

Baseline Ecological Survey of Candidate Dredge Spoil
Disposal Areas 1.2 and 2.2 and Adjacent Reference
areas: Crude Shipping Project, Bream Bay, Whangarei
November 2016



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Cover Photo: The starfish *Luidia australiae* with a tuft of foliose red algae tucked between two arms, photographed at Area 2.2A sample location 38

For: Chancery Green on behalf of Refining NZ

Report by: V.C. Kerr B.Sc., Roger Grace PhD.

Kerr and Associates, Whangarei

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1 Summary

A survey of epibenthic and benthic infauna communities was undertaken in Bream Bay in April-May 2016 at the candidate dredge disposal sites 1.2 and 2.2 and their adjacent reference areas 1.2A and 1.2B and 2.2A and 2.2B respectively. This survey and set of results form part of a body of information collected to inform a resource consent application in support of a proposal to dredge the entrance channel to the Whangarei Harbour and the turning basin directly in front of the Marsden Point jetty and Northport.

A diver crew collected benthic core samples at 36 sample locations spread evenly in an approximate spatial sense across the 6 areas, for invertebrate community analysis and sediment samples for particle size analysis and to test for heavy metal contaminants. Imagery for a set of five replicate photo quadrats was taken at all sample locations to characterise surface sediments and observe epibenthic organisms present at the sites. Results of this survey are presented in the body of this report and in accompanying field and lab data.

At the time of writing this report analysis of the benthic invertebrate samples for reference Areas 2.2A and 2.2B have not been processed and are preserved in storage. Sediment particle size samples, heavy metals analysis and photographic survey of epibenthic fauna and flora have been completed and are discussed in this report.

2 Introduction

Refining NZ is proposing to carry out dredging work to deepen and re-align the entrance channel to the Whangarei Harbour and the turning basin immediately in front of the Marsden Point jetty and Northport. In preparation for this work a series of studies have been commissioned.

This report describes the results of biotic and substrate survey work carried out in April and May 2016 in two areas (1.2 & 2.2) in Bream Bay, which were at the time under consideration for disposal of dredge spoils. Also surveyed in this work are four additional areas in Bream Bay that have been identified as reference areas for each of the disposal areas 1.2 and 2.2. These reference areas can serve as control areas in any future monitoring program involved with the disposal of dredge spoils.

The design of the survey methodology is described in a report by Brian Coffey, (2016a). The general aim of the program is to gather sufficient habitat and biological community information to adequately describe the areas of interest. Additionally the intention is to set up a quantitative biological monitoring programme that will serve as a baseline for the areas, as well as provide for future monitoring needs if the proposed disposal of the dredged material proceeds.

The scope of this report is confined to presenting the methodology used, reporting and summarising the results of the fieldwork. Further analysis and evaluation of suitability of the candidate disposal sites will be treated in additional technical reports.

3 Methods

3.1 Selection of sample sites

From the work presented in the Coffey report (2016a) on the recommended methodology for this study, it was determined that for each of the six areas (two candidate sites and four reference sites), we would create six sample locations distributed evenly in a spatial sense within the pre-determined boundaries of each of the survey areas. At each sample location replicate samples were located haphazardly within a 15 metre distance from the anchor dropped on the waypoint. The map, in Figure, 1-3 illustrate the sample locations used in this survey. GPS information on the 18 sample locations relating to sites: 1.2, 1.2A, 1.2B, 2.2, 2.2A and 2.2B are recorded in Appendix 1. For the candidate area 2.2 we used sample locations which had previously been located for preliminary survey work at this site, reported in (Kerr and Grace 2016) and (West and Bell, 2015). For the other survey areas the boundaries were plotted in a similar manner on a GIS platform.

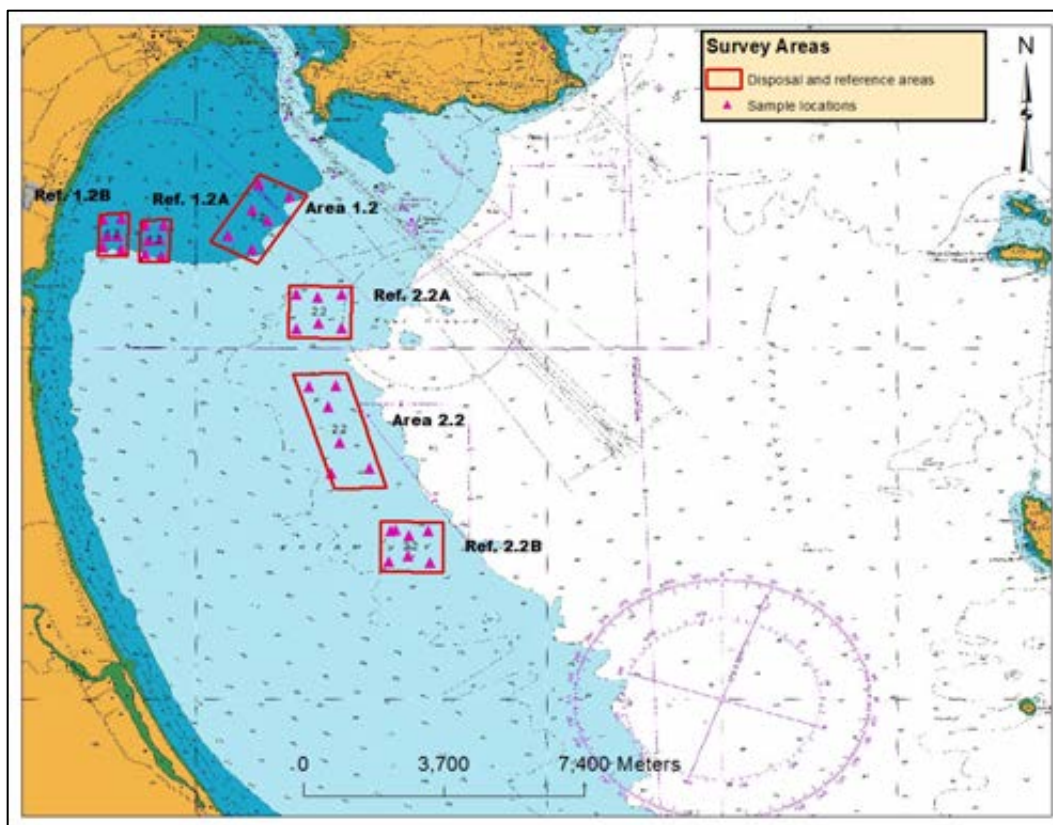


Figure 1 Map of Bream Bay Area showing candidate disposal areas and adjacent reference areas with sampling locations indicated.

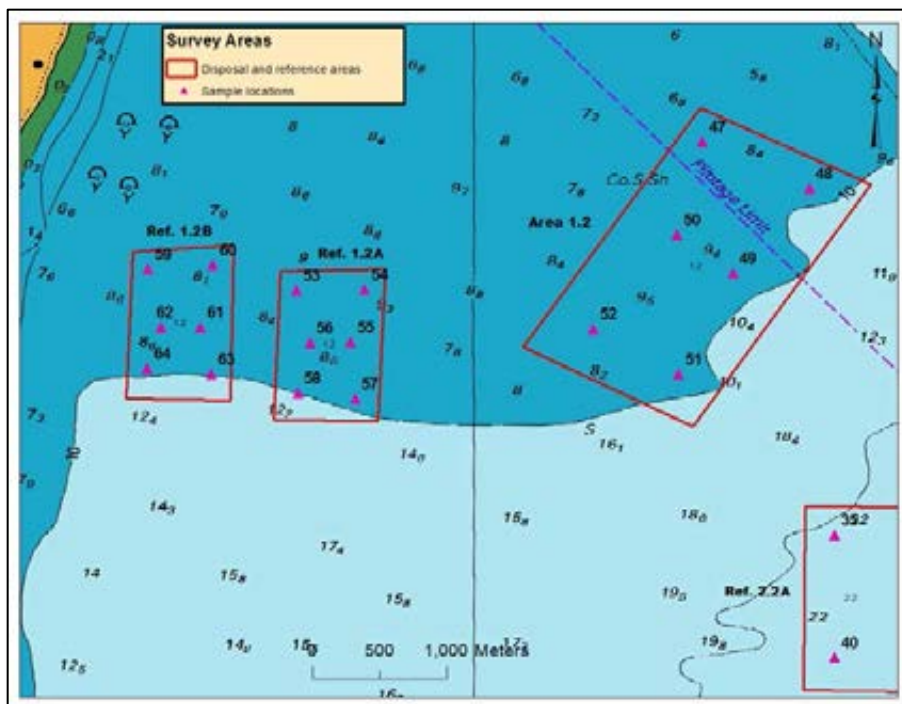


Figure 2 Map of Bream Bay Area showing candidate disposal areas and adjacent reference areas with sampling locations indicated.

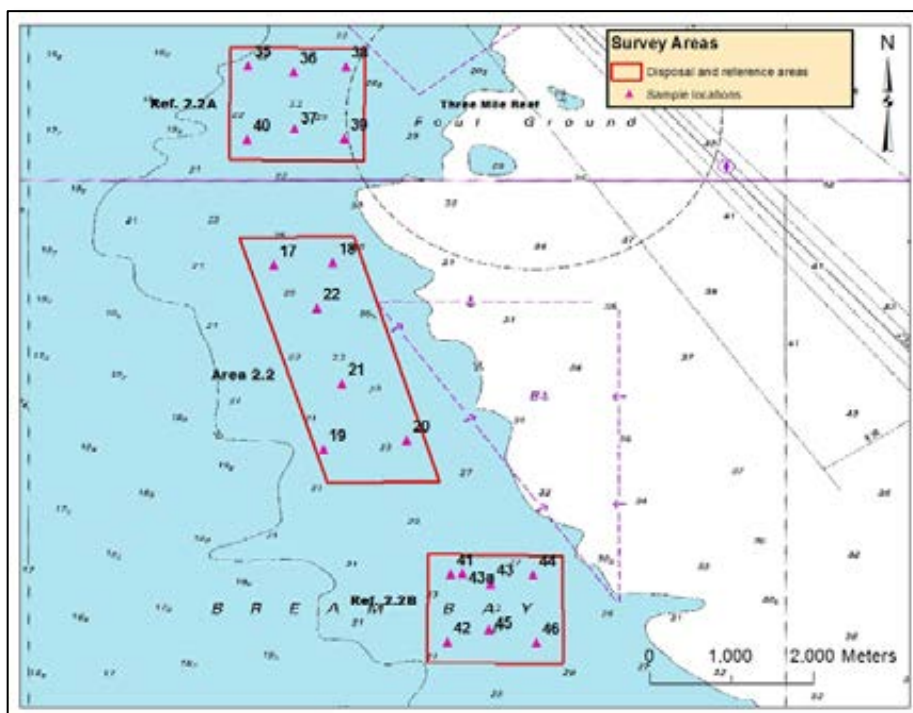


Figure 3 Map of Bream Bay Area showing candidate disposal areas and adjacent reference areas with sampling locations indicated.

3.2 Benthic invertebrate communities

The methodology adopted for this baseline study calls for five replicate samples to be taken from each sample location for analysis of benthic invertebrate community composition and abundance. A dive team of two using a hand-coring device, shown in Figure 4 below, took the samples. The dimensions of the coring tool are 138mm diameter with a 150mm coring depth. On the bottom of the seabed the divers immediately transferred the contents of the corer to a sieve bag sealable on both ends made of solid flexible material with a plastic scientific-quality 500 micron mesh across the central area. The samples were transported to the surface where the cleaning and sieving process was completed. The remaining substrate material >500 microns and all biological components were placed in a plastic 1 L jar and immediately fixed with a solution of 70% ethanol, 2% glycol and the remainder seawater. Samples were then stored and later sent to the Cawthron Institute, where a specialist team sorted, identified and counted all organisms present to the lowest practical taxonomic level.



Figure 4 The hand-coring tool used in this survey



Figure 5 (left) Diver forcing the coring tool into the substrate, taken at area 1.2A sample location 55, (right) diver filling one of the invertebrate sieving bags with a core sample taken at area 2.2 sample location 21.

3.3 Grain size analysis, metals and contaminants sediments sampling

At each of the sample locations for all 36 areas a further 150mm deep sediment core sample was taken, which the dive team placed in a plastic bag and held on the boat in a chilled condition for further processing onshore. From each of these samples, subsamples were prepared for particle size analysis and chemical testing for heavy metal contaminants. On-shore processing of these samples for particle testing involved taking a subsample that was placed in a zip lock plastic bag, frozen and then transferred to the Waikato University lab for ‘general purpose environmental analysis’. At the lab the samples were hand sieved at 2mm. Sample portions below 2mm were run through a Malvern Lasersizer.

R.J. Hill Laboratory carried out chemical analysis for heavy metal contaminants. Sample jars were filled with a homogenised subsample from the original field core sample and kept chilled until they were sent to R.J. Hill Laboratories for analysis.

3.4 Photo quadrats

At each sample location the dive team laid out a PVC 1m² frame and took a picture with a GoPro Hero 4 camera fitted with twin Sola video lights set at 800 lumens. The procedure was repeated haphazardly five times locating five replicate photo quadrats. The dive team also collected some additional ‘close-up’ photos and short video clips of any features or organisms of interest.

Photos for each site were examined and notes were taken consisting of a qualitative description of the substrate surface and epifauna seen. Presence of ‘sand ripples’ and an estimate of the ‘wave length’ of the sand ripples were recorded. Time of drop and depth from the boat’s sounder and diver’s gauges were also recorded.

4 Results candidate area 1.2, reference areas 1.2A and 1.2B

4.1 Particle Size analysis

Lab analysis results for the distribution of particle sizes making up the sediments of the three areas 1.2; 1.2A and 1.2B are presented below in summarised form according to predominant sediment texture classes. The size range for each sediment texture class is indicated at the top of each table in millimeters.

Overall the three areas can be described as fine to medium sands with relatively low amounts of silt or coarse materials and gravel. However, there are variations in the components between the areas and also within each area.

Candidate disposal area 1.2 sample locations show a range of proportions of fine sands and coarser sands. Three sample locations have a small amount of very fine sand and three have little or no very fine sand. Across all samples in area 1.2 there were no silt or clay components. One sample, location #50 has a proportion of coarse sand and a small amount of gravel, which sets it apart from the other locations in Area 1.2.

Reference areas 1.2A and 1.2B have a quite similar degree of variation to each other and also similar to the variation existing in area 1.2. The main difference is that both reference areas have more sample locations with the coarser mix of sediments. Similar to area 1.2 the two reference areas have no clay and silt components.

Sample	gravel	very coarse sand	coarse sand	medium sand	fine sand	very fine sand	silt	clay
	>2mm	2-1.18mm	1.18-.6mm	.6-.3mm	.3-.150mm	.150-.063mm	.063-.0039mm	<.0039
#47	0.00	0.00	0.01	25.26	64.61	10.12	0.00	0.00
#48	0.00	0.24	1.49	26.58	58.01	13.68	0.00	0.00
#49	0.00	0.81	5.76	34.03	49.66	9.73	0.00	0.00
#50	2.44	9.61	28.85	46.31	12.79	0.00	0.00	0.00
#51	0.00	0.00	6.61	47.85	42.35	3.20	0.00	0.00
#52	0.93	1.60	20.11	52.15	24.48	0.74	0.00	0.00

Table 1 Candidate disposal area 1.2 particle size fraction data expressed in percentages of main texture groups.

