Auckland
Regional Council
TE RAUHITANGA TAIAO

Upper Waitemata Harbour Benthic Habitat Survey

August 2002 Technical Publication 219

Auckland Regional Council
Technical Publication No. 219, August 2002
ISSN 1175 205X, ISBN 187735323X
www.arc.govt.nz

Printed on recycled paper

Upper Waitemata Harbour Benthic Habitat Survey

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Prepared for
Auckland Regional Council

NIWA Client Report: HAM2002-026
August 2002

NIWA Project: ARC02285

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Executive Summary

- In light of plans for increased urban development in the Upper Waitemata Harbour (UWH) catchment, the need to define the benthic ecological values of the UWH's intertidal and subtidal habitats has been identified. This report describes the results of a survey of 74 sites, conducted to quantify the existing intertidal and subtidal benthic communities of UWH. It also includes a qualitative assessment of the potential effect on these communities of long-term habitat change due to increased sediment muddiness.

- This survey has shown that the intertidal and subtidal benthic communities and habitats of UWH are generally in good condition, and are worthy of careful consideration when development occurs in the near future. In some areas of UWH, the sediment organic content is notably high in comparison to similar sites in Mahurangi and Manukau Harbours and the Whitford embayment. However, despite this the communities at these sites do not show characteristics of highly organically enriched areas.

- Sediment organic content and % mud are highly correlated in UWH, and % mud content is the environmental variable which best explains the pattern in community composition at the survey sites.

- By investigating the relationship between the mud content of the sediment and the abundances of individual taxa, we have identified several taxa that are likely to be negatively impacted by long term habitat change resulting in increases in % mud. Monitoring changes in the abundances of these taxa may give some insight or forewarning of habitat degradation due to increased sediment loads.

- Information on the distribution and densities of these sensitive taxa has enabled us to identify ecologically important areas of UWH. These are: the main body of outer UWH; Lucas Creek; Hellyers Creek; the northern side of UWH near the mouth of Paremoremo Creek; and the main body of inner UWH, in the vicinity of Herald Island.

Contents

1. Introduction

In light of plans for increased urban development in the Upper Waitemata Harbour (UWH) catchment, the need to define the benthic ecological values of the UWH's intertidal and subtidal habitats has been identified. The area has been surveyed previously (e.g., Larcombe 1973, Knox 1983), and has been recognised as having important ecological values, such as containing a variety of habitats which are utilised by birds (especially wading species) and fish. UWH was recently considered to contain the best example of muddy, mangrove-lined inlets of the inner Waitemata Harbour (Morrisey 1994). In addition, the area north of Herald Island was noted for having the greatest abundance and variety of birds and most extensive beds of shellfish in UWH (Morrisey 1994). Results of a qualitative survey of the biota and habitats of central Waitemata Harbour were presented in a report by Hayward et al. (1999). The only areas of UWH visited as part of that survey were the intertidal areas around Hobsonville (sampled in 1996-98), and the subtidal area in the main body of UWH (sampled in 1994-95). A qualitative study of the intertidal areas of Lucas Creek, and the main body of UWH in the vicinity of Herald Island, was made by Sukias et al. (1999) as part of an AEE of a potential overflow from the Lake Rosedale wastewater treatment plant. However, to our knowledge there have been no recent, spatially extensive, *quantitative* surveys made of the benthic fauna of UWH. This report describes the results of a survey conducted to describe the existing intertidal and subtidal benthic communities of UWH.

In a recent state of the art monitoring programme designed for the Auckland Marine Region, habitat loss or change through sedimentation from urban development was ranked as being of highest ecological importance to marine habitats (Hewitt 2000). Therefore, as well as providing a quantitative description of UWH's benthic resources, this report also discusses the susceptibility of the UWH biota to potential elevations in sediment load which can occur as a consequence of catchment development. This report does not address sensitivities of the benthic fauna to contaminants; the presence of contaminants within the UWH catchment and estuarine sediments will be considered as a separate part of the wider UWH study currently being undertaken by NIWA.

2. Methods

In order to provide a broad characterisation of benthic communities throughout UWH, a total of 74 sites were chosen for sampling. These included 59 intertidal and 15 subtidal sites (Figure 1). All of the sites were in soft-sediment habitats, which dominate the upper harbour environment. Sites were situated in areas representative of locations predetermined from maps of the harbour, and provide a good geographical spread; sites were situated randomly within these areas. Once established, the exact location of a site was fixed using GPS. General points of interest were also noted for each site (e.g., presence of mangroves, substrate type; Appendix 1). Sampling was conducted on 20-22 November (intertidal) and 6 December (subtidal) 2001.

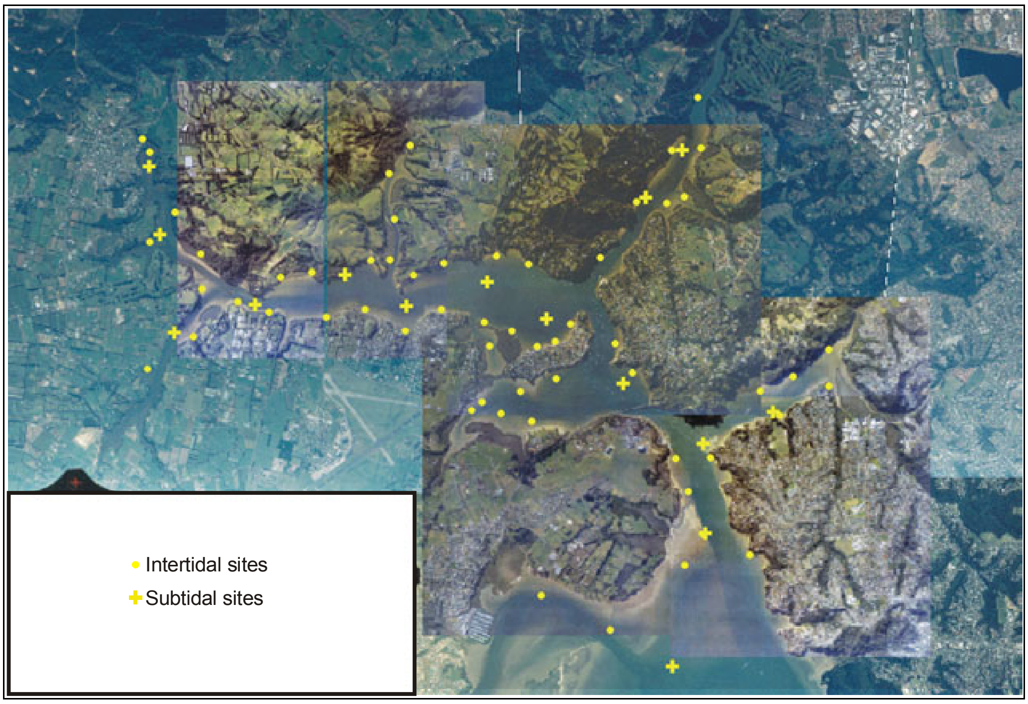

Figure 1. Aerial photograph of Upper Waitemata Harbour and the surrounding catchment. The locations of the 74 sampling sites are also shown.

At each site, 3 core samples were collected to determine macrofaunal community composition. The intertidal sites were situated at about mid-tide level, and the core samples (13 cm dia., 15 cm deep) collected at each site were separated by at least 3 m. Only two core samples were collected at each of intertidal sites 7, 37 and 49. The subtidal sites were all less than 5.5 m water depth, and the core samples (10 cm dia., 15 cm deep) taken at each of these sites were at least 1 m apart. All core samples were sieved (500 µm mesh) and the residues were stained with rose bengal and preserved in 70% isopropyl alcohol. Samples were sorted, and the macrofauna identified to the lowest possible/practical taxonomic level and counted. Although it was necessary to use different sized core samplers at the intertidal and subtidal sites, numbers of macrofauna from the subtidal sites presented throughout this report have been adjusted to enable direct comparisons between all sites.

Also at each site, sediment samples were collected adjacent to one of the core samples and analysed to determine chlorophyll *a* and organic content, and particle size. Two small cores (2 cm diam., 2 cm deep) were collected and pooled for chlorophyll *a* analysis, and another two were collected for organic content/particle size determination. Sediment for the chlorophyll *a* analysis was freeze dried, extracted in 95% ethanol, and the extract was processed using a spectrophotometer. An acidification step was used to separate degradation products from chlorophyll *a* (Sartory 1982). Grain size was determined by digesting the sediments in 6% hydrogen peroxide for 48 h to remove organic matter, and dispersion using Calgon. A Galai particle analyser (Galai Cis - 100; Galai Productions Ltd., Midgal Haemek, Israel) was then used to measure % volumes for the gravel-shell hash, coarse sand, medium sand and fine sand, silt and clay fractions. For the purposes of this report, these size fractions have been combined into 3 categories: 'coarse sand-shell hash' (coarse sand + gravel-shell hash), 'fine-medium sand' (fine sand + medium sand), and 'mud' (silt + clay). Organic content, measured as loss on ignition, was estimated by drying the sediment at 90°C for 48 h, then combusting in a muffle furnace at 400°C for 5.5 h.

Mangrove cover in the area was determined from a 1999 aerial photograph (1:50,000) using Arcview 3.2 software, and is shown on all maps in this report.

2.1 Statistical analyses

To identify similarities in community composition between sites, and assess overall gradients in community composition, multivariate analyses were conducted using PRIMER (Clarke 1993). Sites were assigned to one of seven groups depending upon their location within UWH (see Figure 2; Appendix 1). Differences in assemblage composition between these groups were assessed using the Bray-Curtis similarity index followed by non-metric multi-dimensional scaling (MDS) ordination. Ordinations were run on both untransformed density data and presence/absence data in order to isolate the effects of changes in the densities of species from changes in species composition (Warwick, 1993). To examine the relative contributions of individual taxa to the differences within site groups, SIMPER (similarity percentages) analysis (Warwick and Clarke, 1993), with a specified cut-off of 80%, was also carried out. This information was used to describe the community compositions most characteristic of each location grouping. Finally, BIOENV was used to assess the ability of the environmental variables (i.e., sediment chlorophyll *a*, organic content, and % mud) to explain the difference in community composition between sites.

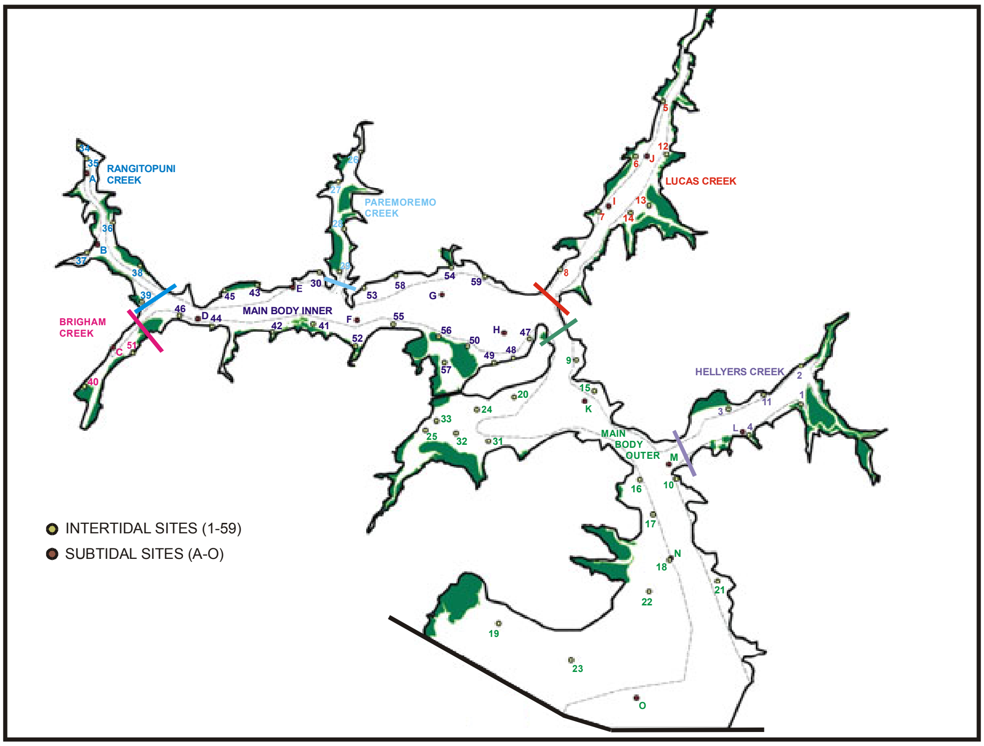

Figure 2. Map of Upper Waitemata Harbour showing the intertidal and subtidal sites sampled and the seven location-based groupings used in the analyses.

Interpolation maps of number of individuals and number of taxa were constructed using ArcGIS 8.1 Spatial Analyst. The interpolation method used was Inverse Distance Weighted (IDW) with parameters set as follows: distance weighted exponentially at a power of 2, search radius was set to variable (therefore unlimited search distances when identifying neighbouring sites), 4 neighbouring sites were used in weighting. IDW was used instead of the krigging method used in Whitford (Norkko et al. 2001), as it is more appropriate for the spatially disjunct nature of UWH (i.e., presence of channels and other physical barriers)

To assess the distribution of a particular taxa in relation to the mud content of UWH sediments, plots were constructed to relate species abundance patterns to gradients of increasing mud content of the sediment. These were examined visually to determine the range and the optimum % mud content the taxa were found at, and thus assess the potential sensitivity of a species to increases in mud content. This information was then used to help identify communities and sites that may be at risk to increased sediment loads in UWH.

3. Results

3.1 Sediment characteristics

Grain size:

In the main body of the inner harbour, and in all five of the arms (i.e., Rangitopuni, Brigham, Paremoremo, Lucas and Hellyers Creeks) the intertidal sediments are comprised predominantly of mud (i.e., silt + clay), or of a combination of mud and fine-medium sand (Figure 3; Appendix 2A). The exceptions are sites 30 and 34, where the sediments are a combination of fine-medium sand and coarse sand-shell hash (Figure 2; Appendix 2A). The outer harbour intertidal sites are comprised predominantly of fine-medium sand (Figure 3; Appendix 2A). In the middle portion of the main body of the harbour, sediments are either fine-medium sand, or a combination of mud and fine-medium sand (Figure 3; Appendix 2A).

Interestingly, some of the intertidal sites have relatively high amounts of coarse sand-shell hash sized particles (i.e., >10% at sites 8, 23, 30, 34, 35, 36, 50 and 56; see Appendix 2A). In the uppermost arm (Rangitopuni Creek), sites 34, 35 and 36 were all located within mangroves. The shorelines adjacent to sites 34, 35 and 36 (in the uppermost arm, Rangitopuni Creek), Site 8 (in the outer reaches of the Lucas Creek arm) and sites 50 and 56 (in the main body of the inner harbour, near Herald Island) are rocky, there was a rock platform < 15 cm below the sediment, and small rocks and pebbles were scattered over the sediment surface. Site 30 was situated on a rocky beach on the northern side of the main body of the inner UWH. At all of these sites the substrate type meant it was sometimes difficult to find a suitable coring spot. The relatively high amount of coarse sand-shell hash at Site 23 (the outermost intertidal site) was due to the presence of oysters.

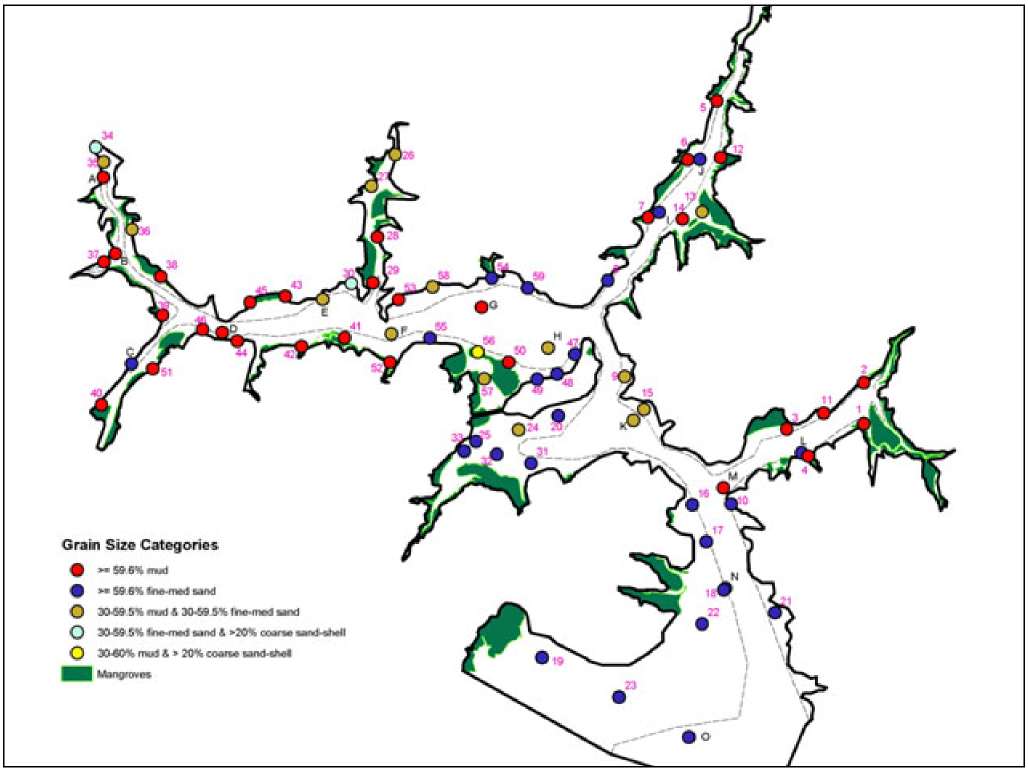

Figure 3. Map of Upper Waitemata Harbour showing substrate type at each site.

