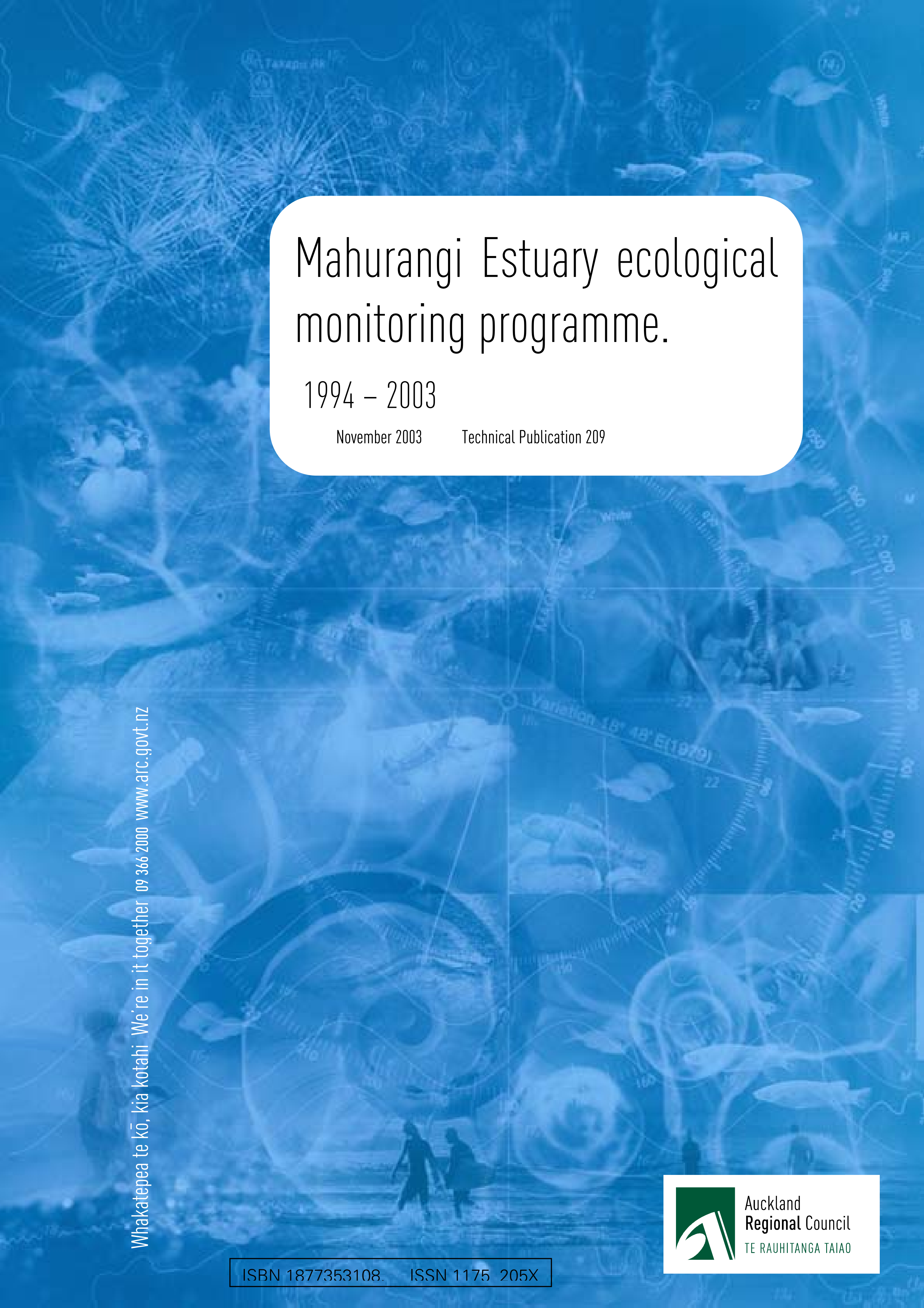

Mahurangi Estuary ecological monitoring programme.

1994 – 2003

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Mahurangi Estuary ecological monitoring programme – report on data collected from July 1994 to January 2003

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Contents

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Executive Summary

The monitoring programme is indicating that the ecology of Mahurangi Estuary is changing, probably as a result of increased sediment loading. Estuary-wide changes in abundance of macrofauna and horse mussels, and in sediment characteristics over the monitored period are still a serious concern.

Population trends have been detected at all of the intertidal sites, the most at Hamilton Landing (9 populations), and the least at Cowans Bay (1 population). Many of these trends are consistent with what we would predict from other studies of elevated sediment loading.

Nine intertidal bivalve populations exhibit trends in abundance. Decreasing trends for *Macomona liliana* were detected at all sites except Cowans Bay, and decreasing trends for *Austrovenus stutchburyi* and *Nucula hartvigiana* were each detected at two sites (Hamilton Landing and Te Kapa Inlet, and Hamilton Landing and Mid Harbour, respectively). The tiny bivalve *Arthritica bifurca* has increased in abundance at Mid Harbour.

Of major concern are the decreasing trends in abundance of the wedge shell, *Macomona liliana*, and the cockle *Austrovenus stutchburyi*. At three sites (Hamilton Landing, Mid Harbour and Te Kapa Inlet), numbers of >16 mm *Macomona* have decreased. Lack of these spawning sized individuals means recruitment at a site will rely on immigration of larval and juvenile stages from elsewhere in the estuary. *Austrovenus stutchburyi* exhibits decreasing trends at Hamilton Landing and Te Kapa Inlet. At Hamilton Landing in the past two years, *Austrovenus* has occurred in very low numbers, or has not been found at all.

