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Mahurangi Estuary ecological monitoring programme –data from July 1994 to January 2005

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Mahurangi Estuary ecological monitoring programme – report on data collected from July 1994 to January 2005

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1 Executive Summary

- ❑ The monitoring programme continues to indicate change in the ecology of Mahurangi Estuary consistent with increased sediment loading. Estuary-wide changes in abundance of macrofauna, horse mussels and sediment characteristics over the monitored period are still of serious concern. Patterns in abundance and size class composition of some of the intertidal bivalve populations suggest that there is potential for recovery, and indicate that efforts to restrict sediment loading to the harbour are likely to result in positive changes in the density of sediment-sensitive species.

- ❑ Population trends have been detected at all of the intertidal sites, the most at Hamilton Landing (ten populations), and the least at Cowans Bay and Mid Harbour (three populations each). Many of these trends are consistent with what we would predict from other studies of elevated sediment loading. The trends reported here are generally consistent with those documented in 2003.

- ❑ Of major concern are the trends of decreasing abundance of *Macomona liliana* at four of the intertidal sites and of *Austrovenus stutchburyi* at one of the sites. These are both ecologically important species. However, peaks in abundance of recruit-sized individuals found at some sites in the past two years of monitoring emphasise their recovery potential.

- ❑ Eight intertidal polychaete populations exhibit decreasing trends in abundance, and nine exhibit increases. Many of these trends are consistent with the anticipated sediment preference of individual species.

- ❑ Comparison of results from parametric regression analysis (routinely employed in this monitoring programme) with non-parametric Mann Kendall analysis (an alternative trend-detection method) did not reveal any major differences between results, reiterating our confidence in the interpretation of patterns apparent in the monitored populations. Only for one population at one site (Nemerteans at Mid Harbour) did the Mann Kendall result reveal a significant trend not detected by the regression analysis that was also more biologically interpretable.

- ❑ Increasing similarity of the monitored communties at Cowans Bay, Hamilton Landing and Te Kapa Inlet, and of the communities at Jamieson Bay and Mid Harbour, is still evident with two additional years of data. This implies that the harbour's intertidal monitored community is becoming more homogeneous.

- ❑ There has been no increase in the abundance of live horse mussels (*Atrina zelandica*) at either subtidal site over the monitored period. The mean sizes of the live individuals has increased only slightly at both sites.

- ❑ Monitoring of Mahurangi Estuary's benthic communities should continue, as the monitoring programme is detecting trends and remarkably consistent patterns estuary-wide. Importantly, this information is being used as part of a broader and integrated strategy of improving catchment management. With two more years of monitoring data our previous recommendations concerning the need to investigate improved sediment controls still stand. However, this additional data has highlighted the positive potential for recovery of the harbour, as source populations are still providing a supply of recruits to the monitored sites.

2 Introduction

In July 1994 a long-term ecological monitoring programme of Mahurangi Estuary's intertidal and subtidal benthic communities was started. The monitoring programme was designed to:

- ☐ provide stocktaking of resources under stewardship;
- ☐ provide information on the ecology of the intertidal and subtidal benthic communities for the Mahurangi Estuary Management Plan;
- ☐ assess the overall condition of Mahurangi Estuary in terms of its benthic communities; and
- ☐ provide a basis on which to document any ecological changes that may occur as a result of catchment and estuary development.

Specific sites and populations for this long-term monitoring programme were identified from a survey conducted in 1993, and recommended in a previous report to ARC Environment (Cummings et al. 1994).

This monitoring programme has now been running for 11.5 years. In this report, we comment on the temporal variation in abundance of some monitored macrofaunal populations at the intertidal and subtidal sites, and on the temporal variation in abundance and size of the horse mussel, *Atrina zelandica*, at the subtidal sites. On the basis of trend and community analyses of the monitored taxa, we describe the current ecological status of the harbour and make recommendations for the future of this monitoring programme.

3 Methods

3.1 Intertidal sites

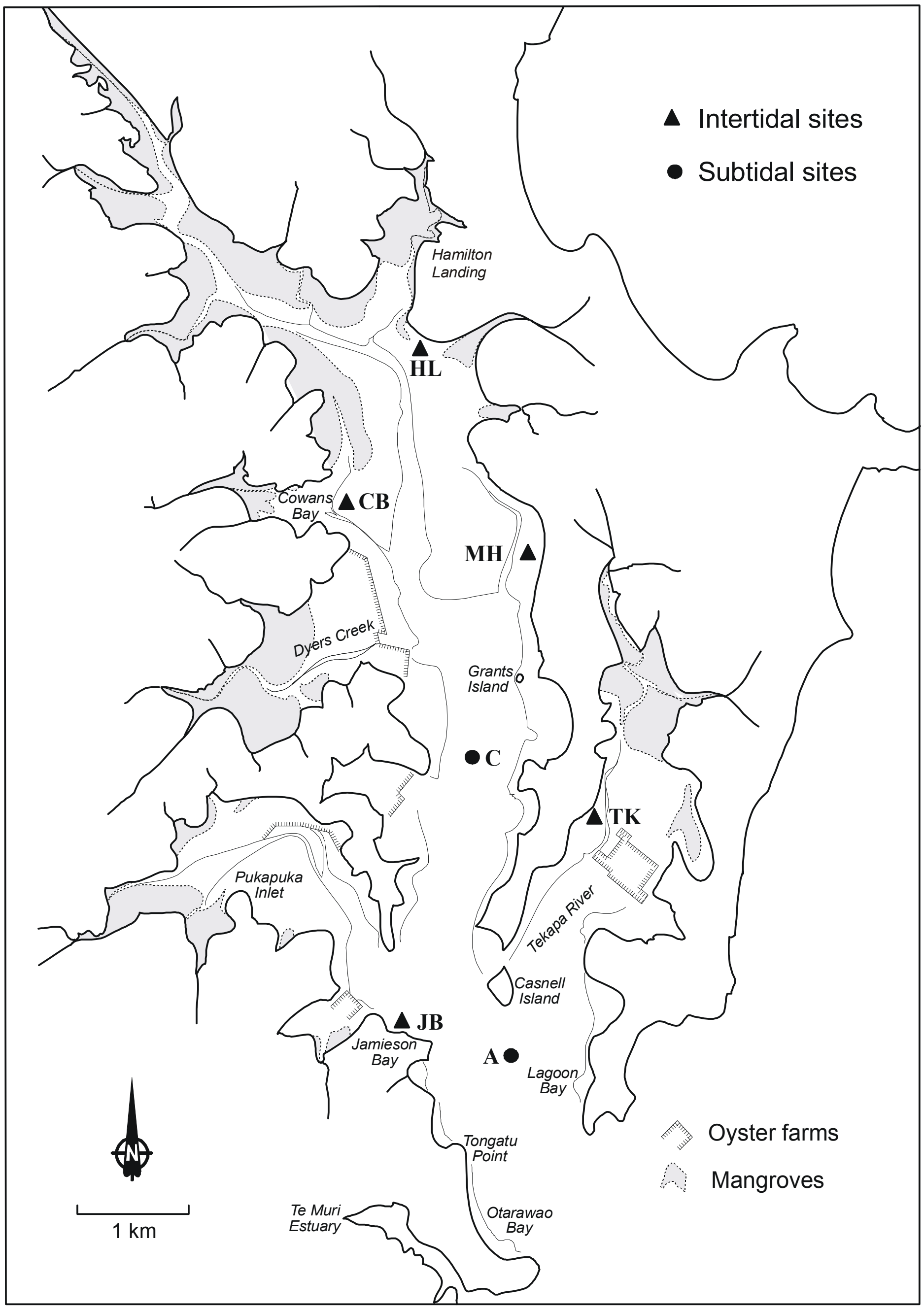
Five permanent intertidal sites were established in locations predetermined from the initial survey of the estuary (Cummings et al. 1994; Figure 1). Four of the five sites cover areas of 9000 m^2 and are situated at about mid-tide level. The fifth intertidal site (Jamieson Bay) is constrained by the size of the bay and occupies a slightly smaller area (7200 m^2). This latter site also covers a greater tidal range than the other sites due to the steep gradient of the beach.

Intertidal sites are sampled at three-monthly intervals, beginning in July 1994.

3.1.1 Macrofauna

On each sampling occasion, core samples (13 cm diameter, 15 cm deep) are collected at 12 predetermined locations at each site. To provide adequate dispersion over the site, each site is 'divided' into 12 equal blocks and one core sample taken from a random location within each block. To reduce the influence of previous sampling activity and spatial autocorrelation (Hewitt et al. 1994; Pridmore et al. 1990; Thrush et al. 1988, 1994), samples are not positioned within a 5 m radius of each other or of any samples collected in the previous 12 months. Core samples are sieved (500 µm mesh) and the residues stained with rose bengal and preserved in 70% isopropyl alcohol in seawater. Samples are then sorted, identified to the lowest possible/practical taxonomic level, counted and stored in 50% isopropyl alcohol. Following the recommendations of an earlier report (Cummings et al. 1997), the monitored bivalve species are measured on each sampling date, to enable determination of the number of individuals in different size classes (i.e., $\leq$4 mm, $\geq$4-8 mm, $\geq$8 – 16 mm, $\geq$16 mm). Measurements are made using either electronic callipers, or a camera lucida and digitising pad.

Figure 1.
Map of Mahurangi Harbour, showing locations of the intertidal and subtidal monitoring sites. Intertidal site abbreviations are as follows: CB = Cowans Bay; HL = Hamilton Landing; JB = Jamieson Bay; MH = Mid harbour; TK = Te Kapa Inlet.



3.1.2 Sediment characteristics

Sediment samples for grain size analysis were collected from each site in April of each year up to April 2000. Since July 2000, sediment samples have been collected on each sampling occasion (following the recommendations made by Hewitt 2000). Surface sediment (0 - 2 cm) is collected from random locations within each site and bulked for subsequent analysis. Prior to analysis, the samples are homogenised and a subsample taken. They are then digested in 6% hydrogen peroxide until all organic matter is removed, and sampled by wet sieving and pipette analysis (Gatehouse 1971). The April 1996 samples were analysed using a Mastersizer Laser Analyser (see Cummings et al. 1999). The results of the grain size analyses are presented as percentage composition of gravel/shell hash (>2000 mm), coarse sand (500 – 2000 mm), medium sand (250 – 500 mm), fine sand (62.5 – 500 mm), silt (3.9 – 62.5 mm) and clay (<3.9 mm).

Also beginning in July 2000, the organic content and chlorophyll *a* content of the sediments at each site have been assessed on each sampling occasion (as recommended by Hewitt 2000). To determine the organic content, 1 teaspoon of the homogenised sediment sample collected for grain size analysis is dried to constant weight at 60°C, and combusted for 5.5 h at 400°C. Six small sediment cores (2 cm diameter, 2 cm deep) are collected at each site to assess sediment chlorophyll *a* content. These sediment cores are collected adjacent to every second macrofaunal core sample, pooled and stored frozen and in the dark. The samples are freeze dried prior to analysis. Chlorophyll *a* is extracted by boiling this freeze dried sediment in 90% ethanol, and the extract processed using a spectrophotometer. An acidification step is used to separate degradation products from chlorophyll *a* (Sartory 1982).

At Te Kapa Inlet, most of the site is 'muddy', but a portion of it is relatively sandy. Therefore, sediment samples for the above analyses are collected from the two different areas of this site. These are referred to as 'Te Kapa Inlet mud' and 'Te Kapa Inlet sand', respectively.

3.2 Subtidal sites

Three permanent subtidal sites were established in locations predetermined from the initial survey of the estuary (Cummings et al. 1994). Following the recommendations made in our 2001 report (Cummings et al. 2001), the number of subtidal sites routinely monitored was reduced, with Sites A and C continuing to be monitored. Both of these sites are situated adjacent to the main estuary channel, in approximately 6 - 10 m of water (Figure 1). The major reason for subtidal sampling in Mahurangi Estuary is to monitor the horse mussels (*Atrina zelandica*).

Due to the difficulties of working subtidally in Mahurangi (e.g., poor visibility, strong tidal currents), each site is relocated at the surface via visual line-of-sight bearings and a weight with a line attached is then dropped to the estuary floor. Thus, a haphazardly chosen 50 m^2 area is sampled within our approximately 300 m^2 site on each sampling occasion. All sampling is carried out by SCUBA divers.

Transects (20 - 50 m long) of the horse mussels and their associated fauna have been videotaped at each site on each sampling occasion. Information gained from the video supplements the quadrat data and provides a visual archive of the communities associated with the horse mussel beds.

Subtidal sites were sampled at six-monthly intervals, beginning in October 1994. Due to recommendations made in Cummings et al. (2001), since July 2001 these subtidal sites (A and C) have been sampled every 3 months.

3.2.1 Macrofauna

On each sampling occasion, 12 core samples (10 cm diameter, 16 cm deep) are collected randomly within a 10 m radius of the weight dropped to the estuary floor. Samples are then processed as described for those from the intertidal sites (see above).

3.2.2 Sediment characteristics

As at the intertidal sites, surface sediment for grain size analysis has been collected from each site in April of each year up to April 2000, and on every sampling occasion thereafter. In addition, beginning in July 2000, sediments at each site are now also assessed for organic and chlorophyll *a* content. Collection and analyses of these sediments are as described for the intertidal sites (see above).

3.2.3 Atrina zelandica

Estimates of size and density of the *Atrina* are made at each subtidal site. Ten quadrats (0.25 m^2) are haphazardly placed on the estuary floor and the number of *Atrina* contained in each quadrat is recorded. The size (maximum shell width) of five randomly selected live *Atrina* within each quadrat is also measured. During the October 1994 sampling, mean numbers of *Atrina* in the quadrats were derived from 8 and 15 quadrats at Sites A and C, respectively. Also during October 1994 sizes of *Atrina* were compiled from measurements of individuals along transects at Site A and adjacent to quadrats at Site C. A total of 32 and 21 *Atrina* were measured at Sites A and C, respectively, on this date.

On the April 1995 sampling occasion we noted that the majority of *Atrina* individuals at one of the sites were dead. Therefore, on every subsequent sampling occasion the number of live and dead *Atrina* within each quadrat has been recorded, and only live individuals are measured. The number of live individuals on the previous sampling occasions was estimated from the video footage.

3.3 Analyses of macrofaunal abundance

3.3.1.1 Biological interpretation of patterns

Plots of total abundance for each monitored population over the monitored period were visually examined to identify repeatable cyclic patterns that indicate seasonal or inter-annual variation in recruitment. We also consider the density of each species at each site in light of our knowledge of the natural history of each species, to ensure that our statisitcal analyses are interpreted in a biologically meaningful fashion.

3.3.1.2 Trend analysis

To formally identify any suggested trends in the abundance of the monitored taxa at both the intertidal and subtidal sites, trend analyses were conducted. Autocorrelation in each time series was investigated using chi-square probabilities (SAS/ETS). Where autocorrelation was indicated, increasing or decreasing trends were investigated by adjusting parameters and significance levels (AUTOREG procedure, SAS/ETS). Otherwise ordinary least squares regression was carried out. Only linear trends were investigated as visual interpretation of the data and investigation of residual variability suggested no other responses. Analyses were carried out on both the original time series and the basal population (i.e., when peak abundances occurred in a repeatable, cyclic pattern, they were removed, and the remaining 'basal' population analysed). Doing both analyses enables identification of trends that are due to changes in recruitment which may not (yet) be affecting basal abundances, and thus aids biological interpretation.

To supplement the regression analysis, we also carried out Mann Kendall tests to assess trends in the monitored taxa. The Mann Kendall test is the non-parametric equivalent of the regression tests described above. They assess the monotonicity of trends (i.e., a tendency to consistently increase, or to decrease), freeing the analyst from the twin assumptions that the trend is linear and that residuals about the trend line are distributed normally. These analyses are much less affected by a few high (or low) points at either end of a time series. They are therefore appropriate for step trends (such as may occur in an environmental intervention) and for highly variable data.

We also assessed the power of the regression analysis to detect trends. Generally, when statistical analyses are performed most attention is paid to having a low probability of erroneously detecting a significant effect. For this monitoring programme, the probability of erroneously saying that a trend occurred when it didn't is set at 5%. However, once the sampling programme is fixed the power to actually a detect a trend can not be independently set, and is a function of the variability of the data and the number of samples available. When a trend has not been detected it is important to know whether, if there was actually a trend, the programme had a reasonable chance (>50%) of detecting it. It is important to remember, however, when interpreting the results of the power analysis that a low power does not mean that there was a trend that wasn't detected; it merely means that with the number of samples available and the variability of the data, there was not high power to detect a trend. Analysis of baselines (time-series with recruitment variability removed) is thus more informative than analysis of raw data. Another way of looking at this result is to say that if there was a trend it is much smaller than other variability in the data, which is a reason why, if enough samples could be taken, trends that are ecologically insignificant can be detected.

3.3.1.3 Community analysis

To make an overall assessment of stability of sites over time, we constructed multivariate ordination plots using monitored taxa only. The intertidal and subtidal sites were analysed separately using correspondence analysis (CANOCO; ter Braak, 1986).

4 Results and Discussion

4.1 Intertidal sites

4.1.1 Sediment characteristics

The sediment grain size characteristics at the intertidal sites have not changed markedly in the past two years (Appendix 1). The increase in the fine sand fraction, and a corresponding decrease in the medium sand fraction that occurred some time between the April 1996 and April 1997 sampling occasions (discussed in Cummings et al. 2001 and 2003) is still evident, and levels of both have remained relatively consistent over the past four years (Figure 2). The proportions of the different grain size fractions at Jamieson Bay fluctuate widely over the monitored period; this can be explained by the heterogeneous nature of the substrate at this site.

The organic and chlorophyll *a* content of the sediments at each site from July 2000 to January 2005 are shown in Table 1. The organic content was generally lowest at Jamiesons Bay and Mid Harbour (ranges of 1.00 – 3.59% and 0.88 – 4.94%, respectively) and highest at Hamilton Landing (1.58 – 6.65%). Similar values were found for the 'muddy' and 'sandy' areas of Te Kapa over the monitoring period (excluding the unusually high value of 11.93% at Te Kapa sandy site, which we believe to be an anomaly; Cummings et al. 2003); these values tend to be slightly higher in the muddy areas on any one sampling occasion. The temporal variability in organic content, although small at each site, tends to follow a similar pattern at Cowans Bay, Jamiesons Bay, and Te Kapa, with relatively high organic content noted at each of these sites in October 2002 and April 2004 (Table 1A).

The chlorophyll *a* content of the sediments continues to be highest at Cowans Bay and lowest at Jamieson Bay (Table 1B). There is no harbour-wide pattern in the temporal variability in sediment chlorophyll levels, although there are similarities between Hamilton Landing and Mid Harbour (Table 1B).

Figure 2 .

Changes in the proportions of mud (i.e., silt/clay; <63 μm), fine sand (62.5 – 250 μm), medium sand (250 –500 μm) and coarse sediment (>500 μm) content at each of the intertidal sites over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 1.

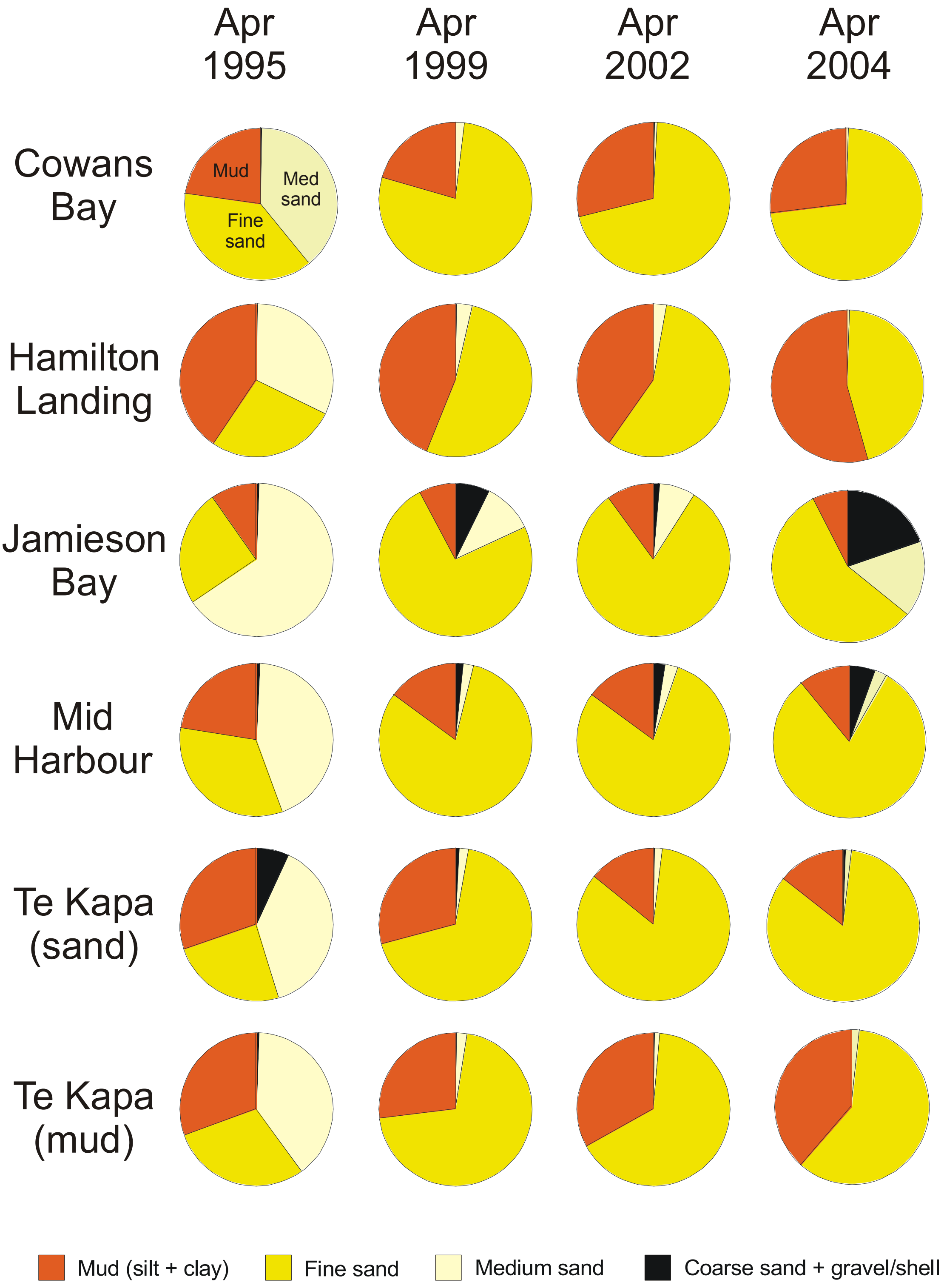


Table 1.

A. Organic content (% dry weight), and B. Chlorophyll *a* content (µg g^{-1} sediment) of sediments at the intertidal sites on each sampling occasion since July 2000. * = highest recorded value at a particular site; ns = not sampled.

A. Organic content

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand
Jul00	1.67	3.87	1.29	1.40	1.87	0.90
Oct00	2.03	3.22	1.00	0.88	2.32	1.57
Jan01	2.00	2.49	1.44	1.38	2.33	1.49
Apr01	2.28	4.60	1.59	3.38	3.06	11.93*
Jul01	2.58	6.35	1.45	2.72	2.90	1.59
Oct01	1.92	4.16	1.32	1.83	2.58	1.20
Jan02	2.06	3.92	2.06	2.17	1.84	2.53
Apr02	2.30	3.47	1.70	1.84	1.40	2.22
Jul02	2.58	1.58	1.71	4.94*	2.46	2.13
Oct02	2.94	5.02	2.13	1.53	3.41	4.62*
Jan03	2.13	4.07	1.72	1.50	2.59	1.68
Apr03	2.01	5.54	1.48	2.96	2.31	1.37
Jul03	2.00	3.89	1.38	1.79	2.18	1.32
Oct03	1.88	3.85	1.45	1.42	2.46	2.08
Jan04	2.27	4.69	1.70	1.49	2.54	1.79
Apr04	2.85	6.65*	3.59*	2.23	4.66*	2.53
Jul04	2.97	4.87	2.34	1.57	2.69	1.85
Oct04	3.18*	5.04	2.31	2.40	3.99	2.29
Jan05	1.74	2.55	1.41	1.63	4.10	1.70

B. Chlorophyll *a*

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand
Jul00	17.81	12.14	4.59	10.03	14.74	6.35
Oct00	23.08*	11.32	3.97	7.33	8.40	15.39
Jan01	12.40	10.04	3.44	6.54	5.94	9.62
Apr01	15.54	12.63	1.76	10.38	13.11	ns
Jul01	21.21	16.74*	6.76*	10.46	17.41*	9.99
Oct01	14.01	8.32	3.65	6.55	12.63	5.22
Jan02	12.23	8.21	2.75	4.53	9.15	5.23
Apr02	18.07	13.13	6.15	9.76	14.32	6.30
Jul02	15.52	6.41	4.58	10.99*	14.16	6.14
Oct02	14.02	7.27	3.14	8.59	9.91	6.48
Jan03	12.63	10.07	5.04	9.02	11.38	7.32
Apr03	12.72	5.93	3.66	7.05	9.11	7.60
Jul03	13.08	6.19	3.50	3.09	9.65	6.76
Oct03	14.04	7.70	5.50	8.98	9.06	5.50

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand
Jan04	10.66	10.78	3.09	8.49	6.07	17.43*
Apr04	16.65	12.35	2.86	10.67	5.96	9.85
Jul04	15.13	10.86	3.38	7.05	7.22	14.10
Oct04	11.02	7.62	3.23	2.53	4.03	7.62
Jan05	12.28	8.48	4.61	10.93	6.90	9.05

4.1.2 Macrofauna – comments on the abundance of common taxa

Throughout this report 'total' abundances (i.e., total numbers of individuals collected in 12 samples) of the monitored taxa are discussed. The abundances of all the intertidal monitored taxa collected at each site on each sampling date since the last report (i.e., from April 2001 to January 2005) are given in Appendix 2.

The following are site-by-site descriptions of the monitored macrofauna. For each site, we discuss the three most abundant taxa, populations exhibiting visually identifiable cycles in abundance, and populations for which statistically identifiable trends in abundance have been detected by trend analysis. A table summarising the trend analysis results is given at the end of this section (Table 7).

4.1.2.1 Cowans Bay

The polychaete *Cossura* sp. continues to dominate this site, with abundances ranging from 135 to 738 individuals over the entire monitored period. It has been the most abundant monitored taxa on all except the most recent sampling occasion (January 2005), when it was the second highest ranked taxa (Table 2). Recent years have seen increased prominence of the bivalve *Nucula hartvigiana* and the amphipod *Torridoharpinia hurleyi* amongst the three most dominant taxa.

Arthritica bifurca was either the second or third ranked taxa on every sampling occasion at Cowans Bay until April 2003; since this time this bivalve has exhibited its lowest numbers since monitoring began, and subsequently it has not featured amongst the dominant taxa (Table 2).

Populations showing cyclic abundance patterns

The polychaete *Cossura* sp. exhibits peaks in abundance in July of most years, except for 1995, 1998 and 2002, when peaks occurred in other months. The bivalve *Nucula hartvigiana* and the mud crab *Macrophthalmus hirtipes* have repeatable temporal cycles in their abundance, exhibiting peak abundances in January or October each year. Nemerteans and *Heteromastus filiformis* show annual cyclic patterns in their abundances, with peaks usually occurring in July or October each year.

Aricidea sp. occur more frequently in July/October, but not every year; particularly high abundances of this polychaete were noted in July of 2003 and 2004.

The amphipod *Torridoharpinia hurleyi* exhibits peaks in abundance in variable months each year, but numbers are always low in April.

Populations showing trends in abundance

In the last two reports, trend analysis has detected a decline in Polydorid polychaete abundances (Table 7). Abundances have been low but steady in recent years, at around 5 to 10 individuals.

Two new trends were detected with the addition of two more years of data: increases in abundances of the amphipods *Paracalliope novizealandiae* and *Torridoharpinia hurleyi* (Table 7). *Paracalliope* is not common at Cowans Bay, having occurred on only seven sampling occasions over the monitored period (maximum of 8 individuals). The increasing trend is driven by the fact that these occurrences have been in the last half of the monitored period, and that highest abundances were recorded in the past year. Numbers of *Torridoharpinia* have been steady throughout the monitored period, ranging from 0 to 93 individuals (Figure 3). In July 2005 however, numbers increased by threefold to 312 individuals. It is likely that these high numbers are just a one off event and that this trend will be disproved with more data.

Figure 3.
Total number of *Torridoharpinia hurleyi* collected at Cowans Bay over the monitored period. An increasing trend in total abundance of this amphipod was detected, due to high abundances in January 2005. This trend is likely to be disproved with more data.

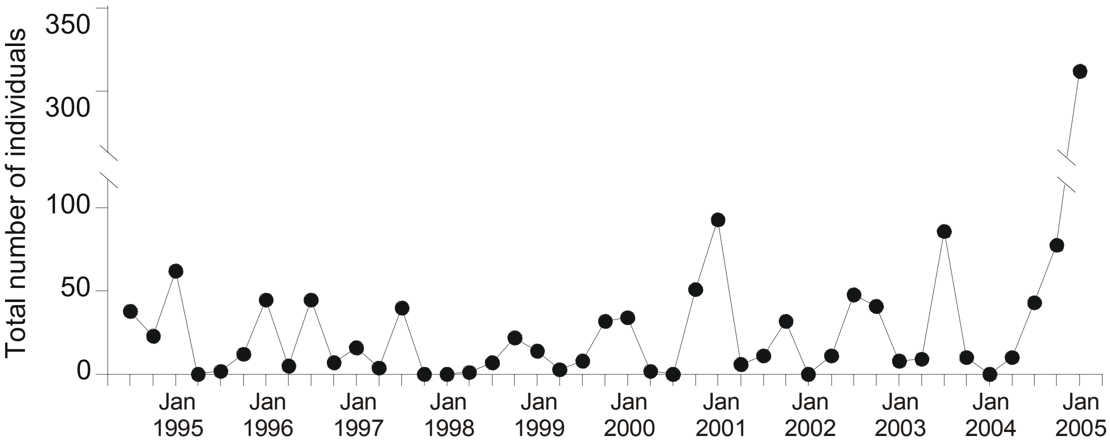


Table 2.