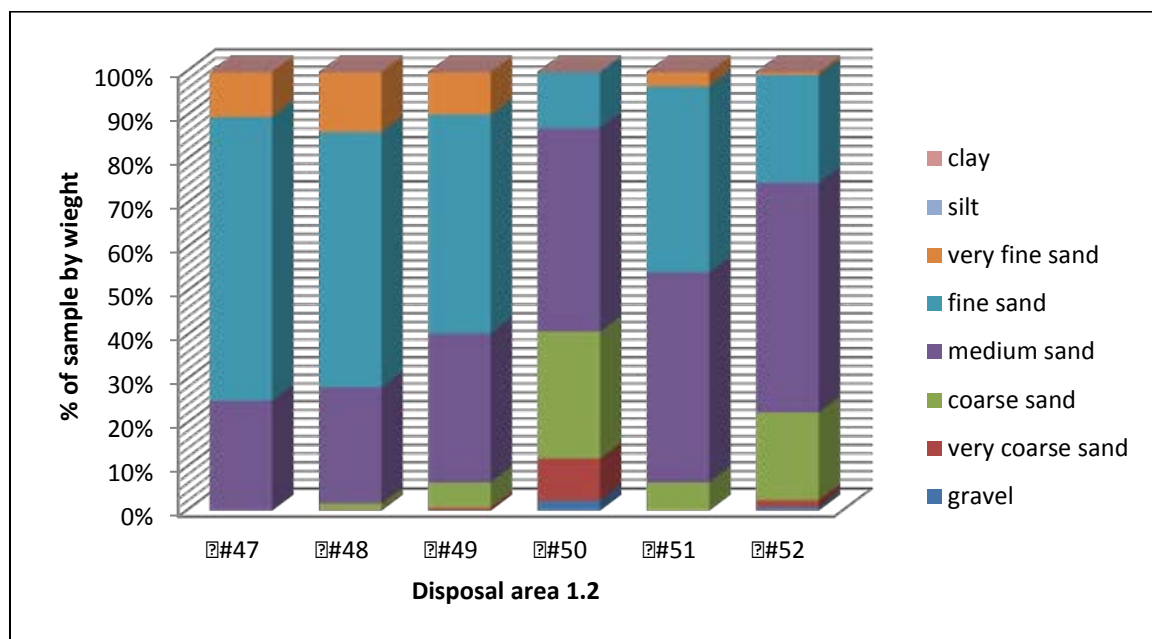


Figure 6 Candidate disposal area 1.2 particle size fraction percentages of main texture groups.

Sample	gravel	very coarse sand	coarse sand	medium sand	fine sand	very fine sand	silt	clay
	>2mm	2-1.18mm	1.18-.6mm	.6-.3mm	.3-.150mm	.150-.063mm	.063-.0039mm	<.0039
#53	1.29	4.56	24.13	50.02	19.65	0.35	0.00	0.00
#54	1.62	7.37	26.95	46.83	16.69	0.53	0.00	0.00
#55	4.75	4.90	23.33	47.77	18.80	0.45	0.00	0.00
#56	17.61	10.07	24.55	36.54	11.06	0.16	0.00	0.00
#57	0.00	0.00	7.42	44.62	42.85	5.11	0.00	0.00
#58	0.00	0.00	2.41	30.40	54.70	12.49	0.00	0.00

Table 2 Reference area 1.2A particle size fractions given in percentages of main texture groups.

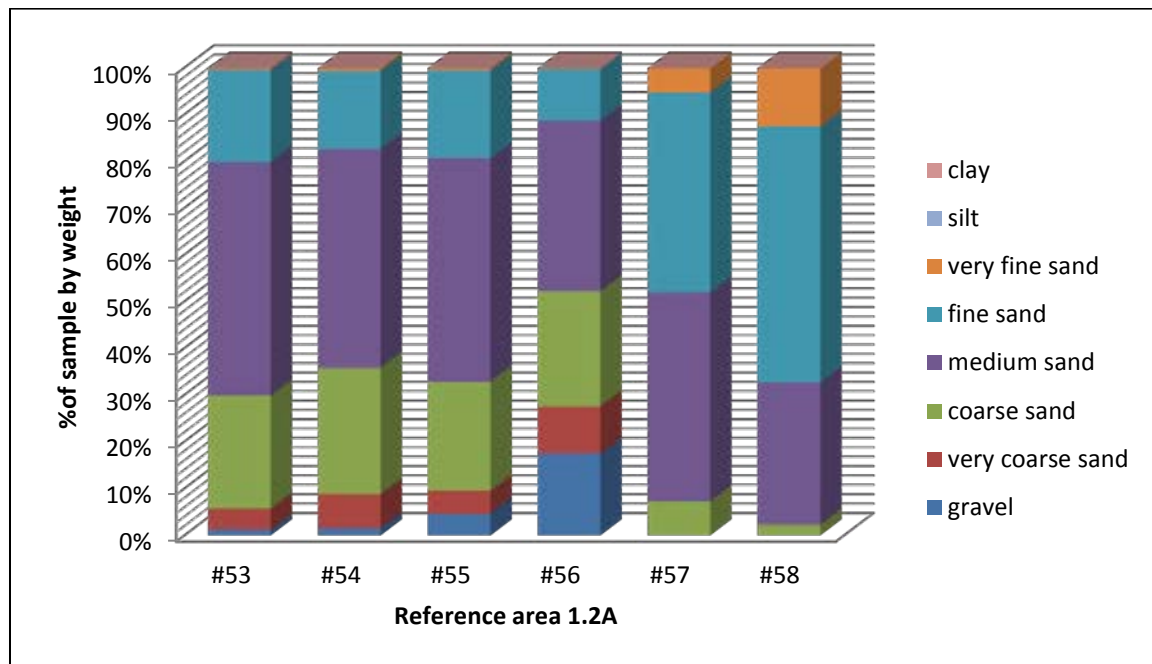


Figure 7 Reference area 1.2A particle size fraction percentages of main texture groups.

Sample	gravel	very coarse sand	coarse sand	medium sand	fine sand	very fine sand	silt	clay
#59	11.59	5.72	25.87	43.25	13.47	0.09	0.00	0.00
#60	5.71	7.66	21.57	40.50	22.25	2.32	0.00	0.00
#61	14.39	11.04	20.50	33.11	18.93	2.02	0.00	0.00
#62	2.36	8.49	25.77	45.55	17.34	0.49	0.00	0.00
#63	0.00	0.38	5.32	33.61	50.13	10.55	0.00	0.00
#64	0.00	0.96	0.90	20.53	60.14	17.47	0.00	0.00

Table 3 Reference area 1.2B particle size fractions given in percentages of main texture groups.

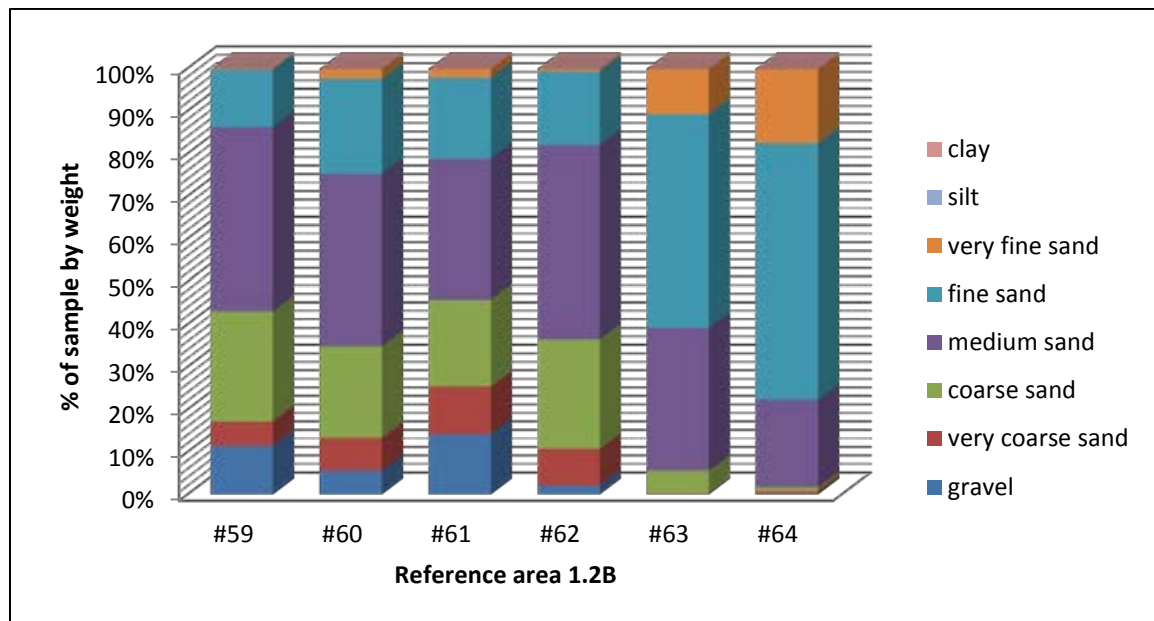


Figure 8 Reference area 1.2B particle size fraction percentages of main texture groups.

4.2 Benthic invertebrate community analysis

The results of the benthic invertebrate community analysis of Areas 1.2 and 2.2, and associated reference areas are presented in this report in Sections 4.3 – 4.7 and 4.8 - 4.12 respectively. The level of taxonomic identification of organisms is in most cases done to family, genus or species level. The raw data is available in spreadsheet format accompanying this report. A first stage analysis of benthic community has been undertaken which attempts a basic description of abundance and diversity and sampling precision. Abundance data is reported on in the form of total number of individual organisms sampled and mean counts for sample locations. Community structure and diversity is presented as the number of taxa found for the main taxonomic groups at the phyla and class level reported as percentage composition of the community. There were eleven major taxonomic groups selected for this analysis.

One of the purposes of this study is to establish a baseline of community level data that could be re-sampled over time in a manner that would allow for change over time analysis. To this end at each sample location five replicate core samples were taken and analysed. For this report mean values of each set of five replicate samples are used for the analysis for abundance and diversity descriptions. An analysis was undertaken of the sampling error or variance found at each sample location, i.e. across the five replicate samples. It was decided it would be useful to report on sampling error across two important taxa groups, the Amphipoda group, (Order level) and the Polychaete worm group, (Class level). Both groups are important ecologically, diverse and abundant in terms of species counts and well distributed across the survey areas. The polychaete worms include a diverse range of functional groups including parasitic and carnivorous species, suspension, infaunal filter, infaunal deposit, epifaunal deposit, scavenger and omnivorous feeders. Amphipods are mainly epifaunal scavengers but make up an important component in most aquatic benthic communities.

For the analysis of sampling error the following calculation was performed. For each sample location a standard deviation value was calculated from the sum of each of the five replicate counts for the taxa group and corresponding sample location mean count for the taxa group.

4.3 Benthic Invertebrate communities Area 1.2

The Table 4 and Figure 9 below shows abundance and diversity measures describing the six sample locations surveyed at Area 1.2.

Area 1.2 taken as a whole had 1,479 individual organisms counted and 65 species or taxa recorded. The range of total individuals counted varied between 143 (sample location 47) to 552 (sample location 51), across the six sample locations. The range of the mean counts of individual organisms for each sample location was the low count of 27 (sample location 50) and a high count of 110 (sample location 51). The large counts in sample location 51 as compared to the other five sample locations is primarily made up of

a higher species counts and higher abundance in the Polychaeta group. The Polychaete family Paraonidae had high numbers with a mean count of 52 individuals and a total number of individuals counted (on 5 replicate samples) of 260. This was an extreme outlier compared to the other sample locations that had mean counts for this species in a range of 0.2 - 3.2.

Total taxa counts were reasonably consistent across the six sample locations falling in a range of between 20 and 39. Mean taxa count values were in a range of between 10 and 21.

Sample locations	47	48	49	50	51	52
Total count individual organisms (5 samples)	143	286	179	136	552	183
Mean count individual organisms	29	57	36	27	110	37
Total taxa count (5 samples)	31	39	26	34	27	20
Mean taxa count	13	21	10	12	16	10

Table 4 Area 1.2 abundance data; individual organisms total counts across five replicate samples for each sample location, mean values of counts for each sample location, diversity data; total taxa counted across five replicate samples and mean taxa counts for each sample location.

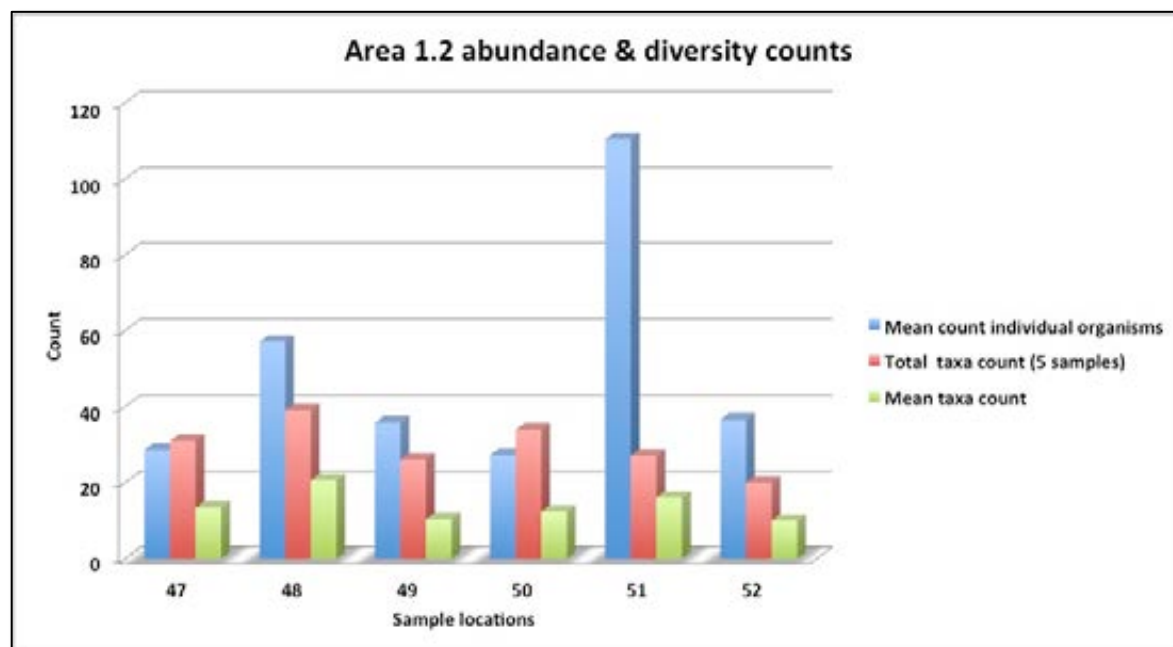


Figure 9 Area 1.2 graphic illustration of abundance and diversity data shown in Table 4 above; total individuals counted, total taxa counted and mean values for individual organisms and taxa counts shown for each sample location.

Table 5 and Figure 10 below show the community composition of eleven major taxa across the six sample locations of Area 1.2.

Sample locations	47	%	48	%	49	%	50	%	51	%	52	%
Cnidaria	0.6	2.1%	0.4	0.7%	0.0	0.0%	0.4	1.5%	0.6	0.5%	0	0.0%
Nematoda	0.8	2.8%	1.6	2.8%	0.0	0.0%	8.2	30.1%	2.4	2.2%	1.8	4.9%
Mollusca, Polyplacophora	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0	0.0%
Molusca, Gastropoda	0.8	2.1%	0.4	0.7%	0.2	0.6%	1.2	4.4%	0.0	0.0%	0	0.0%
Molusca, Bivalvia	1.2	4.2%	4.6	8.0%	3.0	8.4%	0.8	2.9%	1.2	1.1%	1	2.7%
Annelida, Oligochaeta	0.0	0.0%	0.4	0.7%	0.0	0.0%	0.4	1.5%	0.0	0.0%	0	0.0%
Annelida, Polychaeta	5.0	17.5%	11.8	20.6%	3.0	8.4%	7.6	27.9%	70.4	63.8%	5.4	14.8%
Arthropoda, Amphipoda	10.8	37.8%	15.8	27.6%	1.6	4.5%	2.8	10.3%	3.8	3.4%	12	32.8%
Echinodermata	2.0	7.0%	7.4	12.9%	18.2	50.8%	1.6	5.9%	12.8	11.6%	5.6	15.3%
Cephalocordata (lancelet worm)	0.0	0.0%	0.0	0.0%	0.0	0.0%	1.0	3.7%	0.0	0.0%	0	0.0%
Other taxa	7.4	26.6%	14.8	25.9%	9.8	27.4%	3.2	11.8%	19.2	17.4%	10.8	29.5%

Table 5 Area 1.2 counts of the species or taxa making up each of the main taxonomic groups and the percentages of community represented by each group.