Seven intertidal polychaete populations exhibit decreasing trends in abundance, and seven exhibit increases. *Cossura* sp. exhibit increases in abundance at Hamilton Landing and Te Kapa Inlet, while at Jamieson Bay their numbers have declined. The *Heteromastus filiformis* population at Hamilton Landing, and the *Aricidea* sp. population at Mid Harbour, have both increased over the monitored period. All three of these taxa thrive in muddy, organically enriched habitats.

The intertidal communities at the monitored sites in Mahurangi are becoming more similar. This broad-scale loss of diversity may be considered a sign of stress. The communities at Hamilton Landing and Te Kapa Inlet have become more similar to those of the Cowans Bay site in the latter

stage of the monitored period. The monitored communities at Jamieson Bay and Mid Harbour have become more similar to each other.

The estuary-wide decline in the abundance of horse mussels (*Atrina zelandica*) at both subtidal sites over the monitored period has continued. The mean size of live individuals has increased slightly compared with the early stages of the monitoring programme.

A total of six subtidal populations are showing trends in abundance over the monitored period, all of which are increases. Two taxa (the bivalve *Theora lubrica* and Cirratulid polychaetes) have increased at both of the subtidal sites. These species usually respond positively to organic enrichment.

We have noted an increase in the amount of fine sand at all sites, and a corresponding decrease in the amount of medium sand at the intertidal sites only. These changes occurred sometime between April 1996 and April 1997 and have persisted. We have not seen any obvious response to an apparent 'pulse' event by macrofauna, rather the declining or increasing trends are gradual. In addition, the changes in *Atrina* abundance at the subtidal sites occurred prior to this time.

In our last report we 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). We still recommend this action. The indications of change within the harbour highlight the timeliness of initiating this monitoring programme and the merits in its continuation; without such data, detecting broad-scale trends would be very difficult, if not impossible.

1. 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 8.5 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. We conduct trend and community analyses of the monitored taxa at the intertidal and subtidal sites, and make recommendations for the future of this monitoring programme.

2. Methods

2.1 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.

2.1.1 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. Measurements are made using either electronic callipers, or a camera lucida and digitising pad.

