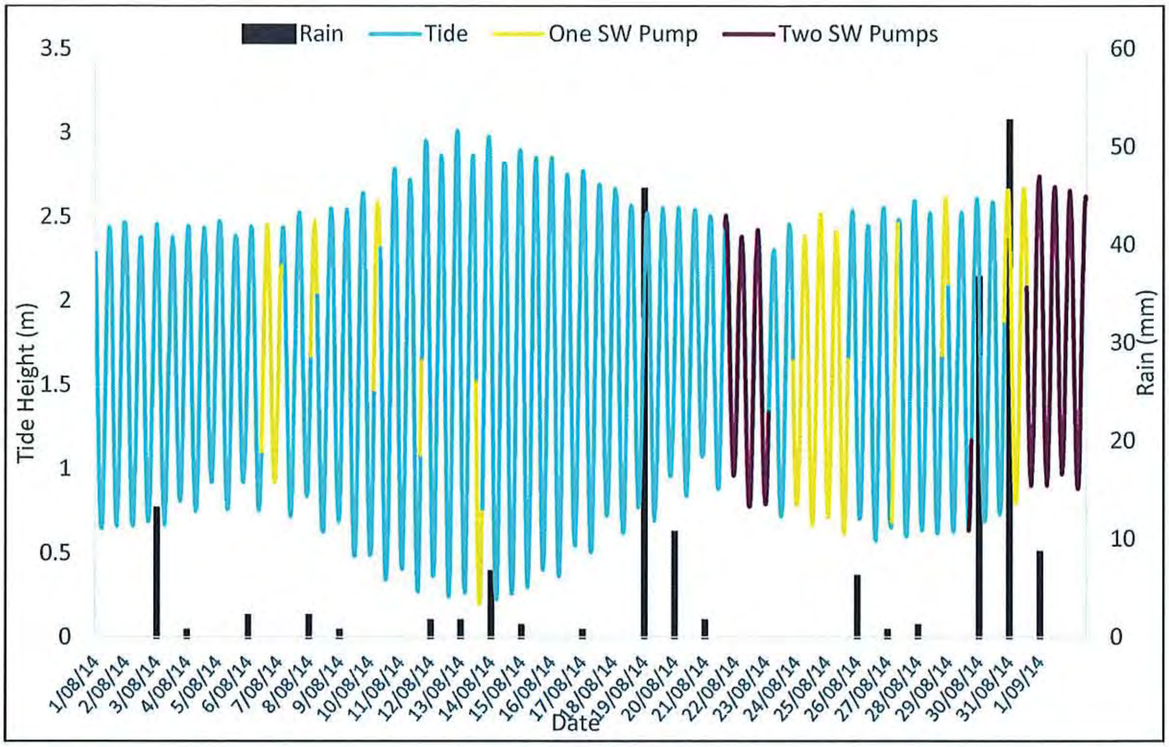

Figure 7: Tidal cycle for August 2014 in blue. Stormwater discharge from one pump in yellow and two pumps in purple. Rain per day is shown in black.

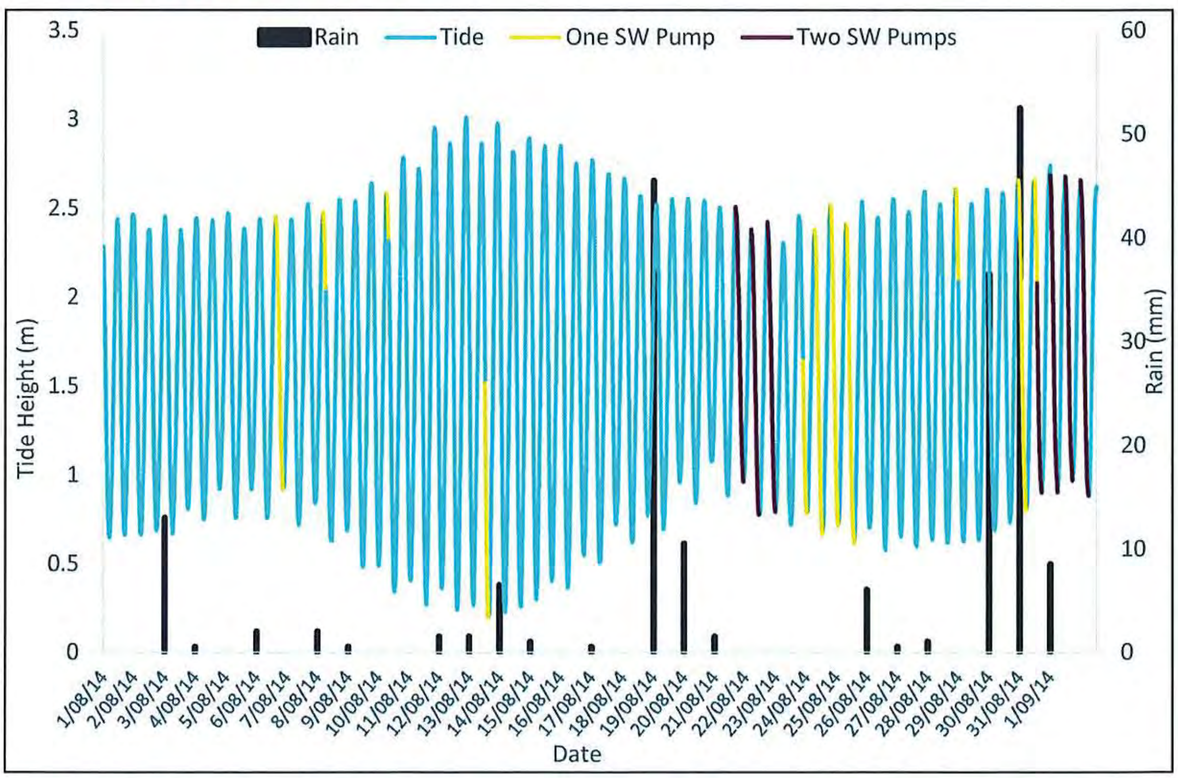

Figure 8: Tidal cycle for August 2014 in blue. Storm water discharge from one pump in yellow and two pumps in purple are shown **for ebb tides only**. Rain per day is shown in black.

3.5 Stormwater Discharge Quality

Summary statistics for the analysis of the stormwater discharge quality is presented below in Table 3. This is based on all available monitoring data covering the period 2003 to March 2015. 4Sight note that Northport have advised that because there has been little discharge in the 2015 only one further monitoring survey has been possible, this being undertaken in July 2015 but for which results are not yet available.