The subtidal sites are all composed predominantly of mud or fine-medium sand (Figure 3; Appendix 2B). The mud content is highest at the uppermost harbour sites (i.e., sites A and B), and lowest at the outermost sites (i.e., sites N and O). Site D, in the upper reaches of the harbour, contains an unusually high proportion of coarse sand/shell hash (27.55%, Appendix 2B). This site is located on the edge of a deep channel, in an area of very high current flow.

In the Rangitopuni Creek arm, and the main body of the UWH, intertidal and subtidal sites within a particular location are comprised of similar sediment types (Figure 3). However, in the Brigham, Lucas and Hellyers Creek arms of the harbour, the intertidal sites are predominantly muddy, whilst subtidally the sediments are predominantly fine-medium sand. This is potentially due to the higher mangrove cover that is found intertidally in these areas.

Organic content:

The organic content of the sediments covered a similar range intertidally and subtidally (i.e., 1.31-11.48% and 2.37-9.48%, respectively), and was higher in the upper reaches of UWH (Figure 4). Two sites in this region of UWH (43 and 44) had the highest levels recorded; at other sites in this area, however, levels were low (i.e., <4% at sites 30, 34 and 42, and subtidal Site C). Subtidal Site G, in the middle of the main body of UWH, had relatively high organic content (8.56 %) considering it's location in the main harbour channel (Appendices 2A and B; Figure 4). As a comparison, organic content of sediments at long term monitoring sites in Mahurangi and Manukau Harbours is below 4% (Cummings et al. 2001; Funnell et al. unpublished data), while sediments surveyed at 90 sites in Whitford contained < 6% (Norkko et al. 2001).

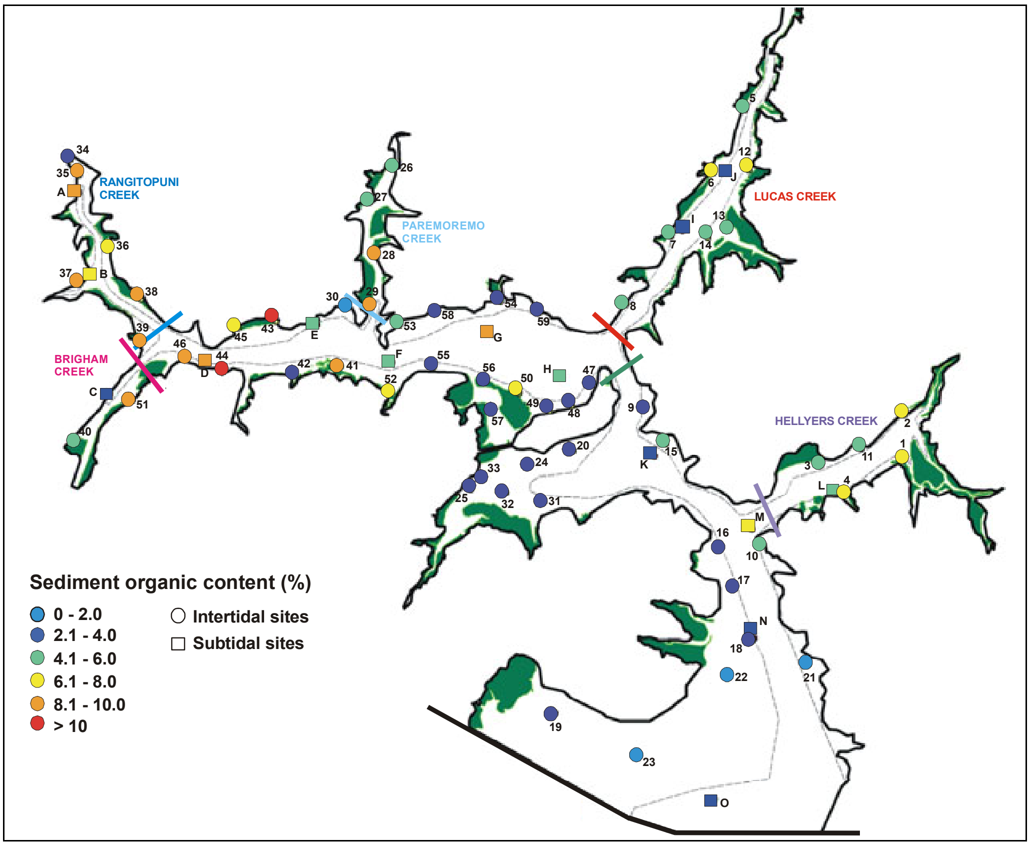

Figure 4. Map of Upper Waitemata Harbour showing the sediment organic content at each site.

Chlorophyll *a*:

Chlorophyll *a* values in UWH ranged from 0.23 to 25.71 µg/g sediment (Appendices 2A and B). With the exception of a very high value of 22.36 µg/g sediment at subtidal Site D, chlorophyll *a* was considerably lower subtidally (range = 0.23 – 8.47 µg/g) than intertidally (range = 1.60 - 25.71 µg/g) (Figure 5). Highest levels of chlorophyll *a* (i.e., > 15 µg/g sediment) were recorded in sediments on a large sandflat in outer UWH (sites 17, 18, 22 and 23), in the middle of the main body of UWH (sites 54 and 20), and in the main body of inner UWH (subtidal Site D). The sites with the highest chlorophyll *a* contents (i.e., sites 23 and D) are both situated close to the edge of channels in high flow areas. The range of values recorded in UWH are similar to those noted from Mahurangi Harbour, where levels are also lower subtidally than intertidally (ARC-Mahurangi monitoring programme data, unpublished). Sediment chlorophyll *a* levels in Whitford were also similar to those in UWH (Norkko et al. 2001), although there was not such a clear difference in values between intertidal and subtidal sites.

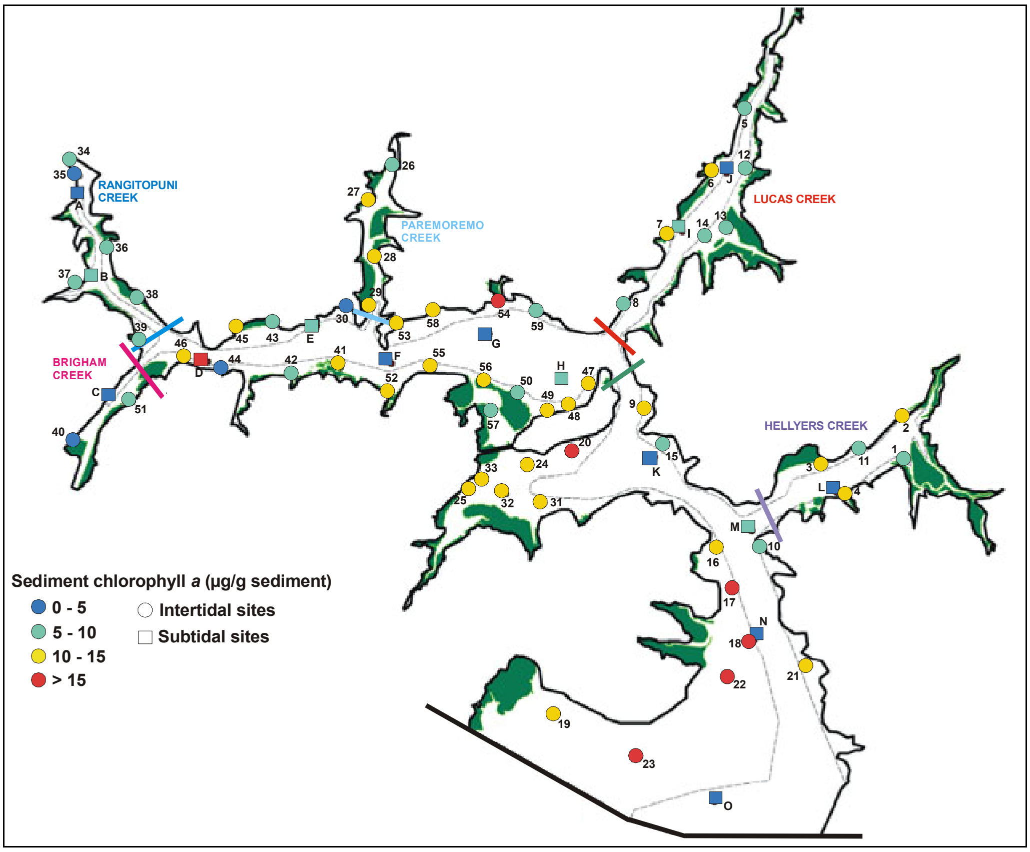

Figure 5. Map of Upper Waitemata Harbour showing the sediment chlorophyll *a* content at each site.

3.2 Macrofauna

Numbers of taxa and individuals:

The number of taxa found ranged from a mean of 3.3 taxa per core at Site 4, to 12.7 taxa at Site 21 (Appendix 3A). Numbers of individuals were lowest at Site 4 (10.7 individuals per core) and highest at Site 21 (138 individuals). Similar numbers of taxa and individuals were found at the subtidal sites (Appendix 3B). The number of taxa ranged from 3.4 species per core at subtidal Site A to 22.5 per core at Site N. Site A also has the lowest numbers of individuals (6.2 per core), while highest abundances were found at Site D (167.8 per core).

Interpolated maps based on the numbers of taxa and individuals collected at the 74 sites sampled in this study are shown in Figures 6 and 7, respectively. The number of taxa was highest in the outer harbour and in the middle region of the Lucas Creek arm (i.e., > 8 taxa/core; Figure 6, Appendix 3). Taxa diversity was also high in the vicinity of Site D. Generally, diversity is higher in regions of lower organic content (cf. Figures 4 and 6). There was a negative correlation between sediment organic content and number of taxa (intertidal $R^2 = 0.31$, $P < 0.0001$; subtidal $R^2 = 0.40$, $P = 0.0123$), and an even stronger negative relationship with % mud (intertidal $R^2 = 0.48$; $P < 0.0001$; subtidal $R^2 = 0.42$; $P = 0.0093$). Sediment organic content and % mud were highly correlated (intertidal $R^2 = 0.64$, $P < 0.0001$; subtidal $R^2 = 0.90$, $P < 0.0001$). The relationship between the number of taxa and all three of the measured environmental variables, investigated using a partial regression, identified sediment % mud content as being the most important explanatory variable [i.e., intertidal $R^2 = 0.48$, mean number of taxa = $14.6 - 4.4(\log_{10} \%\text{mud})$; subtidal $R^2 = 0.42$, mean number of taxa = $30.9 - 11.8(\log_{10} \%\text{mud})$].

There is no obvious pattern in the number of individuals dependent upon location within UWH (Figure 7), although numbers are relatively high in the vicinity of the outer-most intertidal sites (i.e., sites 21, 22 and 23) and, as noted for taxa diversity, in mid-Lucas Creek and around Site D. The number of individuals was negatively correlated with % mud at the intertidal sites only ($R^2 = 0.30$; $P < 0.0001$). The amount of mud in the sediment was the most important variable identified by the partial regression for both intertidal and subtidal sites [i.e., intertidal $R^2 = 0.39$, mean number of individuals = $120.3 - 4.4(\text{organic content}) - 65.1(\log_{10} \%\text{mud})$; subtidal $R^2 = 0.41$, mean number of individuals = $186.5 + 5.8(\text{chlorophyll } a) - 84.8(\log_{10} \%\text{mud})$]

In areas of high organic loading, we would expect the community to be comprised of high numbers of individuals of one or two taxa only. Despite the high sediment organic content observed in some areas of UWH, we don't see this pattern – this indicates there is no serious problem with organic loading in UWH at this stage.

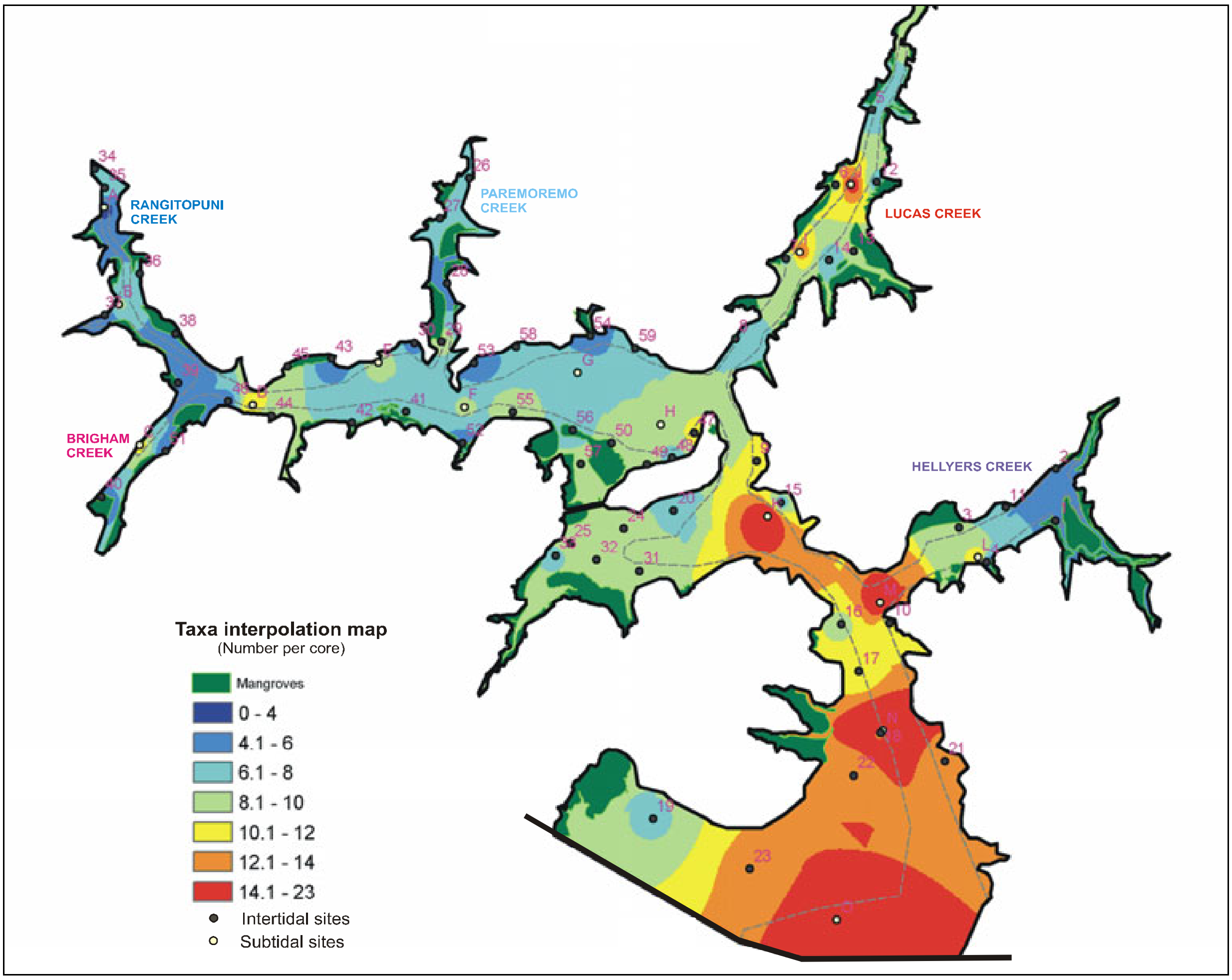

Figure 6. Interpolated map of number of taxa (per core) in Upper Waitemata Harbour.

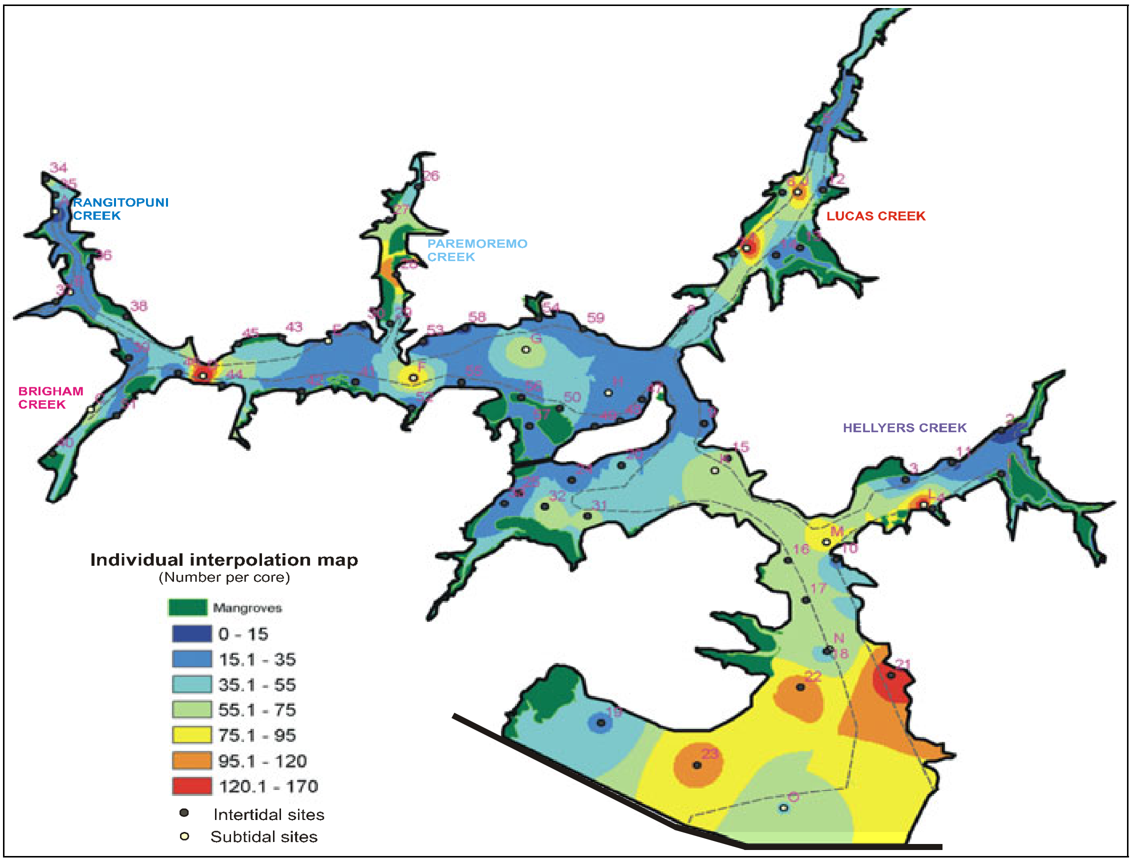

Figure 7. Interpolated map of number of individuals (per core) in Upper Waitemata Harbour.