The three dominant taxa collected at Cowans Bay from July 1994 to January 2005. The most abundant taxa are on the left hand side of the table.

Jul 94	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 94	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 95	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 95	*Cossura* sp.	*Arthritica bifurca*	*Nucula hartvigiana*
Jul 95	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Oct 95	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 96	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 96	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 96	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 96	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 97	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 97	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 97	*Cossura* sp.	*Torridoharpinia hurleyi*	*Arthritica bifurca*
Oct 97	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 98	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 98	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 98	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 98	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 99	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 99	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Jul 99	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 99	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 00	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 00	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 00	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 00	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 01	*Cossura* sp.	*Arthritica bifurca*	*Torridoharpinia hurleyi*
Apr 01	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 01	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Oct 01	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 02	*Cossura* sp.	*Arthritica bifurca*	*Heteromastus filiformis*
Apr 02	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 02	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 02	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jan 03	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 03	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 03	*Cossura* sp.	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Oct 03	*Cossura* sp.	*Heteromastus filiformis*	*Macomona liliana*
Jan 04	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*
Apr 04	*Cossura* sp.	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Jul 04	*Cossura* sp.	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Oct 04	*Cossura* sp.	*Heteromastus filiformis*	*Torridoharpinia hurleyi*
Jan 05	*Torridoharpinia hurleyi*	*Cossura* sp.	*Nucula hartvigiana*

4.1.2.2 Hamilton Landing

The increasing abundance of *Cossura* sp. and *Heteromastus filiformis* at Hamilton Landing has continued and, in the last half of the monitoring programme, these polychaetes have consistently dominated the monitored community. Abundances of both species are now very high: in the past two years their numbers have ranged from 647 to 963 and from 203 to 702, respectively. Abundances of the third ranked taxa at this site over the same time period are considerably lower (i.e., $\leq$ 47 individuals). *Aricidea* sp. has featured amongst the dominant taxa on four occasions since the last report, and *Aquilaspio aucklandica* and *Arthritica bifurca* on two and one occasions, respectively (Table 3).

Table 3.

The three dominant taxa collected at Hamilton Landing from July 1994 to January 2005. The most abundant taxa are on the left hand side of the table. When more than one taxa has the same rank they are represented as (for example) '*Arthritica bifurca*/*Cossura* sp.).

Jul 94	*Austrovenus stutchburyi*	Polydorids	*Cossura* sp.
Oct 94	*Austrovenus stutchburyi*	Polydorids	*Cossura* sp.
Jan 95	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Arthritica bifurca*/*Cossura* sp.
Apr 95	*Austrovenus stutchburyi*	*Cossura* sp.	*Arthritica bifurca*
Jul 95	*Austrovenus stutchburyi*	*Cossura* sp.	Polydorids
Oct 95	*Austrovenus stutchburyi*	Polydorids	*Heteromastus filiformis*
Jan 96	*Austrovenus stutchburyi*	Polydorids	*Heteromastus filiformis*
Apr 96	Polydorids	*Austrovenus stutchburyi*	*Heteromastus filiformis*
Jul 96	Polydorids	*Heteromastus filiformis*	*Cossura* sp.
Oct 96	Polydorids	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 97	Polydorids	*Austrovenus stutchburyi*	*Cossura* sp.
Apr 97	Polydorids	*Cossura* sp.	*Heteromastus filiformis*
Jul 97	Polydorids	*Heteromastus filiformis*	*Cossura* sp.
Oct 97	Polydorids	*Heteromastus filiformis*	*Cossura* sp.
Jan 98	*Heteromastus filiformis*	Polydorids	*Cossura* sp.
Apr 98	*Austrovenus stutchburyi*	Polydorids	*Cossura* sp.
Jul 98	Polydorids	*Austrovenus stutchburyi*	*Cossura* sp.
Oct 98	Polydorids	*Heteromastus filiformis*	*Cossura* sp.
Jan 99	*Austrovenus stutchburyi* / *Cossura* sp.		*Arthritica bifurca* / Polydorids
Apr 99	*Heteromastus filiformis*	*Cossura* sp.	*Austrovenus stutchburyi*
Jul 99	Polydorids	*Heteromastus filiformis*	*Cossura* sp.
Oct 99	*Heteromastus filiformis*	Polydorids	*Cossura* sp.
Jan 00	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Cossura* sp.
Apr 00	*Heteromastus filiformis*	*Cossura* sp.	*Torridoharpinia hurleyi*
Jul 00	*Heteromastus filiformis*	*Cossura* sp.	Oligochaetes
Oct 00	*Heteromastus filiformis*	*Cossura* sp.	*Arthritica bifurca*
Jan 01	*Cossura* sp.	*Heteromastus filiformis*	Nemerteans
Apr 01	*Cossura* sp.	*Heteromastus filiformis*	*Aquilaspio aucklandica*
Jul 01	*Cossura* sp.	*Heteromastus filiformis*	Polydorids
Oct 01	*Cossura* sp.	*Heteromastus filiformis*	Nemerteans
Jan 02	*Cossura* sp.	*Heteromastus filiformis*	*Aquilaspio aucklandica*
Apr 02	*Cossura* sp.	*Heteromastus filiformis*	Polydorids
Jul 02	*Heteromastus filiformis*	*Cossura* sp.	*Arthritica bifurca*
Oct 02	*Cossura* sp.	*Heteromastus filiformis*	*Macrophthalmus hirtipes*
Jan 03	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 03	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Jul 03	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Oct 03	*Heteromastus filiformis*	*Cossura* sp.	*Aquilaspio aucklandica*
Jan 04	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Apr 04	*Cossura* sp.	*Heteromastus filiformis*	*Aquilaspio aucklandica*
Jul 04	*Cossura* sp.	*Heteromastus filiformis*	*Arthritica bifurca*
Oct 04	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Jan 05	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.

Populations showing cyclic abundance patterns

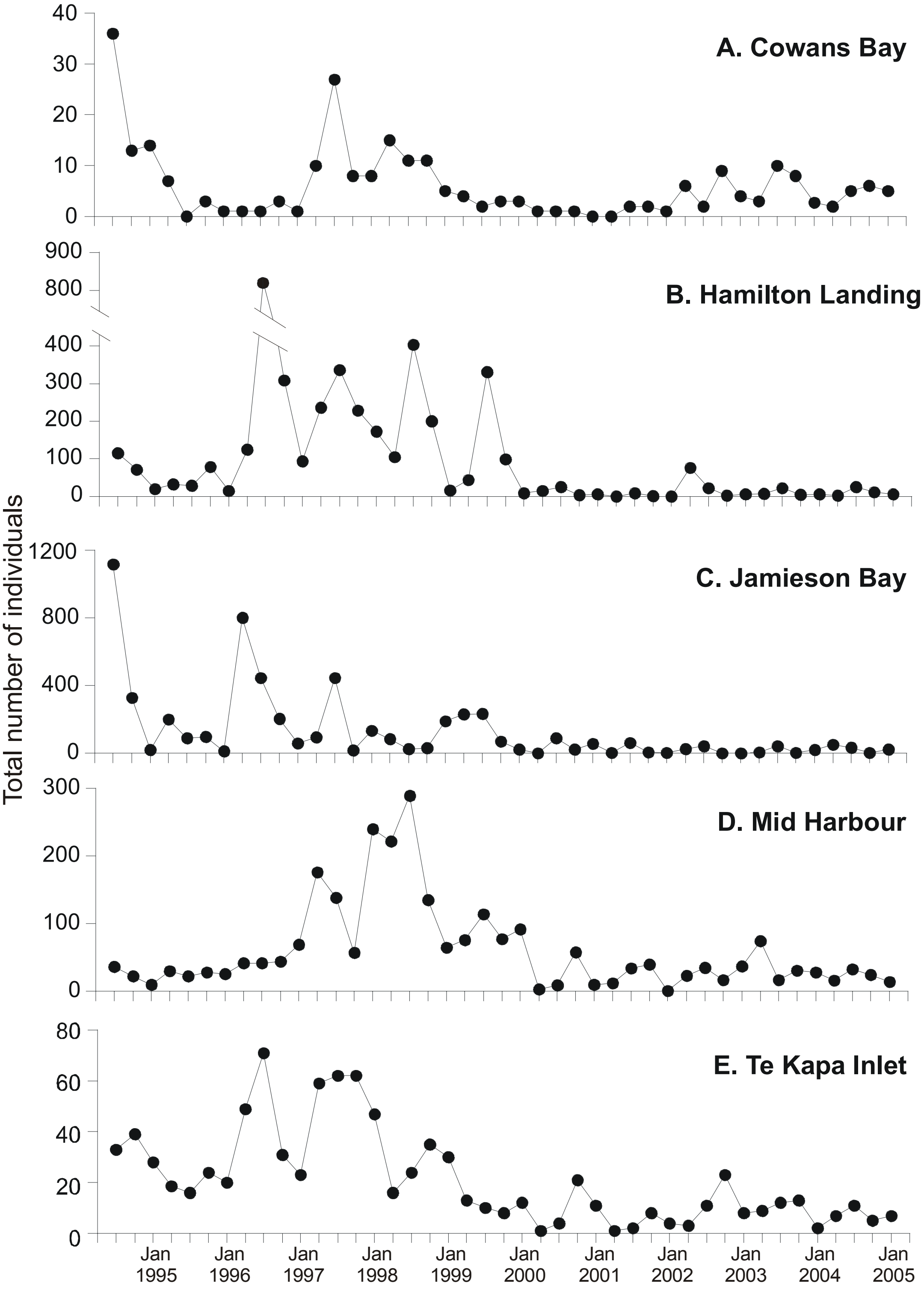
Macrophthalmus hirtipes exhibits a cyclic pattern in abundance with peaks occurring in October of all years except 1996 and 1998, when they occurred in July. *Heteromastus filiformis* exhibits peak abundances in July or October each year (with the exception of a peak in January 1999). *Aquilaspio aucklandica* and *Macomona liliana* exhibit peaks in abundance each year, but the timing of these peaks is not predictable.

The cyclic abundance patterns noted in the previous report for Polydorids has continued despite the decline in abundance of this polychaete; peak abundances have most often occurred in July each year (Figure 4B).

Arthritica bifurca shows signs of a greater than annual abundance cycle, with large peaks noted in January of 1998 and 2003, and October of 2000.

The cyclic pattern noted for *Austrovenus stutchburyi* in our last report is no longer obvious with the additional two years of data, due to the low numbers of this bivalve (0-4 individuals since April 2000).

Figure 4.
Total number of Polydorids collected at the intertidal sites over the monitored period. A decreasing trend in total abundance of this polychaete was detected at all sites except Mid Harbour.



Populations showing trends in abundance

Ten species exhibit increasing or decreasing trends in abundance at Hamilton Landing, most of which were also detected in the 2003 analysis (Cummings et al. 2003; Table 7). Increasing trends were detected for the polychaetes *Heteromastus filiformis*, *Cossura* sp., *Aricidea* sp., *Aquilaspio aucklandica* and Nemerteans. Decreasing trends were noted for the bivalves *Austrovenus stutchburyi*, *Macomona liliana* and *Nucula hartvigiana*, and for the polychaete species Polydorids and *Scoloplos cylindrifer*.

The strong trends of increasing abundance detected previously for *Heteromastus filiformis* and *Cossura* sp. have continued (Table 7). In the latter half of the monitored period, *Cossura* numbers have ranged from 461 (July 2000) to 963 (July 2003). These numbers are considerably higher than those recorded prior to July 2000 (i.e., 7 - 387 individuals). A similar pattern is apparent for *Heteromastus*, whose abundances have steadily increased from 7 to 280 individuals prior to April 1999, to 53 to 703 individuals subsequently. The magnitude of both of these trends has increased, albeit only slightly for *Heteromastus* (Table 7). As noted in our last report, both of these species are often associated with organically enriched muddy sediments. Unfortunately, we have no information on the organic content of the sediments prior to October 2000, and therefore cannot comment on whether there has been an increase in organic content at this site over the entire monitoring period.

Of concern are the declines in abundances of *Austrovenus* and *Macomona*. In the case of *Austrovenus*, a maximum of 9 individuals have been collected on any one sampling date since January 2000 (when 55 individuals were found). Although numbers of *Macomona* are still lower than those recorded in the first half of the monitoring programme, there was a significant abundance peak in July 2003 (25 individuals). This is promising for the *Macomona* population at this site as this peak is of a similar magnitude to previously observed peak numbers (Figure 7A). In addition, 23 of the 25 individuals collected in July 2003 were in the ≤4 mm size class (Figure 7B); the highest number of small *Macomona* collected since we began measuring bivalves in July 1997. However, as noted in our last report, there have been no large individuals (>16 mm) found at this site since January 2001 (Figure 7B).

The decreasing trend for *Nucula hartvigiana* is due to the lack of abundance peaks for this bivalve since April 2000 (Figure 5). Since this time numbers have remained low, at between 0 to 4 individuals.

The increasing trend in *Aquilaspio aucklandica* abundance noted in the last report has continued, with numbers over the past two years consistently amongst the highest for this polychaete over the monitored period (i.e., 17 – 42 individuals). Abundances of Nemerteans, while still higher than in the first half of the monitored period, have remained similar over the last four years (i.e., 4 - 26 individuals).

Three new abundance trends were detected this year: decreases in Polydorids and *Scoloplos cylindrifer*, and an increase in *Aricidea* sp.. Polydorid numbers have been relatively low since January 2000 (i.e., 0 - 77 individuals cf. 15 - 822 prior to this time). Only 0 to 2 *Scoloplos* individuals have been found at this site since July 1999. Peak abundances of *Aricidea* were especially high in July 2003 and January 2004 (Figure 6.). It will become apparent once more data are collected whether this is actually the beginning of a significant increase in abundance.

The trends noted in the last report for Oligochaetes and *Perinereis nuntia* are no longer apparent.

Figure 5.
The total number of *Nucula hartvigiana* collected on each sampling occasion at Hamilton Landing. A decreasing trend in total abundance of this bivalve was detected.

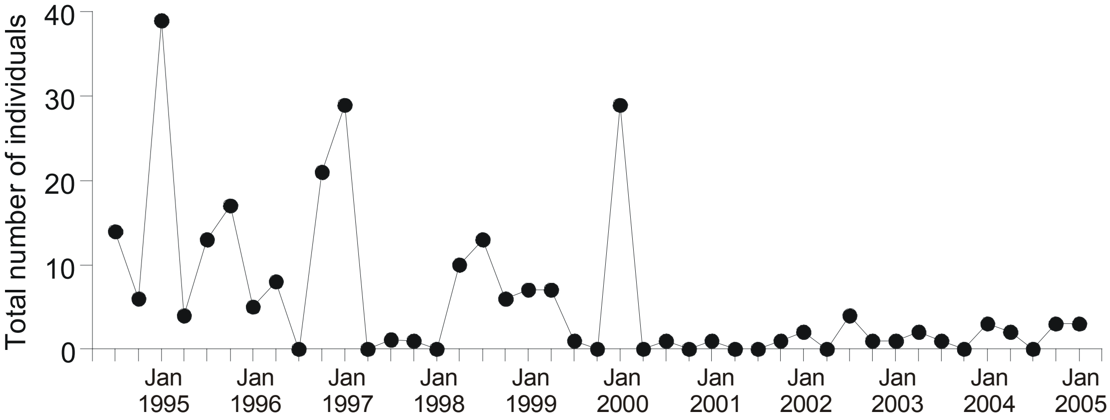


Figure 6.
The total number of *Aricidea* sp. collected on each sampling occasion at Hamilton Landing. An increasing trend in total abundance of this polychaete was detected.

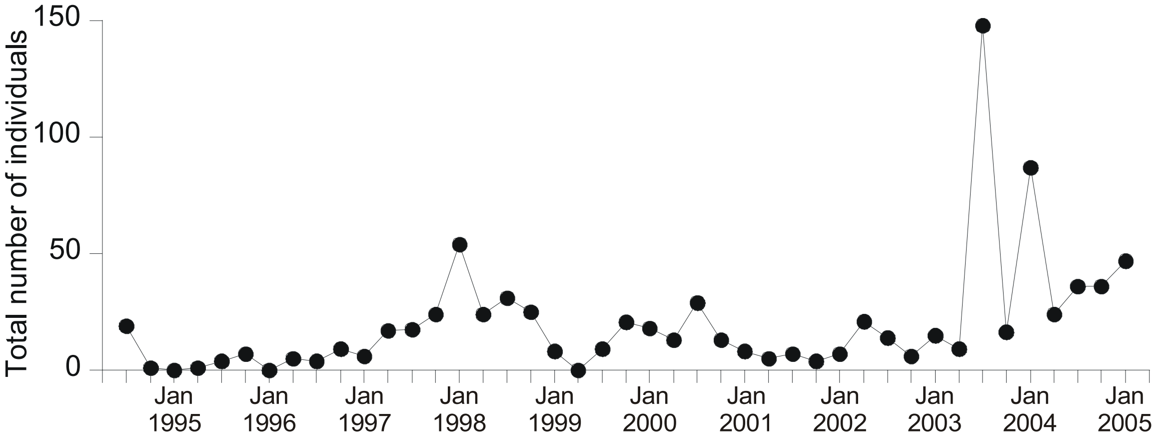
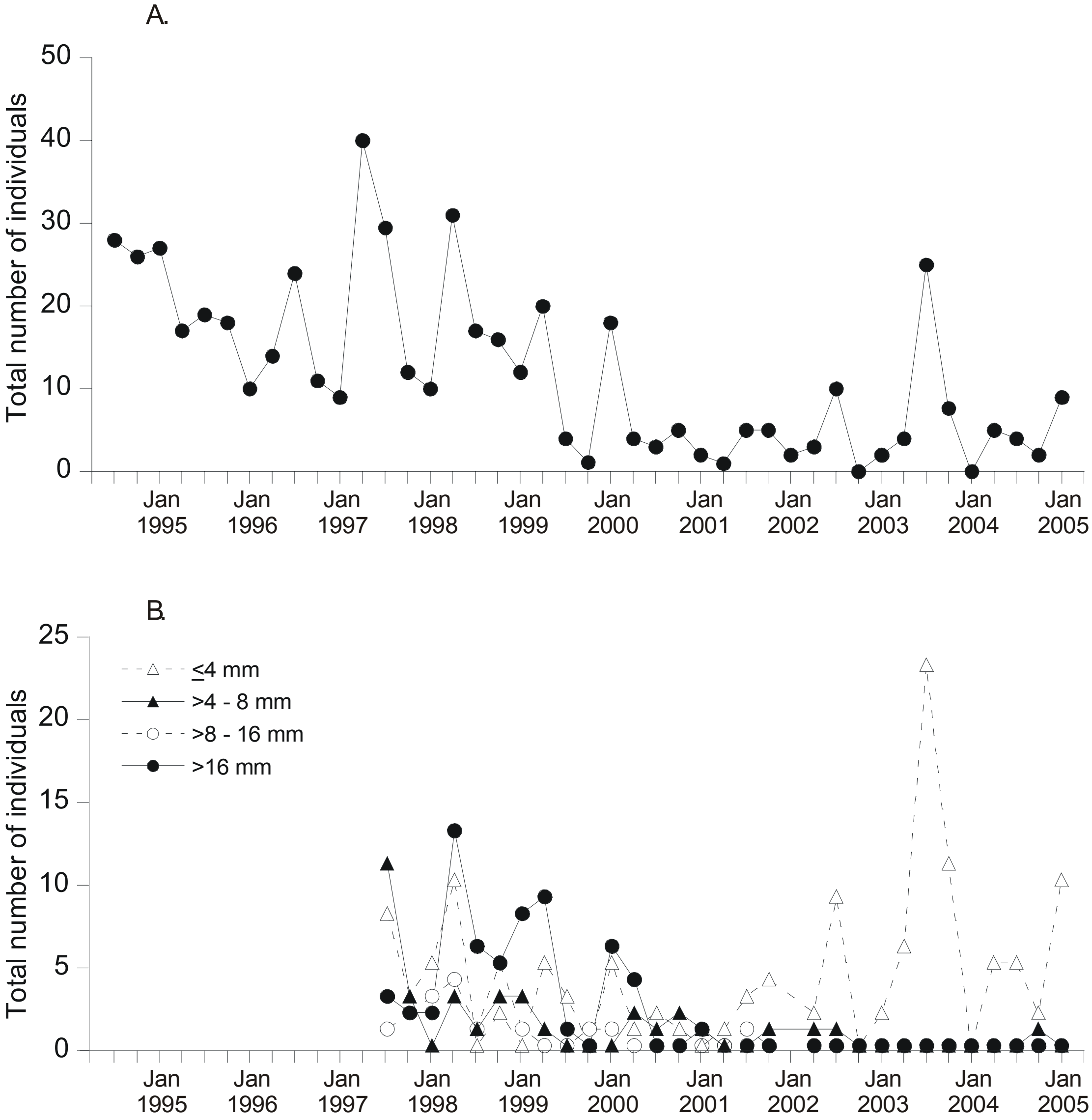


Figure 7..
A. The total number of *Macomona liliana* collected on each sampling occasion at Hamilton Landing. A decreasing trend in total abundance of this bivalve was detected.
B. The total number of individuals in each size class, from July 1997 onwards.



4.1.2.3 Jamieson Bay

Nucula hartvigiana continues to dominate this site (Table 4) with high numbers (92 - 304 individuals) since April 2003. *Aonides oxycephala* has featured amongst the dominant taxa on five of the eight most recent sampling occasions (15 - 56 individuals). *Aricidea* sp., *Heteromastus filiformis*, Polydorids, Oligochaetes, and the amphipod *Torridoharpinia hurleyi* have all featured in the dominant taxa list in the past two years on 1 to 3 occasions.

Populations showing cyclic abundance patterns

Polydorid polychaetes show a cyclic abundance pattern, with peaks generally occurring in July each year (except 1995, 1996 and 2004 when they occurred in April). This cyclic pattern has continued, despite the fact that numbers have declined considerably over the monitored period. *Aricidea* sp. and *Nucula hartvigiana* exhibit cyclic abundance patterns, with peak numbers occurring in one of two sampling months each year (July/October or January/April, respectively). For the past seven years, peaks abundances of *Heteromastus filiformis* have occurred in January. *Macomona liliana* exhibit peaks in abundance each year without a repeatable pattern.

Austrovenus stutchburyi may be exhibiting a greater than annual abundance cycle (Figure 8A). Also of note is the increase in larger (spawning) sized individuals noted at this site in the last year and a half (Figure 8B)

Figure 8.

A. The total number of *Austrovenus stutchburyi* collected on each sampling occasion at Jamieson Bay. There was no trend detected in total abundance of this bivalve.

B. The total number of individuals in each size class, from July 1997 onwards.

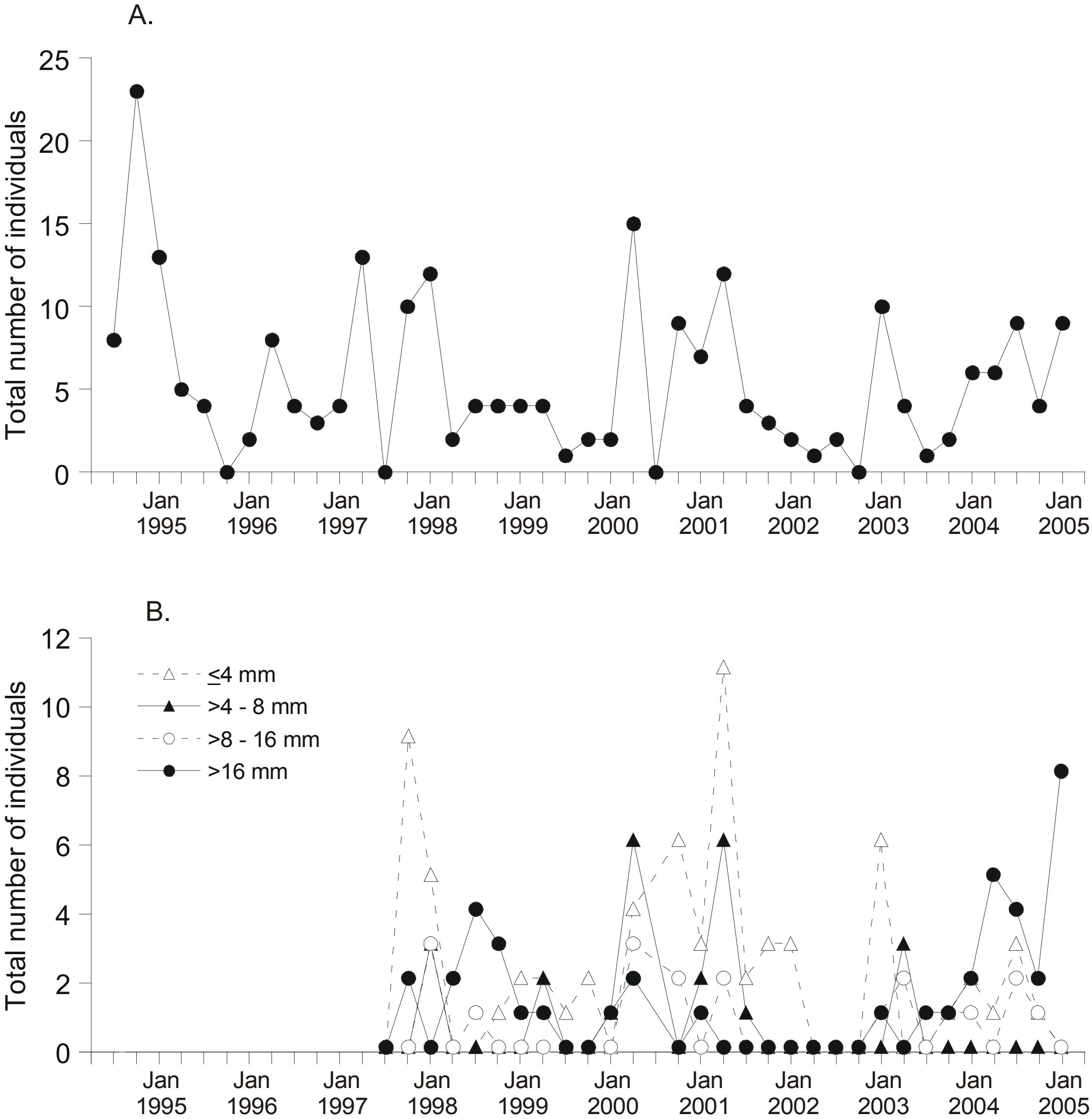


Table 4.

The three dominant taxa collected at Jamieson Bay from July 1994 to January 2005. The most abundant taxa is on the left hand side of the table. When more than one taxa has the same rank they are represented as (for example) '*Arthritica bifurca* / *Cossura* sp.).

Jul 94	Polydorids	*Nucula hartvigiana*	*Macomona liliana*
Oct 94	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Jan 95	*Nucula hartvigiana*	*Macomona liliana*	*Cossura* sp.
Apr 95	*Nucula hartvigiana*	Polydorids	*Torridoharpinia hurleyi*
Jul 95	*Nucula hartvigiana*	Polydorids	*Macomona liliana*
Oct 95	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Jan 96	*Nucula hartvigiana*	*Aonides oxycephala*	*Heteromastus filiformis*
Apr 96	Polydorids	*Nucula hartvigiana*	*Aonides oxycephala*
Jul 96	Polydorids	*Nucula hartvigiana*	*Macomona liliana*
Oct 96	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Jan 97	*Nucula hartvigiana*	Polydorids	*Cossura* sp. / *Heteromastus filiformis*
Apr 97	*Nucula hartvigiana*	Polydorids	*Aonides oxycephala*
Jul 97	Polydorids	*Nucula hartvigiana*	*Torridoharpinia hurleyi*
Oct 97	*Aonides oxycephala*	*Nucula hartvigiana*	*Heteromastus filiformis*
Jan 98	*Nucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Apr 98	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Jul 98	*Aonides oxycephala*	*Nucula hartvigiana*	*Heteromastus filiformis*
Oct 98	*Nucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Jan 99	Polydorids	*Nucula hartvigiana*	*Macomona liliana*
Apr 99	Polydorids	*Nucula hartvigiana*	*Macomona liliana*
Jul 99	Polydorids	*Heteromastus filiformis*	*Nucula hartvigiana*
Oct 99	Polydorids	*Heteromastus filiformis*	*Aonides oxycephala*
Jan 00	*Nucula hartvigiana*	Nemerteans	Polydorids
Apr 00	*Nucula hartvigiana*	*Aonides oxycephala*	*Scoloplos cylindrifer*
Jul 00	Polydorids	*Aonides oxycephala*	*Heteromastus filiformis*
Oct 00	*Nucula hartvigiana*	*Aonides oxycephala*	Polydorids
Jan 01	*Nucula hartvigiana*	Polydorids	*Aonides oxycephala*
Apr 01	*Nucula hartvigiana*	*Aonides oxycephala*	*Paracalliope novizealandiae*
Jul 01	*Nucula hartvigiana*	Polydorids	*Aonides oxycephala*
Oct 01	*Nucula hartvigiana*	*Aricidea* sp.	*Macomona liliana*
Jan 02	*Nucula hartvigiana*	*Cossura* sp.	*Macomona liliana*
Apr 02	*Nucula hartvigiana*	*Paracalliope novizealandiae*	*Cossura* sp.
Jul 02	*Nucula hartvigiana*	*Heteromastus filiformis*	Polydorids
Oct 02	*Nucula hartvigiana*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 03	*Nucula hartvigiana*	*Cossura* sp.	*Paracalliope novizealandiae*
Apr 03	*Nucula hartvigiana*	*Aonides oxycephala*	*Aricidea* sp.
Jul 03	*Nucula hartvigiana*	*Heteromastus filiformis*	Oligochaete
Oct 03	*Nucula hartvigiana*	*Aonides oxycephala*	*Heteromastus filiformis*
Jan 04	*Nucula hartvigiana*	*Heteromastus filiformis*	*Aonides oxycephala*
Apr 04	*Nucula hartvigiana*	Polydorids	*Aonides oxycephala*
Jul 04	*Nucula hartvigiana*	Oligochaete	*Aonides oxycephala*
Oct 04	*Nucula hartvigiana*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 05	*Nucula hartvigiana*	*Torridoharpinia hurleyi*	*Paracalliope novizealandiae*

Populations showing trends in abundance

Trends in abundance were detected for seven populations at Jamieson Bay (Table 7). Six of these were also detected in 2003 (Cummings et al. 2003; Table 7). Increasing trends were detected for *Arthritica bifurca*, *Paracalliope novizealandiae* and *Aricidea* sp. (basal abundances only). Decreases were detected for *Macomona liliana*, Polyorids, *Owenia fusiformis* and *Torridoharpinia hurleyi* (Table 7).