Polycheata, other taxa and Amphipoda were the most abundant of the eleven major taxa groups. They represented 26, 23 and 19 percent of the invertebrate community of Area 1.2 taken as a whole.

The taxa grouped together as ‘other taxa’ consist mainly of Nemerta and the Crustacea Orders; Copepoda, Isopoda, Decapoda, Ostracoda and Cumacea. In addition there were small numbers of Chaetognatha (arrow worms) and a small fish species *Limnichthys polyactis*.

The large quantity of Polycheate worms making up the community of sample location 51 can be seen clearly in the graph below.

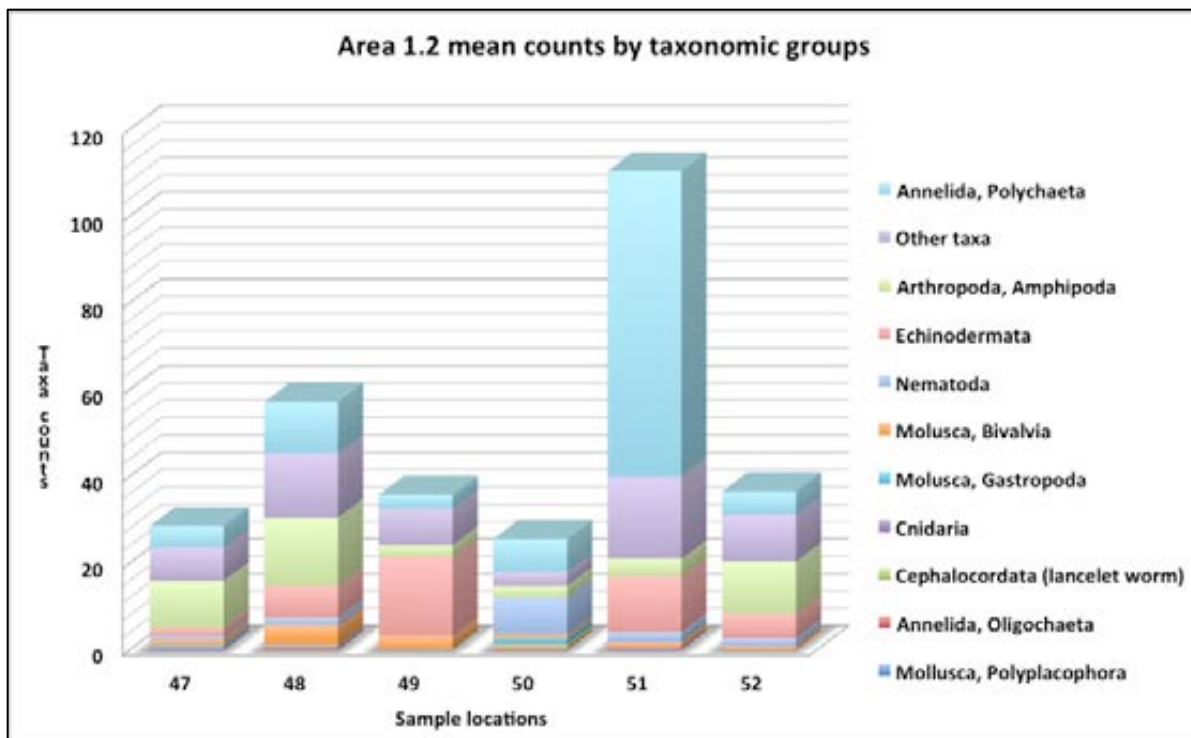


Figure 10 Area 1.2 community diversity expressed as mean counts of eleven major taxonomic groups based on the data shown in Table 5 above.

Figure 11 below show the results of analysis of two major taxonomic groups and the sampling variation within the five replicate samples taken at each sample location. Mean counts for the number of species found in Amphipoda and Polychaeta groups are shown along with the calculated standard deviation across the five replicate samples for each sample location in Area 1.2.

The sampling error or variance observed could be described as what would be expected for this type of survey.

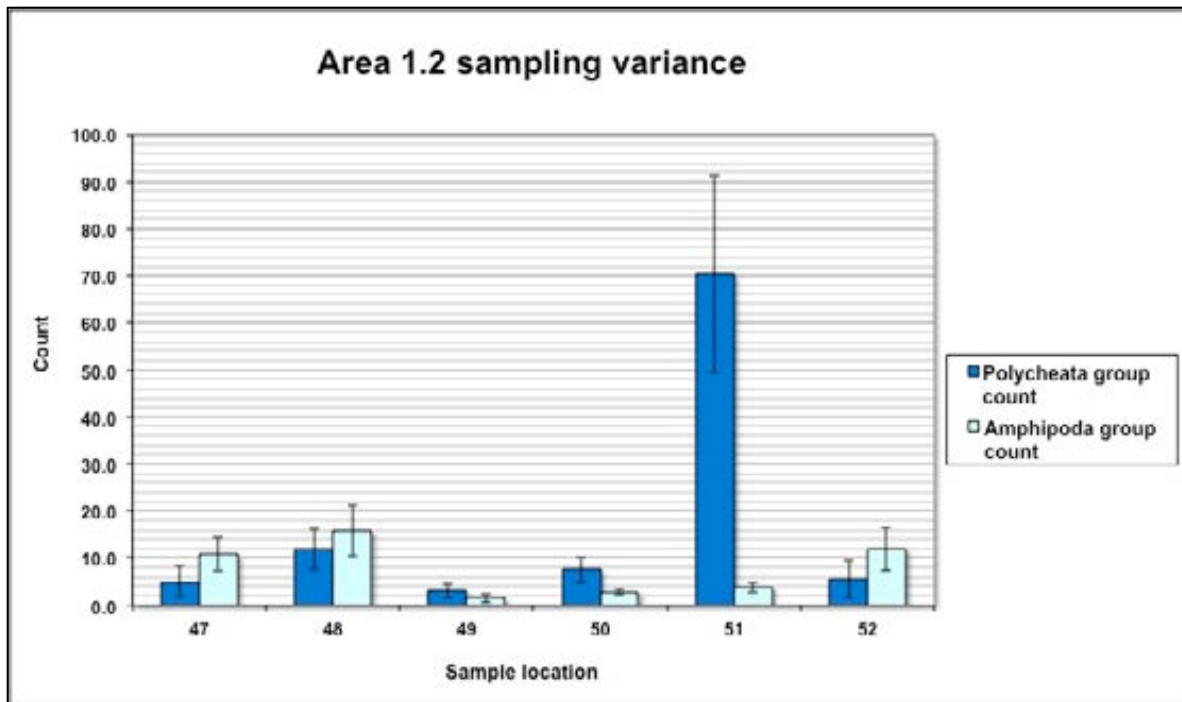


Figure 11 Area 1.2 Sampling variation is expressed as standard deviation values (error bars) calculated across the five replicate samples for each sample location at the taxa group level. Group counts are mean values of the sum of the group counts.

4.4 Benthic Invertebrate communities Area 1.2A

The Table 6 and Figure 12 below show abundance and diversity measures describing the six sample locations surveyed at Area 1.2A.

Area 1.2A taken as a whole had 1,709 individual organisms counted and 61 species or taxa recorded. The range of total individuals counted varied between 156 (sample location 57) to 465 (sample location 56), across the six sample locations. The range of the mean counts of individual organisms for each sample location was the low count of 31 (sample location 57) and a high count of 93 (sample location 56). The relatively large counts in sample locations 55 and 56 as compared to the other four sample locations is primarily made up of a higher species counts and higher abundance in the Polycheata group and to a lesser degree Nematoda. The three Polycheate families making up most of the elevated counts in sample locations 55 and 56 were Paraonidae, Syllidae and Sabellidae.

Total taxa counts were reasonably consistent across the six sample locations falling in a range of between 23 and 38. Mean taxa count values were in a range of between 10.8 and 17.8.

Sample locations	53	54	55	56	57	58
Total count individual organisms (5 samples)	281	175	395	465	156	237
Mean count individual organisms	56.2	35	79	93	31.2	47.4
Total taxa count (5 samples)	25	27	30	38	23	28
Mean taxa count	11.6	11.2	15	17.8	10.8	14.2

Table 6 Area 1.2A abundance data; individual organisms total counts across five replicate samples for each sample location, mean values of counts for each sample location, diversity data; total taxa counted across five replicate samples and mean taxa counts for each sample location.

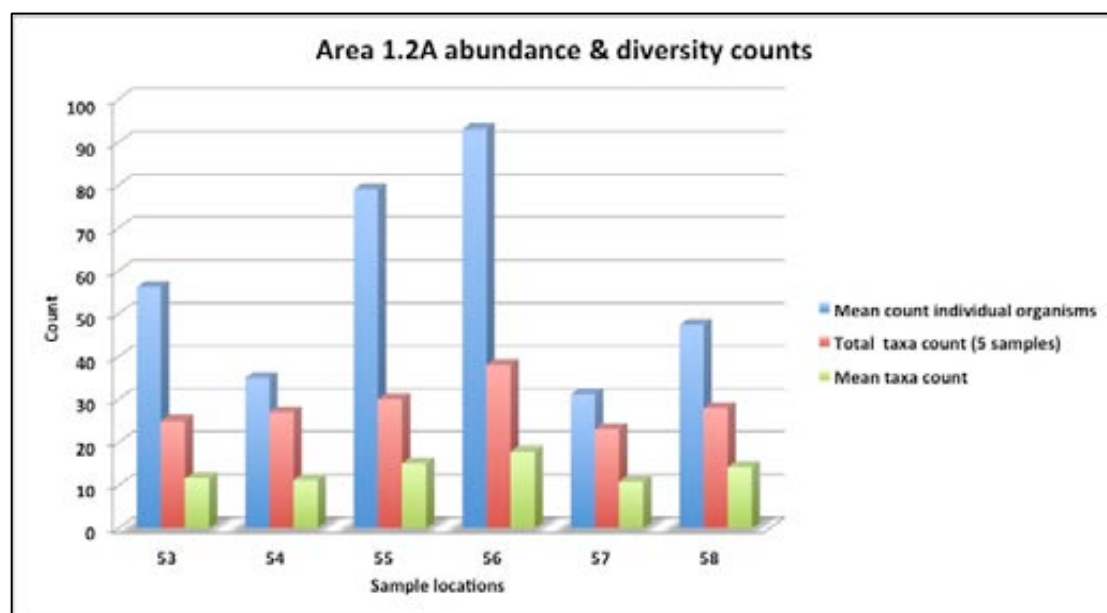


Figure 12 Area 1.2A graphic illustration of abundance and diversity data shown in Table 6 above; total individuals counted, total taxa counted and mean values for individual organisms and taxa counts shown for each sample location.

Table 7 and Figure 13 below show the community composition of eleven major taxa across the six sample locations of Area 1.2A.

Polychaeta, Amphipoda and other taxa and were the most abundant of the eleven major taxa groups. They represented 45, 19 and 13 percent respectively of the invertebrate community of Area 1.2A taken as a whole.

The taxa grouped together as ‘other taxa’ consist mainly of Nemerta and the Crustacea Orders; Copepoda, Isopoda, Decapoda, Ostracoda and Cumacea. In addition there were small numbers of Chaetognatha (arrow worms) and a small fish species *Limnichthys polyactis*.

The large quantity of Polychaete worms making up the community of sample locations 55 and 56 can be seen clearly in the graph below.

Sample locations	53	%	54	%	55	%	56	%	57	%	58	%
Cnidaria	0.0	0.0%	0.2	0.6%	0.4	0.5%	0.8	0.9%	0.0	0.0%	0	0.0%
Nematoda	6.4	11.4%	2.2	6.3%	12.6	15.9%	13.0	14.0%	2.0	6.4%	0.8	1.7%
Mollusca, Polyplacophora	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0	0.0%
Molusca												
, Gastropoda	0.4	0.7%	0.4	1.1%	0.6	0.8%	1.2	1.3%	0.0	0.0%	0.4	0.8%
Molusca, Bivalvia	0.6	1.1%	1.2	3.4%	0.2	0.3%	0.4	0.4%	1.2	3.8%	1.6	3.4%
Annelida, Oligochaeta	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.4	0.4%	0.0	0.0%	0	0.0%
Annelida, Polychaeta	24.4	43.4%	12.8	36.6%	46.6	59.0%	64.8	69.7%	12.8	41.0%	10.4	21.9%
Arthropoda, Amphipoda	12.4	22.1%	10.0	28.6%	10.0	12.7%	2.8	3.0%	5.8	18.6%	13.8	29.1%
Echinodermata	9.6	17.1%	5.4	15.4%	5.0	6.3%	3.6	3.9%	1.4	4.5%	5.2	11.0%
Cephalocordata (lancelet worm)	0.2	0.4%	0.0	0.0%	0.2	0.3%	2.8	3.0%	0.0	0.0%	0	0.0%
Other taxa	2.2	3.9%	2.8	8.0%	3.4	4.3%	3.2	3.4%	8.0	25.6%	15.2	32.1%
Other taxa	2.0	3.6%	2.4	6.9%	2.8	3.5%	3.0	3.2%	8.0	25.6%	15.2	32.1%

Table 7 Area 1.2A counts of the species or taxa making up each of the main taxonomic groups and the percentages of community represented by each group.

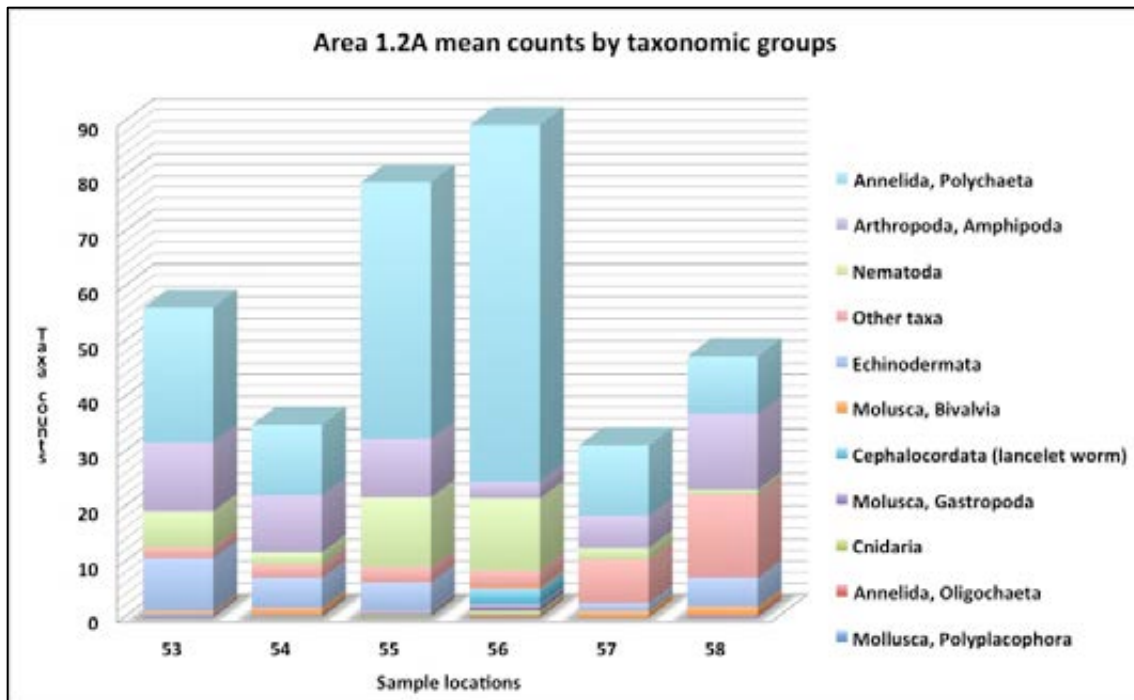


Figure 13 Area 1.2A community diversity expressed as mean counts of eleven major taxonomic groups based on the data shown in Table 8 above.