Table 3: Summary of stormwater discharge quality covering the period 2003 to March 2015

	Consent Limits		Number of Samples	Results				
	Action Value	Discharge		Mean	Median	95th Percentile	Min	Max
Total Suspended Solids (g/m^3)	50	Median 50	95	22.9	11.0		5	210
Total Suspended Solids (g/m^3)	100	95th Percentile 100				78.1		
	Action Values	Receiving Environment						
Aluminium (g/m^3)	0.005	None	15	0.5800	0.2000	1.7000	0.04	2.90
Copper (g/m^3)	0.013	0.0013	29	0.0039	0.0023	0.0110	<0.00053	0.011
Lead (g/m^3)	0.044	0.0044	29	0.0014	0.0013	0.0037	<0.00011	0.0054
Zinc (g/m^3)	0.15	0.015	29	0.0190	0.0155	0.0386	<0.00110	0.108

Results show that the stormwater has total suspended solids concentrations well within the thresholds required by the consent. In the case of Total Suspended Solids the consent imposes median and 95 percentile limits on the discharge before mixing (median is the midpoint value in a range of data and 95 percentile is the value that is exceeded 5 percent of the time).

In respect of copper, lead and zinc results, and taking the statistics at face value, they all show low concentrations. Median and 95 percentile values are below the respective Action Values specified in the consent before any allowance is made for dilution. If these median and 95 percentile values were divided by 200 to allow for the probable minimum dilution in the harbour mixing zone, those derived concentrations would show median values much less than 1% of the receiving environment limit required to protect marine biota. The derived 95 percentile values (i.e. the values in the table divided by 200) are only between 0.4% and 4% of the receiving environment value.

Aluminium is one parameter that has shown recent elevations, thought to be due to acidic leachate from the coal stockpile[4]. However, the risk to the marine environment associated with aluminium is considered to be negligible. ANZECC 2000 states '*...there were limited marine data and procedures for calculating an Environmental Concern Level (ECL section 8.3.4.5)...were used to calculate a low reliability marine trigger value of 0.5 ug/L...*' Consequently no marine environment toxicological threshold is provided in ANZECC 2000. Aluminium toxicity is highly pH dependant and is not considered to be toxic at the typical pH range of coastal seawater. At high pH most aluminium is not in a dissolved form. The GBC Technical report notes hydrolysis of the toxic Al^{3+} species at pH >5 and therefore likely total complexation of Al species at marine pH levels. Consequently Al discharged and entering the receiving environment beyond the mixing zone will not be bioavailable. As noted previously, the 'Action Value' for aluminium stated in the consent, is not a compliance value but is part of an alert system for monitoring trends in stormwater quality. In any event, taking the median Al concentration recorded in Table 3 (0.200 g/m^3) for the raw discharge and applying a 200 times minimum dilution factor expected for the mixing zone, results in an Al concentration well below the Action Value. Even the 95 percentile value for Al (1.700 g/m^3) is less than twice the Action Value after the minimum dilution factor is applied.

[4] Technical Services Report. Prepared for Northport by Golden Bay Cement Ltd. Dated 05/11/14. Technical Report No:14#322

The principal other monitored parameter is Polycyclic aromatic Hydrocarbons (PAH). Eleven samples collected between November 2013 and December 2014 showed concentrations of PAH to be at trace levels (below levels of detection).

In terms of the low concentrations of the individual chemical parameters monitored, the discharge quality has been shown to be consistently high.

3.5.1 Whole Effluent Toxicity Tests (WET Tests)

WET tests are designed to assess the adverse effects or toxicity to a population of aquatic organisms caused by exposure to an effluent, in this case the stormwater discharge from the port. This toxicity can be experimentally determined in the laboratory by exposing sensitive organisms (usually surrogate organisms representative of those found in the local environment) to the stormwater using WET tests. Responses assessed usually include survival, growth, and/or reproduction or some other measurable behaviour. WET testing is used to assess and regulate the combined effects of all constituents of a complex effluent, rather than the conventional methods of controlling the toxicity of single chemicals or constituents. The laboratory populations of organisms used in the WET test can include fish, invertebrates, and algae. NIWA and other laboratory/research organisations have well developed testing protocols for the species used. In broad terms, the laboratory test species are subjected to stormwater samples of varying strength (dilutions) under controlled conditions in order to estimate the environmental toxicity of that sample. Two WET tests have been undertaken on the stormwater discharge; one in 2003 and another in 2005. A further WET test is required under the existing consent requirements.

The results for both toxicity assessments carried out to date have been consistent and have confirmed there is no significant toxicity at a 200 times dilution (i.e. a 0.5% concentration). Furthermore, the toxicity results can be seen as robust as NIWA further concluded in the November 2005 report, that even under the highest tested concentrations (32% and 63.5% for a marine algae and the wedge shell *Macomona liliana*, respectively), there were no adverse effects on the test organisms relative to the control. These tested concentrations are a much more than any realistic worse case situation as they are much higher than could be achieved in the receiving environment after mixing.

3.5.2 Total Resin Acids

Resin acids are compounds which occur naturally in wood. These acids, on release to aquatic environments, have been reported to cause toxicity in some biota. Most toxicity has been reported in relation to freshwater fish, and is heavily documented for salmonid species (e.g. *Salmo gairdneri* and *Oncorhynchus mykiss*) in lakes and rivers. However freshwater biota toxicity studies are not appropriate for determining toxicity in the marine environment.

4Sight could find no data in the literature on resin acid constituent toxicity on NZ marine species. A review of overseas scientific literature on resin acids found that elevated concentrations of abietic acid and dehydroabietic acid (which are significant components of total resin acids associated with log storage runoff) have been reported to show toxicity in marine animals under conditions of sustained exposure and high concentrations. The marine toxicity information relates primarily to investigations of large scale treated and untreated pulp and kraft mill discharges. The scale and generally continuous nature and quality of such pulp and kraft mill discharges bears little relevance to the relatively small scale intermittent chemically untreated stormwater discharge from the port. Large industrial discharges, such as from kraft mills, while they include resin acids, also typically include a 'cocktail' of chemicals such as chlorophenols, dioxin and furans, most of which are by-products of chlorination used in the bleaching process. In this regard the stormwater discharge from the port needs to be clearly distinguished from such other heavy industry wood processing sites associated with the forestry industry.