Community composition:

Initial MDS and cluster analysis revealed a high level of dissimilarity between the macrofaunal communities of the intertidal sites and those found at the subtidal sites 85.26%); thus in all subsequent analyses intertidal and subtidal sites were assessed separately. In each case, sites were grouped based upon their location within UWH (see Figure 2).

Intertidal sites:

Groupings based on site location revealed the general intertidal macrofaunal communities listed in Table 1.

Table 1: Macrofauna common (> 1 individual per core) at the intertidal location groupings (based on simper analysis). Taxa are listed in order of average abundance (highest to lowest). †from untransformed simper analysis. *excluding *Torridoharpinia hurleyi*.

Site grouping	Characteristic common taxa	Within group similarity (%) †	Number of sites in group
Main body, inner	Nereidae, Oligochaeta, *Arthritica bifurca*, *Macrophthalmus hirtipes*, *Aricidea* sp., Spionidae (polydorids)	32.23	19
Main body, outer	*Aricidea* sp., *Nucula hartvigiana* *Heteromastus filiformis*, Nereidae, Phoxocephalidae*, *Macrophthalmus hirtipes*	35.53	16
Rangitopuni Creek	Oligochaeta, Nereidae, *Helice crassa*	36.04	6
Brigham Creek	*Arthritica bifurca*, Nereidae	41.20	2
Paremoremo Creek	Oligochaeta, Nereidae	28.50	4
Lucas Creek	*Aricidea* sp., *Cossura* sp., Nereidae, Oligochaeta, *Heteromastus filiformis*	43.86	7
Hellyers Creek	Oligochaeta, *Cossura* sp., Nereidae, Phoxocephalidae*, *Macrophthalmus hirtipes*	17.84	5

Oligochaete and nereid polychaetes were amongst the common taxa in many of the intertidal location groupings: nereids featured in all groups, and oligochaetes in all groups except Brigham Creek and the main body of outer UWH (Table 1).

Nineteen of the 59 intertidal sites are located in the main body of the inner UWH. Nereids or oligochaetes were the first or second most abundant taxa found at 16 of these 19 sites. Three of the inner harbour sites, however, were dominated by taxa that do not appear in this list – Site 30 by the bivalve *Paphies australis*, Site 50 by paraonid polychaetes (*Aricidea* sp. and Paraonidae spp.), and Site 57 by the polychaete *Cossura* sp (Appendix 4). However, some of the other taxa common at these 3 sites do feature in the list of taxa characteristic of this group (Table 1, Appendix 4).

Sites located in the main body of outer UWH were generally dominated by *Aricidea* sp. and/or *Nucula hartvigiana* (Table 1). However, as was also observed for the inner harbour group, one site in the outer UWH had high abundances of a taxa not characteristically common in this group of sites (i.e., Site 24 was dominated by cirratulid polychaetes).

Communities at sites in the uppermost arm of the harbour, Rangitopuni Creek, and sites in the Paremoremo Creek arm, were similar to those in the main body of inner UWH, in that they were characteristically dominated by either oligochaetes and/or nereid polychaetes (Table 1). However, oligochaetes were not found at all at Site 37 (Appendix 4). The mud crab *Helice crassa* was also common at the Rangitopuni Creek sites.

At Brigham Creek, the bivalve Arthritica bifurca and nereids were the most abundant taxa. The mud snail Amphibola crenata was also common at the two Brigham Creek sites (Appendix 4).

The sites in Lucas Creek featured communities that were most similar to one another than all of the other location groupings (i.e., within group similarity 43.86%, Table 1). Although oligochaetes and nereids were common in Lucas Creek, the most dominant taxa were more likely to be Aricidea and Cossura.

The outermost arm of UWH, Hellyers Creek, contained sites with communities which were quite different from each other; this is reflected in the low within-group similarity (18%, Table 1). All five of the sites in this arm were dominated by one of the common taxa characteristic of this group (Table 1; Appendix 4).

The occurrence of several of the taxa as characteristic of communities in more than one location grouping is reflected in the MDS ordination of the community data. There is some overlap in the untransformed MDS between sites in the outer harbour groups (i.e., Lucas and Hellyers Creeks and the main body of outer UWH; Figure 8A). Sites in the inner harbour arms (i.e., Rangitopuni, Brighams and Paremoremo Creeks) are situated on the right side of the MDS, separate from the sites in the main body of outer UWH.

The MDS ordination of the presence-absence transformed community data shows a similar picture to that of the untransformed MDS (cf. Figures 8A and B). However, in the latter, sites in the Rangitopuni Creek arm appear closer to sites from Brigham Creek than Paremoremo Creek. This suggests that although sites in Rangitopuni and Brigham Creek differ in their densities of common taxa, the taxa found at these two locations are essentially similar (Figure 8B).

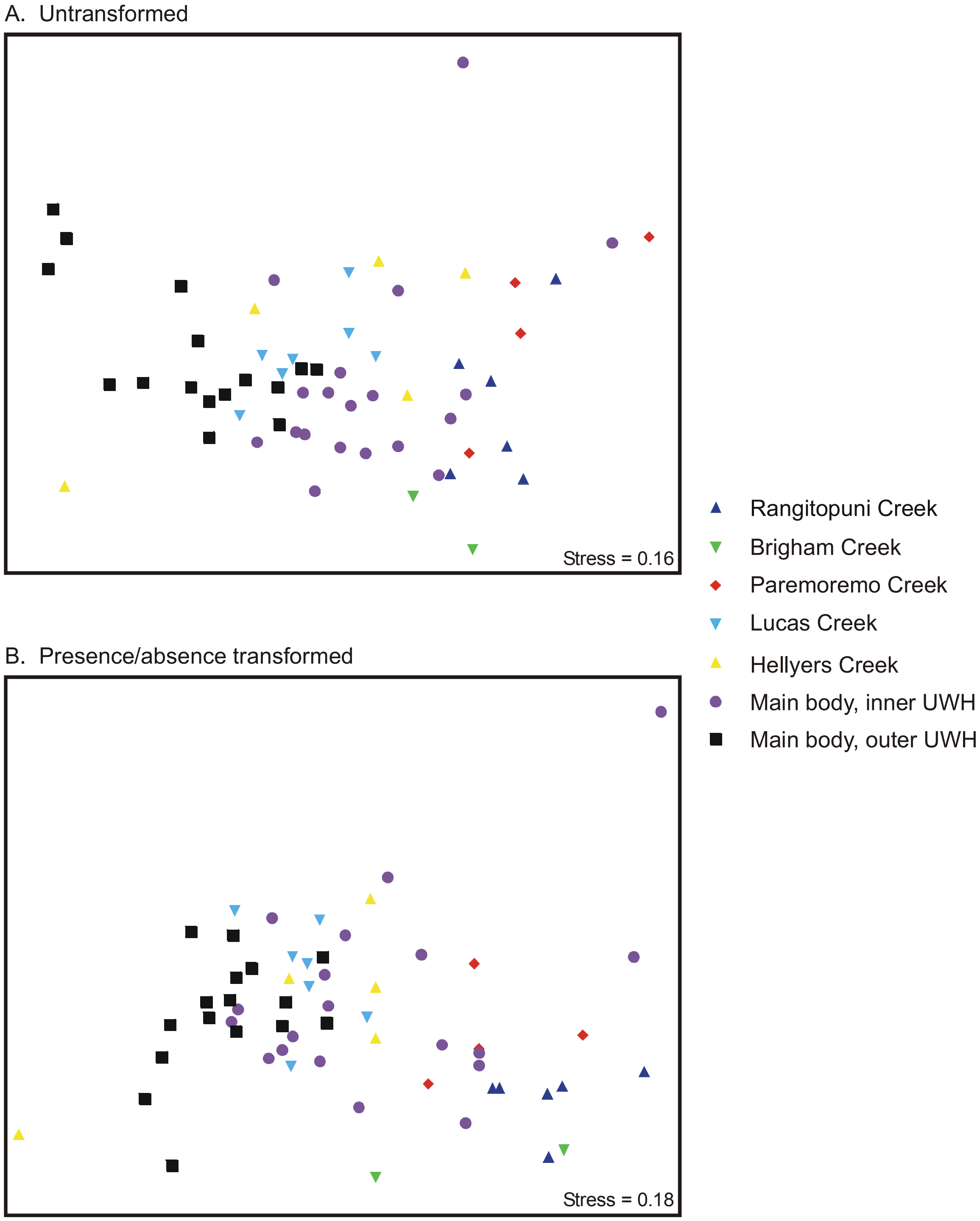

Figure 8. Multidimensional scaling ordinations showing differences in intertidal benthic macrofaunal assemblages in different areas of the Upper Waitemata Harbour.

The % mud content of the sediment is the environmental variable which best explains the pattern in community composition at the intertidal UWH sites (Spearman's rho = 0.87). Chlorophyll *a* and mud content together explain 91% of the pattern. Organic content was not detected as an important environmental variable, however, this is probably due to a very strong correlation with % mud (rho = 0.80; P < 0.0001).

Subtidal sites:

The polychaetes *Aricidea* sp., *Cossura* sp. and *Heteromastus filiformis* were found in most of the subtidal areas sampled (Table 2, Appendix 5). The Asian date mussel *Musculista senhousia* was common at Site D, in the main body of inner UWH, (i.e., 55 individuals per core; Appendix 5); however, it was not found at any other subtidal site (although it did occur in low numbers at intertidal Site 8; Appendix 5).

Table 2: Macrofauna common (> 1 individual per core) at the subtidal location groupings (based on simper analysis). †from untransformed simper analysis; nd = too few samples in group for simper analysis to be conducted. *Phoxocephalidae excludes *Torridoharpinia hurleyi*; Paraonidae excludes *Aricidea* sp. NB. there were no subtidal sites located in Paremoremo Creek.

Site grouping	Contributing taxa	Within group similarity (%)†	Number of sites in group
Main body, inner	*Cossura* sp., *Aricidea* sp.	32.74	5
Main body, outer	Paraonidae*, *Cossura* sp., Phoxocephalidae* *Heteromastus filiformis*, Cirratulidae	28.40	4
Rangitopuni Creek	Capitellidae, Spionidae (polydorids)	11.94	2
Brigham Creek	*Aricidea* sp., *Heteromastus filiformis*, Capitellidae, Cirratulidae, Nereidae	nd	1
Lucas Creek	*Aricidea* sp., *Cossura* sp.	46.03	2
Hellyers Creek	*Aricidea* sp., Paraonidae*, *Cossura* sp., Corophidae sp. 2, *Heteromastus filiformis*	nd	1

Community composition is most similar between sites in Rangitopuni Creek and Brigham Creek, and least similar between sites in Rangitopuni Creek and the main body of outer UWH.

The MDS of the untransformed subtidal community data is shown in Figure 9A. With the exception of sites in Rangitopuni Creek and the main body of outer UWH, the groupings show some overlap in their positions in the ordination space. Both sites in Rangitopuni Creek (i.e., Sites A and B) have high numbers of capitellid polychaetes and relatively low numbers of individuals and taxa compared to the other subtidal sites (Appendices 2 and 5); a feature characteristic of muddy, upper estuary sites. The MDS of the presence–absence transformed data shows more separation between groups than the untransformed MDS (cf. Figures 9A and B), implying that changes in taxa composition as well as species abundance are contributing to the differences between subtidal group communities. Rangitopuni, Brigham and Hellyers Creeks and the main body of outer UWH are all distinctly separated in the ordination space, whilst the main body of inner UWH and Lucas Creek site groupings remain close together (Figure 9B).

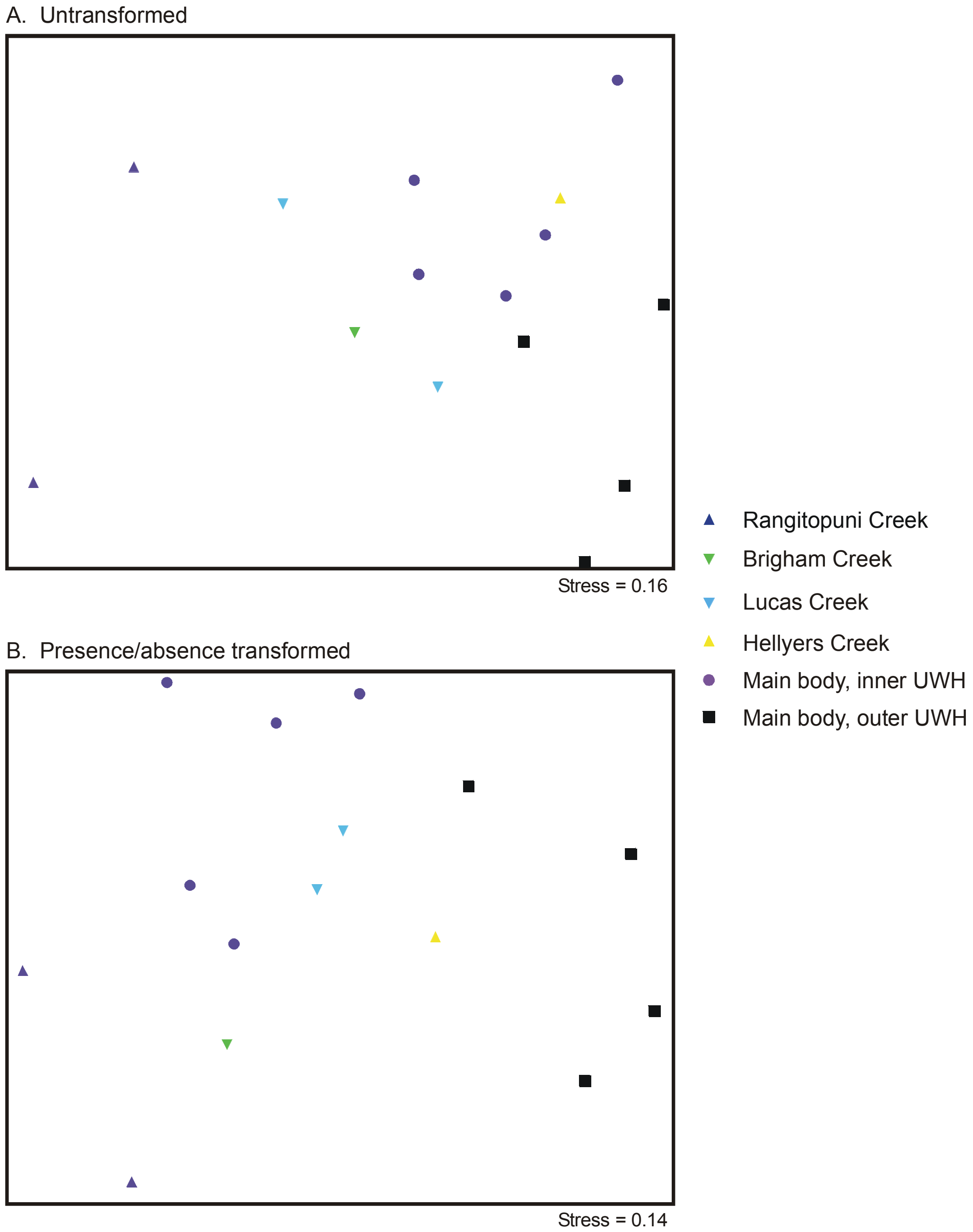

Figure 9. Multidimensional scaling ordinations (MDS) showing differences in subtidal benthic macrofaunal assemblages in different areas of the Upper Waitemata Harbour.

As noted for the intertidal sites, the % mud content of the sediment is the environmental variable which best explains the pattern in community composition at the subtidal UWH sites (Spearman's rho = 0.83). Again, chlorophyll *a* and mud content together increase the explanatory power a little (to 0.87), and organic content was not detected as an important environmental variable, probably due to a very strong correlation with % mud (rho = 0.95; $P < 0.0001$).

4. Discussion of taxa and sites potentially sensitive to increased sediment loads

In this section of the report we focus on the effects of longer term habitat change which can occur as a result of increased sediment inputs over a long time period, rather than the effects of short-term catastrophic inputs of terrestrial sediment.