Figure 14 below show the results of analysis of two major taxonomic groups and the sampling variation within the five replicate samples taken at each sample location. Mean counts for the number of species found in Amphipoda and Polychaeta groups are shown along with the calculated standard deviation across the five replicate samples for each sample location in Area 1.2B.

The sampling error or variance observed for Area 1.2A for the two taxa groups shows a mixed picture of the twelve counts involved. 6 of the counts have standard deviation values that come close or exceed the size of the count value. One count, sample location 56 Amphipoda has error bars, several times greater than the overall count value due to some of the replicates having high values compared to others with low or zero counts. This result would have to be considered an outlier and represents the extreme range of the sampling variation that could be expected for this taxa.

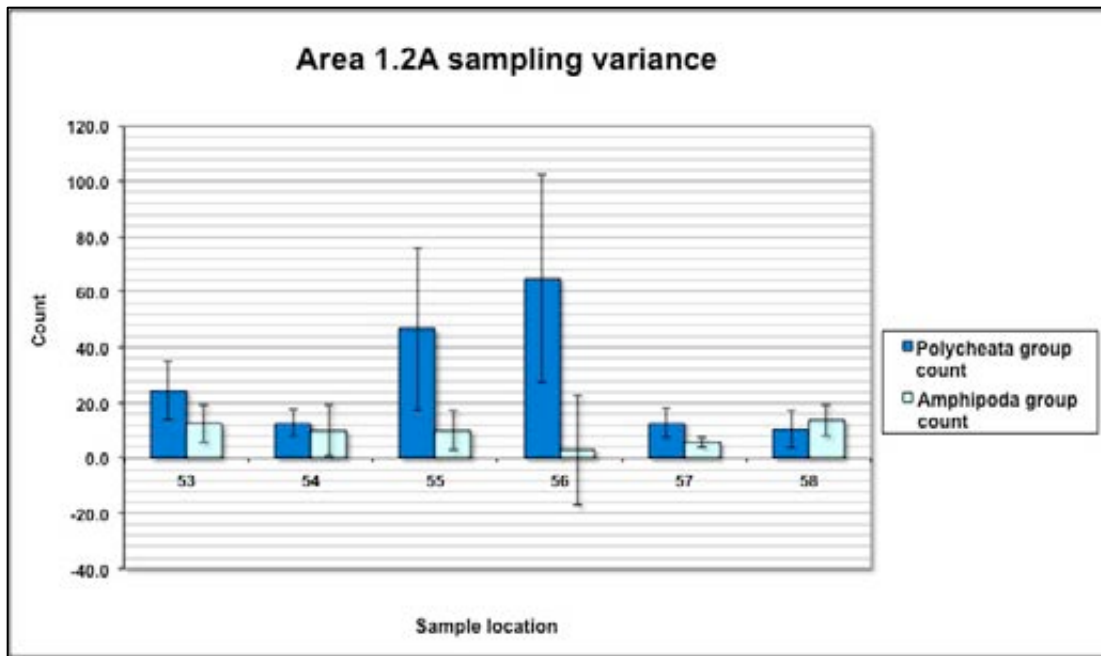


Figure 14 Area 1.2A Sampling variation is expressed as standard deviation values (error bars) calculated across the five replicate samples for each sample location at the taxa group level. Group counts are mean values of the sum of the group counts.

4.5 Benthic Invertebrate communities Area 1.2B

The Table 8 and Figure 15 below shows abundance and diversity measures describing the six sample locations surveyed at Area 1.2B.

Area 1.2B taken as a whole had 1,671 individual organisms counted and 60 species or taxa recorded. The range of total individuals counted varied between 223 (sample location 60) to 367 (sample location 64), across the six sample locations. The range of the mean counts of individual organisms for each sample location was the low count of 41 (sample location 62) and a high count of 73 (sample location 64). Overall Area 1.2B had less variation within its sample location than Areas 1.2 or 1.2B. There were higher levels of individual organisms counts in sample locations 63 and 64, which was mainly created, by counts of Echinodermata (urchins) that were much higher than the other four areas.

Total taxa counts were reasonably consistent across the six sample locations falling in a range of between 20 and 30. Mean taxa count values were in a range of between 12 and 17.

Sample locations	59	60	61	62	63	64
Total count individual organisms (5 samples)	233	223	295	206	347	367
Mean count individual organisms	46.6	44.6	59	41.2	69.4	73.4
Total taxa count (5 samples)	29	20	28	30	27	30
Mean taxa count	13.2	12	16	13.8	16.2	16.8

Table 8 Area 1.2B abundance data; individual organisms total counts across five replicate samples for each sample location, mean values of counts for each sample location, diversity data; total taxa counted across five replicate samples and mean taxa counts for each sample location.

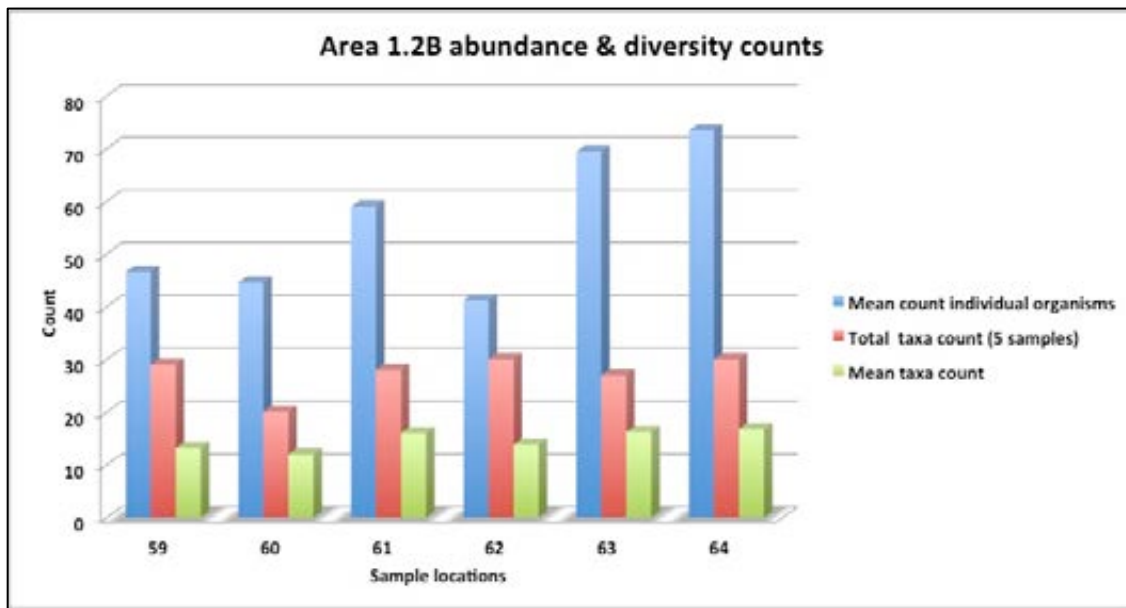


Figure 15 Area 1.2B graphic illustration of abundance and diversity data shown in Table 8 above; total individuals counted, total taxa counted and mean values for individual organisms and taxa counts shown for each sample location.

Table 9 and Figure 16 below show the community composition of eleven major taxa across the six sample locations of Area 1.2B.

Polychaeta, Echinodermata and other taxa were the most abundant of the eleven major taxa groups. They represented 32, 22 and 20 percent respectively of the invertebrate community of Area 1.2B taken as a whole.

The taxa grouped together as ‘other taxa’ consist mainly of Nemerta and the Crustacea Orders; Copepoda, Isopoda, Decapoda, Ostracoda and Cumacea. In addition there were small numbers of Chaetognatha (arrow worms) and a small fish species *Limnichthys polyactis*.

The relatively larger counts of Echinodermata recorded in sample locations 63 and 64 can be seen clearly in the graph below.

Taxa	59	%	60	%	61	%	62	%	63	%	64	%
Cnidaria	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.6	0.9%	0	0.0%
Nematoda	6.0	12.9%	6.6	14.8%	2.2	3.7%	5.4	13.1%	2.8	4.0%	3.2	4.4%
Mollusca, Polyplacophora	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0	0.0%
Molusca, Gastropoda	0.6	1.3%	0.0	0.0%	0.2	0.3%	0.8	1.9%	0.0	0.0%	0.2	0.3%
Molusca, Bivalvia	0.4	0.9%	0.4	0.9%	0.8	1.4%	5.2	12.6%	3.2	4.6%	3.6	4.9%
Annelida, Oligochaeta	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.2	0.5%	0.0	0.0%	0	0.0%
Annelida, Polychaeta	29.6	63.5%	13.4	30.0%	19.8	33.6%	17.6	42.7%	8.0	11.5%	7.8	10.6%
Arthropoda, Amphipoda	4.6	9.9%	5.6	12.6%	3.6	6.1%	3.2	7.8%	12.8	18.4%	9.4	12.8%
Echinodermata	3.0	6.4%	6.6	14.8%	15.6	26.4%	6.6	16.0%	20.6	29.7%	29.4	40.1%
Cephalocordata (lancelet worm)	0.4	0.9%	0.2	0.4%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0	0.0%
Other taxa	2.0	4.3%	11.8	26.5%	16.8	28.5%	2.2	5.3%	21.4	30.8%	19.8	27.0%

Table 9 Area 1.2B counts of the species or taxa making up each of the main taxonomic groups and the percentages of community represented by each group.

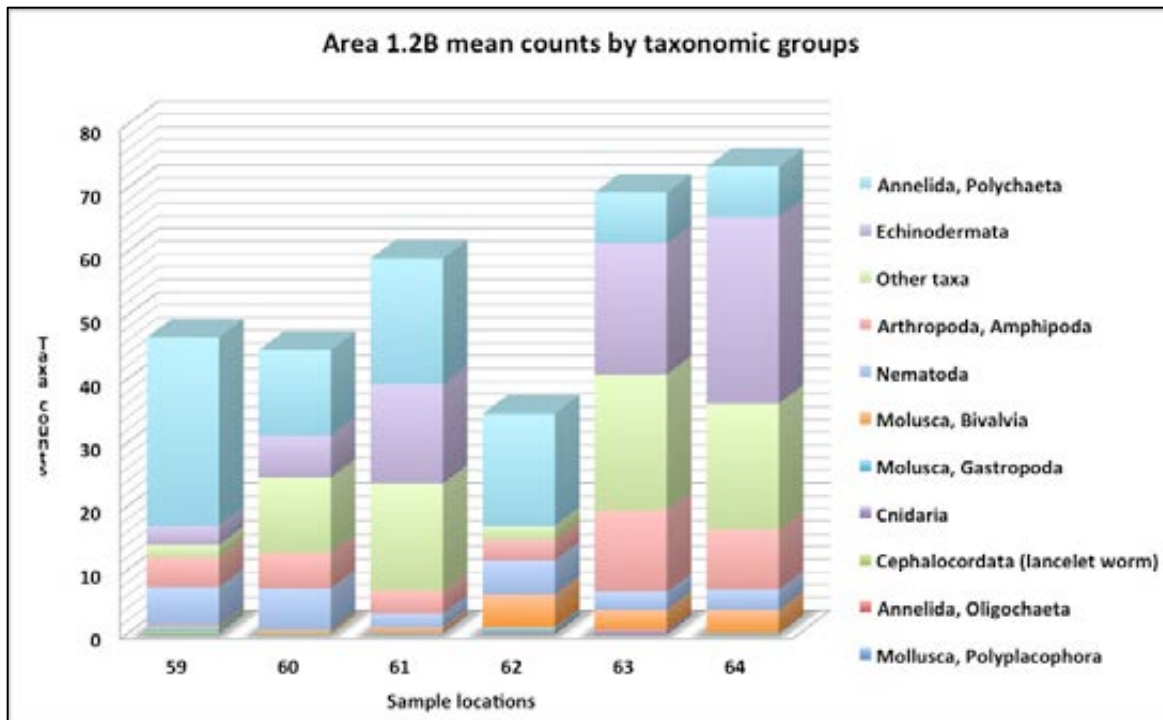


Figure 16 Area 1.2B community diversity expressed as mean counts of eleven major taxonomic groups based on the data shown in Table 9 above.

Figure 17 below show the results of analysis of two major taxonomic groups and the sampling variation within the five replicate samples taken at each sample location. Mean counts for the number of species found in Amphipoda and Polychaeta groups are shown along with the calculated standard deviation across the five replicate samples for each sample location in Area 1.2B.

The sampling error or variance observed is what would be expected for this type of survey. The exception is the count for Amphipoda at sample location 62 that has error bars well in excess of the actual count. In this case the counts overall were low or zero counts with a few replicates recording much higher counts.

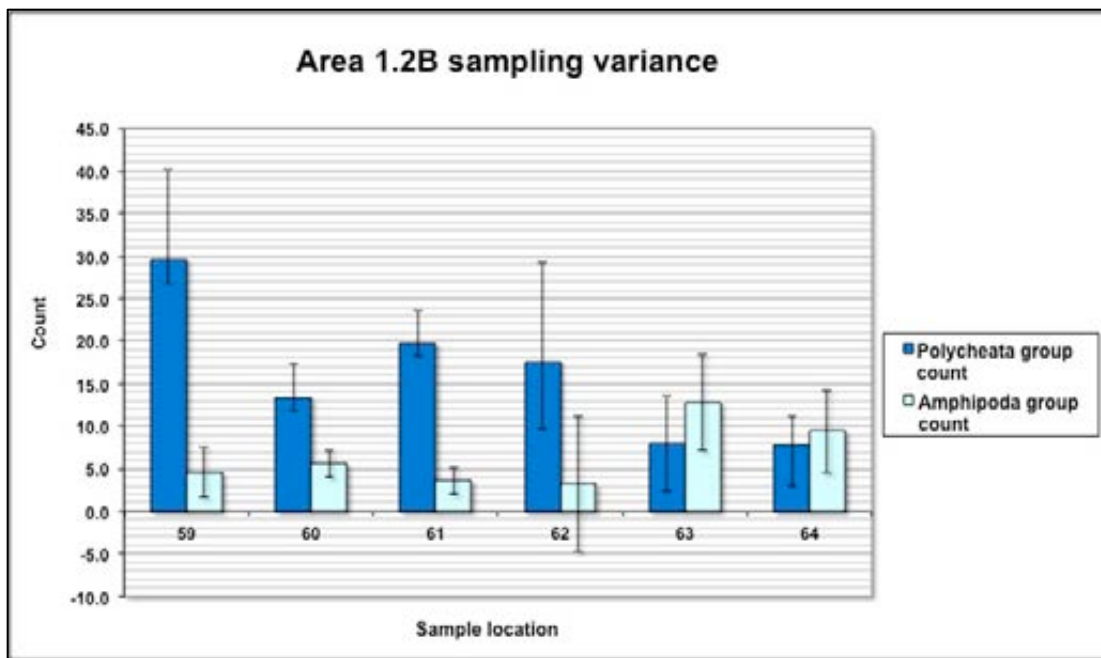


Figure 17 Area 1.2B Sampling variation is expressed as standard deviation values (error bars) calculated across the five replicate samples for each sample location at the taxa group level. Group counts are mean values of the sum of the group counts.