Resin acids have not been measured in the port stormwater discharge. However pond influent total resin acids have been measured and concentrations are low. For example Total Resin Acids in a pond influent sample collected on 15 December 2014 showed a concentration of 0.19 g/m^3. The Evidence of D Ray[5] submitted as part of the original port resource consent applications, predicted a resin acids concentration in the discharge of 0.78 g/m^3. The influent result is consistent with this earlier prediction. The December 2014 influent value is also well below 1 g/m^3 which is

[5] Resource Management Act 1991. Applications By Northland Port Corporation (NZ) Ltd for Resource Consents related to the discharge of contaminants onto and into land and into air. Evidence of David Ray, 11 June 1997.

considered to be a threshold concentration which may cause a toxicological effect in freshwater environments, although its relevance to marine species is unclear. 4Sight note that the consent does not specify a receiving environment limit (there is no ANZECC 2000 threshold for resin acids) and no Action Value for total resin acids. The monitoring has been undertaken only for trend analysis purposes.

Concentrations of resin acids will in any event be further reduced to trace levels very quickly in close proximity to the discharge. On this basis, resin acid toxicity is not considered to pose environmental concern for the Northport stormwater discharge. We have included a summary of a literature review we have undertaken on resin acid toxicity as Appendix E to this report.

3.5.3 Stormwater Pond Management

The stormwater pond was designed to function as an open detention pond. However experience has been that the pond has developed a large biomass of aquatic emergent vegetation which, although it has undergone periodic and sometimes an apparent seasonal dieback, has generally maintained a strong wetland character within parts of the pond.

4Sight considers there are likely to be benefits from maintaining a balance between the areas of open water detention pond and the wetland vegetation. This balance will enhance the range of treatment processes occurring within the site and will also add some benefits to wetland associated wildlife that use the site.

Some additional analysis is required to determine what those proportions should optimally be but in broad terms it is envisaged that a regular programme of clearance and disposal of accumulated sediment and vegetation should be undertaken to maintain a predominance of open water but also allow for significant areas of wetland vegetation.

4 CONCLUSIONS

In summary it is concluded that the stormwater system meets performance and effectiveness that ensures environmental standards are met in the receiving waters. The discharge quality meets resource consent compliance requirements in all respects.

4Sight also conclude that a management plan should be prepared for the detention pond to maintain its treatment function into the future and to provide for an appropriate mix of open water areas and wetland habitat.

It is concluded that a number of factors guide the view as to the influence the port discharge may have on the lower harbour water quality and ecology. These are:

- Stormwater is directed to land for a long period of detention and treatment through natural physical, biological and chemical transformation processes.
- The port in any event generates a range of contaminants at concentrations of low environmental significance and which are not characterised by properties of potentially high bioaccumulation or environmental persistence. Metals for example are likely to be generated at mass loads less than what occurs on local roads and highways and which are not subject to any treatment prior to reaching watercourses and the harbour.
- The stormwater discharge is highly intermittent and there are frequent and sometimes long periods of no discharge interspersed with short periods of discharge.
- It appears from the monitoring data that stormwater quality does not need to rely on mixing and dispersion in harbour waters to reduce potential contaminants to acceptable environmental levels. Such low concentrations appear for the most part to be achieved in the stormwater before discharge.
- Apart from Aluminium, discharges generally contain contaminants at concentrations less than the Action Levels in the consent. The discharge achieves compliance with the resource consent.
- Distance between the port stormwater discharge outlet and ecological 'resources' such as the shellfish beds at Mair Bank, Marsden Bay low shore; One Tree Point and Snake Bank, are at least 1 km or more. Dilution within the consented mixing zone which extends 300 to 350 m around the port, has been estimated in hydraulic modelling studies to be high. Those studies estimated minimum dilution within 250 m of the outlet to be in the order of 200 times. Given that the consented mixing zone is larger than the mixing zone originally modelled, the

actual dilution achieved within the consented mixing zone will be significantly higher than that modelled. Taking into account the additional distance between this mixing zone edge and the potentially sensitive ecological areas, dilution is likely to be at least three orders of magnitude or more.

- Northport pumping records indicate that stormwater discharge to the harbour occurs only about 11% of the time.
- The potentially available mixing and dilution within the port mixing zone and beyond, effectively provides a redundancy in the system which ensures that any contaminant emanating from the port, will quickly be reduced to trace levels and will not influence background concentrations.
- Taking the current interest in Mair bank as a specific case in point, is also the fact that the port pumping records confirm that discharge only occurs on about 11% of the available ebb tide flows.

Taken in overview, based on the combined analysis of the high quality of the stormwater discharge and the large (and highly conservative) estimates of mixing and dilution potential, there is no basis for a speculation that the port stormwater discharge will have materially affected harbour water quality in the past, or will be likely to do so in the future based on normal operating conditions.

4Sight conclude that the port stormwater discharge will not be linked to the fate of the Mair Bank pipi. We have reviewed current information on that matter available from the Ministry of Primary Industries and other sources and note there are presently (and have been historically), a number of areas around the Northland coast that have sustained bivalve shellfish die off. This would suggest other factors are potentially involved. 4Sight have not reviewed and discussed the information we have assembled on this wider environmental phenomenon as it would seem to be unnecessary given the findings of this port stormwater review.

4Sight note there may be continued interest in and perceptions as to potential effects of the port stormwater discharge on shellfisheries in the lower Whangarei Harbour.

5 RECOMMENDATIONS

The following recommendations are made:

i. There is some uncertainty around the actual volume discharged based on current pumping rates and pump capacity. Clarification is required to accurately quantify this aspect as accurate records of pumping hours and volume are a requirement of section 1.2 of Schedule 1 of the resource consent (CON20090505532).

ii. Consideration could be given to amending the required resource consent monitoring to rationalise the need for sampling of some parameters (e.g. resin acids) and to avoid the need for multiple sampling during the first discharge event of 'each season'. Given that there is a significant delay between rainfall and discharge from the detention pond, there is no 'first flush' stormwater quality issue at stake. One-off sampling of more discharge events as and when they occur (as is the current practice of Northport) would be preferable and a better use of monitoring resources.

iii. A management plan should be prepared for the detention pond to maintain its treatment function into the future and to provide for an appropriate mix of open water areas and wetland habitat.

iv. 4Sight has given thought to one avenue of potentially useful work, in relation to the situation at Mair Bank. This would be to survey the low tidal shellfish and invertebrate populations between Marsden Bay and One Tree Point. This is a zone in which annual monitoring was undertaken for 10 years between 1997 and 2007. The funding of that work came from Northport Ltd as part of the consent requirement to establish the Whangarei Harbour Fund. That base data in relation to shellfish, would provide a statistically solid foundation for any comparisons with a current round of data collection and would be premised on the basis that there is as much likelihood of shellfish in that direction that could be affected as in the direction of Mair Bank. One consideration in relation to that avenue of work would be the other local developments which have also occurred over that period such as the Marsden Cove marina and canal development. Monitoring information from that development would also need to be reviewed.