4.1 Sensitive taxa in UWH

To help identify areas of UWH which may be affected as a result of increased sediment loads to the harbour during future catchment development, we examined the current distribution of individual taxa in relation to the mud content of the sediment. This approach has been used previously to identify sensitive taxa in the Whitford embayment (Norkko et al. 2001). Species sensitivity plots were drawn for all common taxa, for intertidal and subtidal sites separately. From these plots we were able to identify a number of taxa which exhibit a threshold response to increasing sediment mud content (i.e., these taxa do not occur at mud contents above a particular level), and a number of taxa which, despite the fact that they occur in a wide range of sediment types, are more or less abundant at muddier sites (Table 3; Appendix 6).

Table 3. Sensitivity of macrofaunal taxa to increasing mud (silt+clay) content of sediments in UWH. *denotes particularly sensitive taxa (i.e., taxa exhibiting a threshold response); all other taxa listed may decline in abundance at higher mud levels. The sensitivity plots on which this table is based are given in Appendix 6.

Taxa	Type	Range of sediment mud content recorded in (%)	Intertidal/ subtidal	Number of sites found at
*Paphies australis**	bivalve	0-11	intertidal	2
*Macomona liliana**	bivalve	< 50	intertidal	13
		17-20	subtidal	2
*Notoacmea helmsi**	limpet	< 65	intertidal	5
*Aonides oxycephala**	polychaete	< 50	intertidal	4
		32-67	subtidal	2
Goniadidae*	polychaete	20-41	intertidal	3
		< 33	subtidal	5
Austrovenus stutchburyi	bivalve	all	intertidal	21
Nucula hartvigiana	bivalve	all	intertidal	14
		<50	subtidal	4
Aricidea sp.	polychaete	all	intertidal	35
		all	subtidal	12
Aquilaspio aucklandica	polychaete	<55	intertidal	14
		all	subtidal	4
Heteromastus filiformis	polychaete	all	intertidal	34
		all	subtidal	11

A number of taxa were not present at sites containing higher (> 67%) levels of mud [i.e., the bivalves *Paphies australis, Macomona liliana* and *Nucula hartvigiana*, the limpet *Notoacmea helmsi*, and the polychaetes *Aonides oxycephala*, Goniadidae and *Aquilaspio aucklandica*; Table 3]. In addition, there were several taxa which were found in a wide range of sediment types, but exhibited their highest abundances at less muddy sites (i.e., the bivalves *Austrovenus stutchburyi* and *Nucula hartvigiana,* the polychaetes *Aricidea* sp., *Aquilaspio aucklandica* and *Heteromastus filiformis*). Other taxa were more often found at muddier sites (e.g., oligochaetes, the crab *Helice crassa* and the amphipod *Torridoharpinia hurleyi*). Abundances of many taxa were unrelated to the mud content of the sediment (e.g., nereids, glycerids, polydorids, *Scolecolepides*, *Cossura*, *Arthritica, Theora,* phoxocephalids and *Macrophthalmus*).

Patterns for many of these species are very similar to those found in the Whitford embayment (Norkko et al. 2001). For example, in Whitford *Aonides* had a very strong affinity to sediments low in silt/clay (0-5%); at intertidal sites in this study, *Aonides* were more abundant in <10% mud (Table 3, Appendix 6). *Notoacmea helmsi* was only found in sediment with a mud content less than 10% in Whitford; in UWH abundances were highest in <10% mud, although it was very occasionally present in sediments containing up to 65% mud (Appendix 6). *Notoacmea* and *Aonides* were both considered highly sensitive to increases in sediment mud content in Whitford (Norkko et al. 2001), and the UWH data reinforces this classification.

Macomona, *Austrovenus, Nucula*, *Goniada emerita*, and *Aricidea* were classed as moderately sensitive species in Whitford (Norkko et al. 2001). Four of these species, *Macomona*, *Austrovenus, Nucula* and *Aricidea,* exhibited similar patterns in their optimal abundances in UWH, although all but *Macomona* were found in wider ranges of sediment mud content in UWH. The patterns observed for *Goniada emerita* in Whitford and Goniadidae in UWH were slightly different: in Whitford this polychaete was found in 0-60% mud, and exhibited maximum densities in sediments near the top of this range; in UWH it was found in sediments with 10-50% mud, and exhibited higher abundances at the lower % mud contents (Appendix 6). These differences suggest that, while this group of polychaetes does not like high % mud, at less muddy sites other factors are important in determining its distribution.

This study has identified two polychaete species (*Aquilaspio aucklandica* and *Heteromastus filiformis*) as being likely to exhibit declines in abundance with increasing sediment mud content (Table 3). However, both of these polychaetes were considered likely to show no response to increasing mud in Whitford. *Aquilaspio* exhibited maximum densities at around 65-70% mud in Whitford. In UWH however, although it was present at 2 muddy subtidal sites (i.e., 69.7 and 91.4% mud), it was not found at any intertidal sites with > 55% mud (Appendix 6). *Heteromastus* was found in a wide range of mud contents at both locations, but showed higher abundance at 20-60% mud in UWH (Appendix 6). Thus we consider both species could be adversely affected by increased sediment mud content in UWH.

We believe that sites containing the taxa highlighted in Table 3 (*) will be most at risk if any increases in sediment loading result in long-term increase in the mud content of the sediments. None of these taxa are found at sites containing high levels of mud (i.e., > 67%). In addition, given the limited distribution of *Austrovenus* in relation to sediment mud content observed in Whitford (Norkko et al. 2001) and it's importance as a species for recreational shellfish gathering, we have included this cockle in the most at-risk group. Pipis, *Paphies australis*, are commonly found as adults at sites with coarse sediment substrate and high current flows. It is an important edible shellfish. *Macomona liliana*, the wedge shell, is a facultative deposit feeder, which also suspension feeds.

4.2 Sensitive areas of UWH

By examining the relative abundances and distribution of these six highly sensitive taxa (i.e., *Paphies australis, Macomona liliana, Notoacmea helmsi, Aonides oxycephala,* Goniadidae, and *Austrovenus stutchburyi*) around UWH, we have identified the following areas:

1. The main body of outer UWH, particularly in the area south of the Hellyers Creek entrance;

2. Lucas Creek and, to a lesser extent, Hellyers Creek;

3. The beach where Site 30 is located (due to its high numbers of *Paphies*).

It is these areas of UWH where the benthic communities are likely to be most adversely affected by increased muddiness. The physiological condition of adult *Paphies* and *Austrovenus* have been shown to be adversely affected by prolonged elevations in suspended sediment concentrations, and growth rates of juvenile *Macomona* were also negatively affected (Hewitt et al. 2001). Furthermore, these adverse effects on *Austrovenus* are enhanced when the suspended sediment is terrestrially derived (Hewitt et al. 2001).

In addition, there is likely to be a decline in numbers (but not complete eradication) of several taxa in response to increased sediment mud content (see Table 3; i.e., *Nucula hartvigiana, Aricidea* sp., *Heteromastus filiformis, Aquilaspio aucklandica*). While these taxa may not be perceived as commercially or aesthetically important in comparison to those discussed above, they are indicative of a community which is still reasonably diverse, are most certainly important as a food source for birds and fish, and thus are worth preserving. Monitoring changes in their abundances may give some insight or forewarning of habitat degradation due to increased sediment loads. The distribution and densities of these sensitive taxa reinforce the conclusions of ecologically important areas of UWH identified above, as these taxa also exhibit their highest abundances in the main body of the outer harbour and Lucas Creek. In addition, the main body of inner UWH, in the vicinity of Herald Island, is also an important area for these taxa.

This study has focussed on benthic communities only, and has not investigated distributions or habitat usage by birds and fish. Given the fact that UWH has previously been recognised as containing habitat important for birds (Larcombe and Knox studies), we would strongly recommend that any catchment development also includes consideration of bird roosting and feeding areas.

5. Conclusions

This survey has shown that the intertidal and subtidal benthic communities and habitats of UWH are generally in good condition, and are worthy of careful consideration when development occurs in the near future. We have noted that in some areas of UWH, organic content notably is high in comparison to similar sites in Mahurangi Harbour and the Whitford embayment. However, despite this the communities at these sites do not show characteristics of highly organically enriched areas. Sediment organic content and % mud are highly correlated in UWH, and % mud content is the environmental variable which best explains the pattern in community composition at the survey sites. By investigating the relationship between the mud content of the sediment and the abundance of individual taxa, we have identified several taxa that are likely to be negatively impacted by long term habitat change resulting in increases in % mud. Monitoring changes in the abundances of these taxa may give some insight or forewarning of habitat degradation due to increased sediment loads. Information on the distribution and densities of these sensitive taxa has enabled us to identify ecologically important areas of UWH, namely, the main body of outer UWH, Lucas Creek, Hellyers Creek; the northern side of UWH near the mouth of Paremoremo Creek; and the main body of inner UWH, in the vicinity of Herald Island.

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7. Acknowledgements

Judi Hewitt, Don Tindale, Kylie Theobald, Corina Kemp, Rick Liefting and Carolyn Lundquist helped with field sampling, and Greig Funnell and Drew Lohrer carried out some of the macrofaunal identifications. Todd Williston conducted the interpolations and produced the maps. Thanks to John Hawken and Kylie Theobald for the particle size analysis, and to Kylie Theobald for the chlorophyll *a* and organic content analyses.

8. Appendices

Appendix 1A. GPS co-ordinates, location within Upper Waitemata Harbour, and points noted during sampling, for each intertidal site.

Site	Southing	Easting	Comments	Location
1	36°46.930	174°41.749		Hellyers Creek
2	36°46.678	174°41.743		Hellyers Creek
3	36°46.972	174°41.161		Hellyers Creek
4	36°47.137	174°41.331		Hellyers Creek
5	36°44.963	174°40.581		Lucas Creek
6	36°45.328	174°40.367		Lucas Creek
7	36°45.689	174°40.074		Lucas Creek
8	36°46.080	174°39.774	Cores on edge of mangroves, rocky shoreline	Lucas Creek
9	36°46.668	174°39.919	Oyster beds	main body, outer UWH
10	36°47.439	174°40.749		main body, outer UWH
11	36°46.871	174°41.443	Cores at edge of mangroves	Hellyers Creek
12	36°45.310	174°40.617	Cores at edge of mangroves	Lucas Creek
13	36°45.647	174°40.484		Lucas Creek
14	36°45.693	174°40.335		Lucas Creek
15	36°46.868	174°40.069		main body, outer UWH
16	36°47.449	174°40.453	Mud bank	main body, outer UWH
17	36°47.675	174°40.566	Mud bank	main body, outer UWH
18	36°47.970	174°40.706	Mud bank	main body, outer UWH
19	36°48.407	174°39.328	Mud bank	main body, outer UWH
20	36°46.918	174°39.418		main body, outer UWH
21	36°48.102	174°41.101		main body, outer UWH
22	36°48.180	174°40.547	Oyster beds	main body, outer UWH
23	36°48.639	174°39.924	Oyster beds, muddy substrate	main body, outer UWH
24	36°47.008	174°39.116	Scattered oyster beds	main body, outer UWH
25	36°47.086	174°38.791		main body, outer UWH
26	36°45.331	174°38.133	Cores in mangroves	Paremoremo Creek
27	36°45.528	174°37.958	Cores in mangroves	Paremoremo Creek
28	36°45.840	174°38.011	Cores in mangroves	Paremoremo Creek
29	36°46.122	174°37.981	Cores at edge of mangroves	Paremoremo Creek
30	36°46.130	174°37.818	Rocky beach	main body, inner UWH
31	36°47.213	174°39.218		main body, outer UWH
32	36°47.162	174°38.954		main body, outer UWH
33	36°47.146	174°38.704	Solid layer ~10cm down, cores at edge of mangroves	main body, outer UWH
34	36°45.321	174°35.849	Hard substrate, cores in mangroves, photo, rocky shoreline	Rangitopuni Creek
35	36°45.411	174°35.911	By boat ramp, cores in mangroves, rocky shoreline	Rangitopuni Creek
36	36°45.823	174°36.136	Cores in mangroves (anoxic sediments), rocky shoreline	Rangitopuni Creek
37	36°46.026	174°35.927	Dense mangroves up inlet, sampled at mouth of main channel	Rangitopuni Creek
38	36°46.108	174°36.362	Cores at edge of mangroves	Rangitopuni Creek
39	36°46.345	174°36.381	Cores at edge of mangroves	Rangitopuni Creek
40	36°46.903	174°35.927	Cores at edge of mangroves	Brigham Creek
41	36°46.464	174°37.775	Cores at edge of mangroves	main body, inner UWH
42	36°46.523	174°37.447	Cores in mangroves	main body, inner UWH
43	36°46.216	174°37.315		main body, inner UWH
44	36°46.496	174°36.955	Cores in mangroves	main body, inner UWH
45	36°46.256	174°37.049	Cores at edge of mangroves	main body, inner UWH
46	36°46.430	174°36.689		main body, inner UWH
47	36°46.538	174°39.534	Sandy shell layer, tricky cores	main body, inner UWH

Site	Southing	Easting	Comments	Location
48	36°46.661	174°39.403	Beach/mud	main body, inner UWH
49	36°46.696	174°39.251	Cores at edge of mangroves	main body, inner UWH
50	36°46.594	174°39.031	Cores in mangroves	main body, inner UWH
51	36°46.676	174°36.315	Cores next to small private boat ramp in mangroves	Brigham Creek
52	36°46.608	174°38.123		main body, inner UWH
53	36°46.222	174°38.182	Semi-beach with a rocky shelf sloping off to mud	main body, inner UWH
54	36°46.080	174°38.889	Cores at edge of mangroves	main body, inner UWH
55	36°46.456	174°38.426	Hard mud with a ~25cm rock base	main body, inner UWH
56	36°46.536	174°38.794	Cores in mangroves	main body, inner UWH
57	36°46.699	174°38.847	Cores in centre of inlet surrounded by mangroves	main body, inner UWH
58	36°46.140	174°38.437	Cores at edge of mangroves	main body, inner UWH
59	36°46.135	174°39.164	Cores at edge of mangroves	main body, inner UWH

Appendix 1B. GPS co-ordinates, depth, location within Upper Waitemata Harbour, and points noted during sampling, for each subtidal site.

Site	Southing	Easting	Depth (m)	Comments	Location
A	36 45 506	174 35 911	2.0	Muddy clay, brown	Rangitopuni Creek
B	36 45 972	174 36 012	2.0	Muddy clay	Rangitopuni Creek
C	36 46 647	174 36 154	3.2	Muddy clay, near mangroves	Brigham Creek
D	36 46 444	174 36 839	3.6	More gravel, sandy mud	main body, inner UWH
E	36 46 229	174 37 602	3.8	Muddy sand	main body, inner UWH
F	36 46 436	174 38 130	5.2	Muddy sand, shell hash	main body, inner UWH
G	36 46 260	174 38 817	5.3	Muddy sand, shell hash	main body, inner UWH
H	36 46 501	174 39 328	2.7	Muddy sand	main body, inner UWH
I	36 45 655	174 40 156	1.6	Muddy clay	Lucas Creek
J	36 45 324	174 40 460	2.1	Muddy clay	Lucas Creek
K	36 46 938	174 39 992	2.6	Pebbley on top, shell hash, strong current	main body, outer UWH
L	36 47 115	174 41 279	<1.0	Muddy clay	Hellyers Creek
M	36 47 341	174 40 687	1.6	Sandy mud with clay	main body, outer UWH
N	36 47 958	174 40 719	3.0	Sandy	main body, outer UWH
O	36 48 877	174 40 461	1.4	Sandy	main body, outer UWH

Appendix 2A. Sediment composition (% volume), organic content (% volume) and chlorophyll *a* content (µg/g sediment) of sediments at the intertidal sites.

Site	Mud	Fine-medium sand	Coarse sand-shell hash	Organic content	Chlorophyll *a*
1	96.36	3.74	0.06	7.44	8.45
2	74.98	23.82	1.20	6.82	11.19
3	63.49	36.13	0.42	4.58	12.80
4	91.29	8.75	0.03	7.35	10.93
5	71.00	29.06	0.05	5.67	9.58
6	89.74	10.06	0.20	7.58	12.04
7	66.68	33.24	0.08	5.37	11.55
8	27.03	59.99	12.98	4.47	5.18
9	41.01	50.99	7.99	3.24	11.75
10	33.35	64.84	1.81	4.14	7.29
11	77.77	22.31	0.00	5.15	9.50
12	92.54	7.43	0.04	7.09	9.56
13	49.02	48.95	2.08	5.89	8.69
14	62.85	36.81	0.37	5.02	6.84
15	49.80	50.02	0.29	4.55	8.88
16	31.80	67.87	0.35	3.77	14.01
17	32.95	67.01	0.07	3.40	15.77
18	10.62	87.25	2.12	2.19	19.39
19	22.47	76.58	0.95	3.04	12.83
20	20.04	78.97	0.99	2.94	18.39
21	2.84	89.07	8.09	1.55	13.35
22	3.49	83.41	13.11	1.45	16.04
23	4.23	78.43	17.33	1.91	25.71
24	51.83	46.25	1.92	3.23	11.14
25	26.36	72.35	1.29	2.24	13.67
26	44.46	44.71	10.83	5.71	9.85
27	47.58	48.47	3.94	5.53	14.17
28	90.01	9.69	0.29	8.69	10.24
29	90.34	9.54	0.12	8.46	10.28
30	0.00	43.32	56.84	1.31	1.60
31	25.82	71.63	2.55	2.40	14.62
32	32.77	65.19	2.04	2.62	14.32
33	25.24	74.24	0.52	2.14	12.14
34	12.22	41.66	46.12	3.73	5.26
35	40.06	38.43	21.51	9.77	2.72
36	42.05	40.81	17.14	6.29	9.35
37	71.62	23.64	4.74	9.76	9.54
38	98.74	1.19	0.07	8.36	7.09
39	93.73	5.67	0.60	8.33	9.38
40	62.88	34.56	2.56	4.29	2.04
41	93.78	5.69	0.54	9.42	10.08
42	86.37	8.27	5.37	3.45	9.57
43	81.76	17.33	0.92	11.48	6.14
44	62.30	29.56	8.14	10.34	2.98
45	70.56	25.73	3.71	7.09	10.28
46	89.97	9.21	0.82	9.07	12.06
47	14.58	74.08	11.34	2.28	10.96
48	26.53	71.62	1.84	3.07	14.19
49	33.55	64.22	2.24	2.76	14.05
50	61.49	3.47	35.04	7.46	6.85
51	91.72	7.34	0.95	9.08	7.51
52	82.34	10.80	6.85	7.26	12.13
53	85.48	14.23	0.29	5.84	13.73
54	22.85	76.74	0.41	2.26	18.28
55	27.30	65.15	7.54	2.45	14.39
56	54.12	24.44	21.44	3.72	10.20

Site	Mud	Fine-medium sand	Coarse sand-shell hash	Organic content	Chlorophyll *a*
57	41.91	57.71	0.38	3.40	8.83
58	46.78	43.21	10.01	3.37	10.17
59	20.90	72.15	6.95	2.56	5.93

Appendix 2B. Sediment composition (% volume), organic content (% volume) and chlorophyll *a* content (µg/g sediment) of sediments at the subtidal sites.