4.6 Photo quadrats areas 1.2, 1.2A and 1.2B

Observations made of epibenthic biota from photographs taken of five replicate 1m² quadrates at each sample location are summarised in Table 4 below.

The candidate dredge disposal area 1.2 and the two reference areas 1.2A and 1.2B have a sparse epifaunal community. The main species seen were the clam *Dosinia spp.*, hermit crabs, *Pagurus novizealandiae* and low numbers of several gastropod species. There was one star fish species observed - the comb star *Astropecten polyacanthus*. All three areas had low numbers of the paddle crab *Ovilipes catharis*.

There was very little encrusting invertebrate life indicating that these fine sand substrates are relatively mobile. Very little drift algae were seen. Most locations had well defined sand waves, with the locations with finer substrates having more irregular small sand waves. There was very little evidence of silt in any of the locations of these three areas.

No fish species were observed in the drop video footage.

Area 1.2 sample locations	Depth (m)	Observations Seabed	Observations biotic community (photoquadrats)	Diver and additional photography notes
47	10	fine sand small irregular bedforms	1 small <i>Dosinia spp.</i> , worm holes	1 olive shell, <i>Amalda australis</i> , numerous hermit crabs
48	11	fine sand small irregular bedforms	1 small <i>Dosinia spp.</i> , 1 <i>Cominella adspera</i> , worm holes	numerous hermit crabs, tube worms
49		fine sand small irregular bedforms	2 pieces of drift brown algae, worm holes, worm holes	
50	12	fine sand, with some shell hash, bedforms height 100mm and period 300mm	1 hermit crab	
51	10	fine sand, with some shell hash, bedforms height 100mm and period 300mm	no large epibenthic species observed, worm holes	hermit crabs numerous
52	11	fine sand, with some shell hash, bedforms height 100mm and period 300mm	1 hermit crab, worm holes	hermit crabs, worm holes
Ref. area 1.2A sample locations	Depth (m)	Observations Seabed	Observations biotic community (photoquadrats)	Diver and additional photography notes
53	11	fine sand, with shell hash, bedforms height 100mm and period 400mm	1 hermit crab, worm holes	<i>Dosinia spp.</i> live and shells, paddle crabs <i>Ovilipes catharis</i> present
54	11	fine sand, with shell hash, bedforms height 100mm and period 300mm	1 hermit crab, 1 paddle crabs <i>Ovilipes catharis</i> , worm holes	<i>Dosinia spp.</i> shells, hermit crabs
55		fine sand, with shell hash, bedforms height 100mm and period 300mm	1 hermit crab, 1 comb star <i>Astropecten polyacanthus</i> , worm holes	<i>Dosinia spp.</i> live and shells, paddle crabs <i>Ovilipes catharis</i> present
56	10	fine sand, with medium sand and shell hash, bedforms height 100mm and period 300mm	1 hermit crab, worm holes	<i>Dosinia spp.</i> live and shells, paddle crabs <i>Ovilipes catharis</i> present, 1 comb star <i>Astropecten polyacanthus</i>

57	11	fine sand, small irregular bedforms	two small rocks with variety of encrusting invertebrates calcareous red algae, sponges and hydroids, worm holes	hermit crabs
58	12	fine sand, small somewhat irregular bedforms height 50mm and period 200-300mm	1 hermit crab, 3 large shells with calcareous encrusting tube worms	<i>Dosinia spp.</i> shells,
Ref. area 1.2B sample locations	Depth (m)	Observations Seabed	Observations biotic community (photoquadrats)	Diver and additional photography notes
59	10	fine sand, with sand shell hash, bedforms height 100mm and period 400mm	4 hermit crabs, worm holes	<i>Dosinia spp.</i> live and shells
60	10	fine sand, with small amounts of shell hash, bedforms irregular height 50mm and period 200mm	1 sand dollar <i>Fellaster zealandiae</i> , worm holes	<i>Dosinia spp.</i> live and shells, hermit crabs
61	11	fine sand with some medium sand and shell fragments, bedforms somewhat irregular, height 150mm and period 600mm, areas of large shell fragments in troughs	4 hermit crabs, worm holes	<i>Dosinia spp.</i> live and shells, hermit crabs
62	11	fine sand, with small amounts of shell hash, bedforms height 150mm and period 400mm	1 large shell with barnacles, 1 hermit crab, worm holes	<i>Dosinia spp.</i> shells, hermit crabs
63	11	fine sand, small irregular bedforms	1 shell encrusted with calcareous tube worms, 1 paddle crabs <i>Ovilipes catharis</i> , worm holes	hermit crabs, 1 comb star <i>Astropecten polyacanthus</i>
64	11	fine sand, small irregular bedforms	4 hermit crabs, worm holes	1 comb star <i>Astropecten polyacanthus</i> , 1 paddle crab <i>Ovilipes catharis</i>

Table 10 Notes and observations from photo quadrats, areas 1.2, 1.2A and 1.2B.

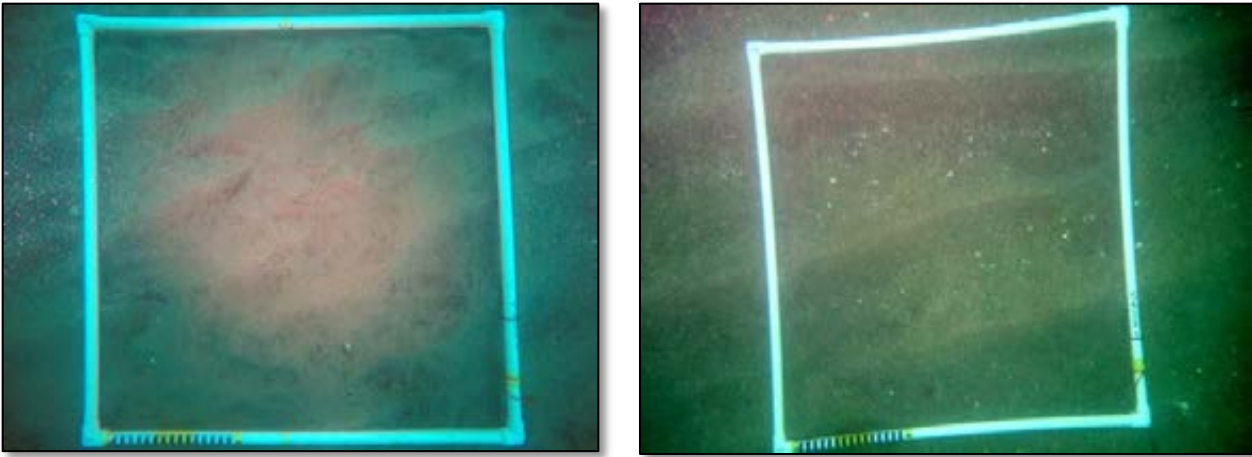


Figure 18 (left) Area 1.2, location 48-4, showing sand waves, fine sand and gastropod on surface lower middle, (right) location 50-1, showing the coarser substrate and higher shell content and sand waves.

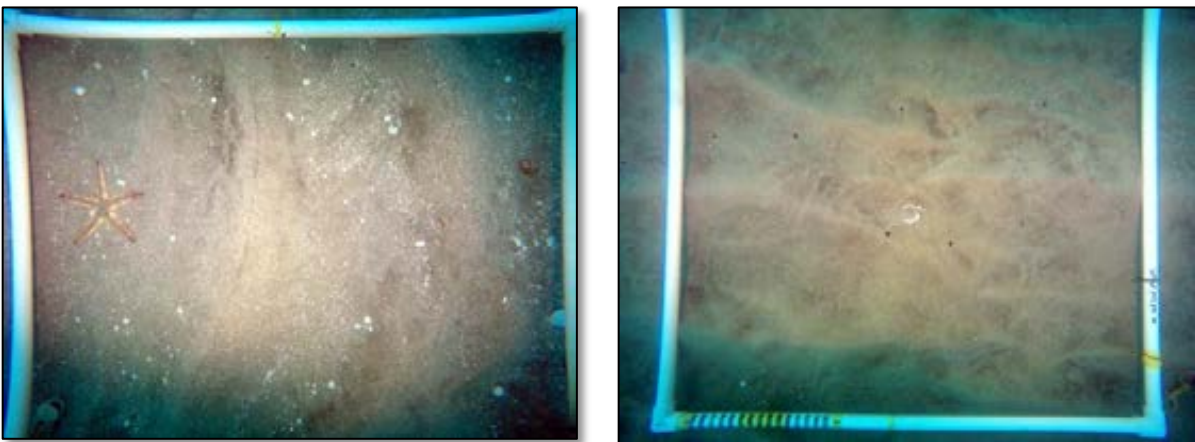


Figure 19 (left) Area 1.2A, location 55-3, showing sand waves, fine and medium sand with shell hash and comb star *Astropecten polyacanthus* on left, (right) location 57-1, showing the fine sand substrate and worm holes, *Dosinia spp.* shell and sand waves.

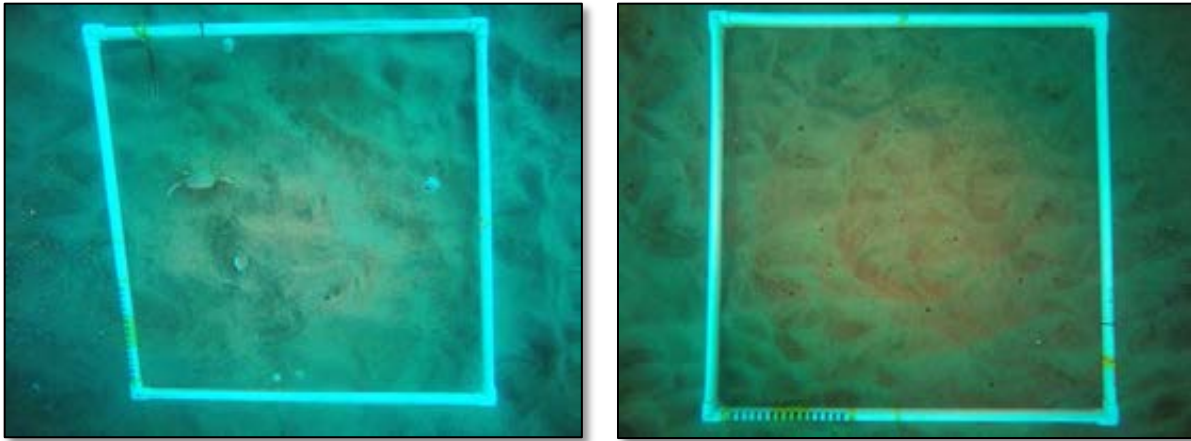


Figure 20 (left) Area 1.2B, location 63-5, showing small irregular sand waves, fine and medium sand and paddle crab *Ovalipes catharis*, (right) location 64-2, showing fine sand substrate and small irregular sand waves.



Figure 21 (left) Area 1.2B, location 63, showing diver with comb star *Astropecten polyacanthus* note fine sand substrate, (right) location 64, paddle crab *Ovilipes catharis* with close-up view of the very fine and fine sand substrate.

4.7 Heavy metals contaminants areas 1.2, 1.2A and 1.2B

Lab results for the chemical testing for heavy metal contaminants are presented below in Table 5. The table shows values at the top of the table from the Australian and New Zealand Environmental and Conservation Council (ANZECC) Interim Sediment Quality Guideline (ISQG) low and high values which describe thresholds for effects of heavy metal contamination (ANZECC, 2000).

All values for the areas below returned test results well below the ANZECC ISQG ‘low’ threshold values for effects of contamination and are in the normal range for these trace elements for marine sediments.

Total Recoverable in mg/kg									
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
ANZECC ISQG	High	20	1.5	80	65	50	0.15	21	200
	Low	70	10	370	270	220	1	52	410
Area	Sample								
1.2	48	2.9	< 0.010	7.4	0.3	1.07	< 0.010	1.7	7.8
1.2	49	3	< 0.010	6.7	0.4	1.09	< 0.010	2	7.3
1.2	50	2.2	< 0.010	3.1	0.3	0.56	< 0.010	1.7	4.1
1.2	51	1.9	< 0.010	5.4	0.3	0.74	< 0.010	1.4	5.8
1.2	52	2.2	< 0.010	4.4	0.3	0.73	< 0.010	1.3	5.9
1.2A	53	3.5	< 0.010	4.1	0.3	0.64	< 0.010	1.9	5
1.2A	54	3.2	< 0.010	4	0.3	0.63	< 0.010	2	5.4
1.2A	55	2.7	< 0.010	4.5	0.3	0.66	< 0.010	1.6	5.6
1.2A	56	2.8	< 0.010	4.4	0.3	0.7	< 0.010	1.9	5.1
1.2A	57	2.2	< 0.010	5.5	0.3	0.76	< 0.010	1.5	6
1.2A	58	2.7	< 0.010	7.5	0.3	1.11	< 0.010	1.8	7.6
1.2B	59	2.9	< 0.010	4.2	0.2	0.59	< 0.010	1.6	4.8
1.2B	60	3.2	< 0.010	5.9	0.3	0.89	< 0.010	1.9	6.5
1.2B	61	3.4	< 0.010	6.2	0.3	0.84	< 0.010	2	6.2
1.2B	62	3.4	< 0.010	5.4	0.3	0.7	< 0.010	1.8	5.7
1.2B	63	2.6	< 0.010	7.3	0.3	1.06	< 0.010	1.8	6.6
1.2B	64	3.2	< 0.010	8.2	0.4	1.15	< 0.010	2	8

Table 11 Heavy metal total recoverable results from areas 1.2, 1.2A and 1.2B.

4.8 Results candidate area 2.2, reference areas 2.2A and 2.2B

4.9 Particle Size analysis

Lab analysis results for the distribution of particle sizes making up the sediments of the three areas 2.2, 2.2A and 2.2B are presented below in summarised form according to predominant sediment texture classes. The size range for each sediment texture class is indicated at the top of each table in millimeters.

In each of the three areas there are essentially two sediment types, the first is a silty fine sand the second type is a more mixed sediment with greater proportions of medium and coarse sand and typically more shell hash and shell fragments as well as less silt and very fine sand. Amongst these two ‘types’ there are further small variations in component makeups.

Areas 2.2 and 2.2A are most similar having four and five sample locations respectively of the silty fine sand type sediments and two and one respectively of the coarse sediment type. Area 2.2B has the opposite bias with five sample locations reflecting the coarse sand and more shelly sediment type and only one sample location reflecting the silty fine sand type.

Sample	gravel	very coarse sand	coarse sand	medium sand	fine sand	very fine sand	silt	clay
	>2mm	2-1.18mm	1.18-.6mm	.6-.3mm	.3-.150mm	.150-.063mm	.063-.0039mm	<.0039
#17	0.00	3.71	2.39	3.32	49.17	37.43	3.50	0.47
#18	0.00	2.52	1.46	4.36	52.64	34.82	3.68	0.51
#19	7.35	9.07	26.10	40.64	15.38	1.23	0.24	0.00
#20	25.88	14.85	20.52	25.54	12.12	0.91	0.17	0.00
#21	0.00	3.84	6.39	18.40	42.06	24.58	4.13	0.59
#22	0.00	2.00	1.36	10.87	51.99	29.30	4.06	0.42

Table 12 Candidate disposal area 2.2 particle size fractions given in percentages of main texture.