Appendix A:

Northport Ltd Stormwater System Configuration

ISSUE	DATE	DETAILS	APPRVD	BY

Northport

P.O BOX 848
WHANGAREI, NEW ZEALAND
TEL 09 432 5010, FAX 09 432 8749
EMAIL ben.sweeny@northport.co.nz

NORTHPORT DEVELOPMENT
STORMWATER SYSTEM

D60-00-102

B SWEENY

NTS

SEPT 2014

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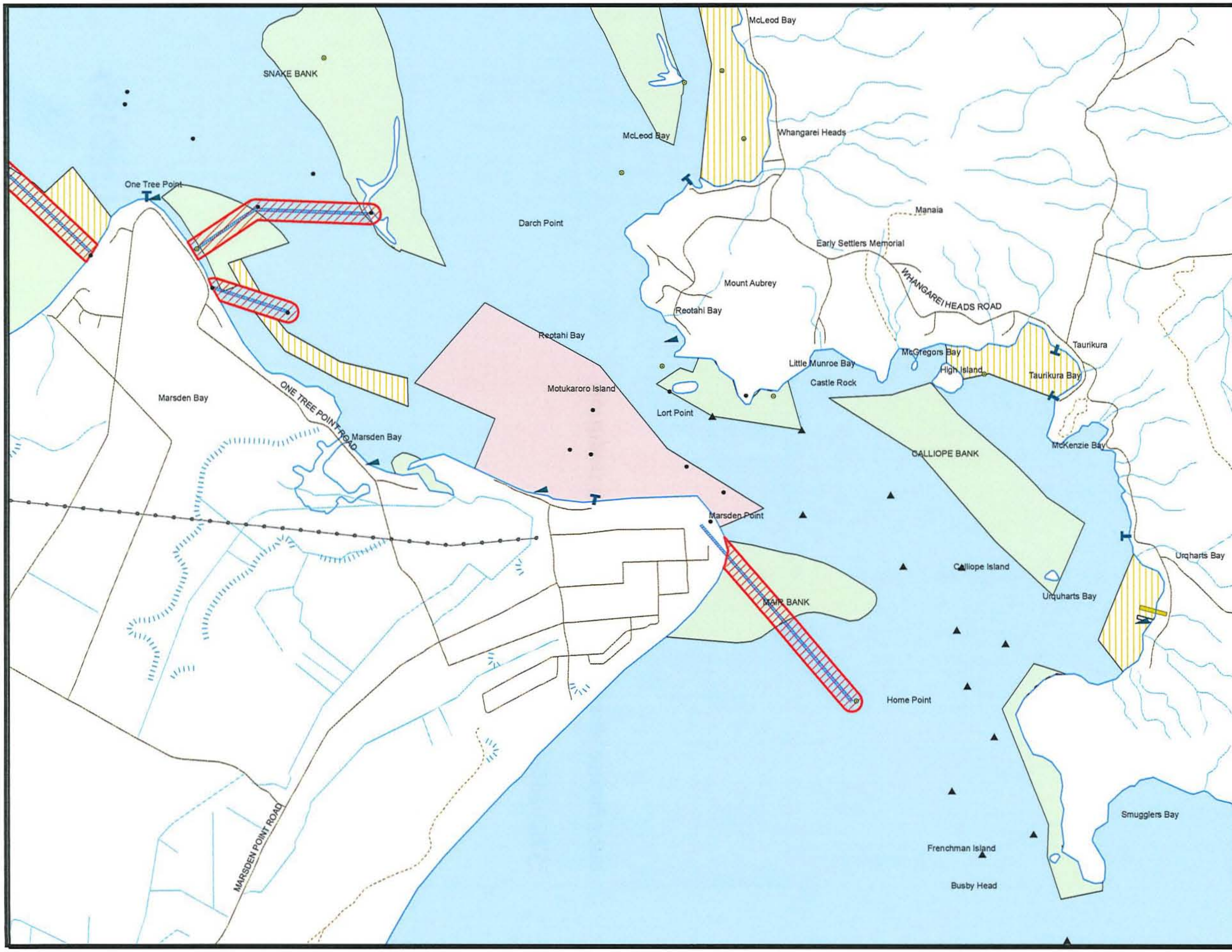
Appendix B:

Regional Coastal Plan Map C13



Map C1

Whangarei Har
Marsden Poi

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Map Sca
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Map grid values are shown
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These maps are an indicative repr
for more specific information conta

The RCP for Northland covers th
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Caution: This map should not
for navigational purpose