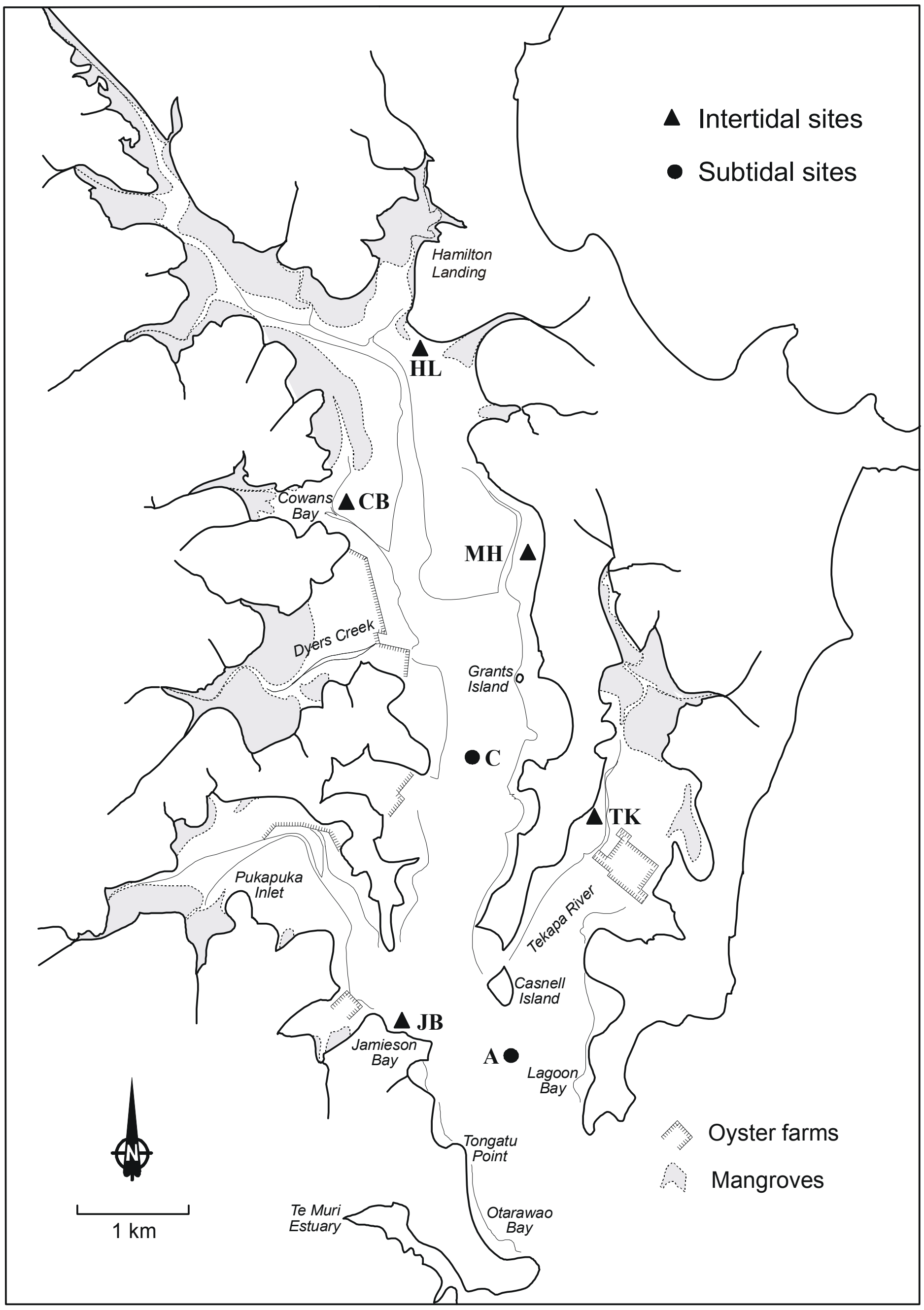

Figure 1: Map of Mahurangi Harbour, showing locations of the intertidal and subtidal monitoring sites. Intertidal site abbreviations are as follows: CB = Cowans Bay; HL = Hamilton Landing; JB = Jamieson Bay; MH = Mid harbour; TK = Te Kapa Inlet.

2.1.2 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 (0 - 2 cm) sediment is collected from random areas 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, dispersed using calgon, 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 µm), coarse sand (500 – 2000 µm), medium sand (250 – 500 µm), fine sand (62.5 – 500 µm), silt (3.9 – 62.5 µm) and clay (< 3.9 µm).

Also beginning in July 2000, the organic content and chlorophyll *a* content of the sediments at each site is 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 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* was extracted by boiling this freeze dried sediment in 90% ethanol, and the extract processed using a spectrophotometer. An acidification step was used to separate degradation products from chlorophyll *a* (Sartory 1982).

At the 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.

2.2 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 the most recent 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 our last report (Cummings et al. 2001), since July 2001 these subtidal sites (A and C) have been sampled every 3 months.

2.2.1 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).

2.2.2 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).

2.2.3 *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.

2.3 Statistical analyses of macrofaunal abundance

Cyclic patterns. Plots of total abundance for each monitored population over the monitored period were visually examined for repeatable cyclic patterns.

To formally identify any suggested trends in the abundance of the monitored taxa at both the intertidal and subtidal sites, trend analyses were conducted.

Trend analysis. Autocorrelation in each time series was investigated using chi-square probabilities (SAS/ETS). Where autocorrelation was indicated, linear trends were investigated by adjusting parameters and significance levels (AUTOREG procedure, SAS/ETS). Otherwise ordinary least squares linear regression was carried out. Only linear trends were investigated as visual observations and investigation of residuals 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.

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 a number of techniques: non-metric multidimensional scaling on Bray Curtis similarities; principal components analysis on Hellinger transformed data; and correspondence analysis. The correspondence analysis results are presented in this report, as these gave the clearest picture (CANOCO; ter Braak, 1986).

Atrina zelandica abundance and size. The significance of differences in both the size and the proportion of live *Atrina* at each site between sampling occasions are tested using ANOVA, following prior tests for normality and homogeneity of variance. Where data did not meet the assumptions of ANOVA, Kruskal-Wallis tests were used.

3. Results and Discussion

3.1 Intertidal sites

3.1.1 Sediment characteristics

The sediment grain size characteristics at the intertidal sites have not changed markedly in the past two years (Appendix 1). Sediment loading and resuspension by waves and tides are still in net balance at each site. As noted in the previous report, there has been an increase in the fine sand and a corresponding decrease in medium sand over the monitored period at all sites. This is discussed in more detail on page 29.

The organic and chlorophyll *a* content of the sediments at each site from July 2000 to January 2003 are shown in Table 1. In the last report we noted that the organic content was low at all sites (i.e., <4%). However, this value has been exceeded on several occasions in the past 2 years, most notably in Te Kapa Inlet's sandy sediments, where a value of 11.93% was recorded in April 2001 (Table 1A). This extremely high value is unusual for this site, and may be the result of a polychaete in the sediment sample. Hamilton Landing generally has the highest organic content of the monitored sites on any one sampling date (Table 1A).

The sediment organic contents in Mahurangi Harbour are considerably higher than those found at long term monitoring sites in Manukau Harbour (range = 0.4 - 1.9%, Funnell et al. 2003), generally similar to those noted in recent surveys of the Whitford Embayment (<6%; Norkko et al. 2001) and the outer regions of Upper Waitemata Harbour (<6%; Cummings et al. 2002), but lower than those found in the inner regions of Upper Waitemata Harbour (>6%; Cummings et al. 2002).

The chlorophyll *a* content of the sediments was always highest at Cowans Bay and lowest at Jamieson Bay (Table 1B). In July 2001, sediment at three sites (Cowans

Bay, Jamieson Bay, and the muddy sediments at Te Kapa) had their highest chlorophyll levels since they have been monitored (i.e., since July 2000).

In our last report we noted that the extent of the muddy area on the upper inlet side of the Te Kapa Inlet site had increased so that it covered approximately $^4/_5$ of the sampling area (Cummings et al. 2001). We have not noted any further expansion of this muddy area in the past two years of monitoring.

Table 1: A. Organic content (% dry weight), and B. Chlorophyll *a* content (µg / g 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

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

3.1.2 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 2003) 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).

Cowans Bay

The taxa comprising the three dominant monitored species at Cowans Bay have not changed from those noted in previous reports (Cummings et al. 1999, 2001). On all 35 sampling occasions, the polychaete *Cossura* sp. has been the dominant taxa. The bivalve *Arthritica bifurca* and the polychaete *Heteromastus filiformis* also continue to be common at this site, and have been the second or third most abundant monitored taxa on each occasion in the past two years (Table 2).