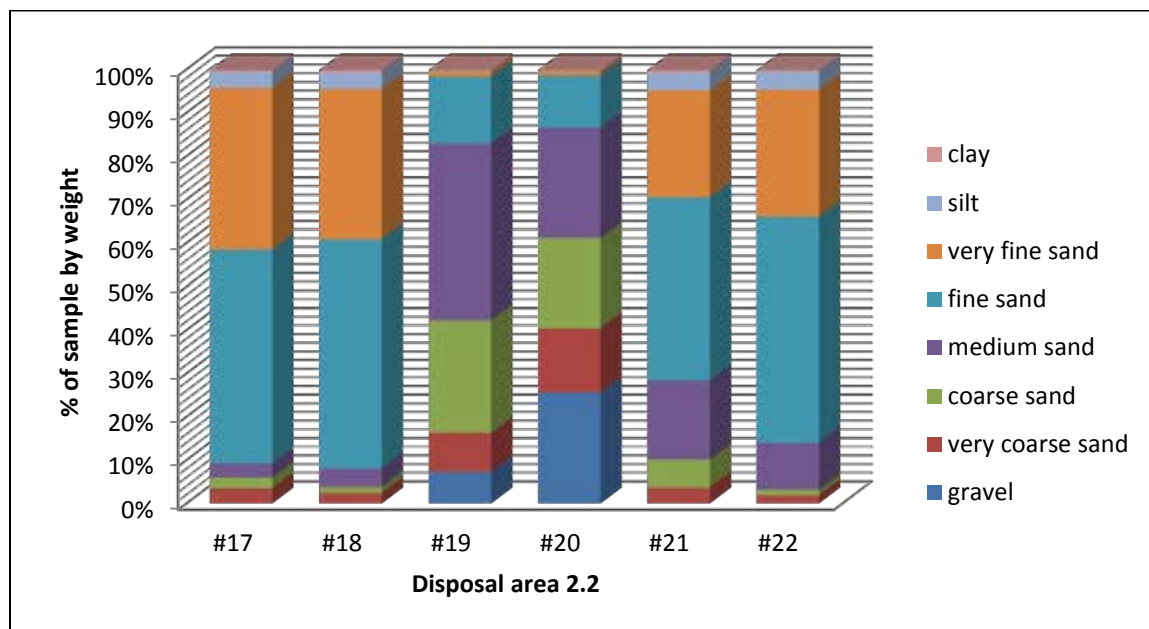


Figure 22 Candidate disposal area 2.2 particle size fraction percentages.

Sample	gravel	very coarse sand	coarse sand	medium sand	fine sand	very fine sand	silt	clay
	>2mm	2-1.18mm	1.18-.6mm	.6-.3mm	.3-.150mm	.150-.063mm	.063-.0039mm	<.0039
#35	0.00	0.00	0.00	9.35	54.69	30.16	5.16	0.63
#36	0.00	1.16	0.74	9.23	51.43	31.93	4.79	0.73
#37	0.00	1.78	0.84	12.89	53.99	27.78	2.52	0.20
#38	0.00	3.82	2.98	9.81	45.26	32.79	4.75	0.60
#39	32.22	8.38	11.40	21.24	18.56	4.05	3.96	0.19
#40	1.27	3.75	3.80	19.85	48.89	22.44	0.00	0.00

Table 13 Reference area 2.2A particle size fractions given in percentages of main texture groups.

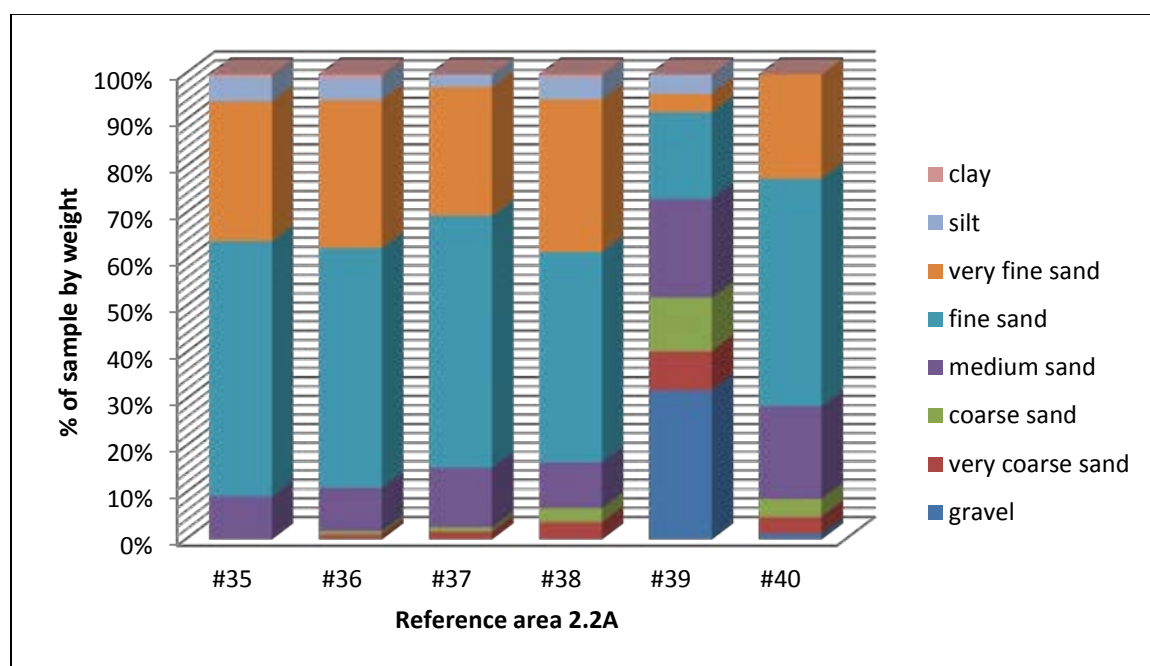


Figure 23 Reference area 2.2A particle size fraction percentages.

Sample	gravel	very coarse sand	coarse sand	medium sand	fine sand	very fine sand	silt	clay
	>2mm	2-1.18mm	1.18-.6mm	.6-.3mm	.3-.150mm	.150-.063mm	.063-.0039mm	<.0039
#41	18.35	13.71	25.64	33.50	8.80	0.00	0.00	0.00
#42	16.65	7.68	22.19	38.56	14.62	0.29	0.00	0.00
#43a	17.56	19.47	27.67	27.52	6.46	0.61	0.71	0.00
#44	0.00	1.00	1.24	15.54	55.12	24.09	2.81	0.20
#45	14.78	17.85	28.06	31.88	7.44	0.00	0.00	0.00
#46	32.74	17.13	24.72	22.59	2.81	0.00	0.00	0.00

Table 14 Reference area 2.2B particle size fractions given in percentages of main texture groups.

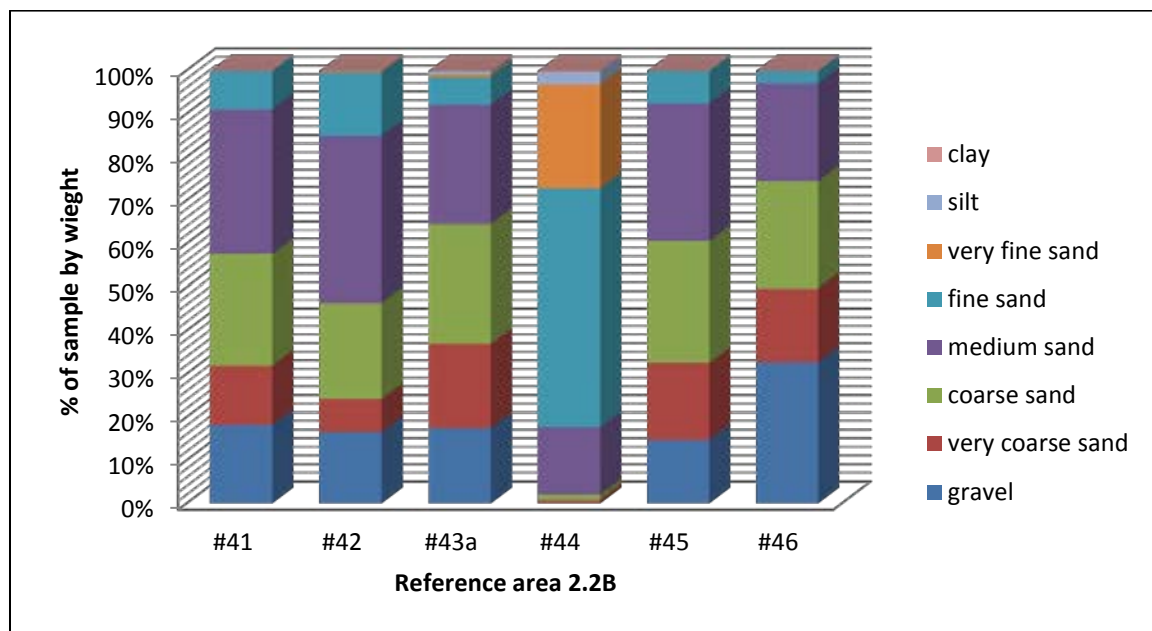


Figure 24 Reference area 2.2B particle size fraction percentages.

4.10 Benthic invertebrate communities Area 2.2

At the time of writing a decision has been made to advance the application for dredge disposal to be carried out at two offshore locations (Areas 1.2 and 3.2). As a result invertebrate samples for Areas 2.2A

and 2.2B have not been analysed and are being held preserved in storage in the event a decision is made to revisit the disposal site selection. Results from Area 2.2 are presented in this report below.

Table 15 and Figure 25 below show abundance and diversity measures describing the six sample locations surveyed at Area 2.2.

Area 2.2 taken as a whole had 2,664 individual organisms counted and 125 species or taxa recorded. The range of total individuals counted varied between 202 (sample location 19) to 776 (sample location 21), across the six sample locations. The range of the mean counts of individual organisms for each sample location was the low count of 40 (sample location 19) and a high count of 155 (sample location 21). The large counts of individual organisms in sample location 21 as compared to the other five sample locations is primarily made up of a higher species counts of all three of the most abundant taxonomic groups; Polychaeta, other taxa and Amphipoda. It is interesting to note that the lowest counts of individual organisms were recorded at sample locations 19 and 20 which both had particle size descriptions showing them to have much higher percentage of coarse substrates than the other sample locations, (refer to Figure 25, particle size results Fig 22).

Total taxa counts were reasonably consistent across the six sample locations falling in a range of between 43 and 67. Mean taxa count values were in a range of between 17 and 32 following a similar pattern to total individual organisms counts.

Sample location	17	18	19	20	21	22
Total count individual organisms (5 samples)	418	599	202	325	776	344
Mean count individual organisms	83.6	119.8	40.4	65	155.2	68.8
Total taxa count (5 samples)	54	59	43	54	67	65
mean taxa count	26.2	32.4	17.4	24.4	29.2	24.8

Table 15 Area 2.2 abundance data; individual organisms total counts across five replicate samples for each sample location, mean values of counts for each sample location, diversity data; total taxa counted across five replicate samples and mean taxa counts for each sample location.

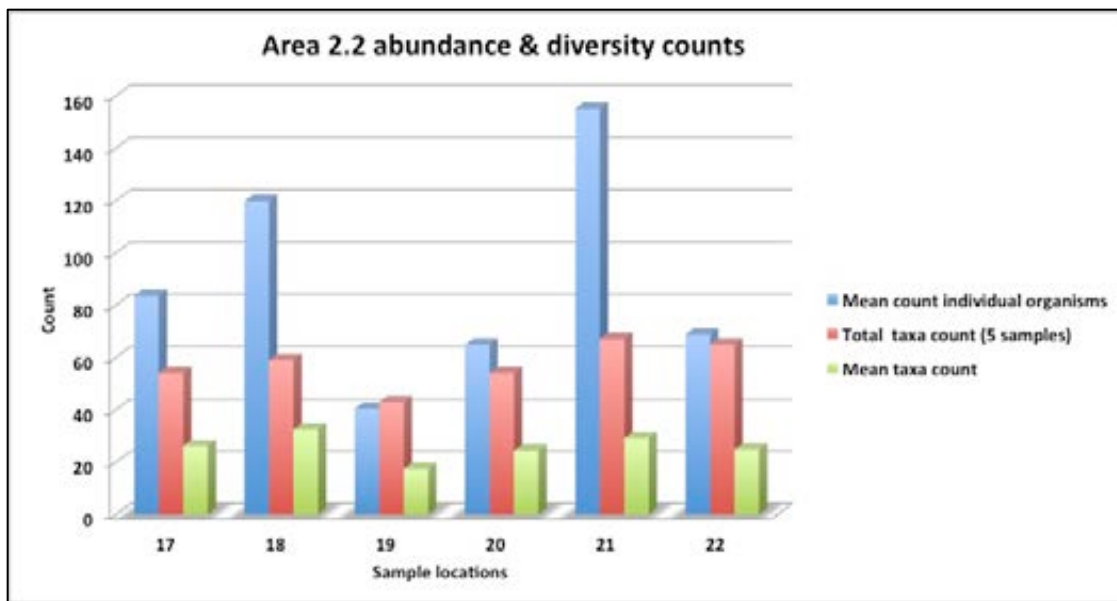


Figure 25 Area 2.2 graphic illustration of abundance and diversity data shown in Table 15 above; total individuals counted, total taxa counted and mean values for individual organisms and taxa counts shown for each sample location.

Table 16 and Figure 26 below show the community composition of eleven major taxa across the six sample locations of Area 2.2.

Polycheata, other taxa and Amphipoda were the most abundant of the eleven major taxa groups. They represented 48, 25 and 18 percent respectively of the invertebrate community of Area 2.2 taken as a whole.

The taxa grouped together as ‘other taxa’ consist mainly of Platyhelminthes, (flat worm), Nemerta, Sipuncula, (peanut worm) and the Crustacea Orders; Copepoda, Isopoda, Decapoda, Ostracoda and Cumacea. In addition there were small numbers of Bryozoa, Hemichordata, Chaetognatha (arrow worms) and Rhodophyta (algae).

The relatively larger counts of Polycheate worms and the other taxa group making up the community of sample location 21 can be seen clearly in the graph below.

Taxa	17	%	18	%	19	%	20	%	21	%	22	%
Cnidaria	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.2	0.3%	0.6	0.4%	0.2	0.3%
Nematoda	0.6	0.7%	1.0	0.8%	3.0	7.4%	1.4	2.2%	0.4	0.3%	5.2	7.6%
Mollusca, Polyplacophora	0.0	0.0%	0.0	0.0%	0.2	0.5%	0.2	0.3%	0.0	0.0%	0	0.0%
Molusca, Gastropoda	1.0	1.2%	1.6	1.3%	0.2	0.5%	0.6	0.9%	0.8	0.5%	0.6	0.9%
Molusca, Bivalvia	1.0	1.2%	4.0	3.3%	0.2	0.5%	0.2	0.3%	4.4	2.8%	0.8	1.2%
Annelida, Oligochaeta	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.2	0.3%	3.6	2.3%	0.2	0.3%
Annelida, Polychaeta	37.4	44.7%	62.2	51.9%	19.8	49.0%	33.8	52.0%	70.8	45.6%	32.8	47.7%
Arthropoda, Amphipoda	16.2	19.4%	26.0	21.7%	3.8	9.4%	13.4	20.6%	30.2	19.5%	13	18.9%
Echinodermata	0.0	0.0%	0.0	0.0%	1.0	2.5%	0.0	0.0%	0.4	0.3%	0.2	0.3%
Cephalocordata (lancelet worm)	0.0	0.0%	0.0	0.0%	0.0	0.0%	1.6	2.5%	0.2	0.1%	2.4	3.5%
Other taxa	27.4	32.8%	25.0	20.9%	12.2	30.2%	13.4	20.6%	43.8	28.2%	13.4	19.5%

Table 16 Area 2.2 counts of the species or taxa making up each of the main taxonomic groups and the percentages of community represented by each group.