Site	Mud	Fine-medium sand	Coarse sand-shell hash	Organic content	Chlorophyll *a*
A	96.72	3.19	0.09	9.48	0.23
B	91.43	8.47	0.09	7.20	6.38
C	17.21	76.40	6.39	2.45	1.37
D	69.71	2.74	27.55	8.63	22.36
E	49.25	49.67	1.08	4.74	5.04
F	41.49	57.74	0.77	5.41	2.27
G	75.68	24.13	0.19	8.56	4.58
H	40.32	59.63	0.05	4.78	8.47
I	17.49	81.18	1.33	2.77	7.09
J	20.60	75.72	3.68	3.31	2.06
K	32.80	59.65	7.55	3.92	2.52
L	32.30	65.47	2.23	4.18	4.54
M	66.35	31.86	1.78	6.72	5.04
N	16.11	74.02	9.87	2.63	2.27
O	15.71	76.60	7.69	2.37	2.75

Appendix 3A. Mean number of individuals and taxa per core found at each of the intertidal sites. SE = standard error.

Site	Number of taxa		Number of individuals	
	Mean	SE	Mean	SE
1	5.3	1.7	32.0	9.6
2	5.3	1.5	12.3	3.9
3	8.0	1.5	18.0	1.5
4	3.3	1.2	10.7	3.2
5	6.7	0.3	16.0	2.9
6	9.3	0.9	47.7	9.8
7	7.5	1.2	26.0	8.9
8	7.3	2.4	37.0	26.5
9	10.0	0.6	24.7	3.8
10	10.3	0.7	25.3	0.9
11	6.0	0.6	14.3	0.9
12	6.7	0.9	15.0	3.0
13	8.7	0.3	24.0	3.1
14	6.3	0.3	16.3	1.5
15	7.0	1.5	56.3	2.7
16	9.3	1.2	69.0	6.4
17	10.3	0.7	62.7	11.3
18	10.3	2.3	23.7	8.2
19	7.7	0.3	33.7	7.8
20	7.3	1.9	37.3	5.7
21	12.7	0.9	138.0	9.7
22	12.0	2.3	106.7	15.4
23	12.3	1.2	101.0	13.1
24	8.7	0.9	25.7	1.5
25	8.7	0.3	23.0	2.3
26	7.0	1.5	38.3	5.9
27	8.0	1.5	68.7	36.9
28	4.3	0.3	108.7	11.2
29	9.3	0.7	49.7	5.0
30	5.3	1.2	12.7	1.5
31	9.7	0.7	57.3	5.8
32	9.0	0.6	69.3	17.4
33	7.7	1.2	23.7	9.1
34	7.0	0.0	65.0	12.2
35	7.3	0.9	48.3	11.3
36	6.0	1.2	19.7	9.0
37	4.0	0.8	16.5	6.9
38	4.7	0.3	49.3	39.3
39	4.0	1.2	24.3	10.4
40	5.7	0.3	55.0	3.2
41	6.3	0.9	17.3	3.5
42	7.0	0.6	26.7	0.3
43	4.3	0.9	53.3	13.8
44	8.0	0.6	24.0	2.5
45	8.7	0.9	43.0	6.4
46	5.0	1.2	14.3	1.3
47	10.7	0.3	32.3	2.3
48	7.0	3.1	23.0	9.7
49	9.5	1.2	29.5	0.4
50	9.3	2.3	46.0	15.6
51	4.3	0.9	22.7	7.4
52	4.7	1.2	12.3	5.0
53	4.0	0.0	12.3	1.9

Site	Number of taxa		Number of individuals	
	Mean	SE	Mean	SE
54	5.3	0.3	15.3	2.7
55	9.7	1.8	20.3	1.5
56	6.3	2.2	19.7	6.8
57	9.7	0.9	30.0	6.7
58	6.3	0.7	14.3	1.7
59	6.7	0.9	24.7	1.9

Appendix 3B. Mean number of individuals and taxa per core collected at each of the subtidal sites. SE = standard error. Numbers have been adjusted for the different core size used, to enable direct comparison with the intertidal sites.

Site	Number of taxa		Number of individuals	
	Mean	SE	Mean	SE
A	3.4	1.0	6.2	3.7
B	8.5	1.0	31.5	12.2
C	10.7	1.1	65.3	9.8
D	12.4	3.0	167.9	73.1
E	9.0	3.4	18.6	5.9
F	8.5	1.0	99.7	8.3
G	6.8	1.0	74.9	21.2
H	8.5	2.6	34.9	13.9
I	13.5	1.0	154.9	32.2
J	15.8	1.1	121.7	12.8
K	18.6	1.7	68.2	12.1
L	13.0	1.5	158.9	29.3
M	16.9	1.7	95.2	10.9
N	22.5	2.5	87.3	22.3
O	18.0	3.9	54.6	19.3

Appendix 4. Summary of taxa collected at the intertidal sites. Mean = mean abundance per core. SE = standard error. Range = between the 5th and 95th percentile. Total = Total number of individuals collected in 3 samples (calculated by mean abundance*3). The taxa grouping 'Phoxocephalidae' excludes *Torridoharpinia hurleyi*, and 'Paraonidae' excludes *Aricidea* sp. †denotes identifications which are currently being verified.

Site	Taxa	Mean	SE	Range	Total	Median
1	Oligochaeta	21.7	8.21	26	65	15
1	Phoxocephalidae	3.7	1.86	6	11	5
1	Nereidae	2.0	1.00	3	6	3
1	*Pseudosphaeroma campbellensis*†	1.7	1.67	5	5	0
1	Barnacles	0.7	0.67	2	2	0
1	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
1	*Aricidea* sp.	0.3	0.33	1	1	0
1	*Arthritica bifurca*	0.3	0.33	1	1	0
1	*Cossura* sp.	0.3	0.33	1	1	0
1	Nemerteans	0.3	0.33	1	1	0
1	*Scolecolepides* sp.	0.3	0.33	1	1	0
2	*Helice crassa*	4.0	1.00	3	12	5
2	Nereidae	4.0	3.51	11	12	1
2	*Cossura* sp.	0.7	0.67	2	2	0
2	*Heteromastus filiformis*	0.7	0.33	1	2	1
2	Phoxocephalidae	0.7	0.67	2	2	0
2	*Scolecolepides* sp.	0.7	0.33	1	2	1
2	Spionidae (polydorids)	0.7	0.33	1	2	1
2	Exogoninae	0.3	0.33	1	1	0
2	*Nucula hartvigiana*	0.3	0.33	1	1	0
2	Oligochaeta	0.3	0.33	1	1	0
3	*Cossura* sp.	7.3	0.88	3	22	7
3	*Heteromastus filiformis*	3.0	0.58	2	9	3
3	*Aricidea* sp.	1.3	0.88	3	4	1
3	Phoxocephalidae	1.3	0.67	2	4	2
3	*Macrophthalmus hirtipes*	1.0	0.00	0	3	1
3	Nereidae	1.0	0.00	0	3	1
3	Oligochaeta	1.0	0.58	2	3	1
3	*Arthritica bifurca*	0.7	0.33	1	2	1
3	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
3	Capitellidae	0.3	0.33	1	1	0
3	Eusiridae	0.3	0.33	1	1	0
3	*Theora lubrica*	0.3	0.33	1	1	0
4	*Macrophthalmus hirtipes*	4.0	1.00	3	12	5
4	Oligochaeta	2.7	2.67	8	8	0
4	*Cossura* sp.	1.7	1.67	5	5	0
4	Nereidae	1.3	0.88	3	4	1
4	Glyceridae	0.7	0.33	1	2	1
4	Spionidae (polydorids)	0.3	0.33	1	1	0
5	Nereidae	3.7	0.88	3	11	4
5	Spionidae (polydorids)	3.3	0.67	2	10	4
5	Oligochaeta	3.0	3.00	9	9	0
5	*Aricidea* sp.	1.7	1.20	4	5	1
5	*Helice crassa*	1.0	1.00	3	3	0
5	Phoxocephalidae	0.7	0.33	1	2	1
5	*Arthritica bifurca*	0.3	0.33	1	1	0
5	Corophidae sp. 1	0.3	0.33	1	1	0
5	*Cossura* sp.	0.3	0.33	1	1	0
5	*Cyclomactra ovata*	0.3	0.33	1	1	0
5	Glyceridae	0.3	0.33	1	1	0
5	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
5	Pontoporeidae	0.3	0.33	1	1	0

Site	Taxa	Mean	SE	Range	Total	Median
5	*Scolecolepides* sp.	0.3	0.33	1	1	0
6	Oligochaeta	15.7	13.25	42	47	5
6	*Cossura* sp.	13.0	3.51	11	39	10
6	*Torridoharpinia hurleyi*	4.0	2.08	7	12	5
6	*Macrophthalmus hirtipes*	2.3	1.86	6	7	1
6	*Aricidea* sp.	2.0	1.53	5	6	1
6	Nereidae	2.0	1.00	3	6	1
6	Orbinidae sp. 1	2.0	1.53	5	6	1
6	*Heteromastus filiformis*	1.7	0.88	3	5	2
6	Glyceridae	1.3	0.88	3	4	1
6	Spionidae (polydorids)	1.0	0.58	2	3	1
6	*Arthritica bifurca*	0.7	0.33	1	2	1
6	Corophidae sp. 1	0.7	0.67	2	2	0
6	Paraonidae	0.7	0.67	2	2	0
6	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
6	*Theora lubrica*	0.3	0.33	1	1	0
7	*Aricidea* sp.	7.0	5.00	10	21	7
7	Nereidae	5.0	2.00	4	15	5
7	*Cossura* sp.	4.5	1.50	3	13.5	4.5
7	Paraonidae	3.5	3.50	7	10.5	3.5
7	*Heteromastus filiformis*	2.0	1.00	2	6	2
7	Oligochaeta	1.0	1.00	2	3	1
7	Phoxocephalidae	1.0	1.00	2	3	1
7	*Arthritica bifurca*	0.5	0.50	1	1.5	0.5
7	Glyceridae	0.5	0.50	1	1.5	0.5
7	*Macrophthalmus hirtipes*	0.5	0.50	1	1.5	0.5
7	Spionidae (polydorids)	0.5	0.50	1	1.5	0.5
8	*Aricidea* sp.	11.7	10.20	32	35	3
8	Paraonidae	8.7	4.70	15	26	5
8	Nereidae	4.7	2.73	9	14	3
8	Cirratulidae	4.0	4.00	12	12	0
8	*Austrovenus stutchburyi*	2.3	1.86	6	7	1
8	*Heteromastus filiformis*	2.0	1.53	5	6	1
8	*Helice crassa*	0.7	0.67	2	2	0
8	Spionidae (polydorids)	0.7	0.67	2	2	0
8	*Arthritica bifurca*	0.3	0.33	1	1	0
8	*Cominella glandiformis*	0.3	0.33	1	1	0
8	Glyceridae	0.3	0.33	1	1	0
8	*Musculista senhousia*	0.3	0.33	1	1	0
8	*Nucula hartvigiana*	0.3	0.33	1	1	0
8	Oligochaeta	0.3	0.33	1	1	0
8	*Torridoharpinia hurleyi*	0.3	0.33	1	1	0
9	*Aricidea* sp.	8.0	4.36	15	24	9
9	*Heteromastus filiformis*	3.3	0.33	1	10	3
9	Nereidae	3.3	0.67	2	10	4
9	Orbinidae sp. 1	2.7	0.33	1	8	3
9	*Austrovenus stutchburyi*	1.3	0.33	1	4	1
9	Phoxocephalidae	1.3	0.33	1	4	1
9	Glyceridae	0.7	0.33	1	2	1
9	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
9	Sipunculid	0.7	0.67	2	2	0
9	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
9	*Arthritica bifurca*	0.3	0.33	1	1	0
9	Capitellidae	0.3	0.33	1	1	0
9	Goniadidae†	0.3	0.33	1	1	0
9	Oligochaeta	0.3	0.33	1	1	0
9	Spionidae (polydorids)	0.3	0.33	1	1	0
9	Syllidae	0.3	0.33	1	1	0
10	*Aricidea* sp.	6.3	0.88	3	19	6

Site	Taxa	Mean	SE	Range	Total	Median
10	Nereidae	4.7	0.88	3	14	5
10	*Heteromastus filiformis*	4.3	1.20	4	13	5
10	*Austrovenus stutchburyi*	3.0	1.73	6	9	3
10	Oligochaeta	1.0	0.58	2	3	1
10	*Arthritica bifurca*	0.7	0.33	1	2	1
10	*Cyclomactra ovata*	0.7	0.33	1	2	1
10	*Macomona liliana*	0.7	0.33	1	2	1
10	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
10	Orbinidae sp. 1	0.7	0.33	1	2	1
10	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
10	*Cossura* sp.	0.3	0.33	1	1	0
10	Glyceridae	0.3	0.33	1	1	0
10	*Helice crassa*	0.3	0.33	1	1	0
10	Nemerteans	0.3	0.33	1	1	0
10	*Notoacmea helmsi*	0.3	0.33	1	1	0
10	*Nucula hartvigiana*	0.3	0.33	1	1	0
10	*Scolecolepides* sp.	0.3	0.33	1	1	0
11	Nereidae	4.7	1.45	5	14	5
11	Orbinidae sp. 1	3.0	0.58	2	9	3
11	*Arthritica bifurca*	2.3	0.67	2	7	3
11	*Macrophthalmus hirtipes*	1.3	0.88	3	4	1
11	Phoxocephalidae	1.0	0.58	2	3	1
11	*Theora lubrica*	0.7	0.67	2	2	0
11	*Heteromastus filiformis*	0.3	0.33	1	1	0
11	Nemerteans	0.3	0.33	1	1	0
11	*Pectinaria australis*	0.3	0.33	1	1	0
11	*Scolecolepides* sp.	0.3	0.33	1	1	0
12	*Cossura* sp.	4.7	1.76	6	14	4
12	Nereidae	3.7	1.33	4	11	5
12	Oligochaeta	1.7	0.88	3	5	2
12	Glyceridae	0.7	0.33	1	2	1
12	*Heteromastus filiformis*	0.7	0.67	2	2	0
12	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
12	Spionidae (polydorids)	0.7	0.67	2	2	0
12	*Torridoharpinia hurleyi*	0.7	0.67	2	2	0
12	*Aricidea* sp.	0.3	0.33	1	1	0
12	*Arthritica bifurca*	0.3	0.33	1	1	0
12	Corophidae sp. 1	0.3	0.33	1	1	0
12	Exogoninae	0.3	0.33	1	1	0
12	Sigalionidae	0.3	0.33	1	1	0
13	*Aricidea* sp.	6.7	1.20	4	20	6
13	Nereidae	4.7	1.45	5	14	5
13	Orbinidae sp. 1	3.0	0.58	2	9	3
13	*Heteromastus filiformis*	1.7	0.33	1	5	2
13	Oligochaeta	1.7	1.20	4	5	1
13	Glyceridae	1.3	1.33	4	4	0
13	*Cossura* sp.	1.0	0.58	2	3	1
13	Phoxocephalidae	1.0	0.58	2	3	1
13	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
13	*Theora lubrica*	0.7	0.67	2	2	0
13	*Aonides oxycephala*	0.3	0.33	1	1	0
13	Capitellidae	0.3	0.33	1	1	0
13	*Macomona liliana*	0.3	0.33	1	1	0
14	*Aricidea* sp.	5.3	1.76	6	16	6
14	*Cossura* sp.	3.3	1.33	4	10	2
14	Nereidae	2.7	0.33	1	8	3
14	*Heteromastus filiformis*	1.3	0.88	3	4	1
14	*Macrophthalmus hirtipes*	1.3	1.33	4	4	0
14	Glyceridae	0.7	0.33	1	2	1