Populations showing cyclic abundance patterns

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 the polychaetes *Aquilaspio aucklandica*, *Aricidea* sp. and *Heteromastus filiformis* all show annual cyclic patterns in their abundances, with peaks usually occurring in July or October each year.

Arthritica bifurca and the amphipod *Torridoharpinia hurleyi* both exhibit peaks in abundance each year, but the timing of these peaks is variable and unpredictable.

Populations showing trends in abundance

In the last report, trend analysis detected a decline in Polydorid polychaete abundances and an increase in numbers of the bivalve *Austrovenus stutchburyi* (Table 7). While a negative trend is still apparent for Polydorids, with additional data the increasing trend in *Austrovenus* abundance is no longer apparent (Table 7). *Austrovenus* is generally found in very low numbers (i.e., 0 – 2 individuals) at this site, but on 4 occasions from October 1999 to January 2001 numbers, either 4 or 10 individuals were collected. These abundances have not persisted however, and in the past 2 years numbers have ranged from 0 – 1 individual.

Table 2: The three dominant taxa collected at Cowans Bay from July 1994 to January 2003. 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*

Hamilton Landing

A total of nine taxa have featured amongst the three dominant ones over the monitored period (Table 3). For the first three years of the programme, Hamilton Landing was dominated by *Austrovenus stutchburyi* and Polydorids. However, the community is now dominated by *Heteromastus filiformis* and *Cossura* sp.. A number of taxa (*Aquilaspio aucklandica*, Polydorids, *Arthritica bifurca*, the crab *Macrophthalmus hirtipes* and Nemerteans) have featured among the third most abundant monitored taxa in the past two years (on 1 - 2 occasions each).

Table 3: The three dominant taxa collected at Hamilton Landing from July 1994 to January 2003. 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*

Populations showing cyclic abundance patterns

Polydorids have ranged in number from very low to very high over the monitored period (i.e., 0 - 822 individuals). They exhibit a strongly cyclic abundance pattern, with peaks generally occurring in July of each year. The exception to this was 2002, when peak numbers were found in April (77 individuals). Polydorids have declined in abundance at this site over the monitored period, with only 0 - 77 individuals collected on any one sampling occasion since January 2001.

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 exhibit peaks in abundance most years, most often in October or July.

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

Aquilaspio aucklandica and *Austrovenus stutchburyi* exhibit peak abundances in October or April, and October or January, respectively.

Populations showing trends in abundance

Nine species exhibit increasing or decreasing trends in abundance at this site. Five of these trends were also detected in the 2001 trend analysis (Cummings et al. 2001; Table 7). Using data up to January 2003, decreasing trends were detected for the bivalves *Austrovenus stutchburyi*, *Macomona liliana and Nucula hartvigiana*, and the polychaete *Perinereis nuntia*. Increasing trends were detected for *Heteromastus filiformis*, *Cossura* sp., *Aquilaspio aucklandica*, Nemerteans and Oligochaetes.

Of concern are the declines in *Austrovenus* and *Macomona*. In the case of *Austrovenus*, only 1 - 9 individuals have been collected on any one sampling date since January 2000 (when 55 individuals were found) (Figure 2). This decreasing trend is apparent for both all data, and baseline data only (Table 7). There has been no significant recruitment of *Austrovenus* since January 2000 (Figure 2).

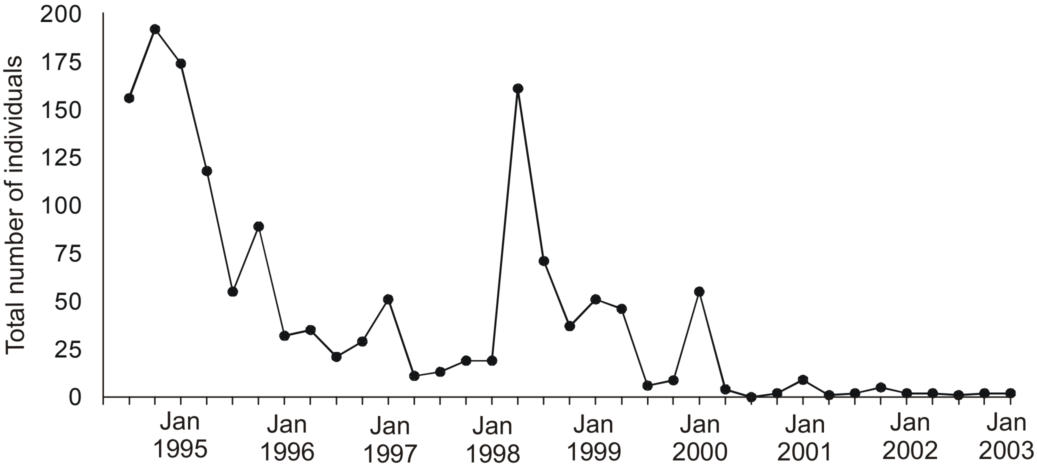

Figure 2: The total number of *Austrovenus stutchburyi* collected on each sampling occasion at Hamilton Landing.

The decreasing trend in *Macomona* abundance noted in the last report has continued with two more years of data (Table 7). In the past two years, the population has comprised mostly small (≤4 mm) sized animals (a peak in abundance of these small individuals was noted in July 2002; Figure 3A). There have been no large individuals (>16 mm) found at this site since January 2001 (Figure 3B). The latter is of major concern, as it implies the site no longer has any spawning-sized animals, and thus recolonisation will rely on a good supply of recruits from elsewhere in the estuary. The fact that we are seeing small individuals at this site despite a lack of adults is evidence that this is possible at this time.