Arthritica abundances have risen slightly over the monitored period, from 0 to 9 individuals prior to January 2000, to 1 to 20 individuals since. *Paracalliope* abundances, as is common for amphipods, fluctuate considerably (0 - 77 individuals). This increasing trend is due to the fact that peak abundances did not occur early in the monitoring programme, and that the sizes of the peaks in the latter half of the programme have increased. Basal abundances of *Aricidea* were low in the first two years of monitoring (<3 individuals on six out of nine sampling occasions). However, numbers have only been this low on five occasions since this time, and the basal population now sits at around 5 to 10 individuals.

Polydorid polychaetes have exhibited lower total and basal abundances in the second half of the monitored period (i.e., 1 - 90 individuals since January 2000 cf. 13 - 1117 prior; Figure 4C). *Owenia* occurs in low numbers at this site (0 – 9 individuals), and the decreasing trend is driven by the occurrence of 5, 6 and 9 individuals on one occasion each in the first two years of the monitoring programme. Similarly, the declining trend detected for *Torridoharpinia* is due to high numbers found on a few occasions in the first two years of monitoring; this trend is likely to be disproved with collection of more data.

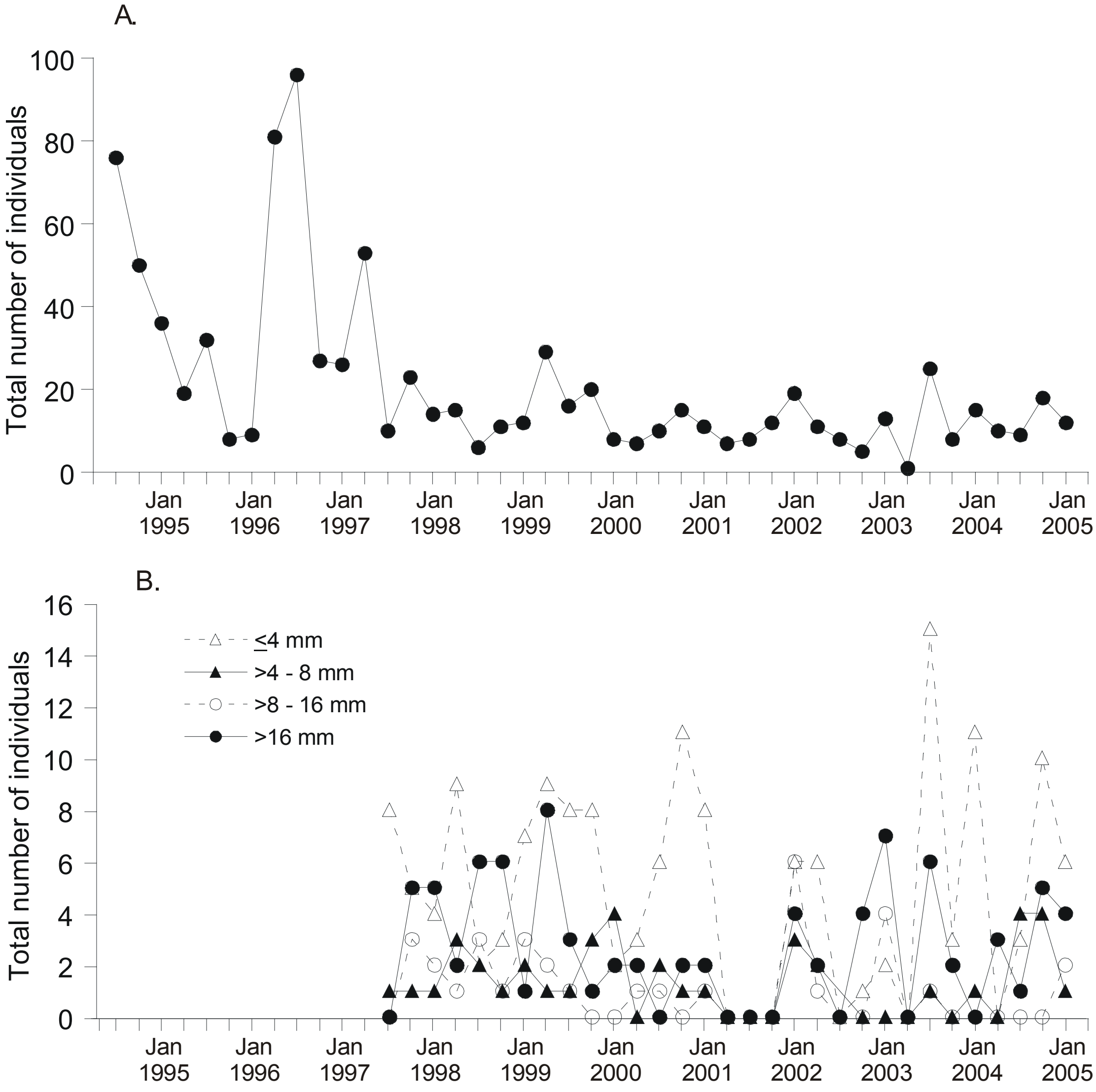
A decreasing trend was detected for *Macomona liliana*, with highest numbers found prior to July 1997. However, *Macomona*'s basal population has remained steady at around 10 individuals (Figure 9A). Larger individuals continue to occur at this site, although in low numbers. Relatively high numbers of recruit-sized *Macomona* ($\leq$4 mm) have been found on three of the eight sampling occasions since the last report: July 2003 (15 individuals), January 2004 (10 individuals) and October 2004 (20 individuals) (Figure 9B).

The increasing trend in abundance noted for *Notoacmea helmsi* in 2001 is no longer apparent (Table 7).

Figure 9.

A. The total number of *Macomona liliana* collected on each sampling occasion at Jamieson Bay. A decreasing trend in total abundance of this bivalve was detected.

B. The total number of individuals in each size class, from July 1997 onwards.



4.1.2.4 Mid Harbour

Nucula hartvigiana continues to dominate Mid Harbour, with abundances ranging from 279 to 435 over the past two years of monitoring. *Cossura* sp., *Heteromastus filiformis*, *Arthritica bifurca* and Polydorids have also featured amongst the dominant taxa in the last two years (Table 5). Interestingly, *Macomona liliana* featured amongst the top ranked taxa in January 2005 (16 individuals), for the first time over the entire monitored period. This is due to lower abundances of the other monitored taxa at this site, rather than to higher than usual numbers of *Macomona*.

Populations showing cyclic abundance patterns

Nucula hartvigiana and *Macrophthalmus hirtipes* exhibit annual cyclic abundance patterns, with peak numbers occurring in either July or October each year. *Cossura* sp. peak abundances have occurred mostly in July or October months. *Macomona liliana* exhibits a yearly abundance cycle, with no predictable pattern in the timing of these peak abundances. *Arthritica bifurca* exhibits peak abundances in January, July or October each year, and a greater than annual cyclic pattern is suggested in recent years. *Heteromastus filiformis* exhibits large fluctuations in abundance (0 – 186 over the entire monitored period), but peak abundances tend to occur in July or October months.

Populations showing trends in abundance

Only two populations (*Aricidea* sp. and *Macomona liliana*) showed trends in abundance at Mid Harbour (Table 7), and all of these were also detected in 2003. The increase in *Aricidea* sp. abundances is driven by higher than normal abundances of this polychaete in July 2001 and January 2002 (49 and 48 individuals, respectively). The baseline abundance appears to have increased by around 3 individuals. The validity of this trend will be determined with collection of more data. *Macomona* still shows a decreasing trend in the size of its peak abundances only, but the magnitude of this trend has declined in the past six years of monitoring. In comparison to the early years of the monitoring programme, recruitment of *Macomona* has been low. The considerable drop in numbers of large individuals (i.e., >16 mm shell length), noted in our last report has, fortunately, not continued; 2 to 7 large individuals were found on each sampling occasion in the past two years (Figure 10B). In addition, numbers of small individuals (<4 mm) found in April 2003 and January 2004 are the highest since bivalve measurements began in July 1997 (Figure 10B).

The trends noted for *Arthritica bifurca* and *Nucula hartvigiana* in 2003, and that noted for *Cossura* sp. in both 2001 and 2003, are no longer apparent (Table 7).

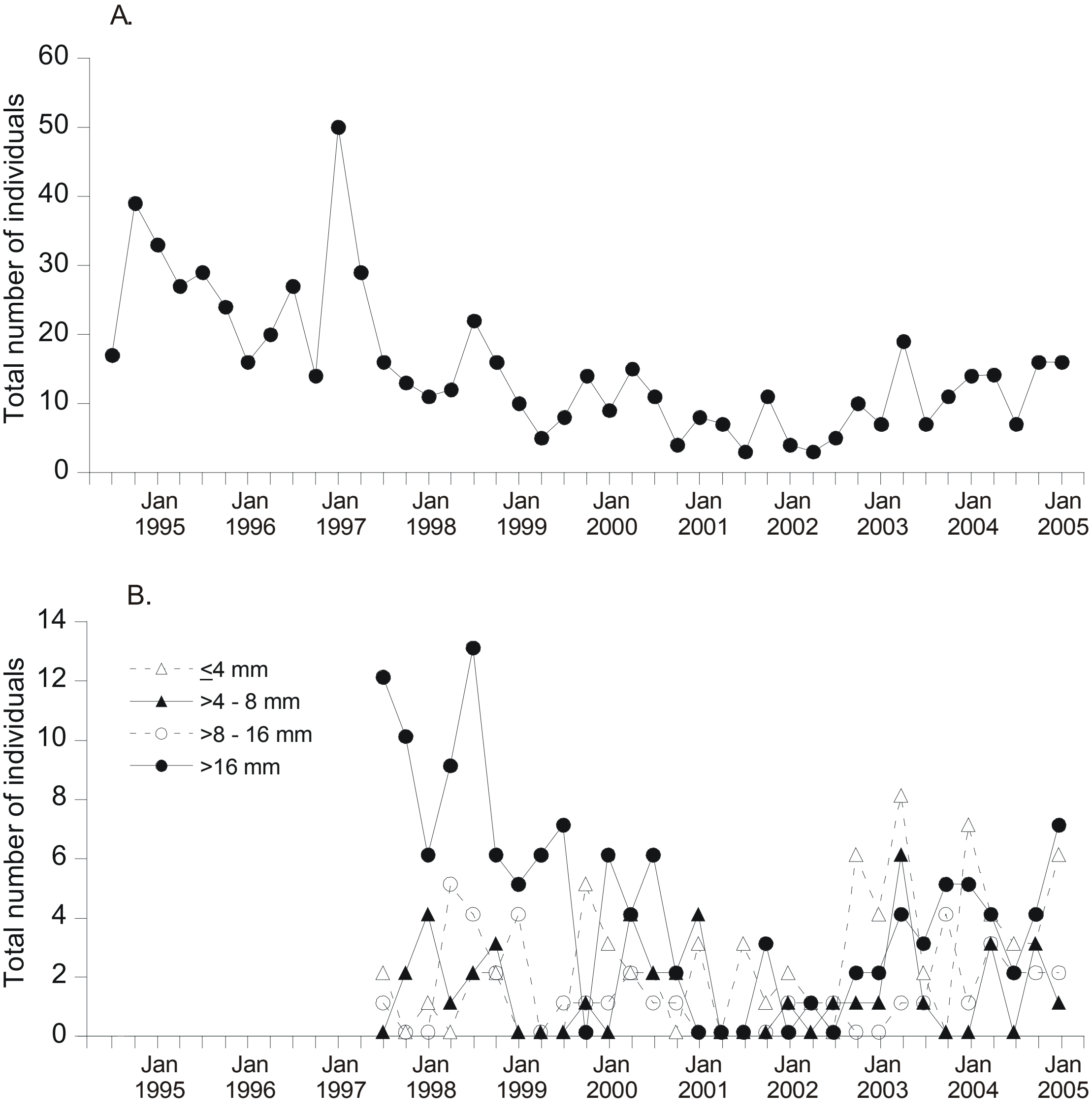
Table 5.

The three dominant taxa collected at Mid Harbour from July 1994 to January 2005. The most abundant taxa is on the left hand side of the table. When more than one taxa has the same rank they are represented as (for example) *Arthritica bifurca* / *Cossura* sp.

Jul 94	*Heteromastus filiformis*	*Cossura* sp.	*Nucula hartvigiana*
Oct 94	*Nucula hartvigiana*	*Cossura* sp.	*Macomona liliana*
Jan 95	*Nucula hartvigiana*	*Cossura* sp.	*Arthritica bifurca*
Apr 95	*Nucula hartvigiana*	*Cossura* sp.	Polydorids
Jul 95	*Nucula hartvigiana*	*Cossura* sp.	*Macomona liliana*
Oct 95	*Nucula hartvigiana*	*Cossura* sp.	*Arthritica bifurca*
Jan 96	*Nucula hartvigiana*	*Cossura* sp.	Polydorids
Apr 96	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jul 96	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Oct 96	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jan 97	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Apr 97	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jul 97	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Oct 97	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jan 98	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Apr 98	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jul 98	*Nucula hartvigiana*	Polydorids	*Austrovenus stutchburyi*
Oct 98	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jan 99	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Apr99	*Nucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Jul 99	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Oct 99	*Nucula hartvigiana*	Polydorids	*Heteromastus filiformis*
Jan 00	*Nucula hartvigiana*	Polydorids	*Arthritica bifurca*
Apr 00	*Nucula hartvigiana*	*Arthritica bifurca*	*Cossura* sp.
Jul 00	*Nucula hartvigiana*	*Cossura* sp.	*Heteromastus filiformis*
Oct 00	*Nucula hartvigiana*	Polydorids	*Arthritica bifurca*
Jan 01	*Nucula hartvigiana*	*Arthritica bifurca*	*Cossura* sp.
Apr 01	*Heteromastus filiformis*	*Aquilaspio aucklandica*	*Aricidea* sp. / Nemerteans
Jul 01	*Heteromastus filiformis*	*Aricidea* sp.	*Arthritica bifurca*
Oct 01	*Nucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 02	*Nucula hartvigiana*	*Heteromastus filiformis*	*Arthritica bifurca*
Apr 02	*Nucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jul 02	*Nucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Oct 02	*Nucula hartvigiana*	*Cossura* sp.	*Heteromastus filiformis*
Jan 03	*Nucula hartvigiana*	*Cossura* sp.	*Arthritica bifurca*
Apr 03	*Nucula hartvigiana*	Polydorids	*Cossura* sp.
Jul 03	*Nucula hartvigiana*	*Cossura* sp.	*Heteromastus filiformis*
Oct 03	*Nucula hartvigiana*	*Heteromastus filiformis*	Polydorids
Jan 04	*Nucula hartvigiana*	*Cossura* sp.	*Arthritica bifurca*
Apr 04	*Nucula hartvigiana*	*Cossura* sp.	*Heteromastus filiformis*
Jul 04	*Nucula hartvigiana*	*Arthritica bifurca*	*Cossura* sp.
Oct 04	*Nucula hartvigiana*	*Arthritica bifurca*	*Heteromastus filiformis*
Jan 05	*Nucula hartvigiana*	*Cossura* sp.	*Macomona liliana*

Figure 10.
A. The total number of *Macomona liliana* collected on each sampling occasion at Mid Harbour. A decreasing trend in total abundance of this bivalve was detected.

B. The total number of individuals in each size class, from July 1997 onwards.



4.1.2.5 Te Kapa Inlet

The dominance of *Cossura* sp. and *Heteromastus filiformis* at Te Kapa has continued over the past two years, with *Cossura* the top ranked taxa on all recent occasions and *Heteromastus* the second most abundant taxa on all but one occasion (i.e., July 2003) when it was the third most abundant (Table 6). Numbers of these polychaetes are very high, ranging from 490 to 810 and from 107 to 301 individuals, respectively, in the past two years. *Aricidea*, *Austrovenus stutchburyi* and *Nucula hartvigiana* have been the third most abundant taxa on several occasions in the past two years.

Table 6.

The three dominant taxa collected at Te Kapa Inlet from July 1994 to January 2005. The most abundant taxa is on the left hand side of the table.

Jul 94	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Aricidea* sp.
Oct 94	*Austrovenus stutchburyi*	*Heteromastus filiformis*	*Nucula hartvigiana*
Jan 95	*Heteromastus filiformis*	*Cossura* sp.	*Nucula hartvigiana*
Apr 95	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Cossura* sp.
Jul 95	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Heteromastus filiformis*
Oct 95	*Nucula hartvigiana*	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 96	*Heteromastus filiformis*	*Austrovenus stutchburyi*	*Nucula hartvigiana*
Apr 96	*Heteromastus filiformis*	*Nucula hartvigiana*	*Cossura* sp.
Jul 96	*Heteromastus filiformis*	*Cossura* sp.	*Aricidea* sp.
Oct 96	*Heteromastus filiformis*	*Cossura* sp.	*Aricidea* sp.
Jan 97	*Austrovenus stutchburyi*	*Aquilaspio aucklandica*	*Heteromastus filiformis*
Apr 97	*Heteromastus filiformis*	*Aquilaspio aucklandica*	*Aricidea* sp.
Jul 97	*Aquilaspio aucklandica*	*Aricidea* sp.	*Austrovenus stutchburyi*
Oct 97	*Heteromastus filiformis*	*Aricidea* sp.	*Cossura* sp.
Jan 98	*Aricidea* sp.	*Aquilaspio aucklandica*	*Cossura* sp.
Apr 98	*Cossura* sp.	*Heteromastus filiformis*	*Aquilaspio aucklandica*
Jul 98	*Heteromastus filiformis*	*Aricidea* sp.	*Aquilaspio aucklandica*
Oct 98	*Aricidea* sp.	*Heteromastus filiformis*	*Cossura* sp.
Jan 99	*Austrovenus stutchburyi*	*Cossura* sp.	*Nucula hartvigiana*
Apr99	*Cossura* sp.	*Austrovenus stutchburyi*	*Aquilaspio aucklandica*
Jul 99	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Oct 99	*Cossura* sp.	*Nucula hartvigiana*	*Austrovenus stutchburyi*
Jan 00	*Cossura* sp.	*Aquilaspio aucklandica*	*Heteromastus filiformis*
Apr 00	*Cossura* sp.	*Aquilaspio aucklandica*	*Austrovenus stutchburyi*
Jul 00	*Cossura* sp.	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Oct 00	*Cossura* sp.	*Heteromastus filiformis*	*Aquilaspio aucklandica*
Jan 01	*Cossura* sp.	*Nucula hartvigiana*	*Austrovenus stutchburyi*
Apr 01	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*
Jul 01	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*
Oct 01	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Jan 02	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*
Apr 02	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Jul 02	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Oct 02	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Jan 03	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*
Apr 03	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Jul 03	*Cossura* sp.	*Aricidea* sp.	*Heteromastus filiformis*
Oct 03	*Cossura* sp.	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 04	*Cossura* sp.	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Apr 04	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*
Jul 04	*Cossura* sp.	*Heteromastus filiformis*	*Aricidea* sp.
Oct 04	*Cossura* sp.	*Heteromastus filiformis*	*Austrovenus stutchburyi*
Jan 05	*Cossura* sp.	*Heteromastus filiformis*	*Nucula hartvigiana*

Populations showing cyclic abundance patterns

Polydorids exhibit a cyclic abundance pattern, with highest numbers occurring most often in October every one to two years.

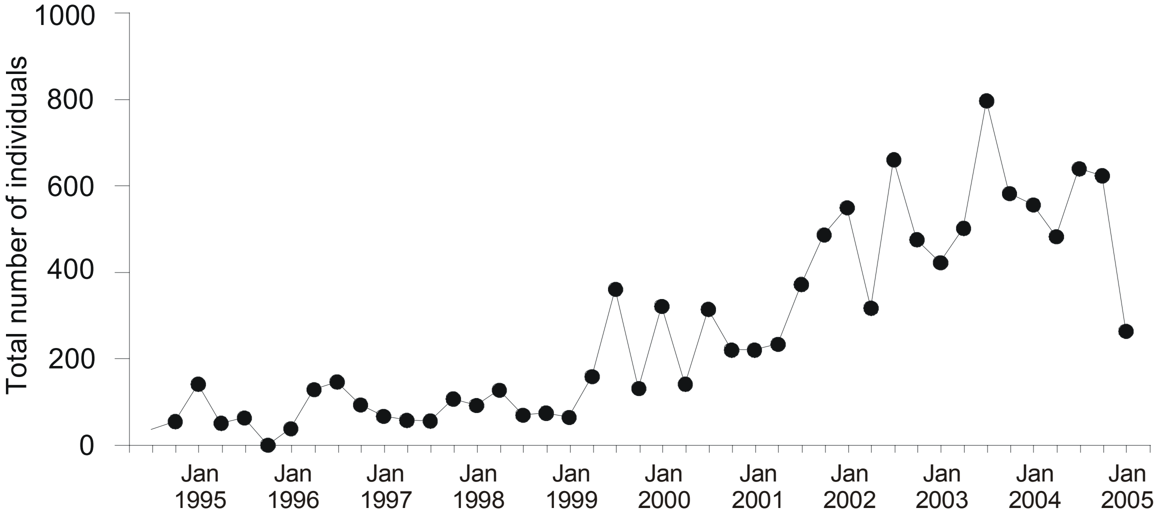
Aricidea sp., *Heteromastus filiformis*, *Scoloplos cylindrifer*, *Macomona liliana* and *Austrovenus stutchburyi* generally show peaks in abundance each year, with no predictable pattern in the timing of these peaks. *Arthritica bifurca* and Oligochaetes exhibit suggestions of greater than annual cyclic patterns in their abundance.

Populations showing trends in abundance

Trends in abundance were detected for seven populations at Te Kapa Inlet. Four of these were also detected in 2003 (Table 7).

Cossura sp. and Nemerteans both continue to show increasing trends. Numbers of *Cossura* have consistently increased over the past five to six years, and are now around three times more abundant than when the monitoring programme began in 1994 (Figure 11). The trend in Nemertean abundance involves an increase of 5 to 10 individuals. Polydorids continue to show a decrease in both peak and baseline abundances (Table 7; Figure 4E).

Figure 11.
A. The total number of *Cossura* sp. collected on each sampling occasion at Te Kapa Inlet. An increasing trend in total abundance of this polychaete was detected.



Three new trends were detected this year: a decline in numbers of *Aquilaspio aucklandica* and increases in the abundance of *Torridoharpinia hurleyi* and *Heteromastus filiformis* (the latter is a baseline trend only; Table 7). *Aquilaspio* abundances have declined from 15 to 197 individuals prior to April 2001, to 14 to 50 individuals since. The increasing trend detected for *Torridoharpinia* is most likely due to the high numbers of this amphipod collected in July 2004; this trend may be disproved with collection of more data. *Heteromastus* basal abundances have not dropped below 100 individuals in recent years, compared with 0 to 35 individuals earlier in the monitoring programme.

Trend analysis in 2001 and 2003 detected a decline in the total and basal population abundance of *Macomona liliana* at this site (Table 7). However, the basal population trend could not be tested in 2005 due to the non-predictability of the timing of the peak abundances for this bivalve. Since July 2003, 10 to 22 individuals have been found; this is an increase over numbers collected in the four years prior to that date when 6 to 14 individuals were found (Figure 12A). As noted above, there is no predictable pattern in the timing of *Macomona* peak abundances: prior to 2000 highest numbers occurred in April each year, but since this time they have occurred in July or October. In the past two years of monitoring, high numbers (≥15 individuals) of recruit-sized bivalves were noted in October 2003 and July 2004 (Figure 12B); this is the highest number of recruits found at Te Kapa Inlet since we began measuring bivalves in July 1997. In addition, on the last sampling date (January 2005), numbers of large *Macomona* (>16mm) were amongst the highest recorded at this site (Figure 12B).

The trends in abundance noted for *Aonides oxycephala* and *Austrovenus stutchburyi* in the last report were not detected in this year's analysis (Table 7). However, it is still worth discussing abundances of *Austrovenus* in more detail. In the past two years, numbers of this bivalve have been more similar to those noted in the early years of the programme, with 119 and 155 individuals collected in October 2003 and January 2004, respectively (Figure 13A). Abundances of spawning-sized *Austrovenus* have been high on two occasions (January of 2004 and 2005; see Figure 13B). On three occasions (January and October 2003, and October 2004), recruit-sized *Austrovenus* comprised over half of the individuals collected (Figure 13B).

Figure 12.

A. The total number of *Macomona liliana* collected on each sampling occasion at Te Kapa Inlet. A decreasing trend in total abundance of this bivalve was detected.

B. The total number of individuals in each size class, from July 1997 onwards.

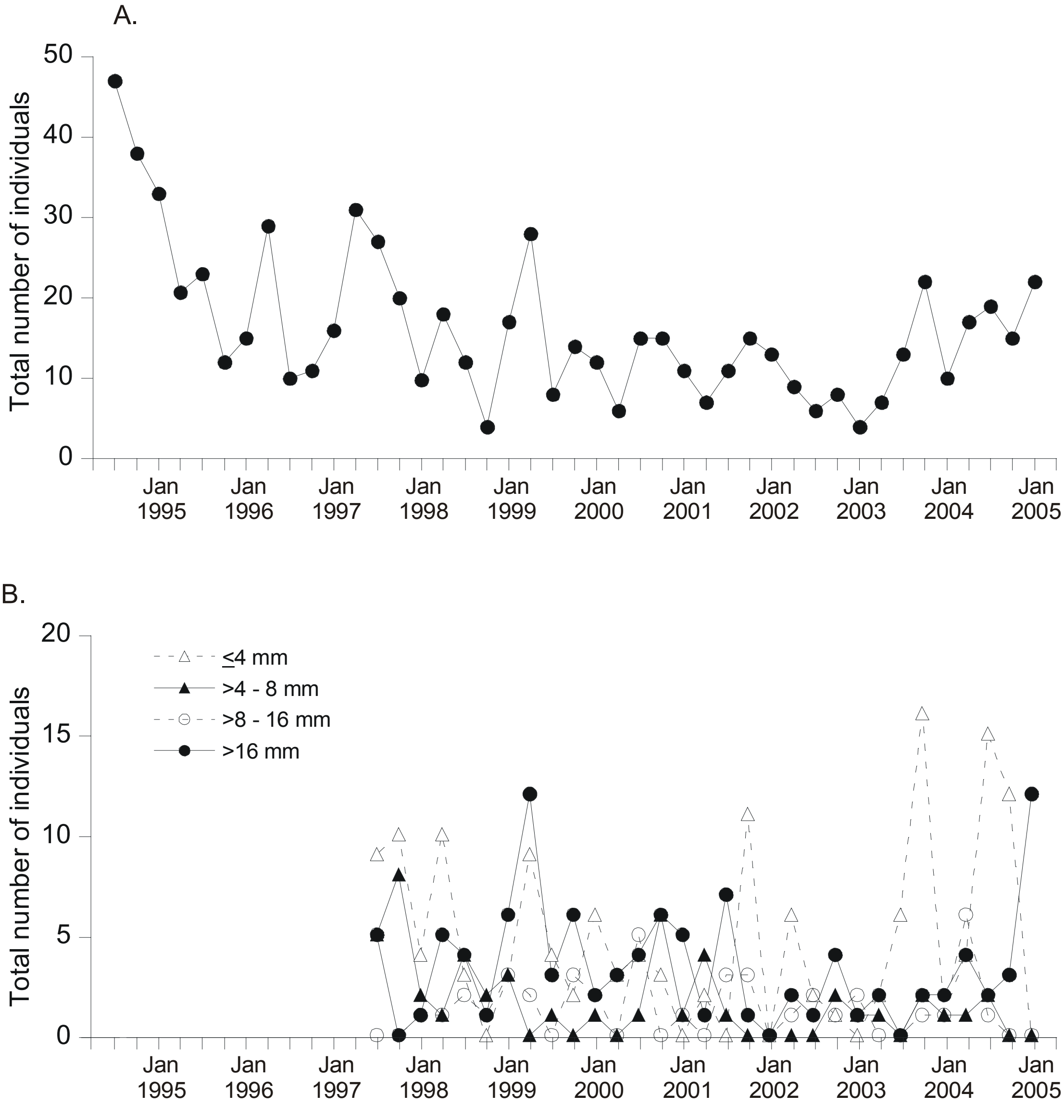


Figure 13.

A. The total number of *Austrovenus stutchburyi* collected on each sampling occasion at Te Kapa Inlet. There was no trend detected in total abundance of this bivalve.