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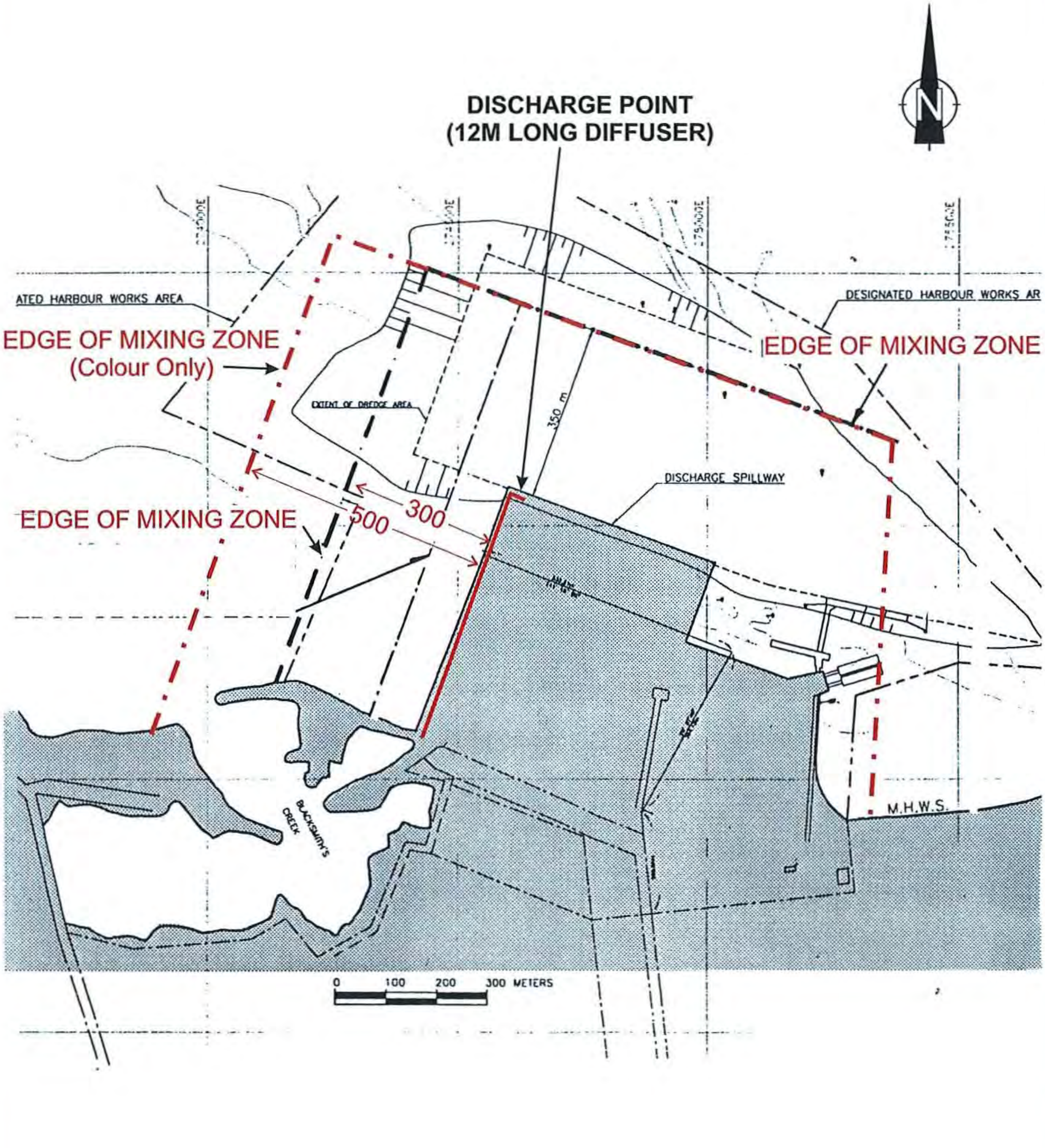
Appendix C:

Northport Ltd Stormwater Discharge Mixing Zone



Location Co-ordinates:
Datum: NZTM
Easting: 1733997
Northing: 6033711

NORTHLAND REGIONAL COUNCIL	**RESOURCE CONSENT CON20090505532 for Northport Ltd Stormwater Mixing Zone**

Scale:	N.T.S.	
Drawn:	CNA	02/10
App'd:		
Plan No.	**3259A**	

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Appendix D:

Whangarei Harbour Water Quality Classification

Northland Regional Coastal Plan Map Legend

Symbol	Description	Symbol	Description
	Regional Boundary Line		Cliff Edge
	TLA Boundary		Track & Walkway
	State Highway		River
	Road		Coastal Marine Area Boundary
	Aircraft Beacon		Surfing Area
	Boat Ramp		Land outside NRC Region
	Jetty/Wharf		Prohibited Anchorage Area
	Pontoon		Skilane
	Grid Point		Marine 1 (Protection) Management Area
	Slip		Marine 2 (Conservation) Management Area
	Protected Anchorage		Marine 3 (Marine Farms) Management Area
			Coastal Permitted Marine Farms (Post 20 December 1994)

Beacon

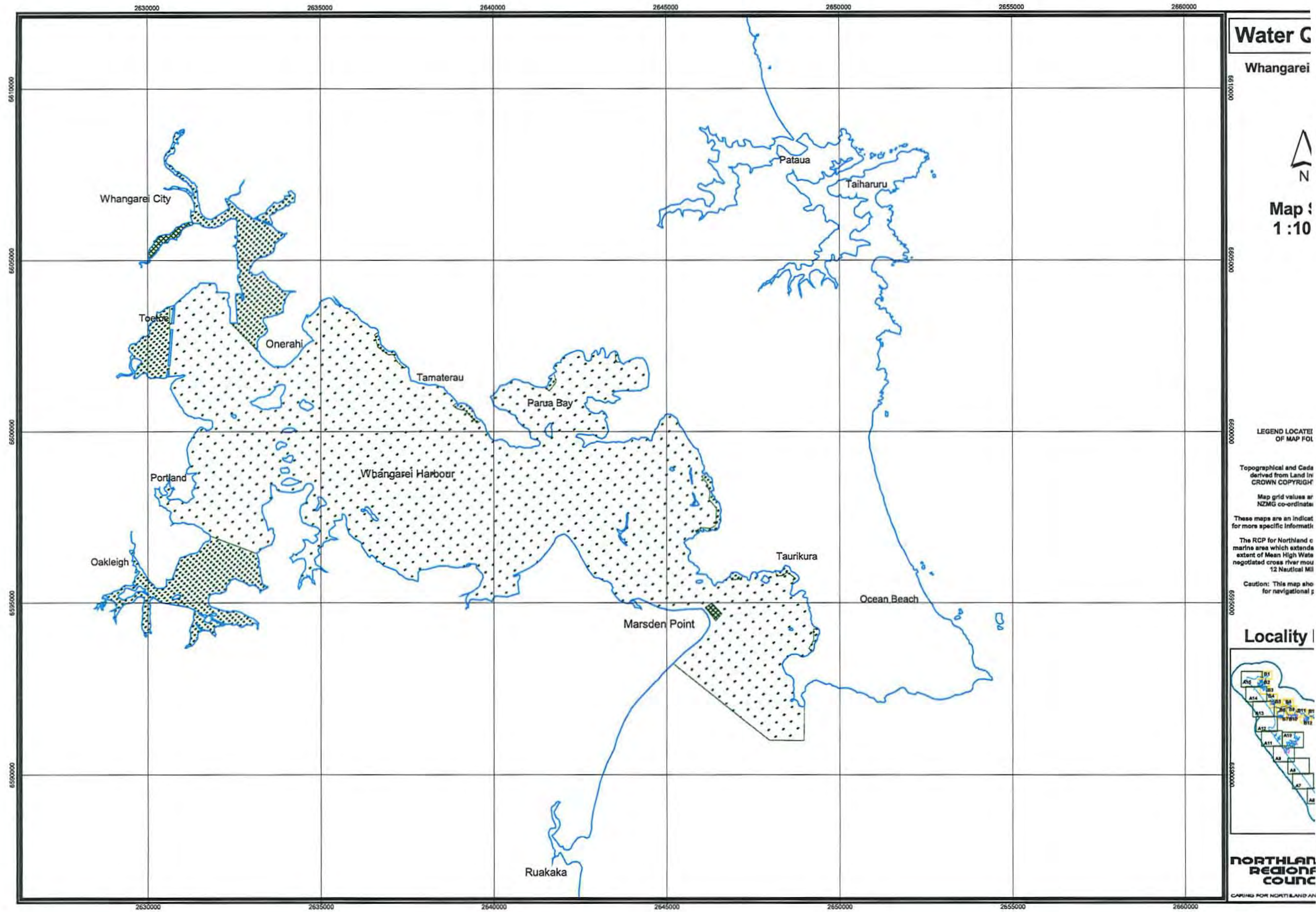
Symbol	Description	Symbol	Description
	lit		Marine 4 (Controlled Mooring) Management Area
	unlit		Marine 4 (Discretionary Mooring) Management Area