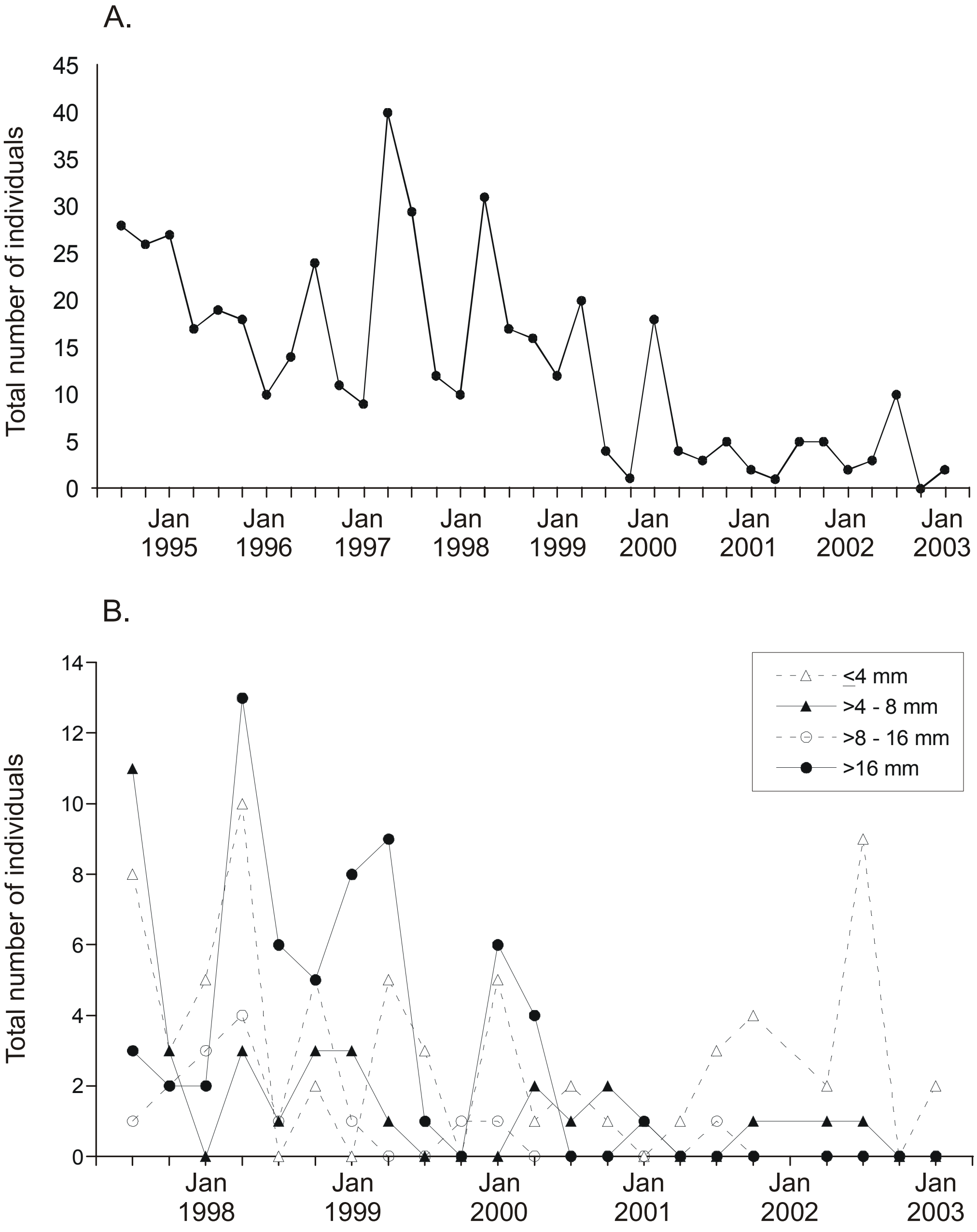

Figure 3. A. The total number of *Macomona liliana* collected on each sampling occasion at Hamilton Landing. and, B. The total number of individuals in each size class, from July 1997 onwards.

The strong trends of increasing abundance detected previously for *Heteromastus filiformis* and *Cossura* sp. have continued (Table 7). Both of these species are often associated with organically enriched muddy sediments. Between 117 - 679 *Heteromastus filiformis* have been collected on each occasion since the last report (i.e., post-January 2001), compared with 7 - 387 individuals before. We now detect a trend in the baseline data as well as the total data for *Heteromastus* (Table 7). *Cossura* sp. has shown a similar increasing pattern, with more individuals found in the last half of the monitored period (i.e., 44 - 659 individuals post-April 2000, compared with 10-150 individuals earlier). This large recent increase in abundance has meant the magnitude of the trend for *Cossura* is now more than double that noted in the last report (Table 7).

Aquilaspio aucklandica, Nemerteans and Oligochaetes are all exhibiting increasing trends in abundance, while the polychaete *Perinereis nuntia* is exhibiting a decrease (see Table 7). For both *Aquilaspio aucklandica* and Nemerteans, small but obvious increases (a total of 10 individuals on average) have been observed. Occurrence of oligochaetes at this site is sporadic (19 occasions over the monitored period), but they have occurred on every date in the past year (2 - 44 individuals). However, *Perinereis* has not been found at this site since April 1999.

Although we noted a decrease in Polydorid numbers (see above discussion of cyclic patterns), this was not detected as significant in the trend analysis. It may become apparent once more data are collected.