B. The total number of individuals in each size class, from July 1997 onwards.

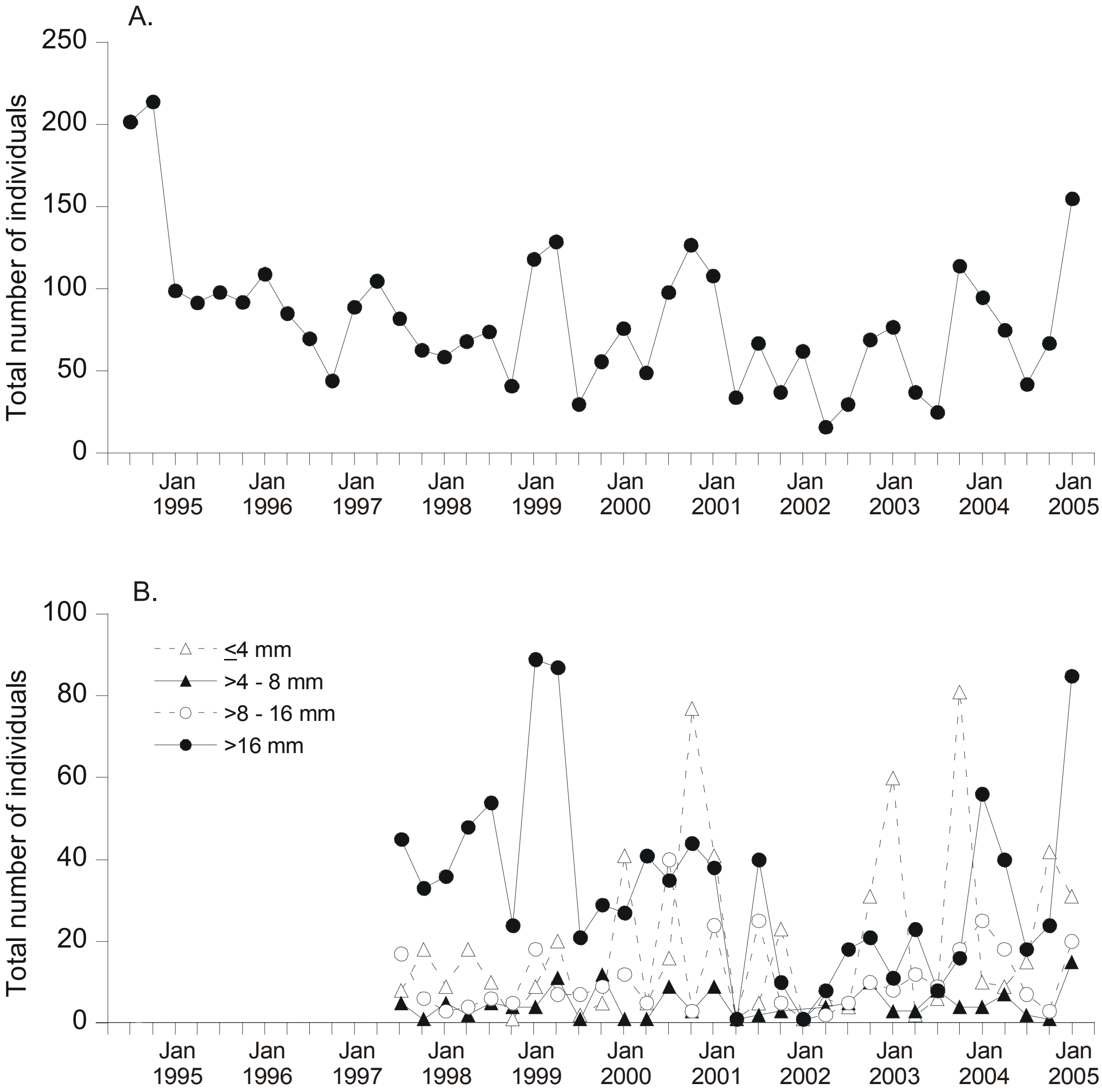


Table 7.

Magnitude of trends in abundance of intertidal taxa (July 1994 – January 2005) as indicated by the slope parameter estimates from regression analysis. Negative numbers indicate a decrease in abundance, while positive numbers indicate an increase. Analysis of each taxa was conducted firstly on all data, and then on baseline data only (i.e., with peak abundances removed). Trends in baseline data are shown in parentheses. When peak abundances did not occur in a repeatable, predictable temporal pattern, baseline trends could not be assessed. Only taxa for which significant trends ($P < 0.05$) were detected are presented. Comments indicate the status of current trends relative to those reported in Cummings et al. 2001 & 2003. See site sections for detailed discussion of trends and abundances. * trend considered uninformative due to sporadic occurrence/low abundances.

	Slope parameter estimate	Comments
Cowans Bay		
Polydorids	-0.182	Trend of decreasing abundance continues; first detected in 2001 analysis. Low density.
Paracalliope novizelandiae	0.048	Recent increase in abundance apparent (detected 2005). Low density, irregular occurrence.
*Torridoharpinia hurleyi**	1.232	Recent increase in abundance apparent (detected 2005). Trend unlikely to persist.
Hamilton Landing		
Aquilaspio aucklandica	0.519	Trend of increasing abundance continues; first detected in 2003 analysis.
Aricidea sp.	0.860	Recent increase in abundance apparent (detected 2005).
Austrovenus stutchburyi	-2.817	Trend of decreasing abundance continues; first detected in 2001 analysis. Low density.
Cossura sp.	22.091	Trend of increasing abundance strengthens; first detected in 2001 analysis. Now very high density.
Heteromastus filiformis	12.369	Trend of increasing abundance strengthens; first detected in 2001 analysis. Now very high density.
Macomona liliana	-0.513	Trend of decreasing abundance continues; first detected in 2001 analysis.
Nemerteans	0.301	Trend of increasing abundance continues; first detected in 2003 analysis.
Nucula hartvigiana	-0.347	Trend of decreasing abundance weakens; first detected in 2003 analysis. Now low density.
Oligochaetes		Trend of increasing abundance no longer apparent; detected in 2003 analysis only. Sporadic occurrence.
Perinereis nuntia		Trend of decreasing abundance no longer apparent; detected in 2003 analysis only. Sporadic occurrence.
Polydorids	-5.050	Recent decrease in abundance apparent (detected 2005).
Scoloplos cylindrifer	-0.304	Recent decrease in abundance apparent (detected 2005). Density now very low.
Jamieson Bay		
Aricidea sp.	(0.356)	Trend of increasing abundance continues, although now restricted to basal population; first detected in 2003 analysis.
Arthritica bifurca	0.159	Recent trend of increasing abundance apparent (detected 2005).
Cossura sp.		Trend of decreasing abundance no longer apparent; first detected in 2001 analysis.

	Slope parameter estimate	Comments
Macomona liliana	-0.891	Trend of decreasing abundance continues; first detected in 2001 analysis.
Notoacmea helmsi		Trends detected in 2001 (decreasing) and 2003 (increasing) no longer apparent.
Owenia fusiformis	-0.051	Trend of decreasing abundance continues; first detected in 2001 analysis. Density low.
Paracalliope novizelandiae	0.343	Trend of increasing abundance continues; first detected in 2003 analysis.
Polydorids	-9.110 (-3.620)	Trend of decreasing abundance continues; first detected in 2001 analysis.
*Torridoharpinia hurleyi**	-0.583	Trend of decreasing abundance continues; first detected in 2003 analysis. Trend unlikely to persist.
Mid Harbour		
Aricidea sp.	0.271	Trend of increasing abundance continues; first detected in 2003 analysis.
Arthritica bifurca		Trend of increasing abundance no longer apparent; detected in 2003 only.
*Aonides oxycephala**	-0.009	Trend of decreasing abundance continues; first detected in 2001 analysis. Present on two occasions only.
Cossura sp.		Trend of decreasing abundance no longer apparent; first detected in 2001 analysis.
Macomona liliana	-0.481	Trend of decreasing abundance continues; first detected in 2001 analysis.
Nucula hartvigiana		Trend of decreasing abundance of basal population no longer apparent; detected in 2003 only.
Te Kapa Inlet		
Aonides oxycephala		Trend of increasing abundance no longer apparent; detected in 2003 only.
Aquilaspio aucklandica	-1.167	Recent trend of decreasing abundance apparent (detected 2005).
Austrovenus stutchburyi		Trend of decreasing abundance no longer apparent; first detected in 2001 analysis.
Cossura sp.	14.896	Trend of increasing abundance continues; first detected in 2001 analysis. Now very high density.
Heteromastus filiformis	(4.575)	Recent trend of increasing abundance in basal population apparent (detected 2005).
Macomona liliana	-0.361	Trend of decreasing abundance continues; first detected in 2001 analysis.
Nemerteans	0.263	Trend of increasing abundance continues; first detected in 2001 analysis.
Polydorids	-0.912 (-1.092)	Trends of decreasing abundance in total and basal population continue; first detected in 2003.
*Torridoharpinia hurleyi**	0.273	Recent trend of increasing abundance apparent (detected 2005). Trend unlikely to persist.

4.1.3 Intertidal sites – general patterns

4.1.3.1 Populations showing trends in abundance

A total of 26 populations are currently showing trends in abundance; 14 of these populations are declining and 12 are increasing (Table 7).

Population trends have been detected at all sites, the most at Hamilton Landing (10 populations), and the least at Cowans Bay and Mid Harbour (2 populations each).

Sites showed a combination of increasing and decreasing trends. However, individual speces are showing consistent patterns across sites. As noted in 2003, decreasing trends were detected for *Macomona liliana* at all sites except Cowans Bay, and for *Austrovenus stutchburyi* and *Nucula hartvigiana* at Hamilton Landing. The declines in abundance detected in 2003 for *Austrovenus* at Te Kapa Inlet and *Nucula* at Mid Harbour are no longer apparent. Similarly, the increase in abundance of tiny bivalve *Arthritica bifurca* at Mid Harbour is no longer detected. *Arthritica* has, however, increased in abundance at Jameson Bay.

Of major concern is *Macomona liliana*, which is still exhibiting a decreasing trend in abundance at four intertidal sites (Table 7). At Mid Harbour and Te Kapa Inlet, numbers of >16 mm sized individuals have increased in the past two years of monitoring (Figures 10B, 12B), while few individuals of this size are found at Jamieson Bay (Figure 9B). This is promising, as the presence of these spawning sized individuals means recruitment may occur from within the site, and that persistence of these populations is not reliant only on supply of larvae and juveniles from elsewhere in the harbour. However, numbers of these large *Macomona* continue to be absent from Hamilton Landing (Figure 7B). Peaks in abundance of recruit-sized individuals were found at Hamilton Landing, Jamieson Bay, Mid Harbour and Te Kapa Inlet in the past two years (Figures 7B, 9B, 10B, 12B).

The concern in Mahurangi is that the decline in the *Macomona* abundance appears to be a harbour-wide phenomenon, based on data for the monitored sites. These sites do provide a good geographical spread of the harbour and populations have declined at all but one of our sites (i.e., Cowans Bay, where only low densities have ever been found (0 to 28 individuals over the monitored period). Recently we have made extensive observations of the intertidal flats in the harbour, while identifing sites suitable for a FRST funded experiment. These generally support the monitoring programme's observation of low *Macomona* abundance. Reasonable densities of *Macomona* were only apparent further up the harbour from the Mid Harbour site and in Lagoon Bay (near the harbour mouth). These populations may well prove to be important source populations, providing a supply of recruits (larvae and juveniles) to other parts of the harbour.

In our last report we noted a decline in abundance of *Austrovenus* at Hamilton Landing, and that the only individuals collected from this site are small ($\leq$4 mm). This is still the case with two more years of data. On a more promising note, at Jamieson Bay and Te Kapa Inlet, abundances of large (>16 mm) individuals have been higher than usual in the past two years, and recruit sized individuals have comprised over half the population at Te Kapa Inlet on at least two occasions (see Figures 8B and 13B). The only site now exhibiting a decline in *Austrovenus* populations is Hamilton Landing: the patterns noted above for Te Kapa Inlet have resulted in disappearance of the decreasing trend detected in previous years (Table 7). Recently, we have observed good cockle populations in Lagoon Bay and Pukapuka Inlet. As noted above for *Macomona*, these populations may potentially provide recruits to other parts of the harbour.

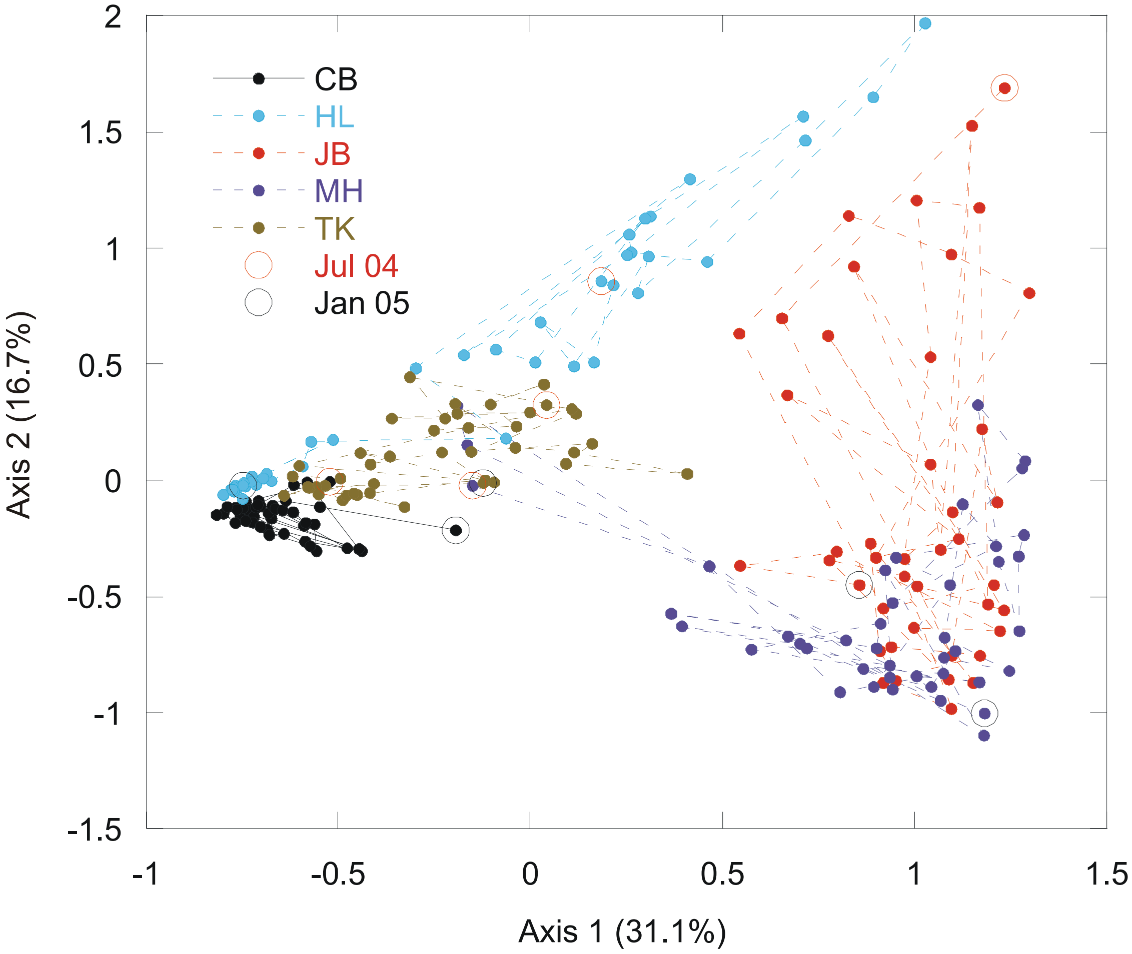
Trend analysis detected declines in eight polychaete populations, and increases in nine (Table 7). *Cossura* sp. exhibited increases in abundance in the last half of the monitored period at Hamilton Landing and Te Kapa Inlet. The *Heteromastus filiformis* population at Hamilton Landing has continued to increase over the monitored period. The *Aricidea* sp. population is now showing an increase at Jamieson Bay and Mid Harbour, and a particularly large increase at Hamilton Landing (Table 7; see also individual site discussions above). Two of these taxa (*Cossura* and *Aricidea*) thrive in muddy, organically enriched habitats.

Polydorids are now showing declines in abundance at all sites except Mid Harbour (Figure 4). At Mid Harbour, they appear to exhibit a greater than annual (i.e., 4 - 5 yearly) abundance pattern, with very high abundances for several years followed by low abundances for a similar length of time (Figure 4D). Once more data have been collected we may find that these apparent decreases at some of the remaining sites are actually part of greater than annual cyclic abundance patterns. In their long term monitoring programme in Manukau Harbour, Funnell et al. (2003) have noted that abundance cycles of a polydorid population (*Boccardia syrtis*) occur on the order of 5 to 7 years. The fact that no trend is detected at Mid Harbour may be because the highest abundances did not occur right at the beginning of the monitored period (as is the case for the Cowans Bay and Jamieson Bay populations; Figure 4).

4.1.3.2 Multivariate analysis of intertidal macrofaunal communities

Figure 14 shows the relative composition of the monitored-taxa communities at each site, and the temporal change in these communities over the sampling period. The patterns noted in our last report are still apparent. The Cowans Bay community is very stable, exhibiting very little temporal variation in community composition relative to the other intertidal sites. Hamilton Landing and Te Kapa Inlet have become more similar to the Cowans Bay site in the latter stage of the monitored period, as illustrated by the fact that these sites were situated close together in ordination space in January 2005. The monitored communities at Jamieson Bay and Mid Harbour have become more similar to each other.

Figure 14.
Correspondence analysis ordination plot, showing the temporal variation in the monitored community composition at each intertidal site over the monitored period. For each site, the positions of the community on the first (July 1994) and the most recent (January 2005) sampling occasions are highlighted. The percentage values associated with each axis indicate the % variance explained. CB = Cowans Bay, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.



4.2 Subtidal sites

4.2.1 Sediment Characteristics

As noted for the intertidal sites, sediment grain size characteristics at the subtidal sites have not changed markedly in the past two years (Appendix 3). The proportion of fine sand in the sediments varies at each site (Figure 15; Appendix 3), although it was considerably lower in April 1995.

The sediment organic and chlorophyll *a* content is shown in Table 8. In the past two years of monitoring, the sediment organic content at both subtidal sites has generally been higher than that noted on previous sampling occasions (Table 8A). Since January 2004, the sediment organic content has ranged from 3.27 to 5.13% at Site A, and from 0.93 to 7.39% at Site C (cf. 1.46 to 3.86% and 2.27 to 4.77%, respectively, prior to this time; Table 8A). Organic content is higher at the inner most harbour site, Site C, on all sampling dates except April 2002 and July 2004.

Sediment chlorophyll *a* levels were very similar at the two sites, ranging from 2.41-6.73 µg g^{-1} sediment at Site A, and from 1.94 - 7.11 µg g^{-1} sediment at Site C (Table 8B). Levels fluctuate in a similar manner at the two sites and, as noted for the intertidal sites, there is no obvious temporal pattern in sediment chlorophyll *a* variability.

Figure 15.
Changes in the proportions of the mud (i.e., silt + clay; <63 µm), fine sand (62.5 – 250 µm), medium sand (250 –500 µm) and coarse sediment (>500 µm) content at each of the subtidal sites over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 3.

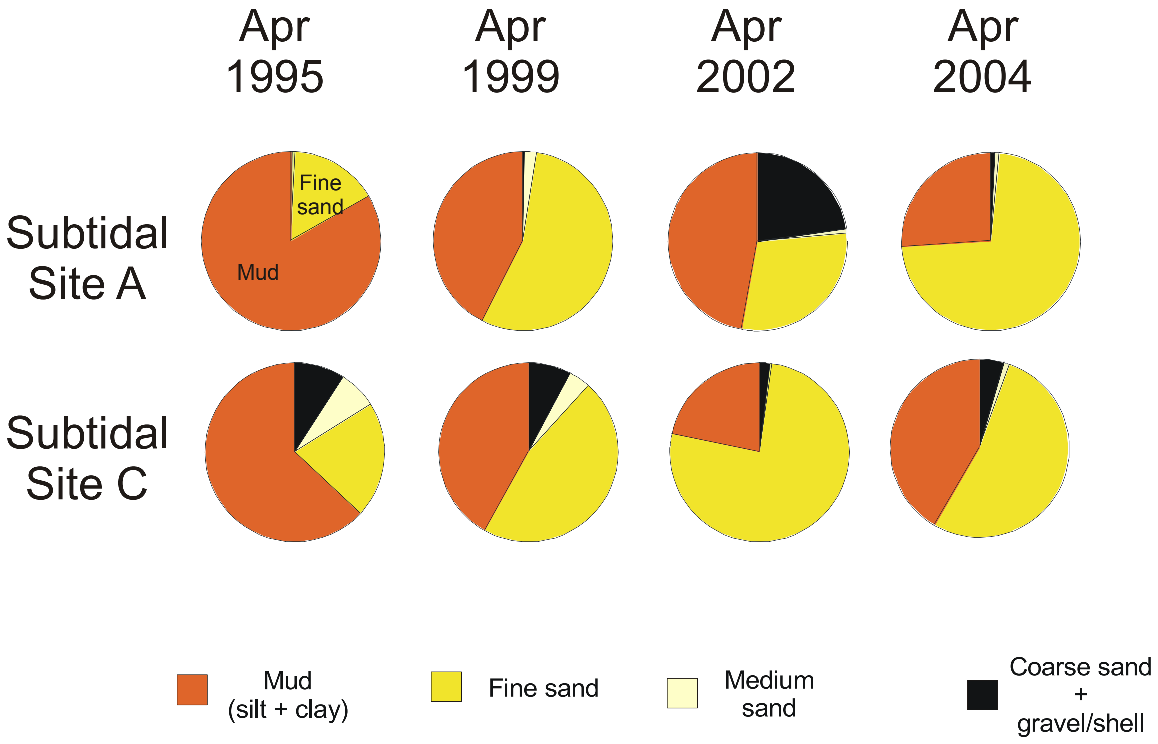


Table 8.

A. Organic content (% dry weight), and B. Chlorophyll *a* content ($\mu g\ g^{-1}$ sediment) of sediments at the subtidal sites from October 2000. * highest value recorded at each site.

A. Organic content

Sampling date	Site A	Site C
Oct00	1.93	3.43
Apr01	2.99	3.23
Oct01	2.42	4.15
Jan02	3.07	4.77
Apr02	3.86	2.44
Jul02	2.53	3.93
Oct02	1.46	2.44
Jan03	2.66	3.76
Apr03	1.85	4.33
July03	2.01	2.27
Oct03	2.40	4.41
Jan04	2.05	3.30
Apr04	5.13*	7.39*
Jul04	3.72	0.93
Oct04	4.26	0.80
Jan05	3.27	7.19

B. Chlorophyll *a*

Sampling date	Site A	Site C
Oct00	4.64	4.71
Apr01	3.66	2.97
Oct01	6.17	5.01
Jan02	3.87	4.99
Apr02	8.00*	5.46
Jul02	4.35	3.62
Oct02	4.32	4.17
Jan03	5.44	4.78
Apr03	4.45	1.94
July03	6.73	7.11*
Oct03	2.41	3.64
Jan04	4.23	4.79
Apr04	3.51	2.87
Jul04	3.28	4.06
Oct04	2.86	2.41
Jan05	4.00	4.57

4.2.2 Atrina zelandica

The low abundances of live *Atrina* at both subtidal sites over the monitored period has continued over the last two years, with similar numbers noted on each sampling occasion, and no differences between sites (Figure 16).

The mean sizes of the live individuals at Site C have increased slightly compared with the early stages of the monitoring programme (Figure 17). In the past two years, individuals at this site ranged from 11.0 ± 1.0 to 14.7 ± 2.0 cm (shell width). In comparison, since January 2003 sizes of individuals at Site A are more consistent between sampling occasions, ranging in size from 12.5 ± 0.4 to 14.0 ± 0.3 cm.

Figure 16.

The number of live *Atrina zelandica* recorded in a 0.25 m^2 quadrat at the two subtidal sites on each sampling occasion.

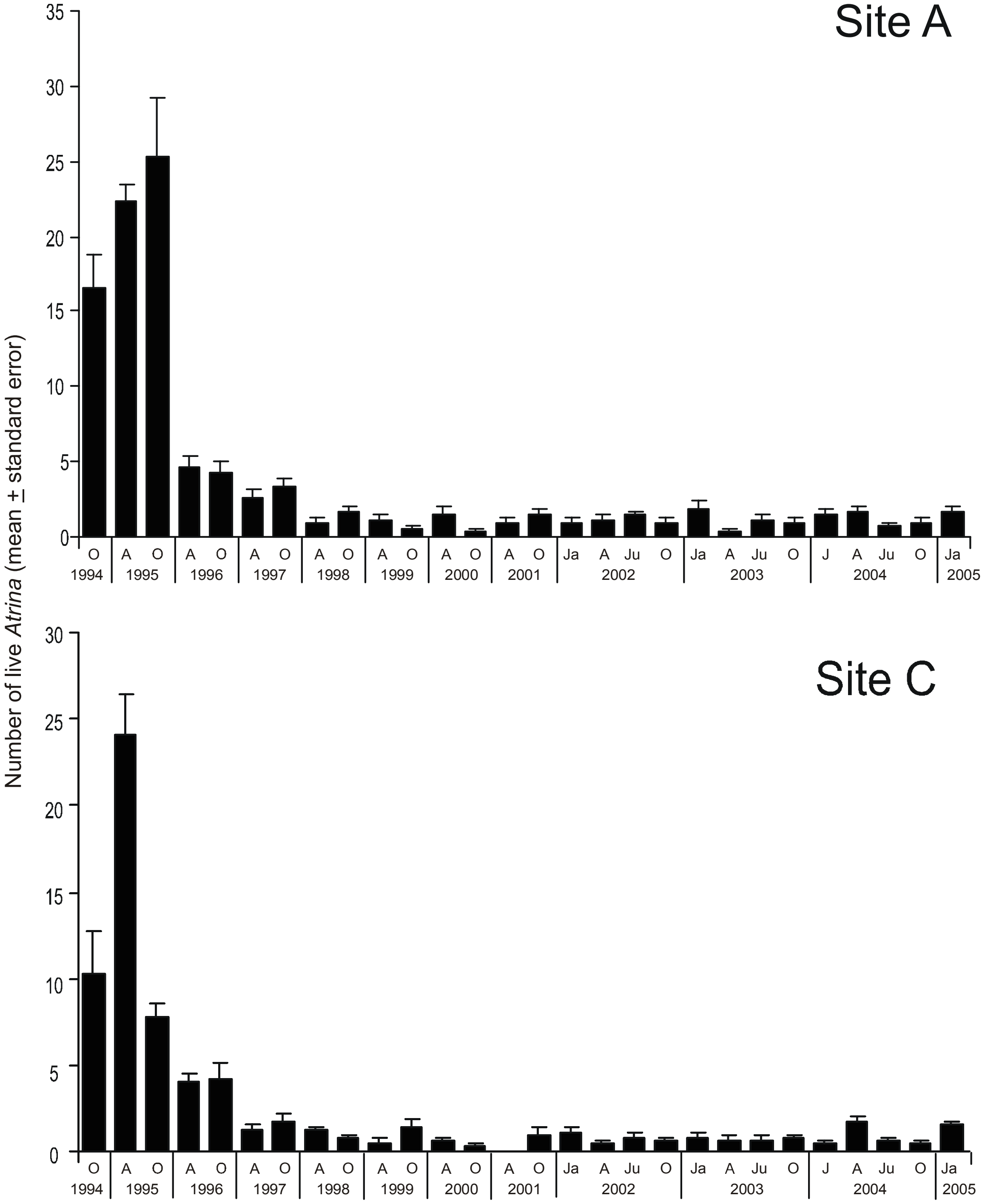
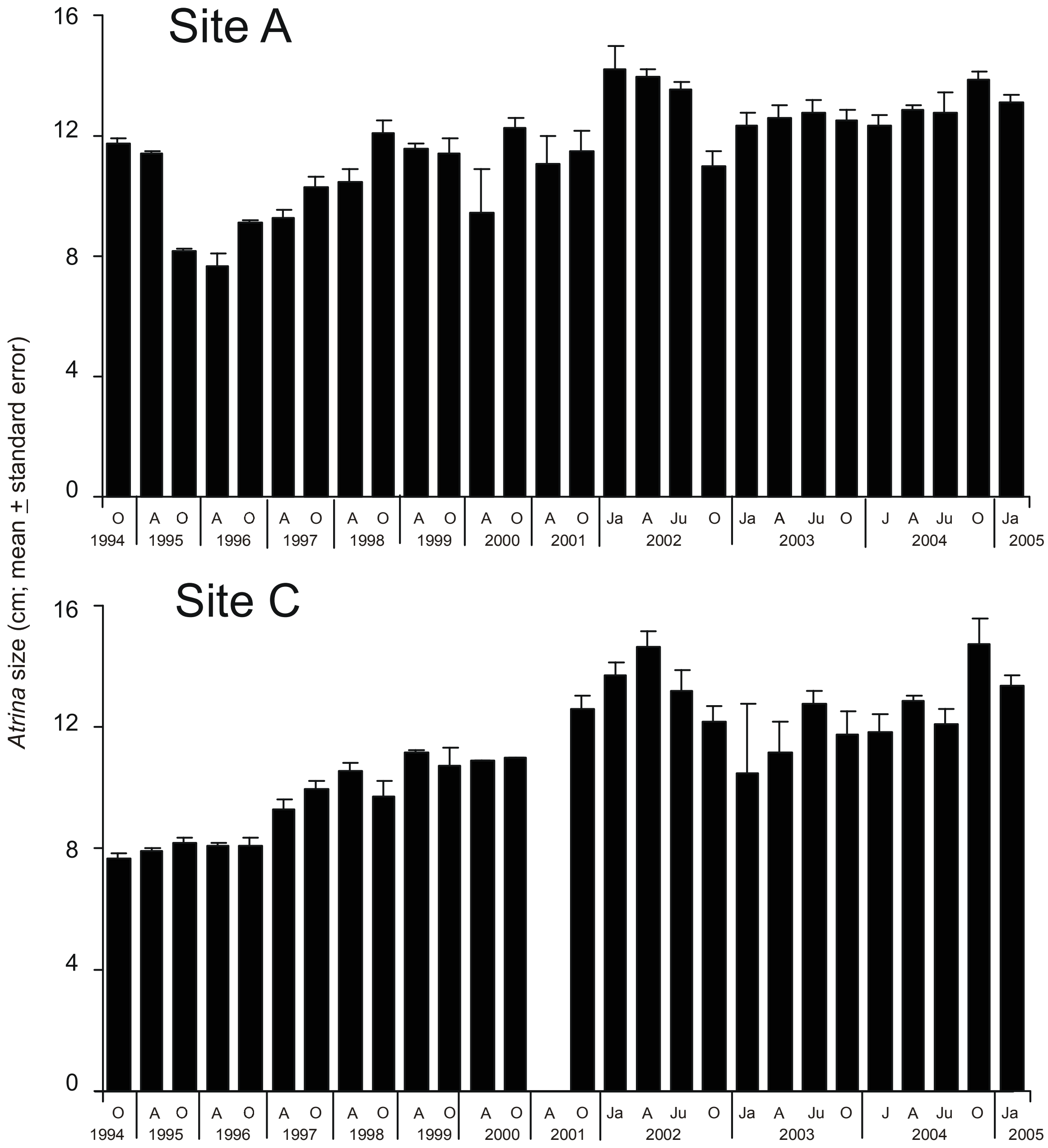


Figure 17.