Site	Taxa	Mean	SE	Range	Total	Median
14	*Helice crassa*	0.3	0.33	1	1	0
14	Nemerteans	0.3	0.33	1	1	0
14	*Notoacmea helmsi*	0.3	0.33	1	1	0
14	Oligochaeta	0.3	0.33	1	1	0
15	*Aricidea* sp.	26.0	3.79	13	78	25
15	*Heteromastus filiformis*	11.0	4.16	14	33	9
15	*Cossura* sp.	9.7	3.28	11	29	8
15	Glyceridae	2.7	1.33	4	8	4
15	Nereidae	2.0	1.00	3	6	3
15	Orbinidae sp. 1	2.0	1.00	3	6	3
15	Phoxocephalidae	1.0	1.00	3	3	0
15	Nemerteans	0.7	0.67	2	2	0
15	*Hiatula siliquens*	0.3	0.33	1	1	0
15	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
15	Paracalliopidae	0.3	0.33	1	1	0
15	Sigalionidae	0.3	0.33	1	1	0
16	*Aricidea* sp.	45.7	8.84	29	137	40
16	*Heteromastus filiformis*	7.7	2.19	7	23	6
16	*Cossura* sp.	6.7	2.03	7	20	7
16	Phoxocephalidae	2.0	1.53	5	6	1
16	*Torridoharpinia hurleyi*	1.3	0.88	3	4	1
16	Nereidae	1.0	0.58	2	3	1
16	Sigalionidae	1.0	0.00	0	3	1
16	*Aquilaspio aucklandica*	0.7	0.67	2	2	0
16	*Macomona liliana*	0.7	0.33	1	2	1
16	*Nucula hartvigiana*	0.7	0.33	1	2	1
16	*Arthritica bifurca*	0.3	0.33	1	1	0
16	Corophidae sp. 2	0.3	0.33	1	1	0
16	Glyceridae	0.3	0.33	1	1	0
16	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
16	Nemerteans	0.3	0.33	1	1	0
17	*Aricidea* sp.	27.7	6.12	21	83	26
17	*Heteromastus filiformis*	10.0	3.00	9	30	7
17	*Cossura* sp.	7.7	1.33	4	23	9
17	Nereidae	4.7	2.33	8	14	4
17	*Nucula hartvigiana*	3.3	0.88	3	10	3
17	Nemerteans	2.0	0.58	2	6	2
17	*Macrophthalmus hirtipes*	1.7	1.20	4	5	1
17	*Austrovenus stutchburyi*	1.3	0.88	3	4	1
17	*Arthritica bifurca*	1.0	1.00	3	3	0
17	*Macomona liliana*	1.0	0.58	2	3	1
17	Glyceridae	0.7	0.67	2	2	0
17	Phoxocephalidae	0.7	0.33	1	2	1
17	*Alpheus* sp.	0.3	0.33	1	1	0
17	Goniadidae	0.3	0.33	1	1	0
17	*Scolecolepides* sp.	0.3	0.33	1	1	0
18	*Nucula hartvigiana*	6.0	3.79	13	18	5
18	*Heteromastus filiformis*	3.0	1.73	6	9	3
18	*Austrovenus stutchburyi*	1.7	0.88	3	5	2
18	*Macrophthalmus hirtipes*	1.7	0.88	3	5	2
18	Spionidae (polydorids)	1.7	1.20	4	5	1
18	*Aquilaspio aucklandica*	1.0	0.58	2	3	1
18	*Aricidea* sp.	1.0	0.58	2	3	1
18	*Arthritica bifurca*	1.0	0.58	2	3	1
18	*Cossura* sp.	1.0	0.00	0	3	1
18	Exogoninae	1.0	0.58	2	3	1
18	*Macomona liliana*	1.0	1.00	3	3	0
18	*Aonides oxycephala*	0.7	0.67	2	2	0
18	*Paphies australis*	0.7	0.67	2	2	0

Site	Taxa	Mean	SE	Range	Total	Median
18	Capitellidae	0.3	0.33	1	1	0
18	*Cominella glandiformis*	0.3	0.33	1	1	0
18	Glyceridae	0.3	0.33	1	1	0
18	*Helice crassa*	0.3	0.33	1	1	0
18	Phoxocephalidae	0.3	0.33	1	1	0
18	*Torridoharpinia hurleyi*	0.3	0.33	1	1	0
19	*Aricidea* sp.	13.3	4.26	14	40	16
19	*Heteromastus filiformis*	8.0	4.51	14	24	4
19	Nereidae	2.7	1.76	6	8	2
19	Spionidae (polydorids)	2.7	1.20	4	8	2
19	*Arthritica bifurca*	2.3	0.67	2	7	3
19	*Macrophthalmus hirtipes*	2.0	0.00	0	6	2
19	*Cossura* sp.	1.3	0.88	3	4	1
19	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
19	Glyceridae	0.3	0.33	1	1	0
19	Nemerteans	0.3	0.33	1	1	0
19	*Scolecolepides* sp.	0.3	0.33	1	1	0
20	*Aricidea* sp.	18.0	4.04	13	54	15
20	*Heteromastus filiformis*	9.3	1.76	6	28	10
20	Nereidae	4.0	0.58	2	12	4
20	*Macrophthalmus hirtipes*	1.0	1.00	3	3	0
20	*Austrovenus stutchburyi*	0.7	0.67	2	2	0
20	*Cossura* sp.	0.7	0.33	1	2	1
20	Goniadidae	0.7	0.33	1	2	1
20	*Macomona liliana*	0.7	0.67	2	2	0
20	*Nucula hartvigiana*	0.7	0.67	2	2	0
20	*Arthritica bifurca*	0.3	0.33	1	1	0
20	Glyceridae	0.3	0.33	1	1	0
20	Nemerteans	0.3	0.33	1	1	0
20	*Scolecolepides* sp.	0.3	0.33	1	1	0
20	*Torridoharpinia hurleyi*	0.3	0.33	1	1	0
21	*Nucula hartvigiana*	90.3	5.61	19	271	88
21	*Austrovenus stutchburyi*	16.3	2.19	7	49	18
21	*Aricidea* sp.	13.0	6.00	18	39	7
21	*Macomona liliana*	3.3	0.33	1	10	3
21	*Notoacmea helmsi*	3.0	1.53	5	9	4
21	*Anthopleura aureoradiata*	2.3	0.88	3	7	2
21	*Aonides oxycephala*	1.7	0.33	1	5	2
21	Nereidae	1.7	1.20	4	5	1
21	*Cyclomactra ovata*	0.7	0.67	2	2	0
21	Exogoninae	0.7	0.67	2	2	0
21	*Heteromastus filiformis*	0.7	0.33	1	2	1
21	*Hiatula siliquens*	0.7	0.67	2	2	0
21	Nemerteans	0.7	0.33	1	2	1
21	Phoxocephalidae	0.7	0.33	1	2	1
21	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
21	*Arthritica bifurca*	0.3	0.33	1	1	0
21	*Cominella glandiformis*	0.3	0.33	1	1	0
21	*Diloma subrostrata*	0.3	0.33	1	1	0
21	*Halicarcinus whitei*	0.3	0.33	1	1	0
21	Paraonidae	0.3	0.33	1	1	0
21	*Zeacumantus lutulentus*	0.3	0.33	1	1	0
22	*Nucula hartvigiana*	70.7	5.61	19	212	73
22	*Austrovenus stutchburyi*	10.0	1.00	3	30	11
22	Spionidae (polydorids)	7.3	3.38	11	22	5
22	*Macomona liliana*	5.3	3.33	10	16	2
22	*Aquilaspio aucklandica*	2.3	1.20	4	7	3
22	*Aricidea* sp.	2.0	0.58	2	6	2
22	Phoxocephalidae	1.7	1.67	5	5	0

Site	Taxa	Mean	SE	Range	Total	Median
22	Exogoninae	1.3	0.88	3	4	1
22	*Notoacmea helmsi*	1.3	0.67	2	4	2
22	*Hemigrapsus crenulatus*	0.7	0.33	1	2	1
22	*Macroclymenella stewartensis*	0.7	0.33	1	2	1
22	*Anthopleura aureoradiata*	0.3	0.33	1	1	0
22	*Arthritica bifurca*	0.3	0.33	1	1	0
22	*Colurostylis lemurum*	0.3	0.33	1	1	0
22	*Cominella glandiformis*	0.3	0.33	1	1	0
22	Crab juvenile	0.3	0.33	1	1	0
22	*Halicarcinus whitei*	0.3	0.33	1	1	0
22	Nereidae	0.3	0.33	1	1	0
22	Paracalliopidae	0.3	0.33	1	1	0
22	*Xymene* sp.	0.3	0.33	1	1	0
22	*Zeacumantus lutulentus*	0.3	0.33	1	1	0
23	*Nucula hartvigiana*	62.0	9.50	29	186	53
23	*Austrovenus stutchburyi*	17.0	1.53	5	51	18
23	Spionidae (polydorids)	4.7	1.20	4	14	4
23	*Aricidea* sp.	4.0	1.53	5	12	5
23	*Notoacmea helmsi*	3.7	0.88	3	11	4
23	*Aquilaspio aucklandica*	2.0	0.58	2	6	2
23	Phoxocephalidae	2.0	0.58	2	6	2
23	*Colurostylis lemurum*	1.0	0.58	2	3	1
23	*Arthritica bifurca*	0.7	0.33	1	2	1
23	*Diloma subrostrata*	0.7	0.33	1	2	1
23	Exogoninae	0.7	0.33	1	2	1
23	*Haminoea* sp.	0.7	0.33	1	2	1
23	*Anthopleura aureoradiata*	0.3	0.33	1	1	0
23	*Cossura* sp.	0.3	0.33	1	1	0
23	Glyceridae	0.3	0.33	1	1	0
23	*Heteromastus filiformis*	0.3	0.33	1	1	0
23	*Macomona liliana*	0.3	0.33	1	1	0
23	Nereidae	0.3	0.33	1	1	0
24	Cirratulidae	8.0	4.04	14	24	8
24	Nereidae	5.0	1.53	5	15	4
24	*Aricidea* sp.	3.7	0.88	3	11	4
24	*Torridoharpinia hurleyi*	2.0	0.58	2	6	2
24	*Heteromastus filiformis*	1.7	0.33	1	5	2
24	Phoxocephalidae	1.7	0.67	2	5	1
24	*Macrophthalmus hirtipes*	1.3	0.88	3	4	1
24	*Cossura* sp.	1.0	0.58	2	3	1
24	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
24	Nemerteans	0.3	0.33	1	1	0
24	*Scolecolepides* sp.	0.3	0.33	1	1	0
24	Spionidae (polydorids)	0.3	0.33	1	1	0
25	Phoxocephalidae	4.7	1.76	6	14	4
25	*Aricidea* sp.	4.3	1.76	6	13	5
25	Nereidae	3.7	2.73	9	11	2
25	*Macrophthalmus hirtipes*	2.3	1.33	4	7	1
25	Oligochaeta	1.7	1.67	5	5	0
25	Spionidae (polydorids)	1.3	0.88	3	4	1
25	*Arthritica bifurca*	1.0	0.58	2	3	1
25	*Heteromastus filiformis*	1.0	0.00	0	3	1
25	Nemerteans	1.0	1.00	3	3	0
25	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
25	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
25	*Cyclomactra ovata*	0.3	0.33	1	1	0
25	Glyceridae	0.3	0.33	1	1	0
25	*Helice crassa*	0.3	0.33	1	1	0
25	*Scolecolepides* sp.	0.3	0.33	1	1	0

Site	Taxa	Mean	SE	Range	Total	Median
26	*Arthritica bifurca*	17.7	5.93	20	53	15
26	Nereidae	8.3	0.67	2	25	9
26	*Amphibola crenata*	4.0	3.51	11	12	1
26	Oligochaeta	3.0	2.08	7	9	2
26	*Helice crassa*	1.3	0.88	3	4	1
26	*Scolecolepides* sp.	1.0	0.58	2	3	1
26	Barnacles	0.7	0.67	2	2	0
26	*Prionospio* sp.	0.7	0.67	2	2	0
26	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
26	Bivalve unid. juvenile	0.3	0.33	1	1	0
26	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
26	Spionidae (polydorids)	0.3	0.33	1	1	0
26	*Zeacumantus lutulentus*	0.3	0.33	1	1	0
27	Oligochaeta	48.7	28.14	97	146	43
27	Nereidae	4.3	0.88	3	13	4
27	*Scoloplos cylindrifer*	4.0	2.52	8	12	2
27	Spionidae (polydorids)	3.3	3.33	10	10	0
27	*Crassostrea gigas*	3.0	3.00	9	9	0
27	Corophidae sp. 1	1.3	0.67	2	4	2
27	*Arthritica bifurca*	0.7	0.67	2	2	0
27	*Austrovenus stutchburyi*	0.7	0.33	1	2	1
27	*Helice crassa*	0.7	0.33	1	2	1
27	Chironomid larvae	0.3	0.33	1	1	0
27	*Cossura* sp.	0.3	0.33	1	1	0
27	*Edwardsia* sp.	0.3	0.33	1	1	0
27	Exogoninae	0.3	0.33	1	1	0
27	*Heteromastus filiformis*	0.3	0.33	1	1	0
27	*Scolecolepides* sp.	0.3	0.33	1	1	0
28	Oligochaeta	92.0	11.24	37	276	85
28	Corophidae sp. 2	11.7	3.84	13	35	10
28	*Helice crassa*	2.7	1.20	4	8	2
28	Nereidae	1.0	1.00	3	3	0
28	*Crassostrea gigas*	0.7	0.67	2	2	0
28	*Arthritica bifurca*	0.3	0.33	1	1	0
28	Crab juvenile	0.3	0.33	1	1	0
29	Oligochaeta	14.0	4.16	14	42	12
29	Barnacles	13.3	6.96	24	40	12
29	*Crassostrea gigas*	6.0	3.21	11	18	5
29	*Helice crassa*	4.7	2.73	9	14	3
29	Nereidae	4.7	1.67	5	14	3
29	Corophidae sp. 1	2.3	0.88	3	7	2
29	*Pseudosphaeroma campbellensis* †	2.0	1.53	5	6	1
29	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
29	*Arthritica bifurca*	0.3	0.33	1	1	0
29	Chironomid larvae	0.3	0.33	1	1	0
29	Cirratulidae	0.3	0.33	1	1	0
29	Crab zoea	0.3	0.33	1	1	0
29	Spionidae (polydorids)	0.3	0.33	1	1	0
29	*Xenostrobus pulex*	0.3	0.33	1	1	0
30	*Paphies australis*	4.7	1.20	4	14	4
30	*Scolelepis* sp.	3.0	1.00	3	9	4
30	Oligochaeta	1.7	1.67	5	5	0
30	Amphipod sp. 1†	1.3	0.33	1	4	1
30	Cirolanidae	0.7	0.33	1	2	1
30	Valvifera†	0.7	0.33	1	2	1
30	*Aonides oxycephala*	0.3	0.33	1	1	0
31	*Aricidea* sp.	32.0	5.03	16	96	36
31	Cirratulidae	6.0	2.65	9	18	5
31	*Heteromastus filiformis*	5.3	0.33	1	16	5

Site	Taxa	Mean	SE	Range	Total	Median
31	Nereidae	5.3	1.86	6	16	4
31	*Arthritica bifurca*	2.0	1.53	5	6	1
31	Phoxocephalidae	1.3	0.67	2	4	2
31	*Nucula hartvigiana*	1.0	1.00	3	3	0
31	Exogoninae	0.7	0.33	1	2	1
31	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
31	Nemerteans	0.7	0.33	1	2	1
31	Paraonidae	0.7	0.67	2	2	0
31	*Cossura* sp.	0.3	0.33	1	1	0
31	Eusiridae	0.3	0.33	1	1	0
31	Glyceridae	0.3	0.33	1	1	0
31	*Macomona liliana*	0.3	0.33	1	1	0
31	Paracalliopidae	0.3	0.33	1	1	0
32	*Aricidea* sp.	27.3	17.57	57	82	15
32	*Cossura* sp.	18.7	4.06	14	56	18
32	*Heteromastus filiformis*	5.3	2.19	7	16	7
32	Paraonidae	5.3	2.19	7	16	7
32	Nereidae	3.3	0.88	3	10	3
32	Oligochaeta	3.0	1.73	6	9	3
32	*Nucula hartvigiana*	2.0	1.00	3	6	1
32	Cirratulidae	1.7	1.20	4	5	1
32	*Macrophthalmus hirtipes*	1.0	1.00	3	3	0
32	Nemerteans	0.7	0.67	2	2	0
32	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
32	Glyceridae	0.3	0.33	1	1	0
32	Sabellidae	0.3	0.33	1	1	0
33	*Aricidea* sp.	5.7	4.18	13	17	2
33	Nereidae	4.0	1.53	5	12	3
33	Phoxocephalidae	4.0	1.00	3	12	5
33	Paraonidae	2.7	1.76	6	8	2
33	*Heteromastus filiformis*	1.3	0.67	2	4	2
33	Oligochaeta	1.3	1.33	4	4	0
33	*Aquilaspio aucklandica*	1.0	0.58	2	3	1
33	Corophidae sp. 1	1.0	1.00	3	3	0
33	*Scolecolepides* sp.	1.0	0.58	2	3	1
33	*Macrophthalmus hirtipes*	0.7	0.67	2	2	0
33	*Cossura* sp.	0.3	0.33	1	1	0
33	*Halicarcinus whitei*	0.3	0.33	1	1	0
33	Nemerteans	0.3	0.33	1	1	0
34	Nereidae	25.3	8.37	29	76	25
34	*Arthritica bifurca*	16.3	4.10	14	49	15
34	Corophidae sp. 2	8.0	3.06	10	24	6
34	Eusiridae	6.7	1.86	6	20	8
34	*Helice crassa*	3.7	1.67	5	11	2
34	Oligochaeta	2.7	1.45	5	8	3
34	*Edwardsia* sp.	1.0	0.58	2	3	1
34	*Amphibola crenata*	0.7	0.67	2	2	0
34	*Scolecolepides* sp.	0.7	0.67	2	2	0
35	Nereidae	15.0	5.03	16	45	19
35	*Arthritica bifurca*	12.7	6.77	22	38	8
35	Corophidae sp. 1	9.7	1.67	5	29	8
35	Oligochaeta	5.3	2.85	9	16	3
35	*Helice crassa*	2.3	0.67	2	7	3
35	*Scolecolepides* sp.	1.3	0.67	2	4	2
35	*Amphibola crenata*	0.7	0.67	2	2	0
35	*Capitella* sp.	0.7	0.33	1	2	1
35	Gammaridae	0.3	0.33	1	1	0
35	Holothurian	0.3	0.33	1	1	0
36	Oligochaeta	5.3	4.33	13	16	1