Buoy

Symbol	Description	Symbol	Description
			Marine 5 (Port Facilities) Management Area
	lit		Marine 6 (Wharves) Management Area
	unlit		Cultural Water Quality

Bridge / **Water Quality**

Symbol	Description	Symbol	Description
	Foot Traffic		CA
	Train		CB
	Vehicle		CN
	Powerline		Mixing Zones For Major Dishcarge
	Underwater Cable		
	Underwater Pipe		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Taurikura
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Appendix E:

Resin Acids Review

RESIN ACIDS REVIEW

Cherr et al., 1987[6] investigated resin acid toxicity in the sea urchin *Strongylocentrotus purpuratus*. Sea urchin sperm's ability to fertilize an egg following exposure to a toxicant is a highly sensitive measure of toxicity. This research tested specific constituents such as resin acids (abietic (AA), dehydroabietic acid (DHAA) and isopimaric acid) from paper mill effluent using a bioassay, a sea urchin sperm cell toxicity test. This highly sensitive toxicity test was employed to determine the concentrations of each chemical that inhibit fertilization. This study showed that resin acids that are normally a concern in freshwater environments, need to be one to two orders of magnitude higher in concentration to exhibit toxic effects in seawater using the sperm cell toxicity test.

The abovementioned study found that resin acids are toxic to salmonids, with LC50 values (i.e. Lethal Concentration 50 is a standard measure of toxicity of the surrounding medium that kills half the sample population of a specific test animal) between 0.2 and 0.75 mg/L. It also indicated that sea urchin fertilisation became inhibited at levels above 1.0 mg/L.

Khan et al. (1992)[7] studied flounder (*Pseudopleuronectes americanus*) at three sites near a pulp and paper mill, with some data obtained before the mill was established. While effects shown from this high strength effluent included tumours and necrosis, no specific linkage between the effect and resin acids was provided or implied by this study.

Gravato et al., (2005)[8] studied marine mussels (*Mytilus galloprovincialis*) to improve knowledge of mussels response to pulp mill effluent compounds, with particular focus on resin acids, and potentially using mussels as a monitoring species around pulp mills. These authors noted that a significant percentage of pulp and paper mill effluent toxicity is attributable to resin acids and their transformation products. They cite and reference AA and DHAA as being commonly found at concentrations of 40-2500 ug/L in treated effluents. The study investigated the genotoxic effects (i.e. chemical agents that damages the genetic information within a cell causing mutations) which may lead to cancer and oxidative stress of resin acids in mussels. Mussels were exposed to 2.7 uM AA (0.82 mg/L AA) and DHAA (0.81 mg/L DHAA) for 6, 12, 18, and 24 h. Various enzymes were measured and effects on some enzyme functions occurred after 6 hours of exposure to this concentration but depending on the specific enzyme the range was up to 24 hours for some enzyme functions. The study confirmed the usefulness of Mediterranean mussels in monitoring the effects of pulp and paper mill effluents on marine environments.

Kinnee (2005)[9], assessed the potential effect of pulp mill effluent on the survival, growth, and condition index of marine mussels (*Mytilus edulis*). This is of some interest as it is a species also found in New Zealand. Mussels were exposed to five environmentally relevant concentrations (0.23, 0.46, 1.01, 2.07 and 4.88% v/v) of pulp mill effluent diluted with ambient seawater, and a seawater control for 89 days. This equates to a dilution a range of 434 to 20.4 times dilution. This study was undertaken at Norske Canada pulp and paper mill in British Columbia to satisfy provincial biological monitoring requirements. Mussel tissue was analysed for resin acids. Resin acid concentrations in the mussel tissues were detectable for DHAA in effluent concentrations of 0.23, 1.01, 2.07 and 4.88% v/v and were 0.02, 0.09, 0.08 and 0.15 µg/g wet weight basis respectively. The study showed significant reduced survival in effluent concentrations 0.46 and 4.88% v/v compared to the control. No significant reductions in growth based on changes on length and whole weight were recorded. Condition indices and tissue lipid concentrations of the mussels declined significantly over the exposure compared to the control. Mussels exposed from 1.01 to 4.88% concentration had significantly decreased lipid concentrations. Only DHAA was detected in mussel tissue, at concentrations of <0.2 to

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[6] Cherr, G.N., Shenker, J.M., Lundmark, C., Turner, K.O., 1987. Toxic effects of selected bleached kraft mill effluent constituents on the sea urchin sperm cell. Environ. Toxicol. Chem. 6, 561–569. doi:10.1002/etc.5620060708

[7] Khan, R.A., Barker, D., Hooper, R., Lee, E.M., 1992. Effect of pulp and paper effluent on a marine fish, Pseudopleuronectes americanus. Bull. Environ. Contam. Toxicol. 48, 449–456. doi:10.1007/BF00195646

[8] Gravato, C., Oliveira, M., Santos, M.A., 2005. Oxidative stress and genotoxic responses to resin acids in Mediterranean mussels. Ecotoxicol. Environ. Saf. 61, 221–229. doi:10.1016/j.ecoenv.2004.12.017

[9] Kinnee, K.J., 2005. *Effects of pulp mill effluent on marine mussels in an on-site, flow-through bioassay*. Master of Science Thesis. University of British Columbia.

1.5 ug/g (wet weight). The pulp mill effluent was concluded as having a potential for adverse effects on the long term survival of mussels if they were continually exposed to 0.5% v/v effluent (200 times dilution).

Gravato and Santos, (2002)[10] looked at sea bass responses over 0, 2, 4, 6, and 8 hours, to realistic and environmentally relevant AA or DHAA concentrations (0, 0.0125, 0.025, 0.05, 0.1, 0.3, 0.9, 2.7 μM). Liver damage was measured and liver somatic index (LSI) was used as a general health indicator. A range of enzymatic and other responses were observed with specific responses depending on the concentration and the duration of exposure. DHAA was found to be more genotoxic than AA.