The mean size of live *Atrina zelandica* recorded in a 0.25 m^2 quadrat at the two subtidal sites on each sampling occasion.



4.2.3 Macrofauna – comments on the abundance of common taxa

The abundances of subtidal monitored taxa collected at each site on each sampling date since the last report (i.e., from April 2003 to January 2005) are given in Appendix 4.

The following are site-by-site descriptions of the monitored macrofauna. For each site, we discuss the three most abundant taxa, populations exhibiting visually identifiable cycles in abundance, and populations for which statistically identifiable trends in abundance have been detected by trend analysis (Table 9).

Table 9.

Magnitudes of trends in abundance of subtidal taxa (October 1994 – January 2005) as indicated by the slope parameter estimates from regression analysis. Negative numbers indicate a decrease in abundance, while positive numbers indicate an increase. Analysis of each taxa was conducted firstly on all data, and then on baseline data only (i.e., with peak abundances removed). Trends in baseline data are shown in parentheses. When peak abundances did not occur in a repeatable, predictable temporal pattern, baseline trends could not be assessed. Only taxa for which significant trends (P < 0.05) were detected are presented. Comments indicate the status of current trends relative to those reported in Cummings et al. 2001 & 2003. See site sections for detailed discussion of trends and abundances.

	Slope parameter estimate	Comment
Site A		
Arthritica bifurca	0.401	Recent trend of increasing abundance apparent (detected 2005).
Aricidea sp.	0.361 (0.183)	Trend of increasing total abundance continues; first detected in 2001 analysis. Recent trend in basal population apparent (detected 2005).
Cirratulids	0.444	Trend of increasing abundance continues; first detected in 2003 analysis.
Theora lubrica	2.883	Trend of increasing abundance continues; first detected in 2001 analysis.
Site C		
Arthritica bifurca	-0.972	Recent trend of decreasing abundance apparent (detected 2005).
Cirratulids	0.362	Trend of increasing abundance continues; first detected in 2003 analysis.
Corophidae-complex	0.230	Trend of increasing abundance continues; first detected in 2003 analysis.
Theora lubrica	2.964 (1.316)	Trend of increasing abundance continues; first detected in 2001 analysis.

4.2.3.1 Site A

The bivalve *Theora lubrica* continues to be the dominant taxa at this site (Table 10). Abundances over the past two years have fluctuated considerably (i.e., from 36 – 27 individuals). *Arthritica bifurca* has occurred amongst the three dominant taxa on six of the eight most recent sampling occasions, reflecting the increased abundance of this bivalve at this site. Polydorids, Cirratulids, *Aricidea* sp. and *Torridoharpinia hurleyi* have each featured amongst the dominant taxa on two or three sampling dates in the past two years.

Populations showing cyclic abundance patterns

The polychaete *Armandia maculata* shows peaks in abundance in either April or October over the monitored period. However, the largest peaks occur in April some years, suggesting a greater than annual abundance cycle (Figure 18). As suggested in our last report, *Torridoharpinia hurleyi* appears to be exhibiting a greater than annual cycle in abundance (Figure 19). *Torridoharpinia* numbers were highest in April of 1995, 1998, 2003, and October of 1996, 2000 and 2004.

Populations showing trends in abundance

Increasing trends in abundance have been detected for four taxa at Site A (*Aricidea* sp. Cirratulids and the bivalves *Arthritica bifurca* and *Theora lubrica*; Table 9). *Aricidea* numbers were low at this site (0 - 2 individuals) until around October 2000, when 7 individuals were collected. Numbers have remained higher since this time, with 24 individuals collected in January 2003. An increase in *Aricidea* basal abundances was also detected. *Theora* abundances have also been higher in the second half of the monitored period; since 2002, peak numbers have occurred around April and have been higher than those on any previous sampling occasion (Figure 20). This year's trend analysis has also detected an increase in abundance of *Arthritica bifurca*, for the first time (Table 9). With the exception of April 1998, when 17 individuals were found, *Arthritica* numbers have been higher in the past two years than on any other sampling occasion (i.e., 11 – 24 individuals; Figure 21). Cirratulid numbers continue to increase at this site, and around 18 individuals are now generally found.

Figure 18.

The total number of *Armandia maculata* collected on each sampling occasion at the subtidal Site A. There was no trend detected in the total abundance of this polychaete.

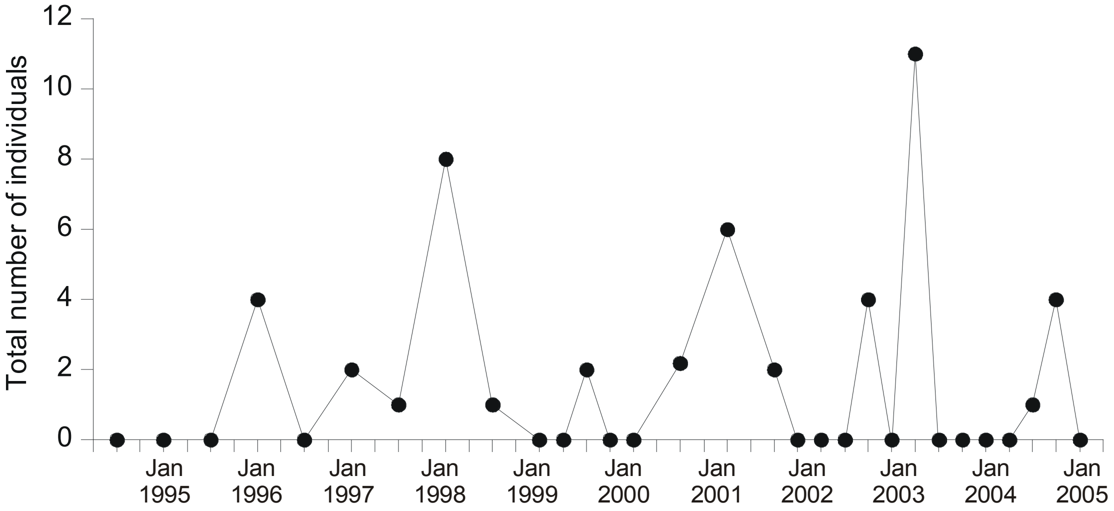


Figure 19.

The total number of *Torridoharpinia hurleyi* collected on each sampling occasion at subtidal Site A. There was no trend detected in the total abundance of this amphipod.

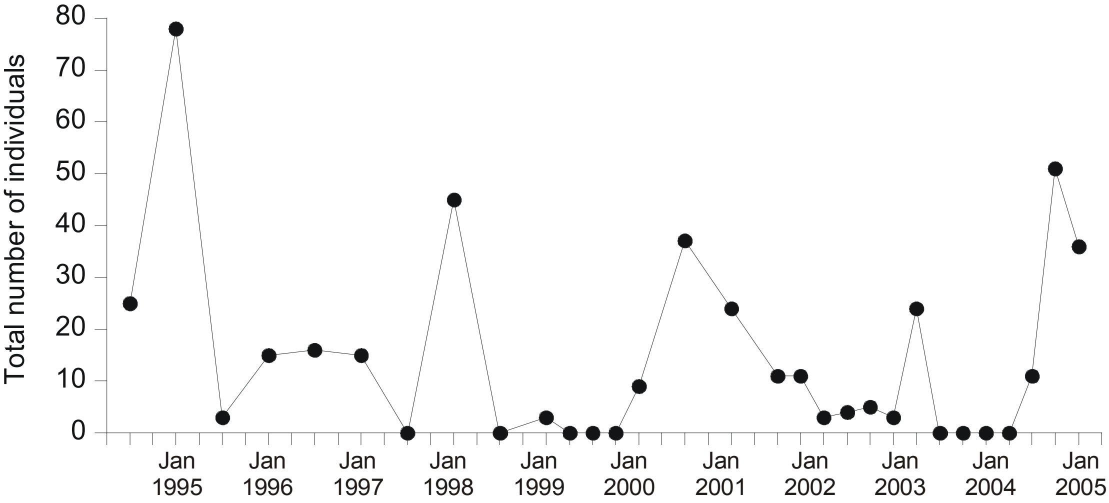


Table 10.

The three dominant taxa collected at subtidal Site A from October 1994 to January 2005. The most abundant taxa are on the left hand side of the table. When more than one taxa has the same rank they are represented as (for example) '*Arthritica bifurca* / *Cossura* sp.

Oct 94	*Prionospio* sp.	*Theora lubrica*	*Torridoharpinia hurleyi*
Apr 95	*Torridoharpinia hurleyi* / *Nucula hartvigiana*		*Theora lubrica*
Oct 95	*Theora lubrica*	*Arthritica bifurca*	Cirratulids
Apr 96	*Theora lubrica*	*Torridoharpinia hurleyi*	*Nucula hartvigiana*
Oct 96	*Theora lubrica*	Oligochaetes	*Torridoharpinia hurleyi*
Apr 97	*Theora lubrica*	*Torridoharpinia hurleyi*	*Prionospio* sp.
Oct 97	*Theora lubrica*	Cirratulids / *Prionospio* sp.	
Apr 98	Polydorids	*Torridoharpinia hurleyi*	*Theora lubrica*
Oct 98	*Theora lubrica*	Cirratulids	Oligochaetes / *Prionospio* sp.
Apr 99	*Theora lubrica*	*Arthritica bifurca*	Oligochaetes
Oct 99	*Theora lubrica*	Oligochaetes	*Arthritica bifurca* / Polydorids
Apr 00	*Theora lubrica*	Cirratulids / *Torridoharpinia hurleyi*	
Oct 00	*Theora lubrica*	*Torridoharpinia hurleyi*	Cirratulids
Apr 01	*Theora lubrica*	*Torridoharpinia hurleyi*	*Prionospio* sp.
Oct 01	*Theora lubrica*	Cirratulids	*Torridoharpinia hurleyi*
Jan 02	*Theora lubrica*	Cirratulids	*Torridoharpinia hurleyi*
Apr 02	*Theora lubrica*	Cirratulids	Polydorids
Jul 02	*Theora lubrica*	Cirratulids	*Prionospio* sp.
Oct 02	*Theora lubrica*	*Prionospio* sp.	Cirratulids
Jan 03	*Theora lubrica*	*Aricidea* sp.	*Arthritica bifurca*
Apr 03	*Theora lubrica*	*Arthritica bifurca* / *Torridoharpinia hurleyi*	
Jul 03	*Theora lubrica*	*Aricidea* sp.	Polydorids
Oct 03	*Theora lubrica*	*Arthritica bifurca*	Cirratulids
Jan 04	*Theora lubrica*	Polydorids	*Aricidea* sp.
Apr 04	*Theora lubrica*	Cirratulids	*Arthritica bifurca*
Jul 04	*Theora lubrica*	*Arthritica bifurca*	Cirratulids
Oct 04	*Theora lubrica*	*Torridoharpinia hurleyi*	*Arthritica bifurca*
Jan 05	*Theora lubrica*	Polydorids	*Aricidea* sp.

Figure 20.

The total number of *Theora lubrica* collected on each sampling occasion at the subtidal sites. There were increasing trends detected in the total abundance of this bivalve at both sites.

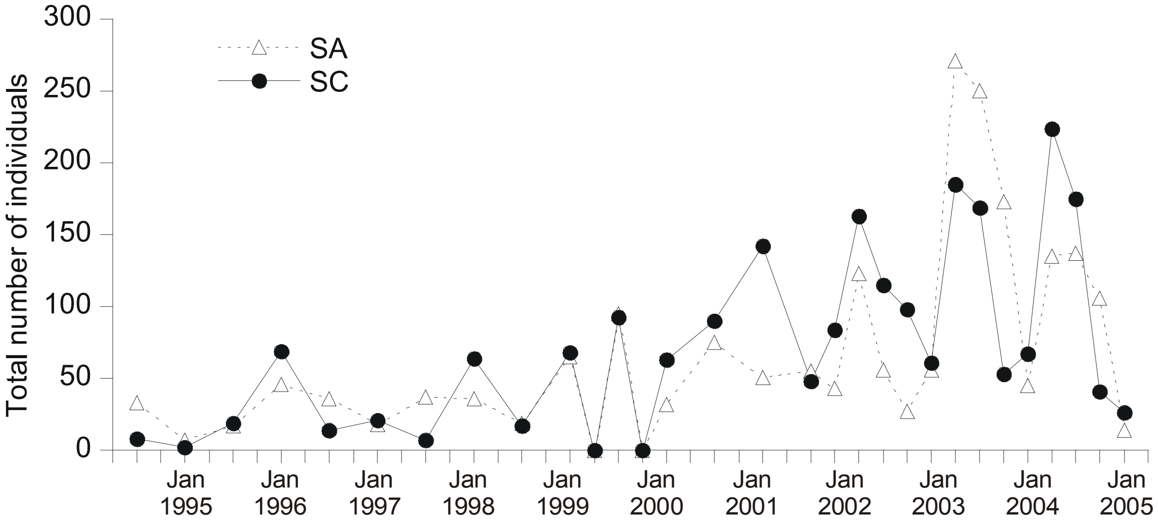
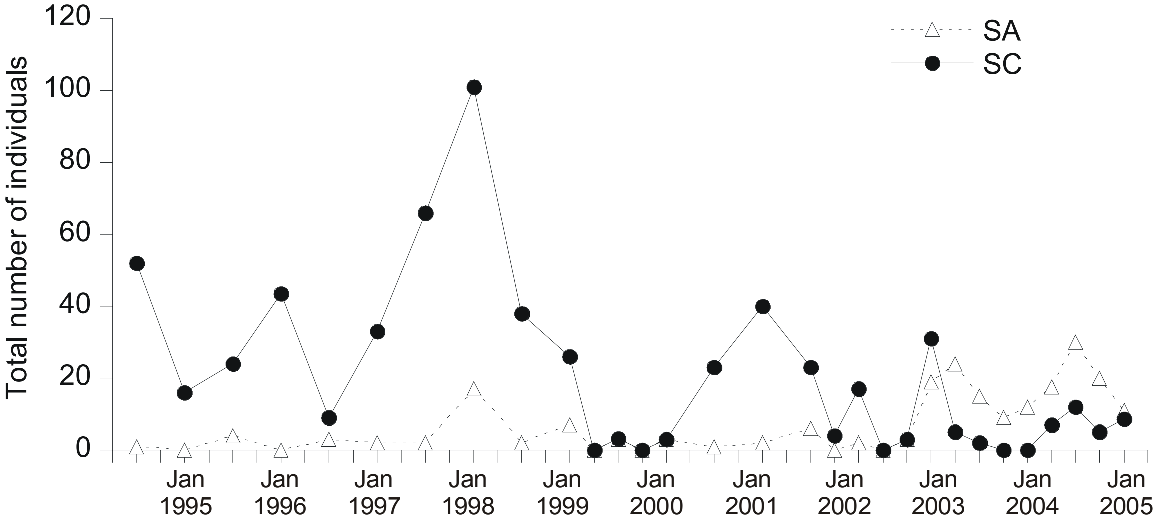


Figure 21.

The total number of *Arthritica bifurca* collected on each sampling occasion at the subtidal sites. There was an increasing trend in the total abundance of this bivalve detected at Site A, and a decrease at Site C.



4.2.3.2 Site C

Theora lubrica has been the first or second most abundant taxa at Site C on all sampling dates in the past two years (Table 11). Oligochaetes fluctuate widely in abundance (from 0 to >100 individuals), and were the most common taxa in January of 2004 and 2005. Since January 2003, Cirratulids and *Torridoharpinia hurleyi* have featured on five and four sampling dates, respectively. *Torridoharpinia* was the most abundant taxa in October 2004. *Arthritica bifurca* and *Prionospio* sp. have both featured amongst the dominant taxa on one occasion only in the past two years.

Populations showing cyclic abundance patterns

Peak abundances of *Theora lubrica* have always occurred in April, with one exception (October 1999); these peaks have occurred annually for the past four years, but were less frequent prior to this time (Figure 20).

Populations showing trends in abundance

Increasing abundance trends were detected for *Theora lubrica*, Cirratulids and Corophidae-complex amphipods, and a (new) decreasing trend was detected for *Arthritica bifurca* (Table 9). In addition, an increase in *Theora* basal abundances was also detected by this year's trend analysis. *Theora* numbers have continued to rise at this site; peak abundances have occurred in April in the past three years of monitoring (as also noted for Site A), when they were the highest ever recorded for this bivalve at this site (i.e., up to 224 individuals; Figure 20). Cirratulid numbers have also continued to increase, and are found in similar numbers to Cirratulids at Site A (although the timing of the peak abundances differ). On five sampling occasions over the past two years, abundances of Corophidae amphipods have been the highest ever recorded at this site. A trend was detected in *Arthritica bifurca* numbers for the first time this year; in contrast to Site A, however, numbers of this bivalve appear to be declining (Figure 21). Since January 2003, abundances have ranged from 0 to 12 individuals, compared to 0 to 101 individuals previously.

Table 11.

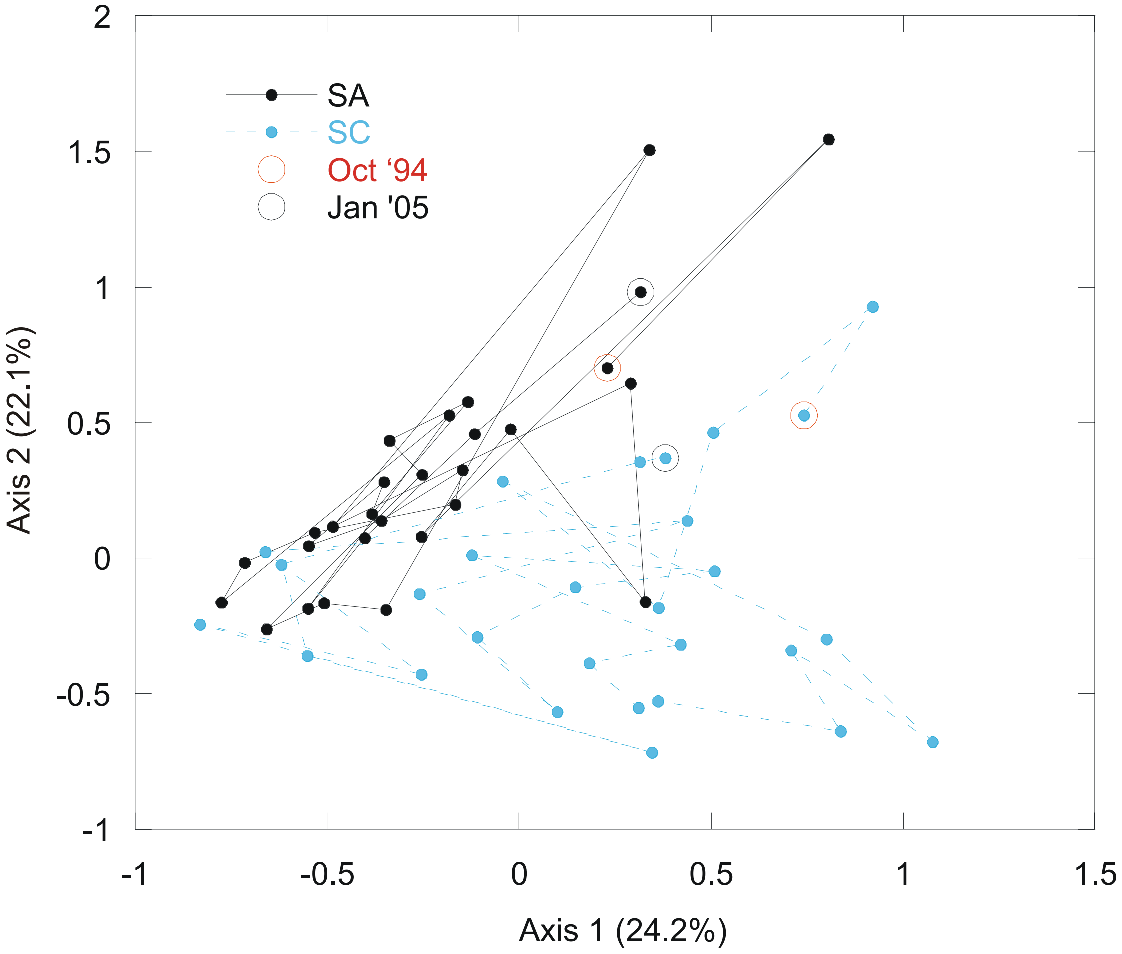
The three dominant taxa collected at subtidal Site C from October 1994 to January 2005. The most abundant taxa is on the left hand side of the table. When more than one taxa has the same rank they are represented as (for example) *Arthritica bifurca* / *Cossura* sp.

Oct 94	*Arthritica bifurca*	*Prionospio* sp.	*Torridoharpinia hurleyi*
Apr 95	*Nucula hartvigiana*	*Arthritica bifurca*	Polydorids
Oct 95	*Arthritica bifurca*	*Theora lubrica*	Polydorids
Apr 96	*Theora lubrica*	*Arthritica bifurca*	Oligochaetes
Oct 96	*Theora lubrica*	Tanaid B	*Arthritica bifurca*
Apr 97	Oligochaetes	*Arthritica bifurca*	*Theora lubrica*
Oct 97	Oligochaetes	*Arthritica bifurca*	*Prionospio* sp.
Apr 98	Oligochaetes	*Arthritica bifurca*	*Theora lubrica*
Oct 98	Oligochaetes	*Arthritica bifurca*	*Theora lubrica*
Apr 99	*Theora lubrica*	Oligochaetes	*Arthritica bifurca*
Oct 99	Oligochaetes	*Theora lubrica*	*Torridoharpinia hurleyi*
Apr 00	*Theora lubrica*	Oligochaetes	Cirratulids
Oct 00	Oligochaetes	*Theora lubrica*	*Torridoharpinia hurleyi*
Apr 01	*Theora lubrica*	*Arthritica bifurca*	Oligochaetes
Oct 01	Oligochaetes	*Theora lubrica*	*Torridoharpinia hurleyi*
Jan 02	*Theora lubrica*	Oligochaetes	Polydorids / Cirratulids
Apr 02	*Theora lubrica*	Oligochaetes	*Arthritica bifurca* / Cirratulids
Jul 02	*Theora lubrica*	Oligochaetes	Cirratulids
Oct 02	*Theora lubrica*	Oligochaetes	*Torridoharpinia hurleyi*
Jan 03	*Theora lubrica*	*Nucula hartvigiana*	*Arthritica bifurca*
Apr 03	*Theora lubrica*	*Prionospio* sp.	Cirratulids / *Torridoharpinia hurleyi*
Jul 03	*Theora lubrica*	Oligochaetes	*Aricidea* sp.
Oct 03	*Theora lubrica*	Cirratulids	Oligochaetes
Jan 04	Oligochaetes	*Theora lubrica*	Cirratulids
Apr 04	*Theora lubrica*	Oligochaetes	Cirratulids
Jul 04	*Theora lubrica*	Cirratulids	*Arthritica bifurca* / *Torridoharpinia hurleyi*
Oct 04	*Torridoharpinia hurleyi*	*Theora lubrica*	Oligochaetes
Jan 05	Oligochaetes	*Theora lubrica*	*Torridoharpinia hurleyi*

4.2.4 Multivariate analysis of subtidal macrofaunal communities

While the monitored communities at Sites A and C have exhibited considerable fluctuations over the monitored period, they are currently similar to those apparent at the start of the monitoring programme (Figure 22). On the last sampling date (January 2005) the communities at the two sites were also reasonably similar, both to each other and to those of the first sampling occasion (October 1994).

Figure 22.
Correspondence analysis ordination plot, showing the temporal variation in the monitored community composition at the subtidal sites over the monitored period. For each site, the positions of the community on the first (July 1994) and the most recent (January 2005) sampling occasions are highlighted. The percentage values associated with each axis indicate the % variance explained.



4.2.5 Subtidal sites – general patterns

4.2.5.1 Sediment characteristics

Similar to the intertidal sites, the sediment grain size composition has remained reasonably consistent at the two subtidal sites since our last report (Cummings et al. 2003). The increase in fine sand previously reported between the April 1996 and April 1997 is still apparent (Figure 15, Appendix 3).

4.2.5.2 *Atrina zelandica*

As noted in previous reports, abundances of *Atrina* declined markedly at both subtidal sites between October 1995 and April 1996 (Site A), and April 1995 and October 1995 (Site C) (see Figure 16). With little change in the size of individuals, and no apparent recruitment since monitoring began, we appear to be following one cohort through time.

4.2.5.3 Macrofauna

Cirratulids have increased at both sites over the monitored period, as has *Theora lubrica*. *Theora* continues to show very similar temporal fluctuations in abundance at Site A and Site C (Figure 20).

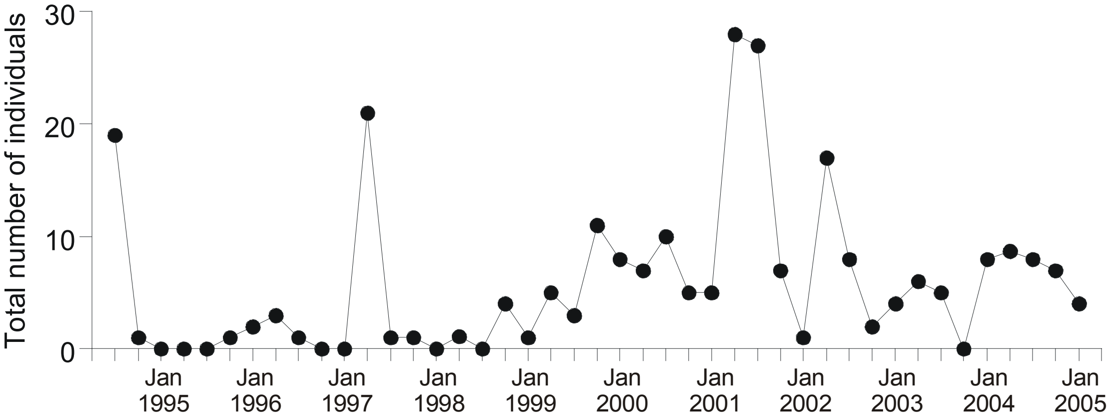
Trends in abundance were detected for *Arthritica bifurca* at both sites this year: an increase in abundance at Site A, and a decrease at Site C (Figure 21).

4.2.6 Alternative statistical test for trends

Comparison of the non-parametric Mann Kendall and the parametric regression analyses did not reveal any major differences between these two methods, underlining our confidence in the trend detcted by regression analysis. While there were some discrepancies between the Mann Kendall and the regression analyses results (Appendix 5), close examination of the abundance data for these species showed that the trend analysis result was, with one exception (i.e., Nemerteans at Mid Harbour), the most believable. While the size of the peaks in Nemertean abundances at Mid Harbour have not changed over the monitored period, basal abundances have been higher (by around 5 individuals; Figure 23) in the second half of this period. Because of the unpredictability in the timing of these peak abundances, the linear analysis is unable to be used to test for this change, although ANOVA does detect the step change.

Figure 23.

The total number of Nemerteans collected on each sampling occasion at Mid Harbour. There was an increasing trend in the total abundance of this population detected by Mann Kendall analysis only.



4.2.7 Power of detecting trends using regression analysis

The probability of incorrectly detecting a trend when there was not one there was set at 5% for all analyses (i.e., significance level of P=0.05). The observed power (or probability) of correctly detecting (or not detecting) trends in the abundances of each monitored taxa by regression analysis is shown in Table 12. As anticipated, the trends detected had a high power (generally >60%), illustrating the lack of information able to be gained by performing retrospective power analysis.

Effect sizes detectable with 80% power (generally used as a complement to the Type 1 error level of 5%) were calculated using the slope to estimate the magnitude of change over the monitored period and the standard deviation of observed residuals. While this standard deviation is observed rather than a population parameter, we feel this is a best unbiased estimator, due to the procedure adopted to determine the sample size used at each site at each time of sampling. Consideration was given to calculating a single standard deviation across sites for each species, but differences in temporal dynamics and mean population density prevented this from making ecological sense. The range of effect sizes observed in the raw data series of populations were calculated seperately for populations with detextable trends and then for those for which no trends were detected. Use of the baseline analysis resulted in the range of effect sizes being roughly similar for those populations for which trends were detected (0.137 – 80.38) and those for which trends were not detected (0.177 – 60.85).

Table 12.

The observed power (%) of regression analysis correctly detecting (or not detecting) trends in the abundances of the monitored taxa at each of the (A) intertidal and (B) subtidal sites. Values in bold indicate taxa for which significant trends were detected. '– ' = absent at this site.

A. Intertidal taxa	**Cowans Bay**	**Hamilton Landing**	**Jamiesons Bay**	**Mid Harbour**	**Te Kapa Inlet**
Aquilaspio aucklandica	31.84	**>97**	65.50	13.23	**72.57**
Arthritica bifurca	52.99	32.04	**84.89**	76.58	30.30
Aonides oxycephala	36.45	9.97	10.47	**69.19**	40.96
Aricidea sp.	28.26	**86.82**	**75.12**	**60.30**	46.38
Austrovenus stutchburyi	15.89	**>97**	35.86	9.46	78.44
Cossura sp.	44.39	**>97**	14.75	48.64	**>97**
Heteromastus filiformis	36.42	**>97**	31.33	27.36	**33.30**
Macrophthalmus hirtipes	27.33	16.94	4.90	1.76	26.14
Macomona liliana	16.00	**>97**	**>97**	**>97**	**95.37**
Nucula hartvigiana	47.12	**95.22**	29.58	11.00	21.91
Notoacmea helmsi	35.47	17.12	44.99	54.67	42.40
Nemerteans	46.24	**>97**	4.82	47.05	**>97**
Oligochaetes	4.69	34.08	46.09	6.49	7.56
Owenia fusiformis	-	-	**67.91**	-	-
Paracalliope novizelandiae	**85.65**	27.52	**65.00**	79.50	19.81
Perinereis nuntia	20.29	56.93	23.75	0.98	24.34
Polydorids	**67.59**	**85.85**	**>97**	45.48	**>97**
Scoloplos cylindrifer	3.82	**72.83**	4.81	7.60	43.64
Torridoharpinia hurleyi	**63.51**	58.05	**86.19**	6.81	**85.35**

B. Subtidal taxa	**Site A**	**Site C**
Arthritica bifurca	**>97**	**>97**
Aricidea sp.	**>97**	48.16
Armandia maculata	9.47	18.98
Cirratulids	**>97**	**>97**
Corophidae-complex	65.33	**91.56**
Nucula hartvigiana	71.44	31.90
Oligochaetes	33.71	7.71
Polydorids	6.80	23.40
Prionospio sp.	66.13	45.95
Torridoharpinia hurleyi	34.43	29.85
Theora lubrica	**>97**	**>97**
Tawera spissa	49.98	29.88

4.2.8 Synthesis of trends relative to sediment loading

Following the recommendations in Cummings et al. 2003, and subsequent meetings with ARC concerning the broad-scale trends apparent from this monitoring programme, a major initiative has been directed by ARC at improved identification and management of sediment sources in the Mahurangi Estuary catchment. In this section of the report we provide further comment on the general patterns apparent with two more years of data. We discuss trends in individual taxa, and similarity in community composition, in light of our 2003 recommendations and other information now available concerning sediment effects (e.g., Gibbs and Hewitt 2004).