Jamieson Bay

Nucula hartvigiana continues to dominate this site (Table 4). However, Polydorids are less abundant than before, and have only occurred amongst the dominant taxa on two occasions in the last two years. *Cossura* sp., *Aonides oxycephala*, *Aricidea* sp., *Heteromastus filiformis*, *Macomona liliana* and the amphipod *Paracalliope novizelandiae* have all featured in the dominant taxa list on 2 - 3 occasions the past two years.

Populations showing cyclic abundance patterns

Polydorid polychaetes show a cyclic abundance pattern, with peaks generally occurring in July each year (except 1995 and 1996, 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 peaks occurring in one of two sampling months each year. Two taxa, *Macomona liliana* and *Heteromastus filiformis*, exhibit peaks in abundance each year without a repeatable pattern. *Austrovenus stutchburyi* may be exhibiting a greater than annual abundance cycle.

Table 4. The three dominant taxa collected at Jamieson Bay from July 1994 to January 2003. 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*

Populations showing trends in abundance

Trends in abundance were detected for seven populations at Jamiesons Bay (Table 7). Four of these were also detected in 2001 (Cummings et al. 2001; Table 7).

As noted for Hamilton Landing, a decreasing trend in the size of the abundance peaks was detected for *Macomona liliana* (Table 7). Recent peak abundances have been lower than in the first part of the monitored period (Figure 4A. i.e., 15 – 29 individuals in 1998 – 2003 cf. 32 - 96 individuals in 1995 – 97). Unlike the Hamilton Landing site however, larger individuals have comprised a good portion of the population at this site in the past year (Figure 4B).

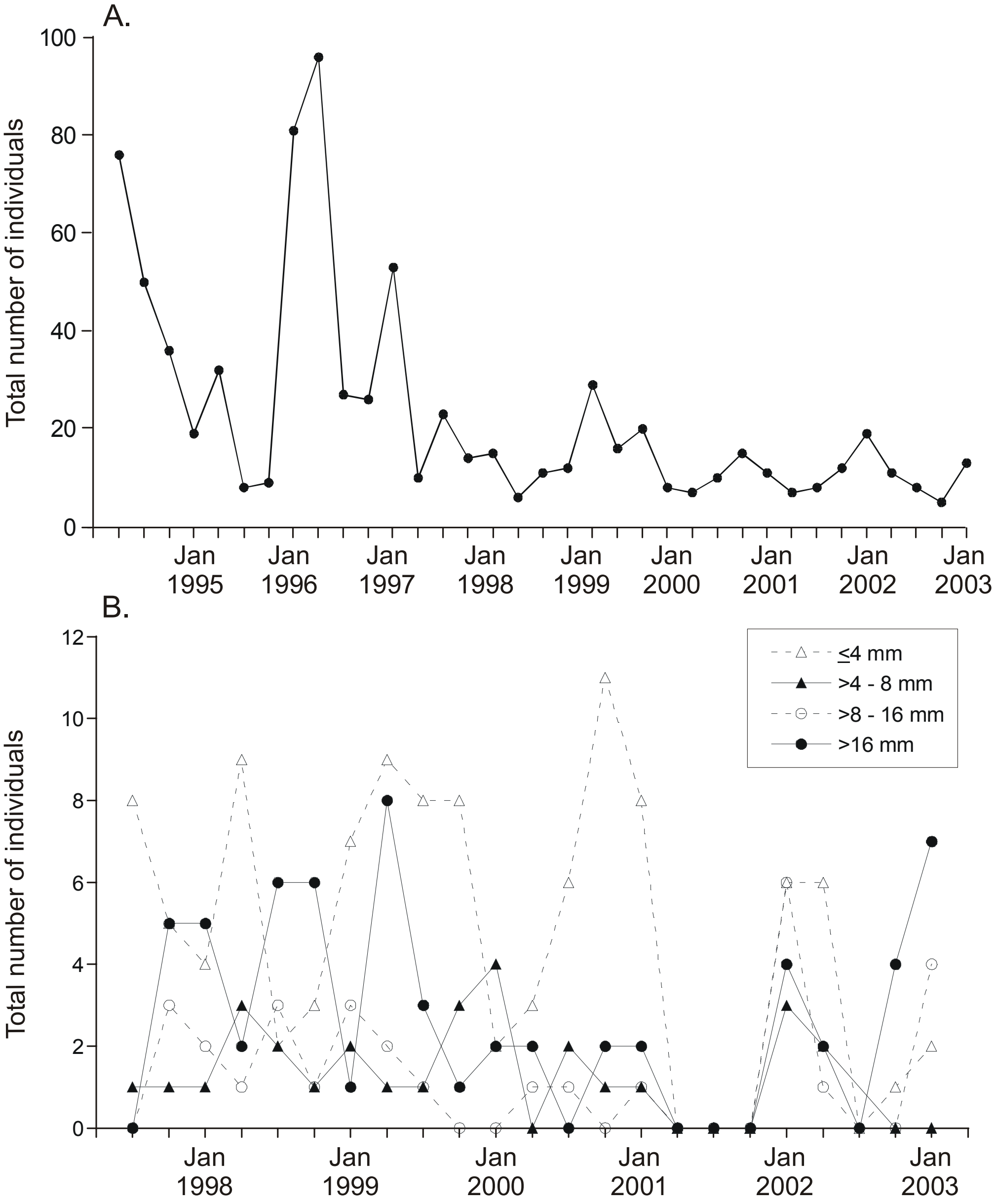

Figure 4. A. The total number of *Macomona liliana* collected on each sampling occasion at Jamieson Bay, and B. The total number of individuals in each size class, from July 1997 onwards.