Maria et al, (2002)[11] also reported genotoxic and liver biotransformation responses to AA in adult eels (*Anguilla anguilla*) at concentrations up to 2.7 uM (0.03 to 0.8 mg/l) and exposures ranging from 8 to 72 hours. Hernández et al., (2008)[12] looked at kraft mill effluent toxicity on two flounder species *Paralychtys microps* and *Paralychtys adspersus* in Golfo de Arauco, off central southern Chile. This is a highly productive marine area with important commercial fisheries. This study reported that an efficient way to evaluate the degree of exposure of a fish to a certain pollutant, is to measure the concentration of the compounds or its metabolites in the bile fluids. In this study, resin acids were considered as useful biomarkers for exposure to this type of effluent. The study found a presence of resin acids in bile from these two flounder species, with DHAA found on average at 17.5 μg/g. However the study involved small sample sizes.

Kinee (2005) provides tissue flesh concentrations for a marine mussel species *(Mytilus edulis)*, which also occurs in NZ. This species could potentially be used as a bio-monitoring tool, which would tie in with the likely use of the same species in the WET testing. Another study on eels (Maria et al 2002) is also of some interest in that the species is of the same genus (Anguilla) as NZ's two species of endemic eel. Although eels may pass through the port area as a part of inward and outward migrations, the juvenile inward migrants will do this quickly and the outward migrants are non-feeding. Therefore effects on eels are unlikely and the relevance of using them for bio-monitoring would be questionable.

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[10] Gravato, C., Santos, M.A., 2002. Juvenile Sea Bass Liver Biotransformation Induction and Erythrocytic Genotoxic Responses to Resin Acids. Ecotoxicol. Environ. Saf. 52, 238–247. doi:10.1006/eesa.2002.2161

[11] Maria, V.L., Correia, A.C., Santos, M.A., 2004. *Anguilla L. genotoxic and liver biotransformation responses to abietic acid exposure.* Ecotoxicol. Environ. Saf. 58, 202–210. doi:10.1016/j.ecoenv.2003.12.005

[12] Hernández, V., Silva, M., Gavilán, J., Jiménez, B., Barra, R., Becerra, J., 2008. Resin acids in bile samples from fish inhabiting marine waters affected by pulp mill effluents. J. Chil. Chem. Soc. 53, 1718–1721. doi:10.4067/S0717-97072008000400018

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Appendix F:

Data Validation

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DATA VALIDATION

The two Excel files 'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records' were received from North Port Ltd along with further data via email, with running times of the two stormwater discharge pumps (Papich Road). These files contained running time and date, and stopping time and date of storm water flow for each of the two pumps. This is a text/email based message service of when the pumps are running and stopped, and it appears this is not fully accurate as some running and stopped times have not been recorded, collected or saved. Data that could be analysed and reliably interpreted was from 10 August 2013 at 16:39 to 11 May 2015 at 13:49, a period of approximately 21 months. However, this is possibly an under representation of the circumstances due to missing logged records.

In August 2014, the total number of hours the storm water pipes were discharging was 266.95 hours. To estimate how accurate the interpretation of the data was it would be ideal to compare these figures to 'Pump Station Monthly Reports', however these reports provided to us were often missing information, especially for recent months (Table 1). Figure 1 shows the total pump run hours for each pump from January 2010 to July 2014, the last 'Pump Station Monthly Report' provided by Northport Ltd.

Table 1. Information provided by 'Pump Station Monthly Reports'.

Papich Road Storm Water Pump Station						
	Pump 1 total run hours	Pump 2 total run hours	Calculated monthly run hours Pump 1	Calculated monthly run hours Pump 2	Total Pump Run hours	Notes
Jan-10	512	640				Reported date 26/01/2010
Feb-10	512	640	0	0	0	Reported date 19/02/2010
Mar-10	512	640	0	0	0	
Apr-10	512	640	0	0	0	Reported date 19/04/2010
May-10	512	640	0	0	0	
Jun-10	707	684	195	44	239	
Jul-10	732	792	25	108	133	
Aug-10	859	792	127	0	127	
Sep-10	859	913	0	121	121	Sept and Oct same report
Oct-10	859	913	0	0	0	Sept and Oct same report
Nov-10	877	913	18	0	18	
Dec-10	877	913	0	0	0	Reported date 20/12/2010
Jan-11	1012	945	135	32	167	
Feb-11	1014	1196	2	251	253	
Mar-11						No report
Apr-11	1029	1306				
May-11	1171	1306	142	0	142	
Jun-11	1316	1307	145	1	146	
Jul-11	1422	1307	106	0	106	
Aug-11	1422	1343	0	36	36	
Sep-11	1422	1366	0	23	23	
Oct-11	1422	1446	0	80	80	
Nov-11	1422	1446	0	0	0	
Dec-11	1454	1446	32	0	32	

Jan-12	1578	1446	124	0	124	
Feb-12	1578	1448	0	2	2	
Mar-12	1684	1716	106	268	374	
Apr-12	1688	1722	4	6	10	
May-12	1699	1736	11	14	25	
Jun-12	1735	1768	36	32	68	
Jul-12	1776	1775	41	7	48	
Aug-12	1778	2035	2	260	262	
Sep-12	1855	2051	77	16	93	
Oct-12	1873	2051	18	0	18	
Nov-12	1883	2051	10	0	10	
Dec-12	1883	2051	0	0	0	
Jan-13					17	No report
Feb-13					17	No report
Mar-13	1934	2051			17	
Apr-13	1961	2051	27	0	27	
May-13	2011	2051	50	0	50	
Jun-13	2125	2051	114	0	114	
Jul-13	2125	2051	0	0	0	
Aug-13	2173	2051	48	0	48	
Sep-13						No report
Oct-13						No report
Nov-13						No report
Dec-13						No report
Jan-14						No report
Feb-14	2386	2295				
Mar-14	2391	2297	5	2	7	
Apr-14						No report
May-14	2415	2342				
Jun-14						Report showed incorrect run hours
Jul-14	2551	2425				
Aug-14						Report showed incorrect run hours
Sep-14						No report
Oct-14						No report
Nov-14						No report
Dec-14						No report
Jan-15						No report
Feb-15						No report
Mar-15						No report
Apr-15						No report
May-15						No report