Site	Taxa	Mean	SE	Range	Total	Median
36	Nereidae	4.3	2.33	8	13	5
36	Eusiridae	3.0	2.52	8	9	1
36	*Amphibola crenata*	2.3	2.33	7	7	0
36	*Scolecolepides* sp.	1.3	0.88	3	4	1
36	*Helice crassa*	1.0	1.00	3	3	0
36	Capitellidae	0.3	0.33	1	1	0
36	Chironomid larvae	0.3	0.33	1	1	0
36	*Cominella glandiformis*	0.3	0.33	1	1	0
36	Corophidae sp. 2	0.3	0.33	1	1	0
36	*Halicarcinus whitei*	0.3	0.33	1	1	0
36	*Potamopyrgus* sp.	0.3	0.33	1	1	0
36	*Sphaeroma* sp.*	0.3	0.33	1	1	0
37	Nereidae	8.0	8.00	16	24	8
37	*Amphibola crenata*	3.0	1.00	2	9	3
37	*Helice crassa*	2.5	0.50	1	7.5	2.5
37	Eusiridae	1.5	1.50	3	4.5	1.5
37	Corophidae sp. 1	1.0	1.00	2	3	1
37	*Arthritica bifurca*	0.5	0.50	1	1.5	0.5
38	Oligochaeta	43.0	39.53	121	129	6
38	*Helice crassa*	2.0	1.53	5	6	1
38	Nereidae	2.0	0.58	2	6	2
38	*Amphibola crenata*	0.7	0.67	2	2	0
38	*Arthritica bifurca*	0.7	0.33	1	2	1
38	*Modiolus areolatus*	0.3	0.33	1	1	0
38	Phoxocephalidae	0.3	0.33	1	1	0
38	*Scolecolepides* sp.	0.3	0.33	1	1	0
39	Oligochaeta	11.0	7.37	25	33	8
39	Nereidae	6.3	1.86	6	19	5
39	*Helice crassa*	3.3	2.40	8	10	2
39	Phoxocephalidae	2.0	2.00	6	6	0
39	Paracalliopidae	0.7	0.67	2	2	0
39	*Amphibola crenata*	0.3	0.33	1	1	0
39	*Arthritica bifurca*	0.3	0.33	1	1	0
39	Corophidae sp. 1	0.3	0.33	1	1	0
40	*Arthritica bifurca*	28.0	3.21	11	84	27
40	Nereidae	11.7	3.33	10	35	15
40	*Amphibola crenata*	10.7	3.48	12	32	10
40	Corophidae sp. 2	2.0	2.00	6	6	0
40	*Edwardsia* sp.	1.0	0.58	2	3	1
40	Chironomid larvae	0.7	0.33	1	2	1
40	Gammaridae	0.3	0.33	1	1	0
40	*Helice crassa*	0.3	0.33	1	1	0
40	*Scolecolepides* sp.	0.3	0.33	1	1	0
41	Nereidae	7.7	0.88	3	23	8
41	*Arthritica bifurca*	1.7	1.67	5	5	0
41	*Helice crassa*	1.7	0.33	1	5	2
41	*Macrophthalmus hirtipes*	1.7	0.88	3	5	2
41	Phoxocephalidae	1.7	0.33	1	5	2
41	*Capitella* sp.	1.0	0.58	2	3	1
41	Barnacles	0.7	0.33	1	2	1
41	*Exosphaeroma* sp.	0.7	0.67	2	2	0
41	*Amphibola crenata*	0.3	0.33	1	1	0
41	*Scolecolepides* sp.	0.3	0.33	1	1	0
42	Nereidae	9.3	2.03	7	28	9
42	*Helice crassa*	5.0	0.00	0	15	5
42	*Arthritica bifurca*	4.3	1.20	4	13	5
42	Oligochaeta	4.0	2.08	7	12	5
42	*Amphibola crenata*	1.0	0.58	2	3	1
42	Chironomid larvae	0.7	0.33	1	2	1

Site	Taxa	Mean	SE	Range	Total	Median
42	Corophidae sp. 2	0.7	0.33	1	2	1
42	Phoxocephalidae	0.7	0.67	2	2	0
42	*Scolecolepides* sp.	0.7	0.33	1	2	1
42	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
43	Oligochaeta	42.3	10.65	36	127	47
43	*Helice crassa*	7.0	2.31	8	21	7
43	Corophidae sp. 1	2.3	1.20	4	7	3
43	Nereidae	0.7	0.33	1	2	1
43	Amphipod sp. 1†	0.3	0.33	1	1	0
43	*Cominella glandiformis*	0.3	0.33	1	1	0
43	Crab zoea	0.3	0.33	1	1	0
44	Nereidae	4.0	1.53	5	12	3
44	*Scoloplos cylindrifer*	4.0	1.00	3	12	5
44	Corophidae sp. 2	3.7	1.33	4	11	5
44	*Arthritica bifurca*	3.3	2.85	9	10	1
44	Oligochaeta	3.3	1.33	4	10	2
44	*Helice crassa*	2.0	1.00	3	6	1
44	*Scolecolepides* sp.	1.3	0.88	3	4	1
44	*Halicarcinus whitei*	0.7	0.67	2	2	0
44	Spionidae (polydorids)	0.7	0.67	2	2	0
44	*Amphibola crenata*	0.3	0.33	1	1	0
44	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
44	Nemerteans	0.3	0.33	1	1	0
45	*Arthritica bifurca*	16.7	8.65	29	50	21
45	Nereidae	12.3	2.03	7	37	12
45	Barnacles	4.3	3.84	12	13	1
45	*Amphibola crenata*	2.0	0.58	2	6	2
45	*Helice crassa*	1.3	0.88	3	4	1
45	Oligochaeta	1.3	0.88	3	4	1
45	Phoxocephalidae	1.3	0.88	3	4	1
45	Corophidae sp. 1	1.0	0.58	2	3	1
45	*Macrophthalmus hirtipes*	0.7	0.33	1	2	1
45	*Halicarcinus whitei*	0.3	0.33	1	1	0
45	Holothurian	0.3	0.33	1	1	0
45	Nemerteans	0.3	0.33	1	1	0
45	Paracalliopidae	0.3	0.33	1	1	0
45	*Scolecolepides* sp.	0.3	0.33	1	1	0
45	Spionidae (polydorids)	0.3	0.33	1	1	0
46	Nereidae	6.7	2.19	7	20	5
46	*Aricidea* sp.	1.7	1.67	5	5	0
46	Oligochaeta	1.7	1.67	5	5	0
46	*Macrophthalmus hirtipes*	1.0	0.00	0	3	1
46	*Austrovenus stutchburyi*	0.7	0.67	2	2	0
46	Cirratulidae	0.7	0.67	2	2	0
46	Spionidae (polydorids)	0.7	0.67	2	2	0
46	*Amphibola crenata*	0.3	0.33	1	1	0
46	*Crassostrea gigas*	0.3	0.33	1	1	0
46	*Scolecolepides* sp.	0.3	0.33	1	1	0
46	*Torridoharpinia hurleyi*	0.3	0.33	1	1	0
47	Cirratulidae	11.0	0.58	2	33	11
47	*Aricidea* sp.	4.0	1.53	5	12	5
47	Nereidae	3.3	1.45	5	10	3
47	*Aquilaspio aucklandica*	3.0	1.73	6	9	3
47	*Austrovenus stutchburyi*	2.3	1.86	6	7	1
47	*Macrophthalmus hirtipes*	2.0	1.00	3	6	1
47	Spionidae (polydorids)	1.3	0.67	2	4	2
47	*Arthritica bifurca*	1.0	0.58	2	3	1
47	Glyceridae	0.7	0.67	2	2	0
47	*Colurostylis lemurum*	0.3	0.33	1	1	0

Site	Taxa	Mean	SE	Range	Total	Median
47	Corophidae sp. 1	0.3	0.33	1	1	0
47	*Crassostrea gigas*	0.3	0.33	1	1	0
47	Exogoninae	0.3	0.33	1	1	0
47	*Heteromastus filiformis*	0.3	0.33	1	1	0
47	*Macomona liliana*	0.3	0.33	1	1	0
47	Oligochaeta	0.3	0.33	1	1	0
47	Paracalliopidae	0.3	0.33	1	1	0
47	Phoxocephalidae	0.3	0.33	1	1	0
47	*Scolecolepides* sp.	0.3	0.33	1	1	0
47	*Scoloplos Leadamas* sp.	0.3	0.33	1	1	0
48	Nereidae	6.0	2.00	6	18	4
48	Cirratulidae	4.7	2.40	8	14	6
48	*Aricidea* sp.	3.7	1.86	6	11	5
48	*Macrophthalmus hirtipes*	3.3	1.76	6	10	4
48	Glyceridae	1.3	0.67	2	4	2
48	*Arthritica bifurca*	1.0	0.58	2	3	1
48	*Austrovenus stutchburyi*	1.0	0.58	2	3	1
48	*Heteromastus filiformis*	0.7	0.33	1	2	1
48	*Cyclomactra ovata*	0.3	0.33	1	1	0
48	Nemerteans	0.3	0.33	1	1	0
48	*Nucula hartvigiana*	0.3	0.33	1	1	0
48	Spionidae (polydorids)	0.3	0.33	1	1	0
49	Nereidae	9.5	2.50	5	28.5	9.5
49	*Aricidea* sp.	4.5	0.50	1	13.5	4.5
49	*Arthritica bifurca*	4.0	1.00	2	12	4
49	Cirratulidae	3.0	1.00	2	9	3
49	*Heteromastus filiformis*	3.0	1.00	2	9	3
49	*Cossura* sp.	1.5	0.50	1	4.5	1.5
49	*Macrophthalmus hirtipes*	1.5	0.50	1	4.5	1.5
49	Spionidae (polydorids)	1.0	0.00	0	3	1
49	*Aquilaspio aucklandica*	0.5	0.50	1	1.5	0.5
49	*Macomona liliana*	0.5	0.50	1	1.5	0.5
49	Phoxocephalidae	0.5	0.50	1	1.5	0.5
50	*Aricidea* sp.	7.3	0.88	3	22	7
50	Paraonidae	7.3	4.33	13	22	3
50	*Macrophthalmus hirtipes*	5.3	0.88	3	16	5
50	Sigalionidae	4.7	4.18	13	14	1
50	Spionidae (polydorids)	4.7	2.33	7	14	7
50	Oligochaeta	3.0	3.00	9	9	0
50	Exogoninae	2.7	2.67	8	8	0
50	Orbinidae sp. 1	2.3	2.33	7	7	0
50	Corophidae sp. 1	2.0	1.00	3	6	3
50	Nereidae	1.7	0.88	3	5	2
50	*Torridoharpinia hurleyi*	1.7	1.20	4	5	1
50	Glyceridae	1.0	0.58	2	3	1
50	*Heteromastus filiformis*	1.0	1.00	3	3	0
50	Cirratulidae	0.7	0.33	1	2	1
50	Nemerteans	0.7	0.67	2	2	0
51	*Arthritica bifurca*	8.7	8.17	25	26	1
51	Nereidae	5.3	1.20	4	16	6
51	Corophidae sp. 1	3.7	3.67	11	11	0
51	*Amphibola crenata*	2.0	1.00	3	6	3
51	*Cyclomactra ovata*	1.0	1.00	3	3	0
51	*Macrophthalmus hirtipes*	0.7	0.67	2	2	0
51	*Nucula hartvigiana*	0.7	0.67	2	2	0
51	Nemerteans	0.3	0.33	1	1	0
51	*Scoloplos Leadamas* sp.	0.3	0.33	1	1	0
52	*Torridoharpinia hurleyi*	5.3	3.18	11	16	5
52	Nereidae	2.7	0.33	1	8	3

Site	Taxa	Mean	SE	Range	Total	Median
52	Oligochaeta	1.7	1.20	4	5	1
52	*Macrophthalmus hirtipes*	1.3	0.33	1	4	1
52	Paraonidae	0.7	0.33	1	2	1
52	Nemerteans	0.3	0.33	1	1	0
52	Spionidae (polydorids)	0.3	0.33	1	1	0
53	Nereidae	7.3	0.88	3	22	7
53	*Macrophthalmus hirtipes*	2.0	1.00	3	6	1
53	Phoxocephalidae	1.7	0.88	3	5	2
53	*Arthritica bifurca*	0.7	0.33	1	2	1
53	Glyceridae	0.3	0.33	1	1	0
53	*Scolecolepides* sp.	0.3	0.33	1	1	0
54	Nereidae	3.7	1.76	6	11	3
54	*Macrophthalmus hirtipes*	3.3	1.33	4	10	2
54	*Heteromastus filiformis*	2.3	2.33	7	7	0
54	Spionidae (polydorids)	1.7	1.67	5	5	0
54	*Scoloplos Leadamas* sp.	1.3	0.67	2	4	2
54	Glyceridae	1.0	1.00	3	3	0
54	*Arthritica bifurca*	0.7	0.67	2	2	0
54	Cirratulidae	0.7	0.33	1	2	1
54	Phoxocephalidae	0.3	0.33	1	1	0
54	*Scolecolepides* sp.	0.3	0.33	1	1	0
55	Nereidae	4.7	0.67	2	14	4
55	*Austrovenus stutchburyi*	3.0	1.00	3	9	4
55	*Macrophthalmus hirtipes*	2.7	1.45	5	8	3
55	Oligochaeta	1.7	1.20	4	5	1
55	*Heteromastus filiformis*	1.3	0.88	3	4	1
55	Phoxocephalidae	1.3	0.67	2	4	2
55	*Arthritica bifurca*	1.0	0.58	2	3	1
55	Paraonidae	1.0	0.58	2	3	1
55	*Aricidea* sp.	0.7	0.33	1	2	1
55	*Macomona liliana*	0.7	0.33	1	2	1
55	Spionidae (polydorids)	0.7	0.33	1	2	1
55	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
55	Exogoninae	0.3	0.33	1	1	0
55	Sabellidae	0.3	0.33	1	1	0
55	*Scolecolepides* sp.	0.3	0.33	1	1	0
55	*Scoloplos Leadamas* sp.	0.3	0.33	1	1	0
56	*Helice crassa*	4.3	2.33	8	13	5
56	Nereidae	4.0	1.53	5	12	5
56	Paraonidae	2.0	1.15	4	6	2
56	*Aricidea* sp.	1.3	0.88	3	4	1
56	Cirratulidae	1.3	1.33	4	4	0
56	*Heteromastus filiformis*	1.3	1.33	4	4	0
56	*Arthritica bifurca*	1.0	1.00	3	3	0
56	Nemerteans	1.0	1.00	3	3	0
56	Spionidae (polydorids)	1.0	1.00	3	3	0
56	Corophidae sp. 1	0.7	0.67	2	2	0
56	*Cossura* sp.	0.7	0.67	2	2	0
56	Exogoninae	0.3	0.33	1	1	0
56	Orbinidae sp. 1	0.3	0.33	1	1	0
56	Phoxocephalidae	0.3	0.33	1	1	0
57	*Cossura* sp.	7.0	4.51	14	21	3
57	Nereidae	6.3	0.33	1	19	6
57	*Aricidea* sp.	2.7	1.20	4	8	2
57	*Heteromastus filiformis*	2.7	1.33	4	8	4
57	Nemerteans	1.7	1.20	4	5	1
57	Phoxocephalidae	1.7	0.67	2	5	1
57	Spionidae (polydorids)	1.7	1.67	5	5	0
57	Paraonidae	1.3	0.67	2	4	2

Site	Taxa	Mean	SE	Range	Total	Median
57	*Macrophthalmus hirtipes*	1.0	0.58	2	3	1
57	*Alpheus* sp.	0.7	0.67	2	2	0
57	Corophidae sp. 1	0.7	0.67	2	2	0
57	*Helice crassa*	0.7	0.67	2	2	0
57	*Theora lubrica*	0.7	0.67	2	2	0
57	Barnacles	0.3	0.33	1	1	0
57	*Capitella* sp.	0.3	0.33	1	1	0
57	Oligochaeta	0.3	0.33	1	1	0
57	Sigalionidae	0.3	0.33	1	1	0
58	Nereidae	5.3	0.88	3	16	5
58	*Aricidea* sp.	2.3	0.33	1	7	2
58	*Heteromastus filiformis*	2.0	0.00	0	6	2
58	Glyceridae	1.0	0.58	2	3	1
58	*Macrophthalmus hirtipes*	1.0	0.58	2	3	1
58	Oligochaeta	1.0	0.58	2	3	1
58	Paraonidae	0.7	0.67	2	2	0
58	Phoxocephalidae	0.3	0.33	1	1	0
58	*Scolecolepides* sp.	0.3	0.33	1	1	0
58	Spionidae (polydorids)	0.3	0.33	1	1	0
59	Nereidae	9.3	0.33	1	28	9
59	Cirratulidae	4.0	2.00	6	12	6
59	*Macrophthalmus hirtipes*	2.7	1.76	6	8	2
59	*Arthritica bifurca*	2.3	1.20	4	7	3
59	Spionidae (polydorids)	2.0	0.58	2	6	2
59	*Aricidea* sp.	1.3	0.33	1	4	1
59	*Austrovenus stutchburyi*	1.3	1.33	4	4	0
59	Glyceridae	1.0	0.58	2	3	1
59	Oligochaeta	0.3	0.33	1	1	0
59	Phoxocephalidae	0.3	0.33	1	1	0

Appendix 5. Summary of taxa collected at the subtidal sites. Mean = mean abundance per core. SE = standard error. Range = between the 5th and 95th percentile. Total = Total number of individuals collected in 3 samples (calculated by mean abundance*3). The taxa grouping 'Phoxocephalidae' excludes *Torridoharpinia hurleyi*, and 'Paraonidae' excludes *Aricidea* sp. †denotes identifications which are currently being verified.