Polydorid polychaetes have exhibited lower abundances in the second half of the monitored period. While a declining trend was noted in the last report, this year's analysis has revealed a decline in baseline abundances as well (Table 7). Trends were detected for *Aricidea* sp., *Notoacmea helmsi, Paracalliope novizealandiae* (increasing), the polychaete *Owenia fusiformis* and the amphipod *Torridoharpinia hurleyi* (decreasing) (Table 7). The detection of a decrease in abundance of *Owenia fusiformis* is likely due to the fact that the highest number of individuals of this polychaete collected during the monitored period (9 individuals) were found on the first sampling date. Similarly, the apparent increase in numbers of *Aricidea* sp. may be due to a lower than normal recruitment period early on in the monitored period. Both of these trends will be confirmed/disproved once more data have been collected.

Mid Harbour

This site has been dominated by *Nucula hartvigiana* and Polydorid polychaetes since monitoring began in July 1994 (Table 5). However, in April and July of 2001, *Nucula* numbers declined considerably (to 1 and 24 individuals, respectively). *Heteromastus filiformis* were the dominant taxa on these dates, with 48 and 199 individuals, respectively. However, *Nucula* numbers increased again in October 2001, and this bivalve has been the dominant taxa ever since. *Arthritica bifurca* has also featured amongst the dominant taxa in the past two years, while Polydorids have disappeared from this list (Table 5).

Populations showing cyclic abundance patterns

Nucula hartvigiana, *Macrophthalmus hirtipes* and *Aricidea* sp. all exhibit yearly cyclic abundance patterns, with peak numbers occurring in either July or October each year. *Arthritica bifurca* exhibits peak abundances in January, July or October each year. *Macomona liliana* exhibits a yearly abundance cycle, with no predictable pattern in the timing of these peak abundances. *Heteromastus filiformis,* Polydorids and *Cossura* sp. all show suggestions of a greater than annual cyclic abundance pattern.

Table 5: The three dominant taxa collected at Mid Harbour from July 1994 to January 2003. 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*

Populations showing trends in abundance

Six populations showed trends in abundance at Mid Harbour (Table 7). Three of these (*Aonides oxycephala*, *Cossura* sp., and *Macomona liliana*) were also present in 2001. In the case of *Aonides*, this trend is driven by the fact that they were found (maximum abundance = 2 individuals) on 2 occasions very early in the monitored period, and have not been collected since. *Macomona* now shows a decreasing trend in the size of its peak abundances only, and no longer in the basal population (as was noted in 2001; Table 7; Figure 5A). There has been a considerable drop in numbers of large individuals (i.e., >16 mm shell length) which, as noted for the *Macomona* population at Hamilton Landing, is of concern (Figure 5B). However, the number of small individuals (<4 mm) found in October 2002 was the highest since bivalves have been measured.

Cossura sp. has exhibited continual fluctuations in abundance over the monitored period, and this has most likely contributed to the detection of a decreasing trend for this polychaete (Table 7). Abundances have been relatively high in recent months, and it is likely that this trend will disappear with more data. A declining trend for *Nucula hartvigiana* (basal population only) was noted (Table 7), most likely due to the low numbers collected in April and July of 2001. However, numbers of this bivalve have been high since these dates (i.e., 193 – 449 individuals), so it is likely this trend will also disappear once more data are collected. Trends were detected for *Arthritica bifurca* and *Aricidea* sp. (increases), and *Aonides oxycephala* (a decrease).