Generally the trends in individual taxa reported here are still consistent with those noted in the 2003 report (Table 13). Of particular note in 2003 were the decreasing trends apparent for large bivalves at the intertidal sites – these are still apparent. We noted that bivalves considered to be 'valuable' members of intertidal sandflat communities had all but disappeared from Hamilton Landing over the monitored period (Cummings et al. 2003). This is still the case, with very low numbers of *Austrovenus* now found at this site. No spawning sized *Macomona* have been found at Hamilton Landing since January 2001. High numbers of recruit-sized individuals were noted at Hamilton Landing on occasion over the past two years. While the ability of these recruits to survive at Hamilton Landing is doubtful (due to the unsuitability of the substrate for this species), it is promising that populations are spawning elsewhere and thus that recruits are available for settlement should they encounter more suitable areas of the harbour. Recruitment peaks were also noted for *Macomona* at Jamieson Bay, Mid Harbour and Te Kapa, further supporting this idea. Although numbers of the largest size class of *Macomona* also remain low at Jamieson Bay, Mid Harbour and Te Kapa Inlet (i.e., <7 individuals), their numbers have increased at the latter two sites in recent years. For *Austrovenus*, the only monitored site with moderate numbers of spawning individuals is Te Kapa Inlet, where their numbers have increased in the past two years.

While predominantly mud sensitive bivalve species continue to decline, and species with a preference for muddy habitats continue to increase, this report does indicate the potential for recovery: juvenile life stages of some of the bivalves are reported at sites with low adult density, indicating that populations in other areas of the harbour could provide source populations to facilitate recovery if conditions at monitoring sites ameliorate.

The patterns in *Austrovenus stutchburyi* distribution noted in Mahurangi are consistent with those. found in Okura Estuary by Ford et al. (2003). In Okura, *Austrovenus* are consistently more numberous in low and medium sediment deposition areas.

Table 13.

Summary of sediment preferences for monitored taxa showing trends in abundance at Mahurangi monitoring sites. The general trend noted for each species in 2003, and the sites at which they were reported, is also given. HL = Hamilton Landing, CB = Cowans Bay, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet, SA = subtidal Site A, SC = subtidal Site C. Trends detected but considered uninformative due to sporadic occurrence or low taxa abundances (see Tables 7 and 9) are not included here.

Taxa currently showing trends	Decreasing sites	Increasing sites	General pattern reported in 2003[1]
Aquilaspio aucklandica	TK	HL	Increase (HL)
Aricidea sp.		HL; JB; MH; SA	Increase (JB, MH, SA)
Arthritica bifurca	SC	JB; SA	Increase (MH)
Austrovenus stutchburyi	HL		Decrease (HL; TK)
Cirratulids		SA; SC	Increase (SA; SC)
Corophidae-complex		SC	Increase (SC)
Cossura sp.		HL, TK	Increase (HL; TK)
Heteromastus filiformis		HL; TK	Increase (HL)
Macomona liliana	HL; JB; MH; TK		Decrease (HL; JB; MH, TK)
Nemerteans		HL; TK	Increase (HL; TK)
Nucula hartvigiana	HL		Decrease (HL; MH)
Owenia fusiformis	JB		Decrease (JB)
Paracalliope novizelandiae		CB; JB	Increase (JB)
Polydorids	CB; HL; JB; TK		Decrease (CB; JB; TK)
Scoloplos cylindrifer	HL		
Theora lubrica		SA; SC	Increase (SA; SC)

4.1.3.3 Sediment preferences of monitored taxa exhibiting trends

Information from a variety of surveys and experiments conducted over the years has been used to summarise the distribution patterns of many estuarine species with respect to the mud (i.e., silt and clay) content of the sediment (Norkko et al. 2001, Thrush et al. 2003). Some taxa have a very strong affinity to sediments low in mud, and are therefore not found in sediments with high mud content (e.g. the polychaete *Aonides oxycephala*, Norkko et al. 2001). Other taxa are found in a broad range of sediment types, and exhibit more gradual negative or positive responses to increasing sediment mud content. Despite having broad distribution ranges, some of these species might have a narrow range where their abundances are highest. For example, cockles (*Austrovenus*) were found in sediments containing up to 60% mud (albeit in low abundances), but their highest densities occurred in sediments with less than 10% mud (Norkko et al. 2001).

Based on results of laboratory and field experiments, and information from broad-scale habitat surveys (see Gibbs and Hewitt 2004 for summary and primary references), taxa can be ranked as being ‘sensitive’ or exhibiting ‘intermediate’ responses to increasing

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[1] Based on Cummings et al. 2003. An overview of these patterns was also provided in a power point presentation to ARC in November 2003.

sediment mud content (Gibbs and Hewitt 2004). The sediment preferences of the taxa showing trends in abundance in Mahurangi Estuary are shown in Table 14. S indicates those taxa which exhibit a wide distribution but a preference for sandy sediments. Intermediate taxa, I, prefer some mud, but not particularly high percentages. Taxa that have a strong preference for mud are indicated by MM.

There is remarkable consistency in the direction of trends in abundance relative to our assessment of sediment preference for these taxa (Table 14). Generally, taxa with a preference for sandy sediments are exhibiting decreasing abundance trends (blue arrows), while the one taxa with a preference for muddy sediments exhibits an increasing trend (yellow arrows).

As would be expected, taxa with intermediate sediment preferences are showing both increasing and decreasing trends. In addition, two species are showing different in trends at different sites (i.e., *Aquilaspio aucklandica* exhibits an increasing trend at Hamilton Landing and a decreasing trend at Te Kapa Inlet; *Aricidea* sp. is increasing at Mid Harbour and Hamilton Landing, and decreasing at Jamieson Bay; Table 14). It is important to note that the history of a site may account for between-site differences in the trend exhibited by a particular species. For example, an increase in the muddiness of a relatively sandy site may be more of a shock to it's communities than to those at a site that is already conditioned to considerable levels of mud.

Several taxa that are not routinely monitored in Mahurangi Estuary are also considered sensitive to increases in sediment mud content (Gibbs and Hewitt 2004). Examination of their abundance patterns at the monitored sites (e.g., *Goniada emerita*, Exogoninae) are consistent with responses to increased sediment loading.

The long term monitoring programme in Manukau Harbour has detected trends in abundance of some species that are consistent with those noted in Mahurangi Estuary. *Austrovenus stutchburyi*, *Macomona liliana*, *Owenia fusiformis* and are decreasing at Cape Horn, and *Boccardia syrtis* is declining at Clarks Beach (Funnell et al. 2005). The fact that we are seeing similar patterns in two estuaries that are widely separated geographically could indicate regional climate patterns are influencing these populations.

Table 14.

Summary of sediment preferences for monitored taxa showing trends in abundance at Mahurangi monitoring sites. Sediment preferences (Sed pref) are derived from Tables 5 & 6 in Gibbs & Hewitt 2004. * indicates preferences derived from Norkko et al. (2001). S = sand preference, I = prefers some mud but not high percentages; MM = strong mud preference. HL = Hamilton Landing, CB = Cowans Bay, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet, SA = subtidal Site A, SC = subtidal Site C. X indicates these taxa exhibited sporadic occurrences and low abundances, or were not found at all. - = not monitored. l = low abundance (total number of individuals <12); m = moderate abundance (total number of individuals 12-120); h = high abundance (total number of individuals >120).

		Intertidal sites					**Subtidal sites**	
Sed pref	**Taxa currently showing trends**	**JB** **Least muddy**	**MH**	**TK**	**CB**	**HL** **Most muddy**	**SA**	**SC**
S	*Austrovenus stutchburyi*	l-m	X	h	l	⇩ h-l	-	-
S	*Macomona liliana*	⇩ l-m	⇩ m-l	⇩ m	m	⇩ m-l	-	-
S*	*Nucula hartvigiana*	h	h	h	m	⇩ m-l	l	l-m
S	*Scoloplos cylindrifer*	l-m	X	l	X	⇩ m-l	l-m	X
S	*Owenia fusiformis*	⇩ l	X	X	X	X	-	-
I**	Polydorids	⇩ h-l	h	⇩ m	⇩ l-m	⇩ h-l	X	l-m
I	*Aquilaspio aucklandica*	m	X	⇩ m-h	l-m	⇧ m	-	-
I	*Aricidea* sp.	⇩ m	⇧ m	h	m	⇧ m	⇧ l-m	l-m
I	*Cossura* sp.	m	h	⇧ m-h	h	⇧ h	-	-
I	*Heteromastus filiformis*	m	h	⇧ m	h	⇧ h	-	-
I	Nemerteans	m	l-m	⇧ m	l-m	⇧ m	-	-
I	*Arthritica bifurca*	⇧ m	h	m	h	m	⇧ m	⇩ m-l
I	Cirratulids	-	-	-	-	-	⇧ l-m	⇧ l-m
I	*Theora lubrica*	-	-	-	-	-	⇧ m-h	⇧ m-h
MM	*Paracalliope novizelandiae*	⇧ l-m	X	X	⇧ l	X	-	-
	Trends agreeing with expected response of S & MM populations / number of S & MM populations	3/7	1/3	1/4	0/4	4/4	na	na

** note that while Polydorids are monitored in Mahurangi, this classification is for a specific Polydorid, *Boccardia syrtis.*

Atrina

The *Atrina* population has not grown appreciably at either subtidal site over the monitoring period (Figure 16). Individuals at Site A have increased in size only a small amount (2 cm) over the 11 years of monitoring. In comparison, individuals at Site C have grown by around 4 cm over the monitored period (Figure 17). This may be partly due to the different size/age of the individuals at the two sites when monitoring began. Site A individuals were around 12 cm on the first sampling occasion, while those at Site C were much smaller, at around 8 cm. Little is known of the basic natural history of *Atrina*, in fact this monitoring programme provides the only long-term data for the species. Nevertheless, our observations around the region indicate that the growth pattern and recruitment of *Atrina* is similar to other related species of pinnid bivalues found in Austrialia, Mexico and Europe. Dense patches of *Atrina*, as originally occurred in Mahurangi, are created by occasional episodic recruitment events. Once settled, the juveniles probably grow quickly to gain the advantage that size confers on protection from predators and high sediment concentrations near the bed. After fast initial growth (probably to about 6 - 8 cm width), growth rate slows. However, growth of only 4 cm over an 11 year period may be partially explained by the high suspended sediment concentrations at Site C, which are at the limit for survival of *Atrina* in this harbour (Ellis et al. 1999, 2002).

In 2003 we noted that the relative abundances of the monitored species at each site indicated that some sites were becoming more similar in community composition (based on interpretation of the correspondence analysis plots). As noted in a recent summary of the ecological implications of sediment loading to estuaries and coastal ecosystems, this homogenisation of community composition is likely to have significant implications for the diversity and resilience of these communities (Thrush et al. 2004).

5 Conclusions

The monitoring should continue, as it is detecting trends and remarkably consistent patterns in taxa abundances across Mahurangi Harbour. Importantly, this information is being used as part of a broader and integrated strategy of improving catchment management. Thus with two more years of monitoring data our previous recommendations concerning the need to investigate improved sediment controls still stand. However, additional information has also highlighted the positive potential for recovery of the harbour, particularly with evidence that bivalve populations elsewhere in the estuary are potentially supplying recruits to the monitored sites.

In our previous reports we have recommended that the ARC examine possible reasons for the observed changes, and suggested that in the first instance a desktop study be conducted to consider changes in catchment land use and hydrology, on which to base the need for further management decisions (Cummings et al. 2001, 2003). A major joint project is now underway between ARC and the Rodney District Council to develop and implement the Mahurangi Action Plan (MAP), which will address environmental issues with the aim of protecting and enhancing the existing values of Mahurangi Estuary and, especially to 'halt, slow or reverse the adverse effects of sedimentation' on it's health (refer to the website for details: http://www.arc.govt.nz/arc/environment/land/mahurangi-newsletter.cfm). There is a strong focus on the education and participation of both land users and the local community in the MAP; there has been opportunity for these stakeholders to provide input to the MAP from its inception, and a grants fund is available to apply for assistance to undertake restoration and improvement to protect and enhance land, streams and waterways, and thus reduce the potential for sediment generation. Addressing this issue is a priority for ARC, and this ecological monitoring programme will continue to offer important data on the ecological condition of the estuary to support the adaptive development of management actions.

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Appendix 1

Results of grain size analysis for the intertidal sites.

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)
Gravel/ Shell hash	1995	Apr	0.07	0.04	0.37	0.64	3.50	0.24
	1996	Apr	0.00	0.00	0.00	0.00	0.00	0.00
	1997	Apr	0.02	0.00	21.42	6.56	10.14	0.00
	1998	Apr	0.02	1.16	16.08	1.78	1.94	0.01
	1999	Apr	0.03	0.00	5.04	1.50	0.83	0.12
	2000	Apr	0.02	0.18	8.61	0.67	0.43	0.00
		Jul	0.07	0.00	18.96	0.00	3.72	0.00
		Oct	0.05	0.00	7.98	0.10	1.79	0.00
	2001	Jan	0.43	0.04	0.65	0.19	1.60	0.00
		Apr	0.00	0.00	8.5	0.33	0.00	0.04
		Jul	0.00	0.00	0.13	0.46	0.06	0.00
		Oct	0.00	0.00	3.27	0.43	0.68	0.00
	2002	Jan	0.00	0.00	1.79	0.02	1.58	0.00
		Apr	0.02	0.00	0.17	2.38	0.32	0.25
		Jul	1.63	7.34	0.26	0.35	0.00	0.00
		Oct	0.00	0.06	0.02	4.02	31.18	0.16
	2003	Jan	0.00	0.01	0.51	0.07	0.76	0.40
		Apr	0.02	0.00	0.19	1.80	0.46	0.29
		Jul	0.00	0.00	2.88	0.19	0.09	0.07
		Oct	0.00	0.00	19.72	0.16	0.50	0.03
	2004	Jan	0.00	0.00	17.17	0.43	3.93	0.00
		Apr	0.00	0.00	12.01	4.99	0.35	0.00
		Jul	0.00	0.00	5.34	0.51	0.34	1.95
		Oct	0.02	0.02	8.03	0.56	0.65	0.00
	2005	Jan	0.00	0.00	2.83	0.97	2.70	0.00

Coarse sand	1995	Apr	0.08	0.17	0.27	0.20	3.58	0.22
	1996	Apr	0.54	1.47	21.11	6.17	5.99	1.73
	1997	Apr	0.06	0.34	6.02	1.43	0.18	0.03
	1998	Apr	0.06	0.93	11.36	0.34	0.62	0.15
	1999	Apr	0.05	0.21	2.06	0.17	0.08	0.07
	2000	Apr	0.07	0.32	14.01	0.33	0.24	0.14
		Jul	0.07	0.23	9.33	0.13	0.29	0.10
		Oct	0.06	0.08	4.37	0.62	0.23	0.16
	2001	Jan	0.14	0.17	0.65	0.34	0.07	0.09
		Apr	0.06	0.06	18.88	0.05	0.35	0.21
		Jul	0.51	0.15	0.30	0.54	0.09	0.34
		Oct	0.00	0.00	2.80	0.05	0.07	0.00
	2002	Jan	0.02	0.00	7.48	0.00	0.14	0.00
		Apr	0.14	0.10	1.32	0.18	0.09	0.07
		Jul	4.70	3.06	0.14	0.96	0.09	0.04
		Oct	0.06	0.06	0.11	7.86	0.13	0.16
	2003	Jan	0.06	0.12	0.49	0.12	0.49	0.17
		Apr	0.13	0.09	1.50	0.13	0.17	0.08
		Jul	0.07	0.26	2.27	0.20	0.31	0.07
		Oct	0.02	0.12	10.22	0.05	0.09	0.09
	2004	Jan	0.00	0.00	12.67	0.26	1.09	0.15
		Apr	0.00	0.12	7.69	0.54	0.19	0.08
		Jul	0.00	0.02	10.69	0.24	0.41	0.05
		Oct	0.06	0.22	7.54	0.19	0.37	0.14
	2005	Jan	0.00	0.07	7.74	0.00	0.37	0.14
Medium sand	1995	Apr	38.94	30.74	64.93	43.64	38.15	39.60
	1996	Apr	18.37	15.71	32.19	39.50	26.03	13.42
	1997	Apr	8.71	1.08	15.78	5.63	2.19	3.56
	1998	Apr	0.78	5.18	22.67	6.29	2.48	0.50
	1999	Apr	1.84	3.43	11.08	2.26	1.82	2.43
	2000	Apr	0.52	4.81	46.93	4.19	1.10	1.72
		Jul	0.60	1.08	11.94	4.80	2.24	0.33
		Oct	0.90	0.74	33.67	8.10	2.83	1.66
	2001	Jan	0.83	4.52	6.08	5.64	2.05	1.73
		Apr	0.72	0.70	39.23	2.08	0.48	1.50
		Jul	0.67	0.81	5.01	7.4	1.83	1.38
		Oct	0.57	0.13	10.89	5.04	2.17	0.88
	2002	Jan	0.43	0.61	19.77	15.08	1.65	1.28
		Apr	0.66	2.70	7.28	2.75	1.42	1.10
		July	15.14	1.85	3.16	0.90	0.20	0.61
		Oct	0.52	0.34	3.11	19.76	1.53	1.69
	2003	Jan	0.95	0.26	3.44	2.75	1.66	1.34
		Apr	0.65	2.41	8.30	2.08	0.94	1.29
		Jul	0.44	0.53	26.98	2.25	2.93	1.45
		Oct	0.49	0.25	18.79	3.91	1.17	0.77

	2004	Jan	0.69	0.23	20.72	4.51	1.67	1.78
		Apr	0.56	0.35	16.03	2.72	1.32	1.57
		Jul	0.38	0.30	24.34	7.73	1.67	1.10
		Oct	0.61	0.37	15.02	3.27	1.66	1.41
	2005	Jan	0.92	0.23	18.71	3.43	1.63	1.73
Fine sand	1995	Apr	38.04	26.50	24.65	33.05	24.41	29.34
	1996	Apr	28.40	19.08	19.11	26.16	16.90	19.79
	1997	Apr	75.34	33.23	52.17	72.05	73.46	67.23
	1998	Apr	79.76	52.91	47.18	80.72	75.12	58.41
	1999	Apr	77.54	52.55	74.14	81.09	68.21	70.32
	2000	Apr	66.19	60.20	29.26	79.84	79.29	63.18
		Jul	70.18	42.73	56.13	74.69	87.48	54.48
		Oct	71.24	51.56	50.38	86.93	75.16	60.85
	2001	Jan	72.19	62.16	84.19	85.25	85.81	62.42
		Apr	77.79	56.02	31.69	62.62	53.70	62.77
		July	71.76	50.02	87.15	60.77	79.95	60.87
		Oct	80.53	44.40	71.37	83.77	82.89	61.61
	2002	Jan	81.51	57.74	63.83	74.17	79.31	65.13
		Apr	69.70	55.98	80.65	78.88	83.52	64.96
		Jul	70.72	58.54	73.40	76.53	45.41	63.87
		Oct	70.99	49.23	83.39	61.47	56.65	65.82
	2003	Jan	79.42	55.57	84.20	86.93	79.10	76.72
		Apr	69.19	49.97	92.01	59.49	77.47	76.09
		Jul	71.03	47.82	58.73	74.61	82.82	64.66
		Oct	71.70	48.10	45.71	87.08	77.57	57.06
	2004	Jan	67.38	43.87	42.37	86.83	82.64	63.57
		Apr	72.59	45.03	56.77	80.87	83.56	59.64
		Jul	68.43	50.00	54.36	84.43	89.73	58.56
		Oct	68.08	54.08	62.39	86.23	88.12	63.54
	2005	Jan	71.24	57.91	62.94	88.30	86.59	60.75
Silt	1995	Apr	17.42	34.03	6.44	18.37	27.38	23.63
	1996	Apr	38.08	46.32	19.30	19.69	33.01	48.03
	1997	Apr	11.12	39.04	4.09	7.78	7.27	21.66
	1998	Apr	12.74	29.06	2.38	6.71	12.75	29.93
	1999	Apr	8.24	27.77	7.56	8.73	17.98	19.41
	2000	Apr	24.61	20.37	0.30	9.94	12.50	27.58
		Jul	29.01	54.62	3.79	17.36	4.27	34.20
		Oct	22.02	41.08	3.06	3.88	16.76	19.14
	2001	Jan	22.22	28.10	8.00	7.10	7.93	29.95
		Apr	18.98	40.19	0.04	31.70	36.64	29.83
		Jul	26.93	47.46	7.36	30.22	17.02	35.93
		Oct	7.84	48.63	11.09	3.31	11.83	32.13
	2002	Jan	17.60	35.24	6.75	8.09	14.72	29.48
		Apr	22.81	37.26	7.05	10.28	12.78	29.32
		Jul	5.68	17.34	20.52	14.17	30.34	26.90
		Oct	23.51	38.81	9.88	4.14	7.88	25.73

	2003	Jan	15.15	35.03	8.66	6.75	7.20	12.82
		Apr	23.21	27.12	20.00	19.50	26.00	26.15
		Jul	22.25	45.58	7.53	15.59	9.23	32.11
		Oct	23.60	47.52	2.78	5.28	11.00	32.54
	2004	Jan	22.54	54.95	6.70	4.16	4.57	26.93
		Apr	15.66	33.74	3.7	3.11	9.72	31.33
		Jul	23.17	44.03	3.36	3.86	4.58	36.34
		Oct	24.99	33.05	4.82	5.85	4.60	28.56
	2005	Jan	18.56	31.90	3.59	3.13	6.66	23.01
Clay	1995	Apr	5.45	4.96	3.34	4.10	2.98	6.98
	1996	Apr	14.61	17.42	8.29	8.48	18.07	17.03
	1997	Apr	4.75	26.33	0.51	6.54	6.76	7.52
	1998	Apr	6.64	10.77	0.32	4.18	7.09	11.00
	1999	Apr	12.31	16.05	0.14	6.25	11.09	7.65
	2000	Apr	8.60	14.12	0.90	5.03	6.43	7.37
		Jul	0.08	1.34	0.11	3.01	2.00	10.89
		Oct	5.74	6.54	0.53	0.37	3.22	18.19
	2001	Jan	4.19	5.02	0.45	1.47	2.55	5.82
		Apr	2.45	3.04	1.67	3.23	8.83	5.65
		Jul	0.13	1.55	0.05	0.62	1.06	1.49
		Oct	11.05	6.83	0.58	7.40	2.35	5.38
	2002	Jan	0.44	6.41	0.37	2.64	2.61	4.11
		Apr	6.68	3.95	3.53	5.53	1.88	4.31
		Jul	2.13	11.87	2.52	7.09	23.95	8.59
		Oct	4.92	11.50	3.49	2.76	2.63	6.43
	2003	Jan	4.43	9.01	2.64	3.38	10.79	8.55
		Apr	6.79	2.88	10.00	10.50	4.00	3.85
		Jul	6.21	5.82	1.61	7.16	4.62	1.63
		Oct	4.19	4.00	2.78	3.52	9.68	9.52
	2004	Jan	9.39	0.95	0.37	3.81	6.09	7.57
		Apr	11.19	20.77	3.74	7.77	4.86	7.37
		Jul	8.02	5.64	1.92	3.22	3.27	1.98
		Oct	6.25	12.24	2.19	3.90	4.60	6.35
	2005	Jan	9.28	9.90	4.19	4.17	2.05	14.38

Appendix 2

Summary of temporal results[2] at the intertidal sites from April 2003 (Time = 36) to January 2005 (Time = 43).

Taxa	Site	Time	Total[3]	Median	Range[4]	Mean
Aonides oxycephala	CB	36	0	0	0	0.00
Aonides oxycephala	CB	37	0	0	0	0.00
Aonides oxycephala	CB	38	1	0	1	0.08
Aonides oxycephala	CB	39	0	0	0	0.00
Aonides oxycephala	CB	40	0	0	0	0.00
Aonides oxycephala	CB	41	0	0	0	0.00
Aonides oxycephala	CB	42	1	0	1	0.08
Aonides oxycephala	CB	43	0	0	0	0.00
Aonides oxycephala	HL	36	0	0	0	0.00
Aonides oxycephala	HL	37	0	0	0	0.00
Aonides oxycephala	HL	38	0	0	0	0.00
Aonides oxycephala	HL	39	0	0	0	0.00
Aonides oxycephala	HL	40	0	0	0	0.00
Aonides oxycephala	HL	41	0	0	0	0.00
Aonides oxycephala	HL	42	0	0	0	0.00
Aonides oxycephala	HL	43	0	0	0	0.00
Aonides oxycephala	JB	36	56	0	31	4.67
Aonides oxycephala	JB	37	13	0	12	1.08
Aonides oxycephala	JB	38	20	0	9	1.67
Aonides oxycephala	JB	39	38	0	23	3.17
Aonides oxycephala	JB	40	15	0	8	1.25
Aonides oxycephala	JB	41	44	0	16	3.67
Aonides oxycephala	JB	42	10	0	5	0.83
Aonides oxycephala	JB	43	17	0	13	1.42
Aonides oxycephala	MH	36	0	0	0	0.00
Aonides oxycephala	MH	37	0	0	0	0.00
Aonides oxycephala	MH	38	0	0	0	0.00
Aonides oxycephala	MH	39	0	0	0	0.00
Aonides oxycephala	MH	40	0	0	0	0.00
Aonides oxycephala	MH	41	0	0	0	0.00
Aonides oxycephala	MH	42	0	0	0	0.00
Aonides oxycephala	MH	43	0	0	0	0.00
Aonides oxycephala	TK	36	0	0	0	0.00
Aonides oxycephala	TK	37	0	0	0	0.00
Aonides oxycephala	TK	38	0	0	0	0.00
Aonides oxycephala	TK	39	0	0	0	0.00

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[2] Data is only given if the taxa occurred at a site during this time period.

[3] Total number of individuals collected in 12 samples. Calculated by mean abundance*12.

[4] Range = between the 5th and 95th percentile.