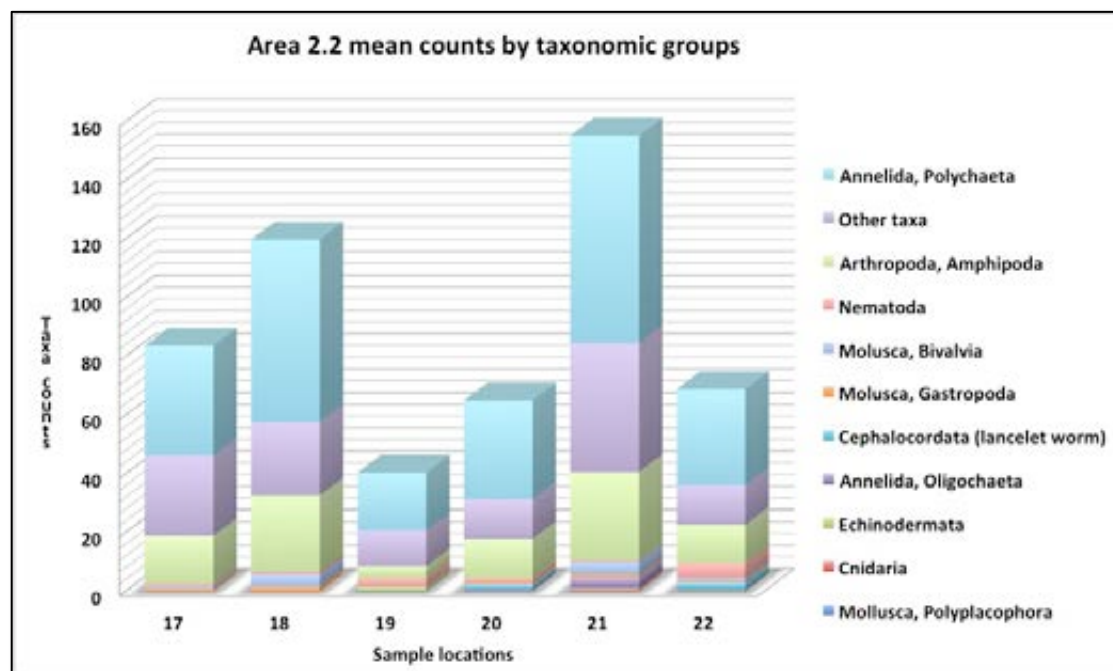


Figure 26 Area 2.2 community diversity expressed as mean counts of eleven major taxonomic groups based on the data shown in Table 16 above.

Figure 27 below show the results of analysis of two major taxonomic groups and the sampling variation within the five replicate samples taken at each sample location. Mean counts for the number of species found in Amphipoda and Polychaeta groups are shown along with the calculated standard deviation across the five replicate samples for each sample location in Area 2.2.

The sampling error or variance observed could be what would be expected for this type of survey with one exception which is at sample location 21 where the error bars are large in relation to the total count value for the Polychaeta group. This was a result of some relatively large counts appearing in some replicates as compared to the sampling range of this survey.

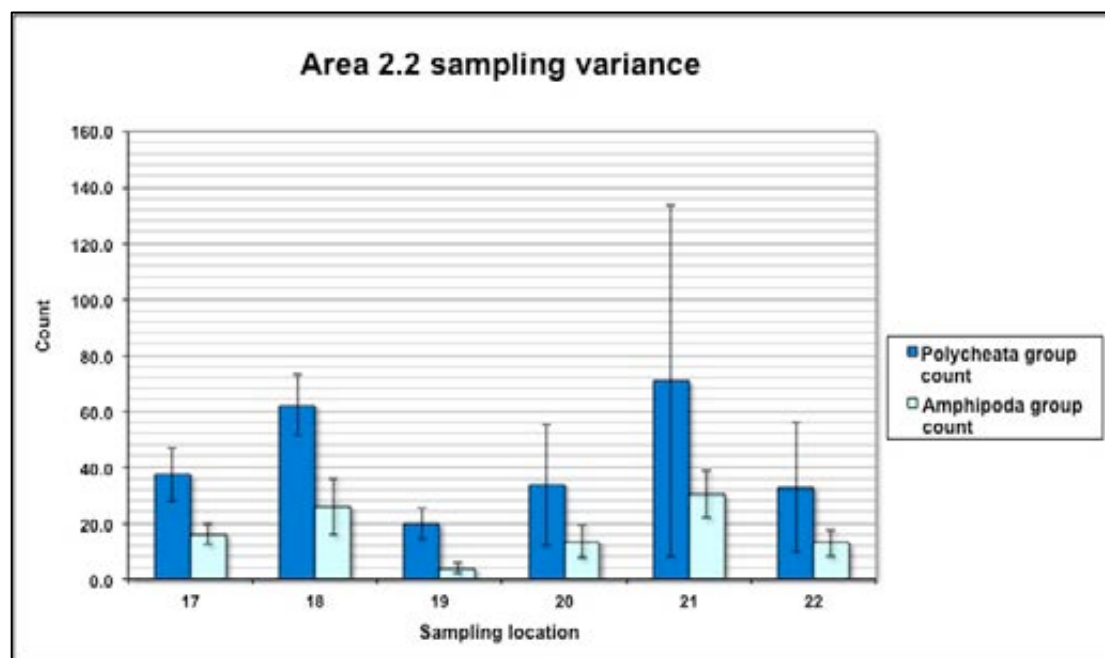


Figure 27 Area 2.2 Sampling variation is expressed as standard deviation values (error bars) calculated across the five replicate samples for each sample location at the taxa group level. Group counts are mean values of the sum of the group counts.

4.11 Photo quadrats areas 2.2, 2.2A and 2.2B

Observations made of epibenthic biota from photographs taken of five replicate 1m² quadrates at each sample location are summarised in Table 17 below.

The candidates dredge disposal area 2.2 and the two reference areas 2.2A and 2.2B have a modest epifaunal community, however scallops were present at low density in all three areas and at most sample

locations. Area 2.2 had a count of 9 scallops from 5m² of quadrats, area 2.2A a count of 15 and area 2.2B a count of 19 for the same number of quadrats. Other species observed were hermit crabs, *Pagurus novizealandiae* and low numbers of several gastropod species. The carrier shell *Xenophora neozelanica* (Figure 20) was observed at two locations, area 2.2 location 22 and area 2.2B location 46. This rather unique mollusc carries a virtual hat of cemented dead shell typically arranged in a symmetrical spiral pattern matching its own shell's geometry. The 'hat' of the carrier shell is then often colonised by a collection of encrusting invertebrates forming a small mobile 'reef' community. There was one starfish species observed at area 2.2A location 38 *Luidia australiae* which is pictured on the cover of this report.

There was very little encrusting invertebrate life observed. Most locations were lacking the large shell fragments that form the base that the encrusting species can establish on. Locations with the coarse substrates often had well-defined sand waves indicating that they were to some degree mobile. There was very little evidence of silt in any of the locations with the coarse substrates such as in Area 2.2.B, but at the locations of finer substrates silt content was visible.

One fish species - a lizardfish *Synodus spp.* - was recorded at Area 2.2B location 42.

Area 2.2 sample locations	Depth (m)	Observations Seabed	Observations biotic community (photoquadrats)	Diver and additional photography notes
17	30	fine sand and silt no bedforms	5 scallops <i>Pecten novaezealandiae</i> , small mounds and worm holes	hermit crabs present
18	28	fine sand some silt not bedforms but surface irregular	1 hermit crab, 2 small orange encrusting sponge and 1 small foliose red algae	hermit crabs present
19	25	medium sand with bedforms height 100-150mm and period 300mm	1 scallop <i>Pecten novaezealandiae</i> , and 1 small foliose red algae small mounds and worm holes	hermit crabs present
20	28	variation of substrates from fine silty substrate to mixed or areas of coarse sand, no bedforms present	1 piece drift foliose red algae <i>Gigartinia</i> , several fine encrusting red algae, 1 orange encrusting sponge with associated red foliose algae and a hydroid species, with tube worm holes	video 581 shows variation in substrate going through site area
21	27	fine sand with small amounts of shell and silt, small irregular bedforms	2 scallops <i>Pecten novaezealandiae</i> , two large shells with encrusting community sponge and hydroid spp small mounds and worm holes	

22	27	fine sand and silt no bedforms	1 scallop <i>Pecten novaezealandiae</i> , small mounds and worm holes, several small encrusting orange sponges, 2 pieces of drift red algae, one carrier shell, <i>Xenophora neozelanica</i>	
Ref. area 2.2A sample locations	Depth	Observations Seabed	Observations biotic community (photoquadrats)	Diver and additional photography notes
35	23	fine sand and silt no bedforms	several pieces of drift red algae	crab holes present and two Gastropod species observed, <i>Cominella adspersa</i> , <i>Struthiloria papulosa</i>
36	25	fine sand and silt no bedforms	2 scallops <i>Pecten novaezealandiae</i> , small mounds and worm holes, several small encrusting orange sponges, several pieces of drift red algae	hermit crabs numerous, orange sponge and red algae growing on horse mussel shell
37	26	fine sand with small amounts of shell and silt, small irregular bedforms	5 scallops <i>Pecten novaezealandiae</i> , small mounds and worm holes	large crab holes
38	26	fine sand with small amounts of shell and silt, small irregular bedforms	3 scallops <i>Pecten novaezealandiae</i> , 1 red foliose algae, several small encrusting orange sponges, small mounds and worm holes	starfish <i>Luidia australiae</i> , hermit crab and crab holes
39	28	medium sand with bedforms height 150mm and period 1m, areas of large shell fragments in troughs	3 scallops <i>Pecten novaezealandiae</i> , small foliose red algae, 1 flat worm	hermit crabs present
40	25	fine sand with small amounts of shell and silt, small irregular bedforms	2 scallops <i>Pecten novaezealandiae</i> , 1 clump of encrusting calcifying polychaetes worms <i>Lanice</i> sp., 1 small encrusting sponge	crab holes
Ref. area 2.2B sample locations	Depth (m)	Observations Seabed	Observations biotic community (photoquadrats)	Diver and additional photography notes

41	28	fine sand with small amounts of shell and silt, small irregular bedforms	8 scallops <i>Pecten novaezealandiae</i> , 1 clump with encrusting red paint algae, 1 small encrusting orange sponge	hermit crabs
42	25	fine sand with some medium sand and shell, bedforms somewhat irregular height 100mm and period 600mm, areas of large shell fragments in troughs	5 scallops <i>Pecten novaezealandiae</i> , small foliose red algae, 1 unidentified limpet	worm/crab/ghost shrimp holes, 1 lizardfish, <i>Synodus spp.</i> , hermit crabs present
43a	30	fine sand with some medium sand and shell, bedforms somewhat irregular height 100mm and period 600mm, areas of large shell fragments in troughs	small encrusted community on large shell, calcareous red algae, several small sponge species and hydroids	
44	31	fine sand and silt no bedforms	2 small orange encrusting sponges, 1 drift foliose red algae, surface algae in places showing gastropod grazing tracks	
45	25	fine sand with some medium sand and shell, bedforms somewhat irregular height 100mm and period 500mm, areas of large shell fragments in troughs	6 scallops <i>Pecten novaezealandiae</i> ,	worm/crab/ghost shrimp holes, 1 lizardfish, <i>Synodus spp.</i> , hermit crabs present, drift red algae
46	29	fine sand with some medium sand and shell fragments, bedforms present, height 150mm and period 800mm, areas of large shell fragments in troughs	small mounds and worm holes, numerous large shell fragments in places with small encrusting sponges and encrusting calcareous red algae species, 2 pieces of drift red algae, one carrier shell, <i>Xenophora neozelanica</i> with encrusting red algae and sponges and hydroids growing on top of shell hat, 1 nudibranch egg string	

Table 17 Notes and observations from drop camera survey areas 1.2, 1.2A and 1.2B.

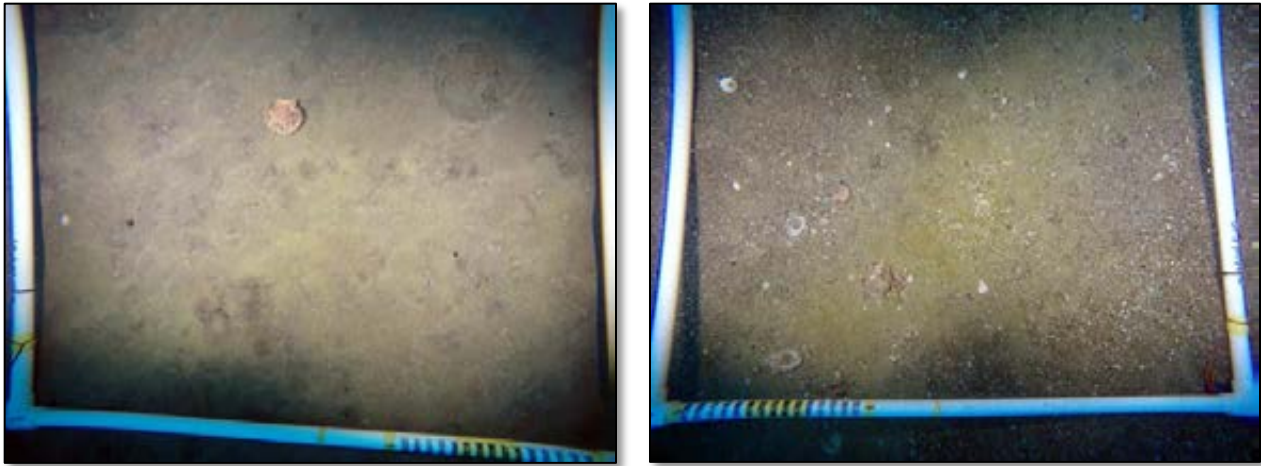


Figure 28 (left) Area 2.2, location 22-3, live scallop *Pecten novaezealandiae* top centre showing fine silty sand substrate and numerous worm holes and mounds on surface, (right) location 20-2, showing mixed of quite coarse sands, shell hash and larger shell fragments as well as significant-sized sand wave bedforms.

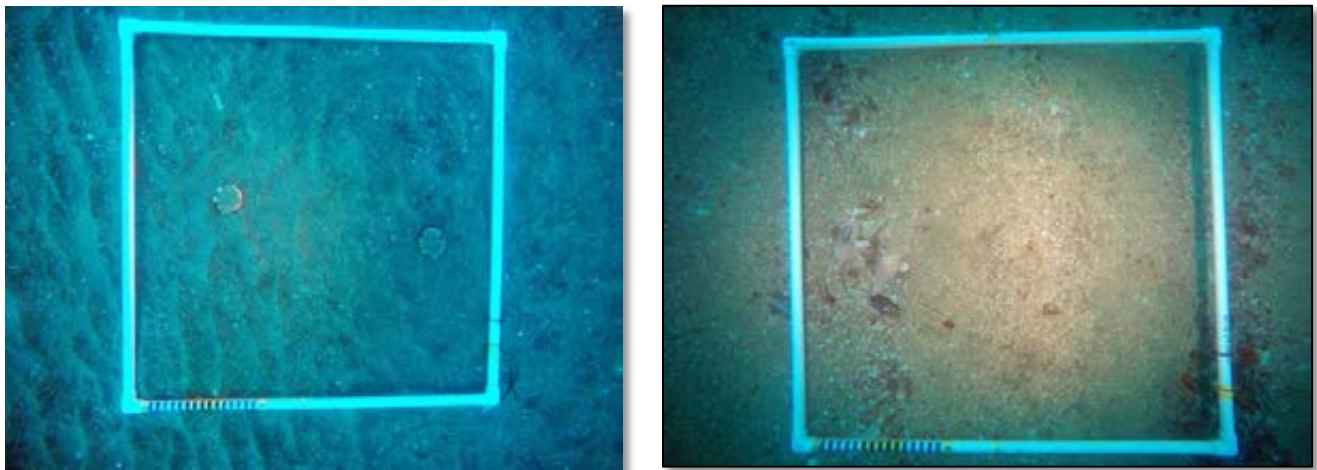


Figure 29 (left) Area 2.2A, location 37-2, 2 live scallops *Pecten novaezealandiae* and fine sand substrate with small irregular sand waves, (right) location 39-2, showing mixed of quite coarse sands and shell hash and larger shell fragments as well as significant-sized sand wave bedforms.