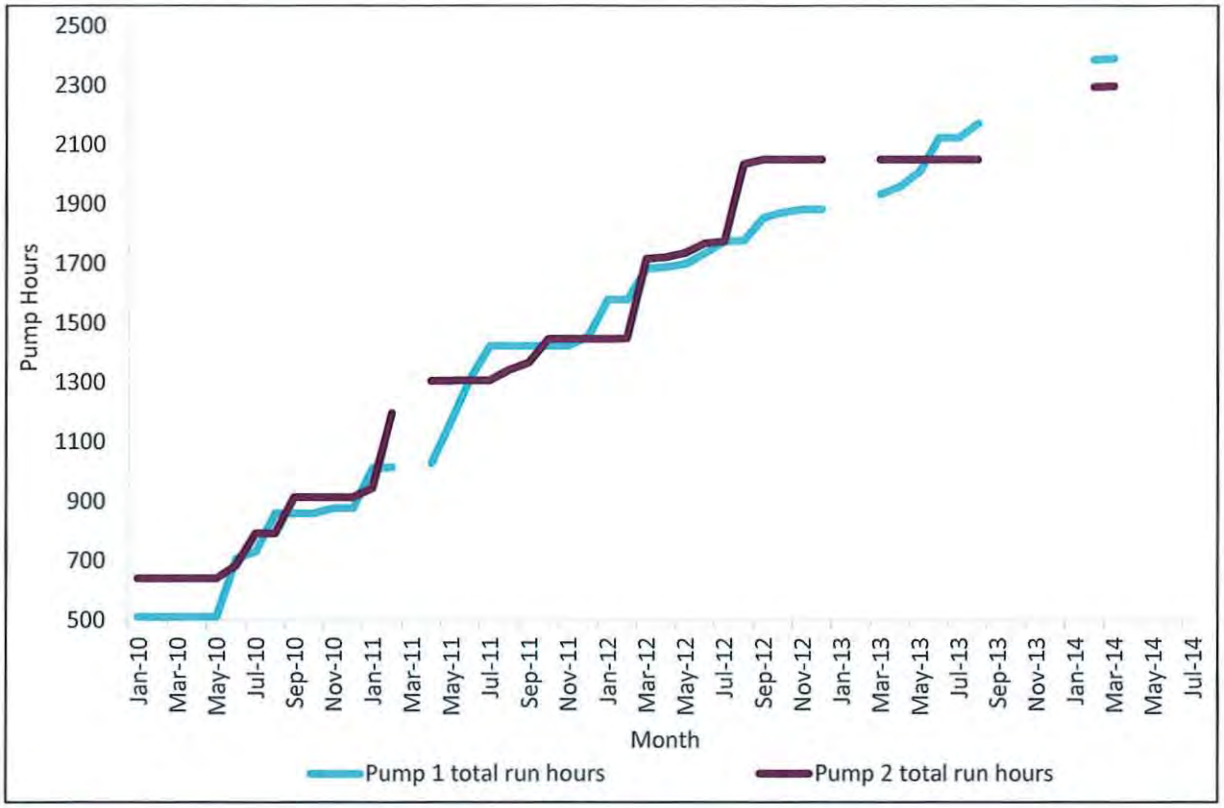

Figure 1. Total pump run hours for Pump 1 and 2.

Annual run hours for each pump and total run hours along with volume (m^3) were calculated from 'Pump Station Monthly Reports' for 2010 to 2013 and are shown in Table 2, along with annual rainfall. Years 2014 and 2015 are calculated from the data received from files 'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records'.

Table 2. Annual run hours for each pump, total run hours and volume (m3) were calculated from 'Pump Station Monthly Reports'. Annual rainfall is calculated from information provided by Northport Ltd, except for April 2014 which was provided by Northland Regional Council.

Year	Annual rainfall mm: Actual	Pump 1 Run Hours	Pump 2 Run Hours	Total Run Hours	Volume (m^3)
2010		365	273	638	165,829
2011	1454.5	577	533	1110	288,511
2012	1269	429	605	1034	268,757
2013*	1211	503	244	747	194,160
2014**	1420.5	-	-	1111	278,882
2015***	225.5	-	-	52	13,604

* 2013 represents January 2013 to February 2014, due to no other data available in the reports to calculate only a year.

** 2014 calculated from 'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records'.

*** 2015 is from January 2015 to 11 May 2015 and calculated from 'Copy of Stormwater Discharge 13-15' and 'Stormwater Discharge Records'.

Rainfall data, provided by Northport Ltd was analysed for the period August 2013 to May 2015. Rain data for the month of April 2014 was a concern and thought to be incorrect, as indicated extreme rainfall (699 mm). Alternative rainfall data was acquired from the Northland Regional Council, from the location of Whangarei Harbour at Marsden Point. This provided us with a potentially more accurate reading of rainfall for April 2014 (73.5 mm).

It is important to note that rainfall data provided by Northport Ltd, was different when compared to the Whangarei Harbour at Marsden Point site data, which was provided by the Northland Regional Council. In comparison for January, February and March 2014, rainfall data provided by Northport Ltd was 32, 62.5 and 49 mm per month respectively. At Whangarei Harbour Marsden Point site the rainfall data provided by the Northland Regional Council for those months were 11.5, 8.0 and 7.5 mm respectively.

However, Northland Regional Council state that rainfall data totals for Marsden Point are significantly low when compared with other sites. Their site 'Whangarei Harbour at Marsden Point', is not a standard setup and no check gauge is present. Therefore, they have also provided rainfall data from Ruakaka at Fosters (manual daily reads). Additionally, they comment that the mean annual rainfall calculated from a NIWA dataset at the Marsden Power Station from 1970-1990 is 1393 mm. Comparisons for rainfall levels are shown in Table 3. All data shown previously in the report is 'Actual Annual Rainfall' received from Northport Ltd, unless otherwise stated.

Table 3. Rainfall (mm) from 2003 to 2015, at Northport Ltd and Northland Regional Council sites of Marsden Point and Ruakaka at Fosters.

Year	Actual Annual Rainfall Port (mm)	Rainfall NRC Marsden Point (mm)	Rainfall NRC Ruakaka at Fosters (mm)
2003	1596		1600
2004	1029		1120
2005	1039		1088
2006	1246		1284.5
2007	1290	1141	1610.5
2008		1207.5	1629.6
2009		768.0	1135.0
2010		913.5	957.3 (missing June)
2011	1454.5	998	1529.5
2012	1269	830	1104.3 (missing July)
2013	1211	792	1151.5
2014	1420.5	758	1453.8
2015	225.5	227 (Jan-May)	179.7 (Jan-Mar)

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