Aonides oxycephala	TK	40	0	0	0	0.00
Aonides oxycephala	TK	41	0	0	0	0.00
Aonides oxycephala	TK	42	0	0	0	0.00
Aonides oxycephala	TK	43	1	0	1	0.08
Aquilaspio aucklandica	CB	36	2	0	1	0.17
Aquilaspio aucklandica	CB	37	0	0	0	0.00
Aquilaspio aucklandica	CB	38	0	0	0	0.00
Aquilaspio aucklandica	CB	39	1	0	1	0.11
Aquilaspio aucklandica	CB	40	0	0	0	0.00
Aquilaspio aucklandica	CB	41	0	0	0	0.00
Aquilaspio aucklandica	CB	42	2	0	1	0.17
Aquilaspio aucklandica	CB	43	0	0	0	0.00
Aquilaspio aucklandica	HL	36	18	2	3	1.50
Aquilaspio aucklandica	HL	37	19	2	4	1.58
Aquilaspio aucklandica	HL	38	21	2	4	1.73
Aquilaspio aucklandica	HL	39	42	3	11	3.50
Aquilaspio aucklandica	HL	40	27	2	5	2.25
Aquilaspio aucklandica	HL	41	17	1	6	1.42
Aquilaspio aucklandica	HL	42	19	1	5	1.58
Aquilaspio aucklandica	HL	43	24	2	5	2.00
Aquilaspio aucklandica	JB	36	2	0	1	0.17
Aquilaspio aucklandica	JB	37	0	0	0	0.00
Aquilaspio aucklandica	JB	38	0	0	0	0.00
Aquilaspio aucklandica	JB	39	1	0	1	0.08
Aquilaspio aucklandica	JB	40	1	0	1	0.08
Aquilaspio aucklandica	JB	41	0	0	0	0.00
Aquilaspio aucklandica	JB	42	5	0	4	0.42
Aquilaspio aucklandica	JB	43	0	0	0	0.00
Aquilaspio aucklandica	MH	36	2	0	1	0.17
Aquilaspio aucklandica	MH	37	0	0	0	0.00
Aquilaspio aucklandica	MH	38	1	0	1	0.08
Aquilaspio aucklandica	MH	39	1	0	1	0.08
Aquilaspio aucklandica	MH	40	0	0	0	0.00
Aquilaspio aucklandica	MH	41	0	0	0	0.00
Aquilaspio aucklandica	MH	42	0	0	0	0.00
Aquilaspio aucklandica	MH	43	0	0	0	0.00
Aquilaspio aucklandica	TK	36	47	4	8	3.92
Aquilaspio aucklandica	TK	37	26	2	6	2.17
Aquilaspio aucklandica	TK	38	23	2	6	1.92
Aquilaspio aucklandica	TK	39	25	2	6	2.08
Aquilaspio aucklandica	TK	40	41	3	12	3.42
Aquilaspio aucklandica	TK	41	21	1	5	1.75
Aquilaspio aucklandica	TK	42	14	1	3	1.17
Aquilaspio aucklandica	TK	43	22	1	7	1.83
Aricidea sp.	CB	36	4	0	2	0.33
Aricidea sp.	CB	37	70	5	13	5.83

Aricidea sp.	CB	38	12	1	2	1.00
Aricidea sp.	CB	39	0	0	0	0.00
Aricidea sp.	CB	40	7	1	2	0.58
Aricidea sp.	CB	41	40	3	9	3.33
Aricidea sp.	CB	42	1	0	1	0.08
Aricidea sp.	CB	43	3	0	1	0.25
Aricidea sp.	HL	36	9	1	2	0.75
Aricidea sp.	HL	37	148	13	35	12.33
Aricidea sp.	HL	38	16	1	3	1.36
Aricidea sp.	HL	39	87	6	14	7.25
Aricidea sp.	HL	40	24	2	6	2.00
Aricidea sp.	HL	41	36	3	8	3.00
Aricidea sp.	HL	42	36	3	6	3.00
Aricidea sp.	HL	43	47	4	8	3.92
Aricidea sp.	JB	36	29	1	9	2.42
Aricidea sp.	JB	37	40	2	21	3.33
Aricidea sp.	JB	38	1	0	1	0.08
Aricidea sp.	JB	39	8	0	7	0.67
Aricidea sp.	JB	40	5	0	1	0.42
Aricidea sp.	JB	41	20	1	5	1.67
Aricidea sp.	JB	42	35	2	12	2.92
Aricidea sp.	JB	43	11	1	3	0.92
Aricidea sp.	MH	36	5	0	1	0.42
Aricidea sp.	MH	37	29	2	8	2.42
Aricidea sp.	MH	38	6	0	2	0.50
Aricidea sp.	MH	39	3	0	1	0.25
Aricidea sp.	MH	40	0	0	0	0.00
Aricidea sp.	MH	41	25	2	4	2.08
Aricidea sp.	MH	42	5	0	2	0.42
Aricidea sp.	MH	43	5	0	3	0.42
Aricidea sp.	TK	36	100	8	25	8.33
Aricidea sp.	TK	37	391	30	75	32.58
Aricidea sp.	TK	38	93	6	17	7.75
Aricidea sp.	TK	39	75	6	18	6.25
Aricidea sp.	TK	40	36	2	8	3.00
Aricidea sp.	TK	41	101	7	39	8.42
Aricidea sp.	TK	42	66	2	20	5.50
Aricidea sp.	TK	43	116	6.5	19	9.67
Arthritica bifurca	CB	36	30	2	7	2.50
Arthritica bifurca	CB	37	15	1	5	1.25
Arthritica bifurca	CB	38	19	1	13	1.58
Arthritica bifurca	CB	39	25	1	6	2.11
Arthritica bifurca	CB	40	2	0	1	0.17
Arthritica bifurca	CB	41	23	1	7	1.92
Arthritica bifurca	CB	42	12	0	5	1.00
Arthritica bifurca	CB	43	6	0	3	0.50

Arthritica bifurca	HL	36	21	2	4	1.75
Arthritica bifurca	HL	37	4	0	1	0.33
Arthritica bifurca	HL	38	9	0	8	0.73
Arthritica bifurca	HL	39	11	1	3	0.92
Arthritica bifurca	HL	40	7	0	6	0.58
Arthritica bifurca	HL	41	9	0	3	0.75
Arthritica bifurca	HL	42	8	0	2	0.67
Arthritica bifurca	HL	43	3	0	2	0.25
Arthritica bifurca	JB	36	1	0	1	0.08
Arthritica bifurca	JB	37	2	0	1	0.17
Arthritica bifurca	JB	38	1	0	1	0.08
Arthritica bifurca	JB	39	18	0	6	1.50
Arthritica bifurca	JB	40	12	0	5	1.00
Arthritica bifurca	JB	41	20	0	9	1.67
Arthritica bifurca	JB	42	8	0	6	0.67
Arthritica bifurca	JB	43	4	0	2	0.33
Arthritica bifurca	MH	36	61	2	28	5.08
Arthritica bifurca	MH	37	31	1	9	2.58
Arthritica bifurca	MH	38	0	0	0	0.00
Arthritica bifurca	MH	39	37	2	9	3.08
Arthritica bifurca	MH	40	13	1	3	1.09
Arthritica bifurca	MH	41	115	8	27	9.58
Arthritica bifurca	MH	42	82	8	20	6.83
Arthritica bifurca	MH	43	7	0	3	0.58
Arthritica bifurca	TK	36	7	0	4	0.58
Arthritica bifurca	TK	37	16	1	9	1.33
Arthritica bifurca	TK	38	12	0	9	1.00
Arthritica bifurca	TK	39	7	0	6	0.58
Arthritica bifurca	TK	40	22	2	7	1.83
Arthritica bifurca	TK	41	35	1	19	2.92
Arthritica bifurca	TK	42	30	2	11	2.50
Arthritica bifurca	TK	43	17	0.5	6	1.42
Austrovenus stutchburyi	CB	36	0	0	0	0.00
Austrovenus stutchburyi	CB	37	0	0	0	0.00
Austrovenus stutchburyi	CB	38	4	0	3	0.33
Austrovenus stutchburyi	CB	39	0	0	0	0.00
Austrovenus stutchburyi	CB	40	0	0	0	0.00
Austrovenus stutchburyi	CB	41	0	0	0	0.00
Austrovenus stutchburyi	CB	42	0	0	0	0.00
Austrovenus stutchburyi	CB	43	2	0	1	0.17
Austrovenus stutchburyi	HL	36	5	0	1	0.42
Austrovenus stutchburyi	HL	37	5	0	2	0.42
Austrovenus stutchburyi	HL	38	4	0	2	0.36
Austrovenus stutchburyi	HL	39	4	0	3	0.33
Austrovenus stutchburyi	HL	40	1	0	1	0.08
Austrovenus stutchburyi	HL	41	0	0	0	0.00

Austrovenus stutchburyi	HL	42	2	0	1	0.17
Austrovenus stutchburyi	HL	43	1	0	1	0.08
Austrovenus stutchburyi	JB	36	4	0	2	0.33
Austrovenus stutchburyi	JB	37	1	0	1	0.08
Austrovenus stutchburyi	JB	38	2	0	2	0.17
Austrovenus stutchburyi	JB	39	6	0	2	0.50
Austrovenus stutchburyi	JB	40	6	0	3	0.50
Austrovenus stutchburyi	JB	41	9	0	6	0.75
Austrovenus stutchburyi	JB	42	4	0	2	0.33
Austrovenus stutchburyi	JB	43	9	0	8	0.75
Austrovenus stutchburyi	MH	36	0	0	0	0.00
Austrovenus stutchburyi	MH	37	0	0	0	0.00
Austrovenus stutchburyi	MH	38	1	0	1	0.08
Austrovenus stutchburyi	MH	39	0	0	0	0.00
Austrovenus stutchburyi	MH	40	0	0	0	0.00
Austrovenus stutchburyi	MH	41	0	0	0	0.00
Austrovenus stutchburyi	MH	42	1	0	1	0.08
Austrovenus stutchburyi	MH	43	0	0	0	0.00
Austrovenus stutchburyi	TK	36	37	0	34	3.08
Austrovenus stutchburyi	TK	37	25	0	22	2.08
Austrovenus stutchburyi	TK	38	114	5	31	9.50
Austrovenus stutchburyi	TK	39	95	2	29	7.92
Austrovenus stutchburyi	TK	40	75	1	24	6.25
Austrovenus stutchburyi	TK	41	42	0	32	3.50
Austrovenus stutchburyi	TK	42	67	1	31	5.58
Austrovenus stutchburyi	TK	43	155	5.5	46	12.92
Cossura sp.	CB	36	314	28	29	26.17
Cossura sp.	CB	37	389	27	31	32.42
Cossura sp.	CB	38	240	17	33	20.00
Cossura sp.	CB	39	351	26	52	29.22
Cossura sp.	CB	40	214	17	30	17.83
Cossura sp.	CB	41	415	35	63	34.58
Cossura sp.	CB	42	319	26	44	26.58
Cossura sp.	CB	43	244	20	26	20.33
Cossura sp.	HL	36	742	56	73	61.83
Cossura sp.	HL	37	963	80	81	80.25
Cossura sp.	HL	38	649	53	50	54.09
Cossura sp.	HL	39	858	70	54	71.50
Cossura sp.	HL	40	647	49	109	53.92
Cossura sp.	HL	41	840	64	157	70.00
Cossura sp.	HL	42	958	80	119	79.83
Cossura sp.	HL	43	685	55	92	57.08
Cossura sp.	JB	36	15	0	5	1.25
Cossura sp.	JB	37	24	0	8	2.00
Cossura sp.	JB	38	14	1	5	1.17
Cossura sp.	JB	39	0	0	0	0.00

Cossura sp.	JB	40	8	0	4	0.67
Cossura sp.	JB	41	19	0	10	1.58
Cossura sp.	JB	42	19	0	10	1.58
Cossura sp.	JB	43	28	2	7	2.33
Cossura sp.	MH	36	68	4	27	5.67
Cossura sp.	MH	37	151	5	52	12.58
Cossura sp.	MH	38	15	1	4	1.25
Cossura sp.	MH	39	38	3	10	3.17
Cossura sp.	MH	40	43	3	9	3.55
Cossura sp.	MH	41	49	4	9	4.08
Cossura sp.	MH	42	35	3	7	2.92
Cossura sp.	MH	43	24	2	4	2.00
Cossura sp.	TK	36	510	41	95	42.50
Cossura sp.	TK	37	810	64	156	67.50
Cossura sp.	TK	38	592	40	128	49.33
Cossura sp.	TK	39	565	33	120	47.08
Cossura sp.	TK	40	490	37	83	40.83
Cossura sp.	TK	41	650	49	129	54.17
Cossura sp.	TK	42	633	60	102	52.75
Cossura sp.	TK	43	268	12.5	70	22.33
Heteromastus filiformis	CB	36	155	13	21	12.92
Heteromastus filiformis	CB	37	190	14	31	15.83
Heteromastus filiformis	CB	38	178	15	20	14.83
Heteromastus filiformis	CB	39	107	8	14	8.89
Heteromastus filiformis	CB	40	39	3	10	3.25
Heteromastus filiformis	CB	41	136	12	21	11.33
Heteromastus filiformis	CB	42	139	11	14	11.58
Heteromastus filiformis	CB	43	38	4	8	3.17
Heteromastus filiformis	HL	36	469	40	62	39.08
Heteromastus filiformis	HL	37	496	35	42	41.33
Heteromastus filiformis	HL	38	683	54	53	56.91
Heteromastus filiformis	HL	39	567	45	46	47.25
Heteromastus filiformis	HL	40	275	24	29	22.92
Heteromastus filiformis	HL	41	230	18	44	19.17
Heteromastus filiformis	HL	42	703	62	71	58.58
Heteromastus filiformis	HL	43	351	29	25	29.25
Heteromastus filiformis	JB	36	8	0	4	0.67
Heteromastus filiformis	JB	37	50	3	17	4.17
Heteromastus filiformis	JB	38	20	1	9	1.67
Heteromastus filiformis	JB	39	49	3	15	4.08
Heteromastus filiformis	JB	40	12	1	5	1.00
Heteromastus filiformis	JB	41	27	2	10	2.25
Heteromastus filiformis	JB	42	27	2	6	2.25
Heteromastus filiformis	JB	43	13	1	6	1.08
Heteromastus filiformis	MH	36	33	2	6	2.75
Heteromastus filiformis	MH	37	49	4	12	4.08

Heteromastus filiformis	MH	38	38	4	6	3.17
Heteromastus filiformis	MH	39	24	2	6	2.00
Heteromastus filiformis	MH	40	23	2	5	1.91
Heteromastus filiformis	MH	41	41	3	7	3.42
Heteromastus filiformis	MH	42	67	6	8	5.58
Heteromastus filiformis	MH	43	11	0	6	0.92
Heteromastus filiformis	TK	36	107	10	16	8.92
Heteromastus filiformis	TK	37	229	20	27	19.08
Heteromastus filiformis	TK	38	202	15	38	16.83
Heteromastus filiformis	TK	39	142	13	29	11.83
Heteromastus filiformis	TK	40	163	13	23	13.58
Heteromastus filiformis	TK	41	264	21	68	22.00
Heteromastus filiformis	TK	42	301	25	48	25.08
Heteromastus filiformis	TK	43	162	10	32	13.50
Macomona liliana	CB	36	2	0	1	0.17
Macomona liliana	CB	37	15	1	4	1.25
Macomona liliana	CB	38	27	3	4	2.25
Macomona liliana	CB	39	5	0	2	0.44
Macomona liliana	CB	40	0	0	0	0.00
Macomona liliana	CB	41	3	0	1	0.25
Macomona liliana	CB	42	11	1	3	0.92
Macomona liliana	CB	43	4	0	1	0.33
Macomona liliana	HL	36	4	0	1	0.33
Macomona liliana	HL	37	25	2	7	2.08
Macomona liliana	HL	38	8	0	2	0.64
Macomona liliana	HL	39	0	0	0	0.00
Macomona liliana	HL	40	5	0	2	0.42
Macomona liliana	HL	41	4	0	1	0.33
Macomona liliana	HL	42	2	0	1	0.17
Macomona liliana	HL	43	9	1	3	0.75
Macomona liliana	JB	36	1	0	1	0.08
Macomona liliana	JB	37	25	1	9	2.08
Macomona liliana	JB	38	8	1	2	0.67
Macomona liliana	JB	39	15	1	5	1.25
Macomona liliana	JB	40	10	1	3	0.83
Macomona liliana	JB	41	9	0	4	0.75
Macomona liliana	JB	42	18	2	4	1.50
Macomona liliana	JB	43	12	0	4	1.00
Macomona liliana	MH	36	19	2	3	1.58
Macomona liliana	MH	37	7	1	2	0.58
Macomona liliana	MH	38	11	1	2	0.92
Macomona liliana	MH	39	14	1	4	1.17
Macomona liliana	MH	40	14	1	4	1.18
Macomona liliana	MH	41	7	1	2	0.58
Macomona liliana	MH	42	16	1	3	1.33
Macomona liliana	MH	43	16	2	3	1.33

Macomona liliana	TK	36	7	0	3	0.58
Macomona liliana	TK	37	13	1	3	1.08
Macomona liliana	TK	38	22	2	4	1.83
Macomona liliana	TK	39	10	0	3	0.83
Macomona liliana	TK	40	17	1	5	1.42
Macomona liliana	TK	41	19	1	8	1.58
Macomona liliana	TK	42	15	1	5	1.25
Macomona liliana	TK	43	22	1	6	1.83
Macrophthalmus hirtipes	CB	36	3	0	2	0.25
Macrophthalmus hirtipes	CB	37	0	0	0	0.00
Macrophthalmus hirtipes	CB	38	1	0	1	0.08
Macrophthalmus hirtipes	CB	39	5	0	3	0.44
Macrophthalmus hirtipes	CB	40	1	0	1	0.08
Macrophthalmus hirtipes	CB	41	4	0	1	0.33
Macrophthalmus hirtipes	CB	42	4	0	2	0.33
Macrophthalmus hirtipes	CB	43	28	2	6	2.33
Macrophthalmus hirtipes	HL	36	0	0	0	0.00
Macrophthalmus hirtipes	HL	37	0	0	0	0.00
Macrophthalmus hirtipes	HL	38	7	0	2	0.55
Macrophthalmus hirtipes	HL	39	2	0	1	0.17
Macrophthalmus hirtipes	HL	40	1	0	1	0.08
Macrophthalmus hirtipes	HL	41	0	0	0	0.00
Macrophthalmus hirtipes	HL	42	3	0	2	0.25
Macrophthalmus hirtipes	HL	43	25	2	7	2.08
Macrophthalmus hirtipes	JB	36	0	0	0	0.00
Macrophthalmus hirtipes	JB	37	0	0	0	0.00
Macrophthalmus hirtipes	JB	38	0	0	0	0.00
Macrophthalmus hirtipes	JB	39	2	0	1	0.17
Macrophthalmus hirtipes	JB	40	2	0	1	0.17
Macrophthalmus hirtipes	JB	41	0	0	0	0.00
Macrophthalmus hirtipes	JB	42	1	0	1	0.08
Macrophthalmus hirtipes	JB	43	1	0	1	0.08
Macrophthalmus hirtipes	MH	36	3	0	3	0.25
Macrophthalmus hirtipes	MH	37	0	0	0	0.00
Macrophthalmus hirtipes	MH	38	5	0	1	0.42
Macrophthalmus hirtipes	MH	39	1	0	1	0.08
Macrophthalmus hirtipes	MH	40	1	0	1	0.09
Macrophthalmus hirtipes	MH	41	0	0	0	0.00
Macrophthalmus hirtipes	MH	42	0	0	0	0.00
Macrophthalmus hirtipes	MH	43	5	0	3	0.42
Macrophthalmus hirtipes	TK	36	2	0	1	0.17
Macrophthalmus hirtipes	TK	37	0	0	0	0.00
Macrophthalmus hirtipes	TK	38	4	0	2	0.33
Macrophthalmus hirtipes	TK	39	2	0	1	0.17
Macrophthalmus hirtipes	TK	40	2	0	1	0.17
Macrophthalmus hirtipes	TK	41	3	0	1	0.25

Macrophthalmus hirtipes	TK	42	2	0	1	0.17
Macrophthalmus hirtipes	TK	43	6	0	3	0.50
Nemerteans	CB	36	2	0	1	0.17
Nemerteans	CB	37	4	0	2	0.33
Nemerteans	CB	38	2	0	1	0.17
Nemerteans	CB	39	0	0	0	0.00
Nemerteans	CB	40	3	0	2	0.25
Nemerteans	CB	41	2	0	1	0.17
Nemerteans	CB	42	3	0	2	0.25
Nemerteans	CB	43	2	0	1	0.17
Nemerteans	HL	36	4	0	2	0.33
Nemerteans	HL	37	22	2	4	1.83
Nemerteans	HL	38	20	2	3	1.64
Nemerteans	HL	39	26	2	7	2.17
Nemerteans	HL	40	8	0	4	0.67
Nemerteans	HL	41	7	1	2	0.58
Nemerteans	HL	42	16	2	3	1.33
Nemerteans	HL	43	9	1	3	0.75
Nemerteans	JB	36	17	1	6	1.42
Nemerteans	JB	37	1	0	1	0.08
Nemerteans	JB	38	3	0	1	0.25
Nemerteans	JB	39	6	0	3	0.50
Nemerteans	JB	40	6	0	4	0.50
Nemerteans	JB	41	6	0	2	0.50
Nemerteans	JB	42	2	0	1	0.17
Nemerteans	JB	43	3	0	2	0.25
Nemerteans	MH	36	6	1	1	0.50
Nemerteans	MH	37	5	0	2	0.42
Nemerteans	MH	38	0	0	0	0.00
Nemerteans	MH	39	8	1	2	0.67
Nemerteans	MH	40	9	1	2	0.73
Nemerteans	MH	41	8	0	4	0.67
Nemerteans	MH	42	7	0	3	0.58
Nemerteans	MH	43	4	0	1	0.33
Nemerteans	TK	36	10	1	2	0.83
Nemerteans	TK	37	17	1	5	1.42
Nemerteans	TK	38	5	0	2	0.42
Nemerteans	TK	39	19	2	4	1.58
Nemerteans	TK	40	15	1	4	1.25
Nemerteans	TK	41	10	0	3	0.83
Nemerteans	TK	42	14	1	6	1.17
Nemerteans	TK	43	12	1	4	1.00
Notoacmea helmsi	CB	36	0	0	0	0.00
Notoacmea helmsi	CB	37	0	0	0	0.00
Notoacmea helmsi	CB	38	0	0	0	0.00
Notoacmea helmsi	CB	39	0	0	0	0.00

Notoacmea helmsi	CB	40	0	0	0	0.00
Notoacmea helmsi	CB	41	0	0	0	0.00
Notoacmea helmsi	CB	42	0	0	0	0.00
Notoacmea helmsi	CB	43	0	0	0	0.00
Notoacmea helmsi	HL	36	0	0	0	0.00
Notoacmea helmsi	HL	37	0	0	0	0.00
Notoacmea helmsi	HL	38	0	0	0	0.00
Notoacmea helmsi	HL	39	0	0	0	0.00
Notoacmea helmsi	HL	40	0	0	0	0.00
Notoacmea helmsi	HL	41	0	0	0	0.00
Notoacmea helmsi	HL	42	1	0	1	0.08
Notoacmea helmsi	HL	43	0	0	0	0.00
Notoacmea helmsi	JB	36	0	0	0	0.00
Notoacmea helmsi	JB	37	1	0	1	0.08
Notoacmea helmsi	JB	38	1	0	1	0.08
Notoacmea helmsi	JB	39	0	0	0	0.00
Notoacmea helmsi	JB	40	0	0	0	0.00
Notoacmea helmsi	JB	41	4	0	3	0.33
Notoacmea helmsi	JB	42	5	0	2	0.42
Notoacmea helmsi	JB	43	8	0	4	0.67
Notoacmea helmsi	MH	36	0	0	0	0.00
Notoacmea helmsi	MH	37	0	0	0	0.00
Notoacmea helmsi	MH	38	0	0	0	0.00
Notoacmea helmsi	MH	39	0	0	0	0.00
Notoacmea helmsi	MH	40	0	0	0	0.00
Notoacmea helmsi	MH	41	0	0	0	0.00
Notoacmea helmsi	MH	42	0	0	0	0.00
Notoacmea helmsi	MH	43	0	0	0	0.00
Notoacmea helmsi	TK	36	0	0	0	0.00
Notoacmea helmsi	TK	37	0	0	0	0.00
Notoacmea helmsi	TK	38	6	0	5	0.50
Notoacmea helmsi	TK	39	0	0	0	0.00
Notoacmea helmsi	TK	40	5	0	5	0.42
Notoacmea helmsi	TK	41	0	0	0	0.00
Notoacmea helmsi	TK	42	14	0	14	1.17
Notoacmea helmsi	TK	43	9	0	5	0.75
Nucula hartvigiana	CB	36	12	1	5	1.00
Nucula hartvigiana	CB	37	5	0	2	0.42
Nucula hartvigiana	CB	38	11	1	2	0.92
Nucula hartvigiana	CB	39	88	6	21	7.33
Nucula hartvigiana	CB	40	2	0	1	0.17
Nucula hartvigiana	CB	41	17	1	5	1.42
Nucula hartvigiana	CB	42	30	2	12	2.50
Nucula hartvigiana	CB	43	83	7	11	6.92
Nucula hartvigiana	HL	36	2	0	1	0.17
Nucula hartvigiana	HL	37	1	0	1	0.08

Nucula hartvigiana	HL	38	0	0	0	0.00
Nucula hartvigiana	HL	39	3	0	2	0.25
Nucula hartvigiana	HL	40	2	0	2	0.17
Nucula hartvigiana	HL	41	0	0	0	0.00
Nucula hartvigiana	HL	42	3	0	1	0.25
Nucula hartvigiana	HL	43	3	0	1	0.25
Nucula hartvigiana	JB	36	92	5	36	7.67
Nucula hartvigiana	JB	37	201	12	48	16.75
Nucula hartvigiana	JB	38	163	9	40	13.58
Nucula hartvigiana	JB	39	236	24	39	19.67
Nucula hartvigiana	JB	40	304	19	71	25.33
Nucula hartvigiana	JB	41	152	10	31	12.67
Nucula hartvigiana	JB	42	94	7	28	7.83
Nucula hartvigiana	JB	43	142	6	49	11.83
Nucula hartvigiana	MH	36	435	35	41	36.25
Nucula hartvigiana	MH	37	362	32	55	30.17
Nucula hartvigiana	MH	38	379	35	28	31.58
Nucula hartvigiana	MH	39	359	32	42	29.92
Nucula hartvigiana	MH	40	372	29	72	31.00
Nucula hartvigiana	MH	41	370	31	19	30.83
Nucula hartvigiana	MH	42	279	23	25	23.25
Nucula hartvigiana	MH	43	371	30	46	30.92
Nucula hartvigiana	TK	36	44	0	39	3.67
Nucula hartvigiana	TK	37	16	0	10	1.33
Nucula hartvigiana	TK	38	75	1	42	6.25
Nucula hartvigiana	TK	39	93	1	41	7.75
Nucula hartvigiana	TK	40	84	2	35	7.00
Nucula hartvigiana	TK	41	65	0	58	5.42
Nucula hartvigiana	TK	42	46	1	39	3.83
Nucula hartvigiana	TK	43	162	2.5	51	13.50
Oligochaetes	CB	36	0	0	0	0.00
Oligochaetes	CB	37	0	0	0	0.00
Oligochaetes	CB	38	0	0	0	0.00
Oligochaetes	CB	39	1	0	1	0.11
Oligochaetes	CB	40	0	0	0	0.00
Oligochaetes	CB	41	0	0	0	0.00
Oligochaetes	CB	42	0	0	0	0.00
Oligochaetes	CB	43	0	0	0	0.00
Oligochaetes	HL	36	0	0	0	0.00
Oligochaetes	HL	37	0	0	0	0.00
Oligochaetes	HL	38	1	0	1	0.09
Oligochaetes	HL	39	19	1	5	1.58
Oligochaetes	HL	40	0	0	0	0.00
Oligochaetes	HL	41	0	0	0	0.00
Oligochaetes	HL	42	0	0	0	0.00
Oligochaetes	HL	43	0	0	0	0.00

Oligochaetes	JB	36	0	0	0	0.00
Oligochaetes	JB	37	48	0	48	4.00
Oligochaetes	JB	38	0	0	0	0.00
Oligochaetes	JB	39	10	0	9	0.83
Oligochaetes	JB	40	0	0	0	0.00
Oligochaetes	JB	41	76	0	34	6.33
Oligochaetes	JB	42	2	0	2	0.17
Oligochaetes	JB	43	3	0	2	0.25
Oligochaetes	MH	36	0	0	0	0.00
Oligochaetes	MH	37	1	0	1	0.08
Oligochaetes	MH	38	0	0	0	0.00
Oligochaetes	MH	39	0	0	0	0.00
Oligochaetes	MH	40	0	0	0	0.00
Oligochaetes	MH	41	0	0	0	0.00
Oligochaetes	MH	42	0	0	0	0.00
Oligochaetes	MH	43	0	0	0	0.00
Oligochaetes	TK	36	0	0	0	0.00
Oligochaetes	TK	37	5	0	4	0.42
Oligochaetes	TK	38	0	0	0	0.00
Oligochaetes	TK	39	10	0	7	0.83
Oligochaetes	TK	40	1	0	1	0.08
Oligochaetes	TK	41	0	0	0	0.00
Oligochaetes	TK	42	0	0	0	0.00
Oligochaetes	TK	43	3	0	2	0.25
Owenia fusiformis	CB	36	0	0	0	0.00
Owenia fusiformis	CB	37	0	0	0	0.00
Owenia fusiformis	CB	38	0	0	0	0.00
Owenia fusiformis	CB	39	0	0	0	0.00
Owenia fusiformis	CB	40	0	0	0	0.00
Owenia fusiformis	CB	41	0	0	0	0.00
Owenia fusiformis	CB	42	0	0	0	0.00
Owenia fusiformis	CB	43	0	0	0	0.00
Owenia fusiformis	HL	36	0	0	0	0.00
Owenia fusiformis	HL	37	0	0	0	0.00
Owenia fusiformis	HL	38	0	0	0	0.00
Owenia fusiformis	HL	39	0	0	0	0.00
Owenia fusiformis	HL	40	0	0	0	0.00
Owenia fusiformis	HL	41	0	0	0	0.00
Owenia fusiformis	HL	42	0	0	0	0.00
Owenia fusiformis	HL	43	0	0	0	0.00
Owenia fusiformis	JB	36	3	0	1	0.25
Owenia fusiformis	JB	37	0	0	0	0.00
Owenia fusiformis	JB	38	0	0	0	0.00
Owenia fusiformis	JB	39	0	0	0	0.00
Owenia fusiformis	JB	40	2	0	1	0.17
Owenia fusiformis	JB	41	0	0	0	0.00

Owenia fusiformis	JB	42	3	0	1	0.25
Owenia fusiformis	JB	43	4	0	2	0.33
Owenia fusiformis	MH	36	0	0	0	0.00
Owenia fusiformis	MH	37	0	0	0	0.00
Owenia fusiformis	MH	38	0	0	0	0.00
Owenia fusiformis	MH	39	0	0	0	0.00
Owenia fusiformis	MH	40	0	0	0	0.00
Owenia fusiformis	MH	41	0	0	0	0.00
Owenia fusiformis	MH	42	0	0	0	0.00
Owenia fusiformis	MH	43	0	0	0	0.00
Owenia fusiformis	TK	36	0	0	0	0.00
Owenia fusiformis	TK	37	0	0	0	0.00
Owenia fusiformis	TK	38	0	0	0	0.00
Owenia fusiformis	TK	39	0	0	0	0.00
Owenia fusiformis	TK	40	0	0	0	0.00
Owenia fusiformis	TK	41	0	0	0	0.00
Owenia fusiformis	TK	42	0	0	0	0.00
Owenia fusiformis	TK	43	0	0	0	0.00
Paracalliope novizealandiae	CB	36	0	0	0	0.00
Paracalliope novizealandiae	CB	37	0	0	0	0.00
Paracalliope novizealandiae	CB	38	0	0	0	0.00
Paracalliope novizealandiae	CB	39	3	0	2	0.22
Paracalliope novizealandiae	CB	40	0	0	0	0.00
Paracalliope novizealandiae	CB	41	8	0	3	0.67
Paracalliope novizealandiae	CB	42	0	0	0	0.00
Paracalliope novizealandiae	CB	43	0	0	0	0.00
Paracalliope novizealandiae	HL	36	0	0	0	0.00
Paracalliope novizealandiae	HL	37	0	0	0	0.00
Paracalliope novizealandiae	HL	38	4	0	3	0.36
Paracalliope novizealandiae	HL	39	0	0	0	0.00
Paracalliope novizealandiae	HL	40	0	0	0	0.00
Paracalliope novizealandiae	HL	41	1	0	1	0.08
Paracalliope novizealandiae	HL	42	5	0	1	0.42
Paracalliope novizealandiae	HL	43	0	0	0	0.00
Paracalliope novizealandiae	JB	36	0	0	0	0.00
Paracalliope novizealandiae	JB	37	10	0	6	0.83
Paracalliope novizealandiae	JB	38	12	1	5	1.00
Paracalliope novizealandiae	JB	39	2	0	2	0.17
Paracalliope novizealandiae	JB	40	14	0	7	1.17
Paracalliope novizealandiae	JB	41	2	0	1	0.17
Paracalliope novizealandiae	JB	42	0	0	0	0.00
Paracalliope novizealandiae	JB	43	30	2	12	2.50
Paracalliope novizealandiae	MH	36	0	0	0	0.00
Paracalliope novizealandiae	MH	37	2	0	2	0.17
Paracalliope novizealandiae	MH	38	0	0	0	0.00
Paracalliope novizealandiae	MH	39	3	0	2	0.25