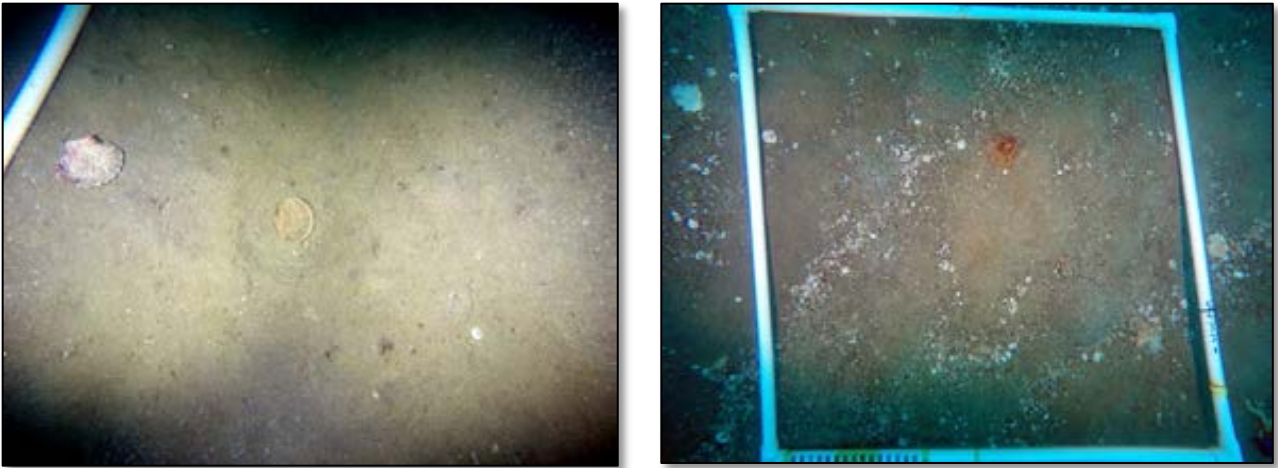


Figure 30 (left) Area 2.2B, location 44-6, a live scallop *Pecten novaezealandiae* and example of fine silty substrate, the only sample location in 2.2B to have this substrate, (right) location 46-5, showing mix of coarse sands, shell hash and larger shell fragments, as well as significant-sized sand wave bedforms typical sediment of area 2.2B, orange object top centre is a carrier shell, *Xenophora neozelanica*.

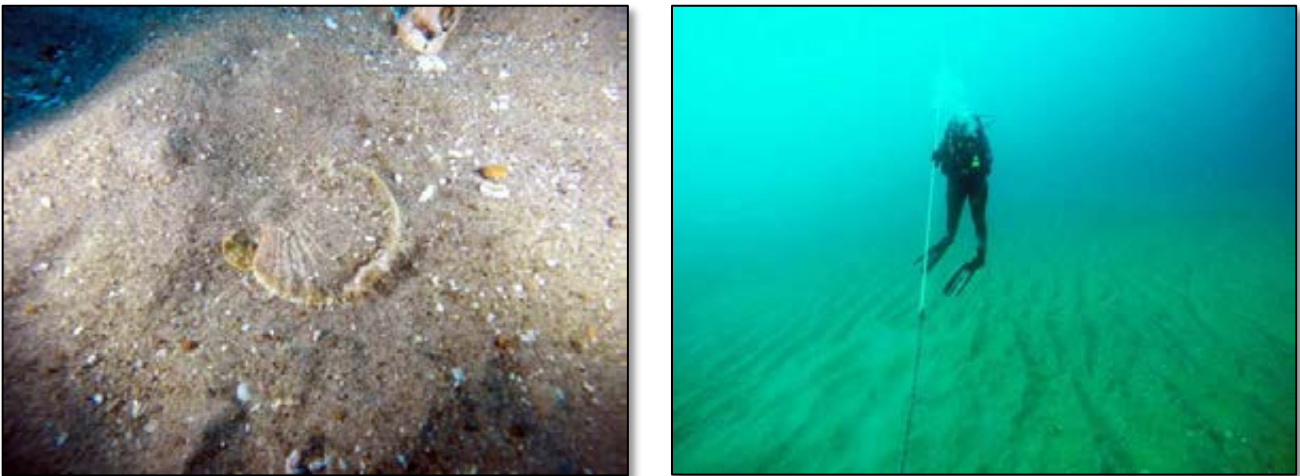


Figure 31 (left) Area 2.2B, location 41-5, a typical view of a scallop and close up view of mixed fine and coarse sand with shell hash, (right) location 42, diver hovering on anchor rope over typical bed form of sand waves.

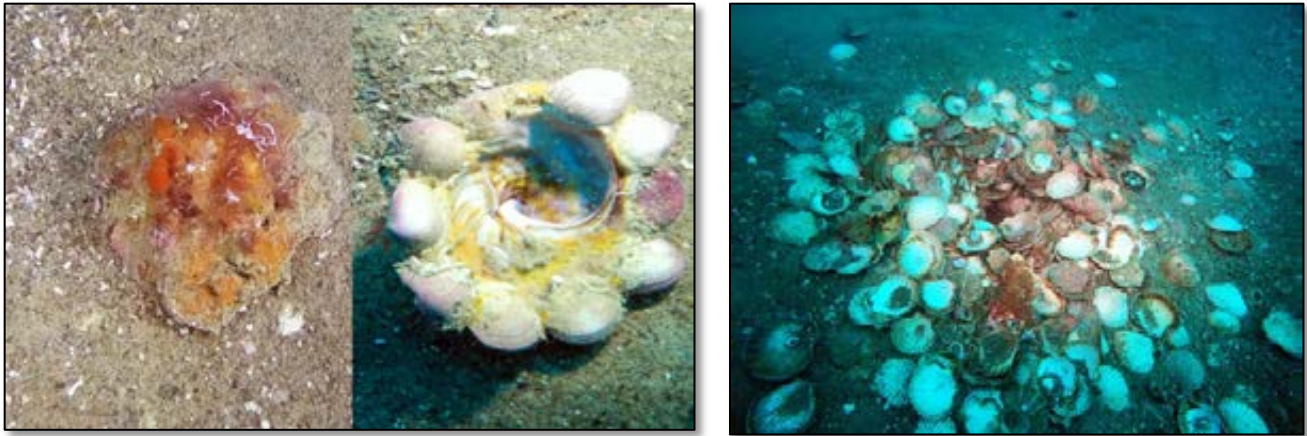


Figure 32 (left) Area 1.2B, location 46-5, the curious carrier shell *Xenophora neozelanica* seen sitting on sand in right side of split photo and turned upside down in left side of split photo; note the colonisation of the carrier shell's 'hat' by sponges, light orange and orange, red algae and polychaete worms - just some of the species involved, (right) location 46, an octopus *Octopus vulgaris* den made up of left over shells from the octopus feeding.

4.12 Heavy metals contaminants areas 2.2, 2.2A and 2.2B

Lab results for the chemical testing for heavy metal contaminants are presented below in Table 9. The table shows values at the top of the table from the Australian and New Zealand Environmental and Conservation Council (ANZECC) Interim Sediment Quality Guideline (ISQG) low and high values, which describe thresholds for effects of heavy metal contamination.

All values for the areas below returned test results well below the ANZECC ISQG 'low' threshold values for effects of contamination are within the normal range for these trace elements for marine sediments (ANZECC, 2000).

Total Recoverable in mg/kg									
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
ANZECC ISQG	High	20	1.5	80	65	50	0.15	21	200
	Low	70	10	370	270	220	1	52	410
Area	Sample								
2.2	17	4.8	< 0.010	16.5	0.9	3	< 0.010	3.4	16.6
2.2	18	6.2	0.013	18.7	1	3.1	0.017	3.8	17.6
2.2	19	4.5	< 0.010	8.5	0.4	1.25	< 0.010	2.2	9.3
2.2	20	6.5	0.011	10.1	0.8	1.45	< 0.010	3.7	11.5
2.2	21	5.6	0.02	15.5	1	2.2	< 0.010	4.1	14
2.2	22	6.2	0.013	17	0.9	2.4	< 0.010	3.8	15.1
2.2A	35	5.1	0.015	17.2	0.9	2.9	< 0.010	3.3	14.9
2.2A	36	5.4	0.014	18.8	1	3.1	< 0.010	3.7	16.6
2.2A	37	4.6	0.012	14.6	0.7	1.94	< 0.010	3	12.9
2.2A	38	5.9	0.019	19.4	0.9	2.9	< 0.010	3.6	15.4
2.2A	39	9	0.05	11.8	0.8	1.61	< 0.02	9.8	8.8
2.2A	40	5.2	0.014	14.8	0.6	1.89	< 0.010	2.8	12.3
2.2B	41	5	< 0.010	7.2	0.4	1.4	< 0.010	1.9	8.7
2.2B	42	4	< 0.010	8.5	0.4	1.17	< 0.010	1.9	8.4
2.2B	43a	6.2	< 0.010	7.2	0.7	1.59	< 0.010	2.9	10.3
2.2B	44	6.2	0.019	17.1	0.9	2.3	< 0.010	3.9	13.6
2.2B	45	6.8	< 0.010	9.3	0.5	1.33	< 0.010	2.5	9.8
2.2B	46	6.5	< 0.010	8.5	0.7	1.43	< 0.010	2.7	11.7

Table 18 Heavy metal total recoverable results from areas 1.2, 1.2A and 1.2B.

5 Discussion

In general terms (substrate and depth), the two candidate dredge disposal areas 1.2 and 2.2 are similar to their respective adjacent reference areas. The 1.2 and 2.2 areas however are markedly different from one another. The major difference is that of depth. The 1.2 areas being typically 8-12m in depth and the 2.2 areas being 23-30m in depth. This difference impacts the wave energy that is experienced by the bottom and sedimentation rates. The resulting sediment makeup and ecological communities are affected accordingly. The two sets of areas also differ in the position relative to the harbour entrance. The 1.2 areas are much closer to the harbour entrance and part of the ebb-tide delta system, whereas the 2.2 areas are further offshore and several kilometres from the harbour entrance and therefore less impacted by

sediment entering Bream Bay. The combined effects of these various factors and the history of sediment movements and evolution in this area account for the observations made in this study as to the nature and diversity of the sediments and biotic communities living in these areas.

The habitats observed were all sand and silt sediments, with some important variations noted in the amount of coarse sands, shell hash, larger shell fragments and the presence or complete absence of bedforms in the form of sand waves. These observations of sediment type and 'surface' appearance are intended as qualitative indications to assist further quantitative physical analysis of the sediments and current and wave energy modeling. The actual views of the benthic environment provided by the photo survey help with description and understanding of these habitats.

The three 1.2 of areas had roughly comparable invertebrate communities with the Polycheta, and Crustacea groups dominating the community in terms of diversity. Generally speaking the invertebrate community is not especially diverse or abundant when compared to some of the high diversity inner harbour locations. Arguably it is representative and significant ecologically in the context of this habitat type and location. Variations were evident across the areas in abundance and diversity, much of this was due to composition of the Polycheta community. These differences may well be associated with the range of depths and substrate fine and coarse components that existed across these areas. Although the depth ranges were small (from 6 to 12 meters) in a dynamic environment with occasional high energy this is most likely a critical environmental factor. Fine scale analysis of this data could bring out more information on how the community composition responds to varying environmental conditions and disturbance factors.

For this report for the three Area 2.2. survey areas, only Area 2.2 had analysis completed of the invertebrate community. Invertebrate communities sample locations within the Area 2.2 generally had similar taxonomic structures. Main groups in terms of abundance are Polycheta and Crustacea. However in terms of overall abundance and diversity there is variation across the sample locations. The southern end represented by two sample locations (19 and 20), had a much more modest invertebrate community in terms of diversity and abundance than the others locations. This southern part of Area 2.2 has marked substrate differences compared to the rest of the area. The southern end has greater proportions of coarse material and less finer substrate components. This primary substrate difference is likely affecting the make up of the invertebrate communities.

6 Acknowledgements

The authors would like to pay thanks to the great efforts and contributions made by the field dive team lead by Brett Sutton and including science divers Alice Morrison and Dan Godoy. They have added much value to the results of this survey. Our skipper Blair Jones of *Ocean Diversity Charters* also made a valuable contribution. Thanks also go to Catherine Langford who provided proofreading and editing support for this report.

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8 Appendix 2 GPS data for survey sample locations

Sample Location	Area	Longitude	Latitude
35	Ref 2.2A	174.5242427	-35.90395476
36	Ref 2.2A	174.5293283	-35.90473428
37	Ref 2.2A	174.5293904	-35.91097638
38	Ref 2.2A	174.5350146	-35.90406271
39	Ref 2.2A	174.5348892	-35.91203597
40	Ref 2.2A	174.5242248	-35.91213388
41	Ref 2.2B	174.5466062	-35.95990902
42	Ref 2.2B	174.5462326	-35.96740839
43	Ref 2.2B	174.5509706	-35.96103993
43a	Ref.2.2B	174.5478626	-35.95981283
44	Ref 2.2B	174.555651	-35.9600041
45	Ref 2.2B	174.5507979	-35.96602728
46	Ref 2.2B	174.5560155	-35.96748512
17	2.2	174.5271335	-35.92592026
18	2.2	174.5336176	-35.92562283
19	2.2	174.5325468	-35.94620517
20	2.2	174.5417077	-35.94525338
22	2.2	174.5318925	-35.93067918
21	2.2	174.5346288	-35.9390073
47	1.2	174.5153772	-35.87766083
48	1.2	174.5225476	-35.88080575
49	1.2	174.5174528	-35.88646661
50	1.2	174.5136789	-35.88388777
51	1.2	174.5138047	-35.89319675
52	1.2	174.508081	-35.89017762
53	Ref. 1.2A	174.488268	-35.88759878
54	Ref. 1.2A	174.4927966	-35.88753589
55	Ref. 1.2A	174.4918532	-35.8910582
56	Ref. 1.2A	174.4891485	-35.8911211
57	Ref. 1.2A	174.4921677	-35.89483211
58	Ref. 1.2A	174.4883308	-35.89445472
59	Ref. 1.2B	174.47833	-35.88615212
60	Ref. 1.2B	174.48267	-35.88590053
61	Ref. 1.2B	174.4818523	-35.89005182
62	Ref. 1.2B	174.4792106	-35.89005182
63	Ref. 1.2B	174.4825442	-35.89319675
64	Ref. 1.2B	174.4782671	-35.89281936

Note: The target waypoint for sample location 43 was not surveyed due to anchor of survey vessel dragging; sample location 43a was surveyed instead of sample location 43.