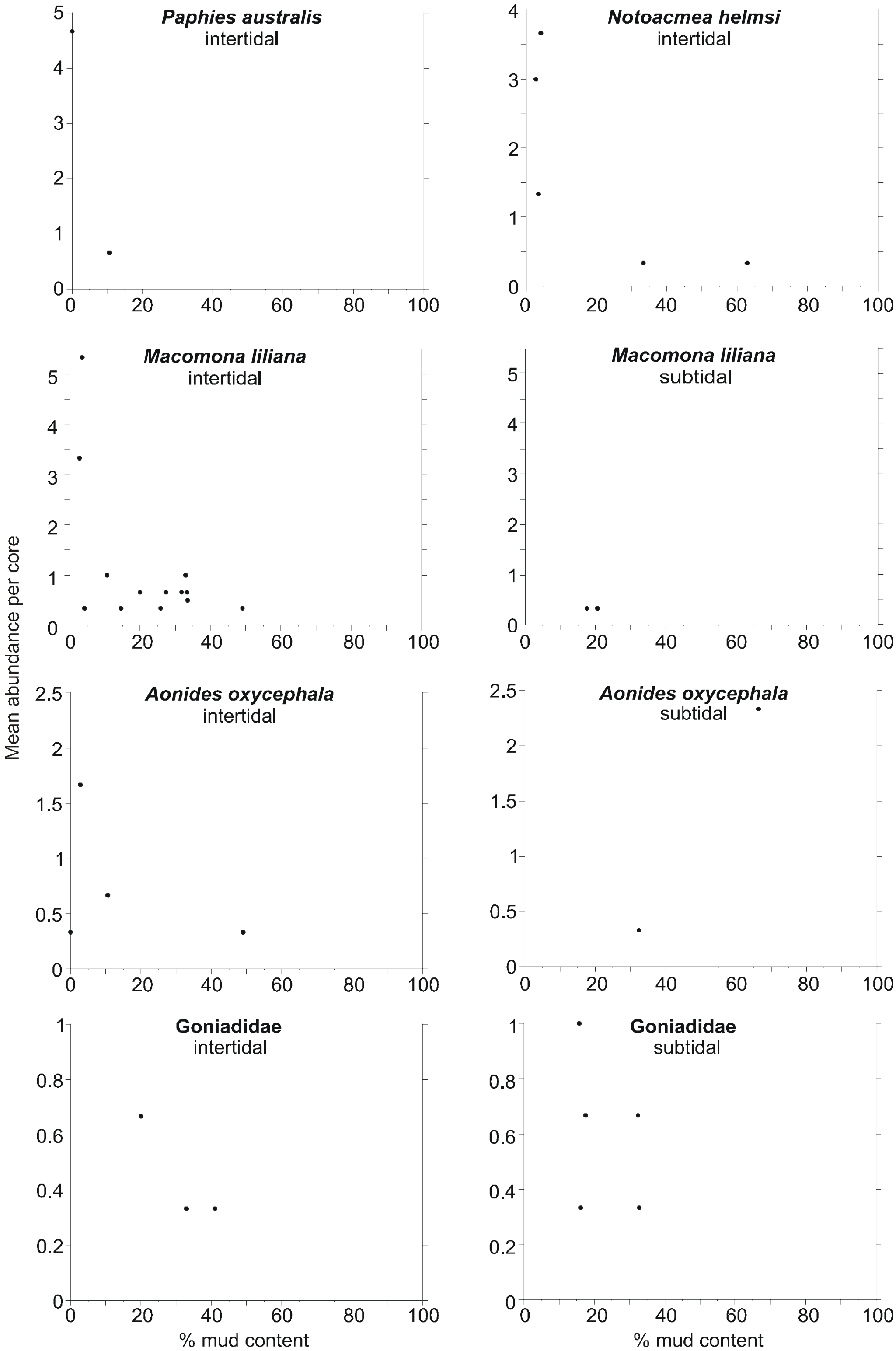
Site	Taxa	Mean	SE	Range	Total	Median
A	*Aricidea* sp.	2.0	1.53	5	6	1
A	*Capitella* sp.	1.0	0.58	2	3	1
A	*Cossura* sp.	0.3	0.33	1	1	0
A	Spionidae (polydorids)	0.3	0.33	1	1	0
B	*Capitella* sp.	9.3	5.90	19	28	5
B	Corophidae sp. 2	4.0	0.58	2	12	4
B	*Helice crassa*	2.0	0.58	2	6	2
B	Nereidae	1.7	0.88	3	5	2
B	Spionidae (polydorids)	1.0	0.58	2	3	1
B	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
B	*Heteromastus filiformis*	0.3	0.33	1	1	0
C	*Aricidea* sp.	22.3	6.01	20	67	19
C	*Heteromastus filiformis*	4.7	1.20	4	14	4
C	*Capitella* sp.	3.3	1.86	6	10	2
C	Cirratulidae	3.0	3.00	9	9	0
C	Nereidae	2.0	0.00	0	6	2
C	Spionidae (polydorids)	1.7	0.88	3	5	2
C	Corophidae sp. 2	0.7	0.67	2	2	0
C	*Austrovenus stutchburyi*	0.3	0.33	1	1	0
C	*Cossura* sp.	0.3	0.33	1	1	0
C	*Helice crassa*	0.3	0.33	1	1	0
D	*Musculista senhousia*	55.7	55.67	167	167	0
D	*Aricidea* sp.	17.3	11.46	39	52	13
D	*Cossura* sp.	9.0	4.93	17	27	10
D	*Heteromastus filiformis*	4.7	2.91	10	14	4
D	Spionidae (polydorids)	4.3	2.19	7	13	6
D	*Aquilaspio aucklandica*	2.3	2.33	7	7	0
D	Corophidae sp. 2	1.7	1.67	5	5	0
D	Cirratulidae	1.3	0.33	1	4	1
D	*Orbinia papillosa*	0.7	0.67	2	2	0
D	*Arthritica bifurca*	0.3	0.33	1	1	0
D	*Capitella* sp.	0.3	0.33	1	1	0
D	Glyceridae	0.3	0.33	1	1	0
D	*Magelona ?dakini*	0.3	0.33	1	1	0
D	Maldanidae	0.3	0.33	1	1	0
D	Nereidae	0.3	0.33	1	1	0
D	*Theora lubrica*	0.3	0.33	1	1	0
E	*Aricidea* sp.	4.0	1.15	4	12	4
E	*Cossura* sp.	2.3	0.67	2	7	3
E	*Capitella* sp.	1.3	1.33	4	4	0
E	Spionidae (polydorids)	0.7	0.67	2	2	0
E	*Theora lubrica*	0.7	0.33	1	2	1
E	Cirratulidae	0.3	0.33	1	1	0
E	Glyceridae	0.3	0.33	1	1	0
E	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
E	Maldanidae	0.3	0.33	1	1	0
E	Nereidae	0.3	0.33	1	1	0
E	*Orbinia papillosa*	0.3	0.33	1	1	0
F	*Cossura* sp.	35.0	13.08	45	105	32
F	*Aricidea* sp.	15.7	6.74	23	47	18
F	*Heteromastus filiformis*	5.0	1.00	3	15	6
F	Phoxocephalidae	1.0	1.00	3	3	0
F	*Orbinia papillosa*	0.7	0.67	2	2	0

Site	Taxa	Mean	SE	Range	Total	Median
F	*Theora lubrica*	0.7	0.67	2	2	0
F	Glyceridae	0.3	0.33	1	1	0
F	Oligochaeta	0.3	0.33	1	1	0
F	Polychaete 1	0.3	0.33	1	1	0
G	*Cossura* sp.	38.3	12.44	41	115	46
G	*Aricidea* sp.	3.3	1.20	4	10	4
G	Glyceridae	0.7	0.67	2	2	0
G	*Orbinia papillosa*	0.7	0.33	1	2	1
G	*Theora lubrica*	0.7	0.67	2	2	0
G	*Agalophamus ?macroura*	0.3	0.33	1	1	0
H	*Aricidea* sp.	13.3	4.98	17	40	15
H	*Heteromastus filiformis*	1.3	0.88	3	4	1
H	*Orbinia papillosa*	1.3	1.33	4	4	0
H	*Theora lubrica*	1.3	0.88	3	4	1
H	*Cossura* sp.	1.0	0.58	2	3	1
H	Corophidae sp. 1	0.7	0.67	2	2	0
H	Oligochaeta	0.7	0.67	2	2	0
H	Cumacean 1	0.3	0.33	1	1	0
H	*Nucula hartvigiana*	0.3	0.33	1	1	0
H	Phoxocephalidae	0.3	0.33	1	1	0
I	*Aricidea* sp.	70.0	15.70	53	210	63
I	*Cossura* sp.	9.3	2.73	9	28	11
I	*Heteromastus filiformis*	5.0	0.58	2	15	5
I	Phoxocephalidae	1.7	1.20	4	5	1
I	Glyceridae	1.3	0.33	1	4	1
I	*Orbinia papillosa*	1.3	1.33	4	4	0
I	*Aquilaspio aucklandica*	0.7	0.33	1	2	1
I	Goniadidae†	0.7	0.33	1	2	1
I	Nereidae	0.7	0.33	1	2	1
I	*Helice crassa*	0.3	0.33	1	1	0
I	*Macomona liliana*	0.3	0.33	1	1	0
I	Syllidae	0.3	0.33	1	1	0
J	*Cossura* sp.	23.3	8.19	28	70	26
J	*Aricidea* sp.	21.3	4.26	14	64	24
J	*Heteromastus filiformis*	9.3	1.20	4	28	10
J	Cirratulidae	8.3	3.18	11	25	8
J	*Nucula hartvigiana*	2.7	2.19	7	8	1
J	*Austrovenus stutchburyi*	1.7	0.88	3	5	2
J	*Cyclapsis thomsoni*	1.0	0.58	2	3	1
J	*Cyclomactra ovata*	1.0	0.58	2	3	1
J	*Macrophthalmus hirtipes*	0.7	0.67	2	2	0
J	Phoxocephalidae	0.7	0.67	2	2	0
J	*Theora lubrica*	0.7	0.33	1	2	1
J	*Aquilaspio aucklandica*	0.3	0.33	1	1	0
J	Glyceridae	0.3	0.33	1	1	0
J	*Helice crassa*	0.3	0.33	1	1	0
J	*Macomona liliana*	0.3	0.33	1	1	0
K	*Aricidea* sp.	21.7	7.88	25	65	28
K	Phoxocephalidae	8.0	0.58	2	24	8
K	Cirratulidae	1.3	0.67	2	4	2
K	Spionidae (polydorids)	1.3	0.33	1	4	1
K	Exogoninae	1.0	0.00	0	3	1
K	*Cossura* sp.	0.7	0.33	1	2	1
K	Syllidae	0.7	0.67	2	2	0
K	Tanaidacea	0.7	0.33	1	2	1
K	Trichobranchidae	0.7	0.67	2	2	0
K	Anthuridae	0.3	0.33	1	1	0
K	Corophidae sp. 1	0.3	0.33	1	1	0
K	Corophidae sp. 2	0.3	0.33	1	1	0

Site	Taxa	Mean	SE	Range	Total	Median
K	Eusiridae	0.3	0.33	1	1	0
K	Glyceridae	0.3	0.33	1	1	0
K	Goniadidae	0.3	0.33	1	1	0
K	*Limaria orientalis*	0.3	0.33	1	1	0
K	Lyssanidae	0.3	0.33	1	1	0
K	Nebalacea	0.3	0.33	1	1	0
K	Nemerteans	0.3	0.33	1	1	0
K	*Nucula hartvigiana*	0.3	0.33	1	1	0
K	*Pectinaria australis*	0.3	0.33	1	1	0
K	Pontoporeidae	0.3	0.33	1	1	0
L	*Aricidea* sp.	56.3	12.57	42	169	63
L	Paraonidae	12.0	6.03	19	36	17
L	*Cossura* sp.	11.3	4.37	14	34	8
L	Corophidae sp. 2	5.7	5.67	17	17	0
L	*Heteromastus filiformis*	2.7	0.67	2	8	2
L	Glyceridae	1.0	1.00	3	3	0
L	Nemerteans	1.0	1.00	3	3	0
L	Cirratulidae	0.7	0.33	1	2	1
L	Goniadidae	0.7	0.33	1	2	1
L	Nereidae	0.7	0.67	2	2	0
L	Oligochaeta	0.7	0.67	2	2	0
L	Phoxocephalidae	0.7	0.67	2	2	0
L	*Aonides oxycephala*	0.3	0.33	1	1	0
L	Sigalionidae	0.3	0.33	1	1	0
M	*Cossura* sp.	26.3	6.67	20	79	33
M	Paraonidae	14.0	4.16	14	42	16
M	Phoxocephalidae	3.3	1.67	5	10	5
M	*Aricidea* sp.	2.7	1.67	5	8	1
M	*Aonides oxycephala*	2.3	1.45	5	7	2
M	Cirratulidae	1.7	0.67	2	5	1
M	*Heteromastus filiformis*	1.7	0.88	3	5	2
M	*Theora lubrica*	1.3	0.33	1	4	1
M	Nemerteans	0.7	0.33	1	2	1
M	*Alpheus* sp.	0.3	0.33	1	1	0
M	Amphipod 1*	0.3	0.33	1	1	0
M	Glyceridae	0.3	0.33	1	1	0
M	*Magelona ?dakini*	0.3	0.33	1	1	0
M	Oligochaeta	0.3	0.33	1	1	0
M	Orbinidae sp. 1	0.3	0.33	1	1	0
M	Sigalionids	0.3	0.33	1	1	0
N	Paraonidae	14.7	5.78	19	44	11
N	Heteromastus *filiformis*	8.7	1.86	6	26	10
N	*Amphibola crenata*	3.3	1.67	5	10	5
N	Ophiura	2.7	0.88	3	8	3
N	Phoxocephalidae	2.7	1.33	4	8	4
N	*Arthritica bifurca*	2.3	1.20	4	7	3
N	*Nucula hartvigiana*	2.3	1.86	6	7	1
N	Spionidae (polydorids)	2.3	1.86	6	7	1
N	Nemerteans	2.0	0.58	2	6	2
N	Orbinidae sp. 1	2.0	2.00	6	6	0
N	*Anthopleura aureoradiata*	1.3	1.33	4	4	0
N	Exogoninae	1.3	0.88	3	4	1
N	Cirratulidae	1.0	0.58	2	3	1
N	Corophidae sp. 1	0.7	0.67	2	2	0
N	*Cossura* sp.	0.7	0.67	2	2	0
N	Lyssanidae	0.7	0.67	2	2	0
N	Anthuridae	0.3	0.33	1	1	0
N	*Capitella* sp.	0.3	0.33	1	1	0
N	*Cyclomactra ovata*	0.3	0.33	1	1	0

Site	Taxa	Mean	SE	Range	Total	Median
N	Goniadidae	0.3	0.33	1	1	0
N	*Limaria orientalis*	0.3	0.33	1	1	0
N	*Phylo* sp.	0.3	0.33	1	1	0
N	Trichobranchidae	0.3	0.33	1	1	0
N	*Zegaluris tenuis*	0.3	0.33	1	1	0
O	Paraonidae	10.0	5.69	19	30	7
O	Anthuridae	4.0	2.31	8	12	4
O	Tanaidacea	4.0	2.31	8	12	4
O	*Heteromastus filiformis*	3.7	2.19	7	11	2
O	*Cossura* sp.	2.0	1.00	3	6	1
O	Phoxocephalidae	1.7	0.88	3	5	2
O	*Anthopleura aureoradiata*	1.0	0.58	2	3	1
O	*Arthritica bifurca*	1.0	0.00	0	3	1
O	Goniadidae	1.0	0.58	2	3	1
O	Orbinidae sp. 1	1.0	0.58	2	3	1
O	*Theora lubrica*	1.0	0.58	2	3	1
O	*Asychis* sp.	0.3	0.33	1	1	0
O	*Macrophthalmus hirtipes*	0.3	0.33	1	1	0
O	Nemerteans	0.3	0.33	1	1	0
O	*Pectinaria australis*	0.3	0.33	1	1	0
O	*Phylo* sp.	0.3	0.33	1	1	0
O	Spionidae (polydorids)	0.3	0.33	1	1	0

Appendix 6. Distribution patterns of selected taxa in relation to increasing mud content of the sediment.



Appendix 6 (cont.) Distribution patterns of selected taxa in relation to increasing mud content of the sediment.