Paracalliope novizealandiae	MH	40	0	0	0	0.00
Paracalliope novizealandiae	MH	41	1	0	1	0.08
Paracalliope novizealandiae	MH	42	0	0	0	0.00
Paracalliope novizealandiae	MH	43	3	0	2	0.25
Paracalliope novizealandiae	TK	36	0	0	0	0.00
Paracalliope novizealandiae	TK	37	0	0	0	0.00
Paracalliope novizealandiae	TK	38	0	0	0	0.00
Paracalliope novizealandiae	TK	39	0	0	0	0.00
Paracalliope novizealandiae	TK	40	0	0	0	0.00
Paracalliope novizealandiae	TK	41	3	0	3	0.25
Paracalliope novizealandiae	TK	42	2	0	1	0.17
Paracalliope novizealandiae	TK	43	5	0	3	0.42
Perinereis nuntia	CB	36	0	0	0	0.00
Perinereis nuntia	CB	37	0	0	0	0.00
Perinereis nuntia	CB	38	0	0	0	0.00
Perinereis nuntia	CB	39	0	0	0	0.00
Perinereis nuntia	CB	40	0	0	0	0.00
Perinereis nuntia	CB	41	0	0	0	0.00
Perinereis nuntia	CB	42	1	0	1	0.08
Perinereis nuntia	CB	43	0	0	0	0.00
Perinereis nuntia	HL	36	0	0	0	0.00
Perinereis nuntia	HL	37	0	0	0	0.00
Perinereis nuntia	HL	38	0	0	0	0.00
Perinereis nuntia	HL	39	3	0	1	0.25
Perinereis nuntia	HL	40	6	1	1	0.50
Perinereis nuntia	HL	41	0	0	0	0.00
Perinereis nuntia	HL	42	0	0	0	0.00
Perinereis nuntia	HL	43	0	0	0	0.00
Perinereis nuntia	JB	36	9	0	5	0.75
Perinereis nuntia	JB	37	0	0	0	0.00
Perinereis nuntia	JB	38	1	0	1	0.08
Perinereis nuntia	JB	39	8	0	4	0.67
Perinereis nuntia	JB	40	5	0	3	0.42
Perinereis nuntia	JB	41	8	0	5	0.67
Perinereis nuntia	JB	42	6	0	5	0.50
Perinereis nuntia	JB	43	0	0	0	0.00
Perinereis nuntia	MH	36	0	0	0	0.00
Perinereis nuntia	MH	37	0	0	0	0.00
Perinereis nuntia	MH	38	0	0	0	0.00
Perinereis nuntia	MH	39	0	0	0	0.00
Perinereis nuntia	MH	40	0	0	0	0.00
Perinereis nuntia	MH	41	0	0	0	0.00
Perinereis nuntia	MH	42	0	0	0	0.00
Perinereis nuntia	MH	43	0	0	0	0.00
Perinereis nuntia	TK	36	0	0	0	0.00
Perinereis nuntia	TK	37	0	0	0	0.00

Perinereis nuntia	TK	38	0	0	0	0.00
Perinereis nuntia	TK	39	0	0	0	0.00
Perinereis nuntia	TK	40	0	0	0	0.00
Perinereis nuntia	TK	41	0	0	0	0.00
Perinereis nuntia	TK	42	3	0	2	0.25
Perinereis nuntia	TK	43	1	0	1	0.08
Polydorids	CB	36	3	0	1	0.25
Polydorids	CB	37	10	1	3	0.83
Polydorids	CB	38	8	0	4	0.67
Polydorids	CB	39	3	0	1	0.22
Polydorids	CB	40	2	0	1	0.17
Polydorids	CB	41	5	0	1	0.42
Polydorids	CB	42	6	1	1	0.50
Polydorids	CB	43	5	0	1	0.42
Polydorids	HL	36	8	0	3	0.67
Polydorids	HL	37	23	2	4	1.92
Polydorids	HL	38	5	0	2	0.45
Polydorids	HL	39	6	0	2	0.50
Polydorids	HL	40	3	0	1	0.25
Polydorids	HL	41	25	2	6	2.08
Polydorids	HL	42	11	1	3	0.92
Polydorids	HL	43	6	0	2	0.50
Polydorids	JB	36	7	0	5	0.58
Polydorids	JB	37	41	2	14	3.42
Polydorids	JB	38	5	0	2	0.42
Polydorids	JB	39	19	0	8	1.58
Polydorids	JB	40	50	1	18	4.17
Polydorids	JB	41	33	0	21	2.75
Polydorids	JB	42	5	0	1	0.42
Polydorids	JB	43	23	1	7	1.92
Polydorids	MH	36	74	7	11	6.17
Polydorids	MH	37	17	2	4	1.42
Polydorids	MH	38	31	2	8	2.58
Polydorids	MH	39	28	1	7	2.33
Polydorids	MH	40	16	1	3	1.36
Polydorids	MH	41	33	3	6	2.75
Polydorids	MH	42	24	2	5	2.00
Polydorids	MH	43	14	1	3	1.17
Polydorids	TK	36	9	1	4	0.75
Polydorids	TK	37	12	1	3	1.00
Polydorids	TK	38	13	1	3	1.08
Polydorids	TK	39	2	0	2	0.17
Polydorids	TK	40	7	0	2	0.58
Polydorids	TK	41	11	1	4	0.92
Polydorids	TK	42	5	0	1	0.42
Polydorids	TK	43	7	0	3	0.58

Scoloplos cylindrifer	CB	36	0	0	0	0.00
Scoloplos cylindrifer	CB	37	0	0	0	0.00
Scoloplos cylindrifer	CB	38	0	0	0	0.00
Scoloplos cylindrifer	CB	39	0	0	0	0.00
Scoloplos cylindrifer	CB	40	0	0	0	0.00
Scoloplos cylindrifer	CB	41	6	0	3	0.50
Scoloplos cylindrifer	CB	42	0	0	0	0.00
Scoloplos cylindrifer	CB	43	0	0	0	0.00
Scoloplos cylindrifer	HL	36	0	0	0	0.00
Scoloplos cylindrifer	HL	37	0	0	0	0.00
Scoloplos cylindrifer	HL	38	0	0	0	0.00
Scoloplos cylindrifer	HL	39	0	0	0	0.00
Scoloplos cylindrifer	HL	40	0	0	0	0.00
Scoloplos cylindrifer	HL	41	0	0	0	0.00
Scoloplos cylindrifer	HL	42	2	0	1	0.17
Scoloplos cylindrifer	HL	43	0	0	0	0.00
Scoloplos cylindrifer	JB	36	5	0	5	0.42
Scoloplos cylindrifer	JB	37	2	0	1	0.17
Scoloplos cylindrifer	JB	38	0	0	0	0.00
Scoloplos cylindrifer	JB	39	1	0	1	0.08
Scoloplos cylindrifer	JB	40	0	0	0	0.00
Scoloplos cylindrifer	JB	41	2	0	2	0.17
Scoloplos cylindrifer	JB	42	0	0	0	0.00
Scoloplos cylindrifer	JB	43	1	0	1	0.08
Scoloplos cylindrifer	MH	36	0	0	0	0.00
Scoloplos cylindrifer	MH	37	0	0	0	0.00
Scoloplos cylindrifer	MH	38	0	0	0	0.00
Scoloplos cylindrifer	MH	39	0	0	0	0.00
Scoloplos cylindrifer	MH	40	0	0	0	0.00
Scoloplos cylindrifer	MH	41	0	0	0	0.00
Scoloplos cylindrifer	MH	42	0	0	0	0.00
Scoloplos cylindrifer	MH	43	0	0	0	0.00
Scoloplos cylindrifer	TK	36	0	0	0	0.00
Scoloplos cylindrifer	TK	37	2	0	2	0.17
Scoloplos cylindrifer	TK	38	0	0	0	0.00
Scoloplos cylindrifer	TK	39	0	0	0	0.00
Scoloplos cylindrifer	TK	40	0	0	0	0.00
Scoloplos cylindrifer	TK	41	0	0	0	0.00
Scoloplos cylindrifer	TK	42	2	0	1	0.17
Scoloplos cylindrifer	TK	43	5	0	4	0.42
Torridoharpinia hurleyi	CB	36	9	0	2	0.75
Torridoharpinia hurleyi	CB	37	86	6	15	7.17
Torridoharpinia hurleyi	CB	38	10	0	5	0.83
Torridoharpinia hurleyi	CB	39	0	0	0	0.00
Torridoharpinia hurleyi	CB	40	10	1	4	0.83
Torridoharpinia hurleyi	CB	41	43	4	7	3.58

Torridoharpinia hurleyi	CB	42	78	6	11	6.50
Torridoharpinia hurleyi	CB	43	312	25	39	26.00
Torridoharpinia hurleyi	HL	36	2	0	1	0.17
Torridoharpinia hurleyi	HL	37	40	2	10	3.33
Torridoharpinia hurleyi	HL	38	0	0	0	0.00
Torridoharpinia hurleyi	HL	39	1	0	1	0.08
Torridoharpinia hurleyi	HL	40	0	0	0	0.00
Torridoharpinia hurleyi	HL	41	4	0	2	0.33
Torridoharpinia hurleyi	HL	42	16	1	7	1.33
Torridoharpinia hurleyi	HL	43	0	0	0	0.00
Torridoharpinia hurleyi	JB	36	1	0	1	0.08
Torridoharpinia hurleyi	JB	37	0	0	0	0.00
Torridoharpinia hurleyi	JB	38	7	0	3	0.58
Torridoharpinia hurleyi	JB	39	13	0	5	1.08
Torridoharpinia hurleyi	JB	40	6	0	2	0.50
Torridoharpinia hurleyi	JB	41	6	0	3	0.50
Torridoharpinia hurleyi	JB	42	17	0	8	1.42
Torridoharpinia hurleyi	JB	43	31	3	6	2.58
Torridoharpinia hurleyi	MH	36	7	1	1	0.58
Torridoharpinia hurleyi	MH	37	0	0	0	0.00
Torridoharpinia hurleyi	MH	38	0	0	0	0.00
Torridoharpinia hurleyi	MH	39	0	0	0	0.00
Torridoharpinia hurleyi	MH	40	0	0	0	0.00
Torridoharpinia hurleyi	MH	41	17	1	6	1.42
Torridoharpinia hurleyi	MH	42	9	1	3	0.75
Torridoharpinia hurleyi	MH	43	4	0	1	0.33
Torridoharpinia hurleyi	TK	36	8	0	3	0.67
Torridoharpinia hurleyi	TK	37	21	1	7	1.75
Torridoharpinia hurleyi	TK	38	0	0	0	0.00
Torridoharpinia hurleyi	TK	39	0	0	0	0.00
Torridoharpinia hurleyi	TK	40	10	0	6	0.83
Torridoharpinia hurleyi	TK	41	39	3	6	3.25
Torridoharpinia hurleyi	TK	42	24	2	8	2.00
Torridoharpinia hurleyi	TK	43	27	2	11	2.25

Appendix 3

Results of grain size analysis for the subtidal sites.

% sediment composition	Year	Month	Site A	Site C
Gravel/shell hash	1995	Apr	0.17	7.10
	1996	Apr	0.00	0.00
	1997	Apr	0.20	3.01
	1998	Apr	0.08	5.22
	1999	Apr	0.05	5.23
	2000	Apr	0.74	14.77
		Oct	0.25	21.47
	2001	Apr	3.88	5.35
		Oct	0.07	1.56
	2002	Jan	0.08	1.47
		Apr	19.08	1.32
		Jul	0.00	0.35
		Oct	1.70	0.27
	2003	Jan	0.68	13.63
		Apr	20.12	1.58
		Jul	0.41	0.01
		Oct	0.00	0.00
	2004	Jan	0.09	11.17
		Apr	0.41	3.46
		Jul	0.80	5.16
		Oct	0.00	2.09
	2005	Jan	2.03	4.74
Coarse sand	1995	Apr	0.17	2.10
	1996	Apr	0.04	0.05
	1997	Apr	0.48	1.65
	1998	Apr	0.17	4.57
	1999	Apr	0.12	2.53
	2000	Apr	0.47	5.29
		Oct	0.48	4.26
	2001	Apr	0.76	2.70
		Oct	0.11	0.67
	2002	Jan	0.27	1.43
		Apr	3.57	0.53
		Jul	0.15	0.11
		Oct	1.05	0.92
	2003	Jan	0.99	2.95
		Apr	3.76	0.64
		Jul	0.45	0.13
		Oct	0.26	0.04
	2004	Jan	0.37	1.76
		Apr	0.52	0.90
		Jul	0.21	1.87

		Oct	0.44	1.69
	2005	Jan	0.00	2.42
Medium sand	1995	Apr	0.51	6.98
	1996	Apr	13.07	12.01
	1997	Apr	0.79	1.20
	1998	Apr	23.31	1.47
	1999	Apr	2.35	3.84
	2000	Apr	1.29	1.53
		Oct	1.04	1.22
	2001	Apr	0.65	1.19
		Oct	0.25	0.57
	2002	Jan	0.49	0.23
		Apr	0.96	0.51
		Jul	1.95	1.21
		Oct	0.63	1.00
	2003	Jan	0.64	1.11
		Apr	0.01	0.62
		Jul	0.79	0.20
		Oct	0.41	0.61
	2004	Jan	0.39	0.57
		Apr	0.64	1.25
		Jul	0.28	0.80
		Oct	0.73	0.81
	2005	Jan	0.68	0.29
Fine sand	1995	Apr	15.83	20.87
	1996	Apr	25.58	25.67
	1997	Apr	74.86	49.10
	1998	Apr	54.79	35.58
	1999	Apr	54.89	46.46
	2000	Apr	73.83	31.02
		Oct	71.15	28.51
	2001	Apr	71.34	46.34
		Oct	44.40	39.82
	2002	Jan	78.85	53.98
		Apr	29.04	76.10
		Jul	75.38	56.23
		Oct	77.04	44.27
	2003	Jan	76.85	41.51
		Apr	30.62	91.30
		Jul	73.89	71.53
		Oct	86.30	38.66
	2004	Jan	72.83	32.71
		Apr	72.27	52.60
		Jul	69.68	37.27
		Oct	69.26	34.18
	2005	Jan	75.60	39.01

Silt	1995	Apr	73.72	55.41
	1996	Apr	41.96	40.91
	1997	Apr	18.13	42.85
	1998	Apr	16.13	46.06
	1999	Apr	29.39	39.47
	2000	Apr	15.37	30.09
		Oct	23.11	37.01
	2001	Apr	20.18	36.55
		Oct	21.31	45.77
	2002	Jan	17.85	35.53
		Apr	14.95	16.15
		Jul	15.76	32.51
		Oct	10.60	34.23
	2003	Jan	12.65	16.32
		Apr	9.47	22.50
		Jul	17.46	18.46
		Oct	12.34	41.61
	2004	Jan	17.69	35.58
		Apr	13.08	23.89
		Jul	27.24	52.63
		Oct	19.71	43.74
	2005	Jan	19.72	49.71
Clay	1995	Apr	9.61	7.48
	1996	Apr	19.35	21.36
	1997	Apr	5.53	2.19
	1998	Apr	5.52	7.11
	1999	Apr	13.20	2.46
	2000	Apr	8.30	17.30
		Oct	3.97	7.52
	2001	Apr	3.19	7.86
		Oct	3.98	11.59
	2002	Jan	2.46	7.37
		Apr	32.40	5.38
		Jul	6.75	9.59
		Oct	8.97	15.32
	2003	Jan	8.18	24.47
		Apr	20.53	7.50
		Jul	6.99	9.67
		Oct	0.69	19.07
	2004	Jan	8.62	18.20
		Apr	13.08	17.91
		Jul	1.79	2.27
		Oct	9.85	17.50
	2005	Jan	1.97	3.82

Appendix 4

Summary of the temporal results[5] at the subtidal sites from April 2003 (Time = 36) to January 2005 (Time = 43).

Taxa	Site	Time	Total[6]	Median	Range[7]	Mean
Aricidea sp.	SA	36	10	0	3	0.83
Aricidea sp.	SA	37	22	1.5	5	1.83
Aricidea sp.	SA	38	1	0	1	0.08
Aricidea sp.	SA	39	13	1	4	1.08
Aricidea sp.	SA	40	2	0	1	0.18
Aricidea sp.	SA	41	14	1	5	1.17
Aricidea sp.	SA	42	8	0	3	0.67
Aricidea sp.	SA	43	16	1	3	1.33
Aricidea sp.	SC	36	1	0	1	0.08
Aricidea sp.	SC	37	18	1	4	1.50
Aricidea sp.	SC	38	1	0	1	0.08
Aricidea sp.	SC	39	1	0	1	0.08
Aricidea sp.	SC	40	1	0	1	0.08
Aricidea sp.	SC	41	9	0.5	4	0.75
Aricidea sp.	SC	42	0	0	0	0.00
Aricidea sp.	SC	43	3	0	1	0.27
Armandia maculata	SA	36	11	1	2	0.92
Armandia maculata	SA	37	0	0	0	0.00
Armandia maculata	SA	38	0	0	0	0.00
Armandia maculata	SA	39	0	0	0	0.00
Armandia maculata	SA	40	0	0	0	0.00
Armandia maculata	SA	41	1	0	1	0.08
Armandia maculata	SA	42	4	0	4	0.33
Armandia maculata	SA	43	0	0	0	0.00
Armandia maculata	SC	36	7	0.5	2	0.58
Armandia maculata	SC	37	4	0	2	0.33
Armandia maculata	SC	38	0	0	0	0.00
Armandia maculata	SC	39	1	0	1	0.08
Armandia maculata	SC	40	0	0	0	0.00
Armandia maculata	SC	41	0	0	0	0.00
Armandia maculata	SC	42	1	0	1	0.08
Armandia maculata	SC	43	0	0	0	0.00
Arthritica bifurca	SA	36	24	1	13	2.00
Arthritica bifurca	SA	37	15	0	8	1.25
Arthritica bifurca	SA	38	9	0.5	3	0.75

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[5] Data are only given if the taxa occur at a site during this time period.

[6] Total number of individuals collected in 12 samples. Calculated by mean abundance*12.

[7] Range = between the 5th and 95th percentile.

Arthritica bifurca	SA	39	12	0.5	4	1.00
Arthritica bifurca	SA	40	17	1	5	1.45
Arthritica bifurca	SA	41	30	2	9	2.50
Arthritica bifurca	SA	42	20	0.5	6	1.67
Arthritica bifurca	SA	43	11	1	3	0.92
Arthritica bifurca	SC	36	5	0	2	0.42
Arthritica bifurca	SC	37	2	0	1	0.17
Arthritica bifurca	SC	38	0	0	0	0.00
Arthritica bifurca	SC	39	0	0	0	0.00
Arthritica bifurca	SC	40	7	0.5	2	0.58
Arthritica bifurca	SC	41	12	0.5	5	1.00
Arthritica bifurca	SC	42	5	0	3	0.42
Arthritica bifurca	SC	43	9	0	4	0.73
Cirratulids	SA	36	21	2	3	1.75
Cirratulids	SA	37	18	1	4	1.50
Cirratulids	SA	38	8	0.5	2	0.67
Cirratulids	SA	39	12	1	3	1.00
Cirratulids	SA	40	21	1	6	1.73
Cirratulids	SA	41	25	2	5	2.08
Cirratulids	SA	42	14	1	4	1.17
Cirratulids	SA	43	10	1	3	0.83
Cirratulids	SC	36	9	0	3	0.75
Cirratulids	SC	37	13	1	3	1.08
Cirratulids	SC	38	7	0	2	0.58
Cirratulids	SC	39	22	1.5	8	1.83
Cirratulids	SC	40	25	1.5	6	2.08
Cirratulids	SC	41	19	1	5	1.58
Cirratulids	SC	42	17	2	3	1.42
Cirratulids	SC	43	22	1	6	1.82
Corophidae-complex	SA	36	2	0	1	0.17
Corophidae-complex	SA	37	0	0	0	0.00
Corophidae-complex	SA	38	0	0	0	0.00
Corophidae-complex	SA	39	3	0	1	0.25
Corophidae-complex	SA	40	1	0	1	0.09
Corophidae-complex	SA	41	3	0	2	0.25
Corophidae-complex	SA	42	9	0	7	0.75
Corophidae-complex	SA	43	12	0	7	1.00
Corophidae-complex	SC	36	0	0	0	0.00
Corophidae-complex	SC	37	1	0	1	0.08
Corophidae-complex	SC	38	0	0	0	0.00
Corophidae-complex	SC	39	9	0	4	0.75
Corophidae-complex	SC	40	0	0	0	0.00
Corophidae-complex	SC	41	10	0	3	0.83
Corophidae-complex	SC	42	9	0	9	0.75
Corophidae-complex	SC	43	16	0	9	1.36
Nucula hartvigiana	SA	36	5	4.2	0	2.00

Nucula hartvigiana	SA	37	0	0	0	0.00
Nucula hartvigiana	SA	38	4	0	2	0.33
Nucula hartvigiana	SA	39	0	0	0	0.00
Nucula hartvigiana	SA	40	0	0	0	0.00
Nucula hartvigiana	SA	41	0	0	0	0.00
Nucula hartvigiana	SA	42	1	0	1	0.08
Nucula hartvigiana	SA	43	0	0	0	0.00
Nucula hartvigiana	SC	36	14	1	3	1.17
Nucula hartvigiana	SC	37	9	0.5	2	0.75
Nucula hartvigiana	SC	38	0	0	0	0.00
Nucula hartvigiana	SC	39	0	0	0	0.00
Nucula hartvigiana	SC	40	1	0	1	0.08
Nucula hartvigiana	SC	41	0	0	0	0.00
Nucula hartvigiana	SC	42	2	0	1	0.17
Nucula hartvigiana	SC	43	0	0	0	0.00
Owenia fusiformis	SA	36	0	0	0	0.00
Owenia fusiformis	SA	37	3	0	1	0.25
Owenia fusiformis	SA	38	0	0	0	0.00
Owenia fusiformis	SA	39	3	0	1	0.25
Owenia fusiformis	SA	40	8	0	3	0.64
Owenia fusiformis	SA	41	0	0	0	0.00
Owenia fusiformis	SA	42	1	0	1	0.08
Owenia fusiformis	SA	43	3	0	1	0.25
Owenia fusiformis	SC	36	0	0	0	0.00
Owenia fusiformis	SC	37	69	1.5	19	5.75
Owenia fusiformis	SC	38	2	0	2	0.17
Owenia fusiformis	SC	39	100	4	40	8.33
Owenia fusiformis	SC	40	38	1	11	3.17
Owenia fusiformis	SC	41	0	0	0	0.00
Owenia fusiformis	SC	42	24	1.5	9	2.00
Owenia fusiformis	SC	43	29	1	10	2.45
Polydorids	SA	36	17	1	4	1.42
Polydorids	SA	37	21	1.5	5	1.75
Polydorids	SA	38	1	0	1	0.08
Polydorids	SA	39	30	0	17	2.50
Polydorids	SA	40	3	0	2	0.27
Polydorids	SA	41	9	0	8	0.75
Polydorids	SA	42	10	1	2	0.83
Polydorids	SA	43	18	1	4	1.50
Polydorids	SC	36	7	0.5	2	0.58
Polydorids	SC	37	1	0	1	0.08
Polydorids	SC	38	0	0	0	0.00
Polydorids	SC	39	4	0	1	0.33
Polydorids	SC	40	0	0	0	0.00
Polydorids	SC	41	1	0	1	0.08
Polydorids	SC	42	0	0	0	0.00

Polydorids	SC	43	20	1	5	1.64
Prionospio sp.	SA	36	6	0	3	0.50
Prionospio sp.	SA	37	2	0	1	0.17
Prionospio sp.	SA	38	4	0	3	0.33
Prionospio sp.	SA	39	5	0	2	0.42
Prionospio sp.	SA	40	3	0	2	0.27
Prionospio sp.	SA	41	7	0	3	0.58
Prionospio sp.	SA	42	7	0	2	0.58
Prionospio sp.	SA	43	2	0	2	0.17
Prionospio sp.	SC	36	12	0.5	3	1.00
Prionospio sp.	SC	37	2	0	2	0.17
Prionospio sp.	SC	38	0	0	0	0.00
Prionospio sp.	SC	39	2	0	1	0.17
Prionospio sp.	SC	40	4	0	2	0.33
Prionospio sp.	SC	41	5	0	2	0.42
Prionospio sp.	SC	42	7	0	2	0.58
Prionospio sp.	SC	43	5	0	2	0.45
Tawera spissa	SA	36	0	0	0	0.00
Tawera spissa	SA	37	0	0	0	0.00
Tawera spissa	SA	38	0	0	0	0.00
Tawera spissa	SA	39	0	0	0	0.00
Tawera spissa	SA	40	0	0	0	0.00
Tawera spissa	SA	41	0	0	0	0.00
Tawera spissa	SA	42	0	0	0	0.00
Tawera spissa	SA	43	5	0	2	0.42
Tawera spissa	SC	36	0	0	0	0.00
Tawera spissa	SC	37	0	0	0	0.00
Tawera spissa	SC	38	0	0	0	0.00
Tawera spissa	SC	39	0	0	0	0.00
Tawera spissa	SC	40	0	0	0	0.00
Tawera spissa	SC	41	0	0	0	0.00
Tawera spissa	SC	42	0	0	0	0.00
Tawera spissa	SC	43	2	0	1	0.18
Theora lubrica	SA	36	271	23	37	22.58
Theora lubrica	SA	37	250	23.5	22	20.83
Theora lubrica	SA	38	173	14	16	14.42
Theora lubrica	SA	39	45	3.5	7	3.75
Theora lubrica	SA	40	135	11	18	11.27
Theora lubrica	SA	41	137	11	20	11.42
Theora lubrica	SA	42	106	9	9	8.83
Theora lubrica	SA	43	14	1	3	1.17
Theora lubrica	SC	36	185	10	38	15.42
Theora lubrica	SC	37	169	13.5	24	14.08
Theora lubrica	SC	38	53	3	8	4.42
Theora lubrica	SC	39	67	5	13	5.58
Theora lubrica	SC	40	224	15.5	37	18.67

Theora lubrica	SC	41	175	14	11	14.58
Theora lubrica	SC	42	41	3	7	3.42
Theora lubrica	SC	43	26	2	4	2.18
Torridoharpinia hurleyi	SA	36	24	1	8	2.00
Torridoharpinia hurleyi	SA	37	0	0	0	0.00
Torridoharpinia hurleyi	SA	38	0	0	0	0.00
Torridoharpinia hurleyi	SA	39	0	0	0	0.00
Torridoharpinia hurleyi	SA	40	0	0	0	0.00
Torridoharpinia hurleyi	SA	41	11	1	3	0.92
Torridoharpinia hurleyi	SA	42	51	3	16	4.25
Torridoharpinia hurleyi	SA	43	36	3	6	3.00
Torridoharpinia hurleyi	SC	36	9	0	5	0.75
Torridoharpinia hurleyi	SC	37	0	0	0	0.00
Torridoharpinia hurleyi	SC	38	0	0	0	0.00
Torridoharpinia hurleyi	SC	39	2	0	2	0.17
Torridoharpinia hurleyi	SC	40	0	0	0	0.00
Torridoharpinia hurleyi	SC	41	12	0	4	1.00
Torridoharpinia hurleyi	SC	42	48	3	10	4.00
Torridoharpinia hurleyi	SC	43	25	2	5	2.09

Appendix 5

Summary of the significant trends in abundance of monitored taxa detected at (A) intertidal and (B) subtidal sites by Mann Kendall (MK) and linear (L) trend analysis. '– ' = absent at this site.

A. Intertidal	**Cowans Bay**		**Hamilton Landing**		**Jamieson Bay**		**Mid Harbour**		**Te Kapa Inlet**	
	MK	**L**	**MK**	**L**	**MK**	**L**	**MK**	**L**	**MK**	**L**
Aonides oxycephala							Y	Y		
Aquilaspio aucklandica			Y	Y					Y	Y
Aricidea sp.			Y	Y	Y	Y	Y	Y		
Arthritica bifurca	Y		Y		Y	Y	Y			
Austrovenus stutchburyi			Y	Y					Y	
Cossura sp.	Y		Y	Y			Y		Y	Y
Heteromastus filiformis			Y	Y			Y			Y
Macomona liliana			Y	Y	Y	Y	Y	Y	Y	Y
Macrophthalmus hirtipes										
Nemerteans			Y	Y			Y		Y	Y
Notoacmea helmsi							Y			
Nucula hartvigiana			Y	Y						
Oligochaetes										
Owenia fusiformis	-	-	-	-	Y	Y	-	-	-	-
Paracalliope novizelandiae	Y	Y			Y	Y	Y			
Perinereis nuntia			Y							
Polydorids		Y	Y	Y	Y	Y			Y	Y
Scoloplos cylindrifer			Y	Y						
Torridoharpinia hurleyi		Y			Y	Y			Y	Y

B. Subtidal	**Site A**		**Site C**	
	MK	L	MK	L
Aricidea sp.	Y	Y		
Armandia maculata				
Arthritica bifurca	Y	Y		Y
Cirratulids	Y	Y	Y	Y
Corophidae-complex			Y	Y
Nucula hartvigiana				
Oligochaetes				
Polydorids	Y			
Prionospio sp.				
Tawera spissa				
Theora lubrica	Y	Y	Y	Y
Torridoharpinia hurleyi				