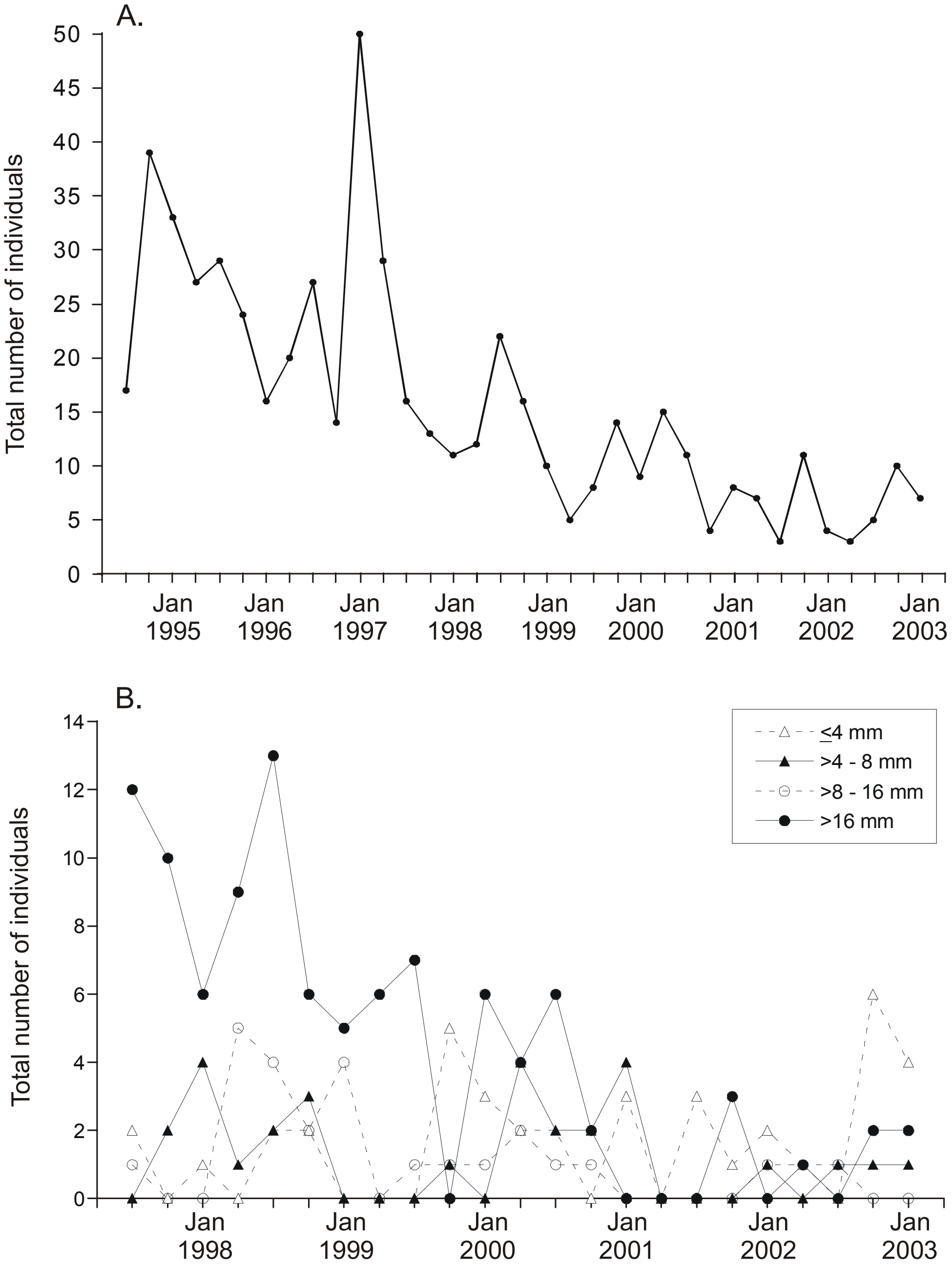

Figure 5. A. The total number of *Macomona liliana* collected on each sampling occasion at Mid Harbour, and B. The total number of individuals in each size class, from July 1997 onwards.

Te Kapa Inlet

In our last report we noted a switch in the taxa at Te Kapa Inlet, from a *Heteromastus* - *Austrovenus* dominated community to a *Cossura* sp. dominated community

(Cummings et al. 2001; Table 6). This has continued over the past two years, with *Cossura* now the top ranked taxa and *Heteromastus* the second most abundant taxa. Relative abundances of *Nucula hartvigiana* and *Aricidea* sp. have been such that both of these species have been the third most abundant taxa on several occasions in the past two years. *Austrovenus stutchburyi* and *Aquilaspio aucklandica*, which previously occurred amongst the dominant taxa at this site, have not featured since January 2001 and October 2000, respectively.

Populations showing cyclic abundance patterns

Polydorids and *Macomona liliana* exhibit cyclic abundance patterns, with their highest numbers occurring in one of two sampling months each year.

Several taxa at this site (i.e., *Aquilaspio aucklandica*, *Aricidea* sp., *Macrophthalmus hirtipes* and *Austrovenus stutchburyi*) generally show peaks in abundance every year, with no predictable, repeating pattern.

Arthritica bifurca and Oligochaetes show suggestions of greater than annual cyclic patterns in their abundance.

Table 6: The three dominant taxa collected at Te Kapa Inlet from July 1994 to January 2003. 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*

Populations showing trends in abundance

Trends in abundance were detected for six populations at Te Kapa Inlet. Four of these were also detected in 2001 (Table 7).

Two new trends were detected this year: a decline in numbers of Polydorids, and a very slight increase in the abundance of *Aonides oxycephala* (Table 7). Polydorid numbers were considerably higher in the first half of the monitoring programme (i.e., 16 – 71 individuals prior to April 1999, cf. 1 – 23 individuals since). *Aonides* have been found on a total of 4 occasions since April 2000 ($\leq$4 individuals), but only occurred on one occasion prior to this. *Cossura* sp. and Nemerteans both show increasing trends. For *Cossura* sp. this has involved a very large increase in numbers: peak abundances in the last half of the monitored period have ranged from 320 – 671, compared with peaks of 64 – 143 individuals prior to 1999. A similar timing of increases in peak abundances can be seen for Nemerteans (i.e., 8 - 10 individuals pre-1999, cf. 13 – 18 since).

Trend analysis in 2001 detected a decline in abundance of all three monitored bivalve species at this site (Table 7). While this trend is no longer detected for *Nucula hartvigiana*, *Austrovenus stutchburyi* (total population only; Figure 6A) and *Macomona liliana* (total and basal populations; Figure 7A) are still declining (Table 7; Figure 6A).

Although no decrease in the basal population of *Austrovenus stutchburyi* was detected, since October 2001, fewer than 20 large individuals (>16 mm) were found on any one sampling occasion (cf. 20 – 40 individuals before; Figure 6B).

Macomona liliana has shown a decline in both peak and baseline abundances. Baseline numbers have declined slightly, from a low of 10 - 12 individuals up to January 1998, to 4 - 12 individuals since (Figure 7A). The size of the abundance peaks has also declined, with the most recent peak comprising only 8 individuals (October 2002). Prior to 2000, peak abundances occurred in April each year (Figure 7A). However, since this time highest numbers have occurred in July or October, with the lowest numbers recorded in April each year (Figure 7A). The October 2001 population had a high proportion of recruit-sized individuals, indicating that this shift in peak abundance times is actually a shift in recruitment periods, rather than just a lack of any recruitment in April (Figure 7B). In addition, numbers of large-sized individuals have declined (Figure 7B).

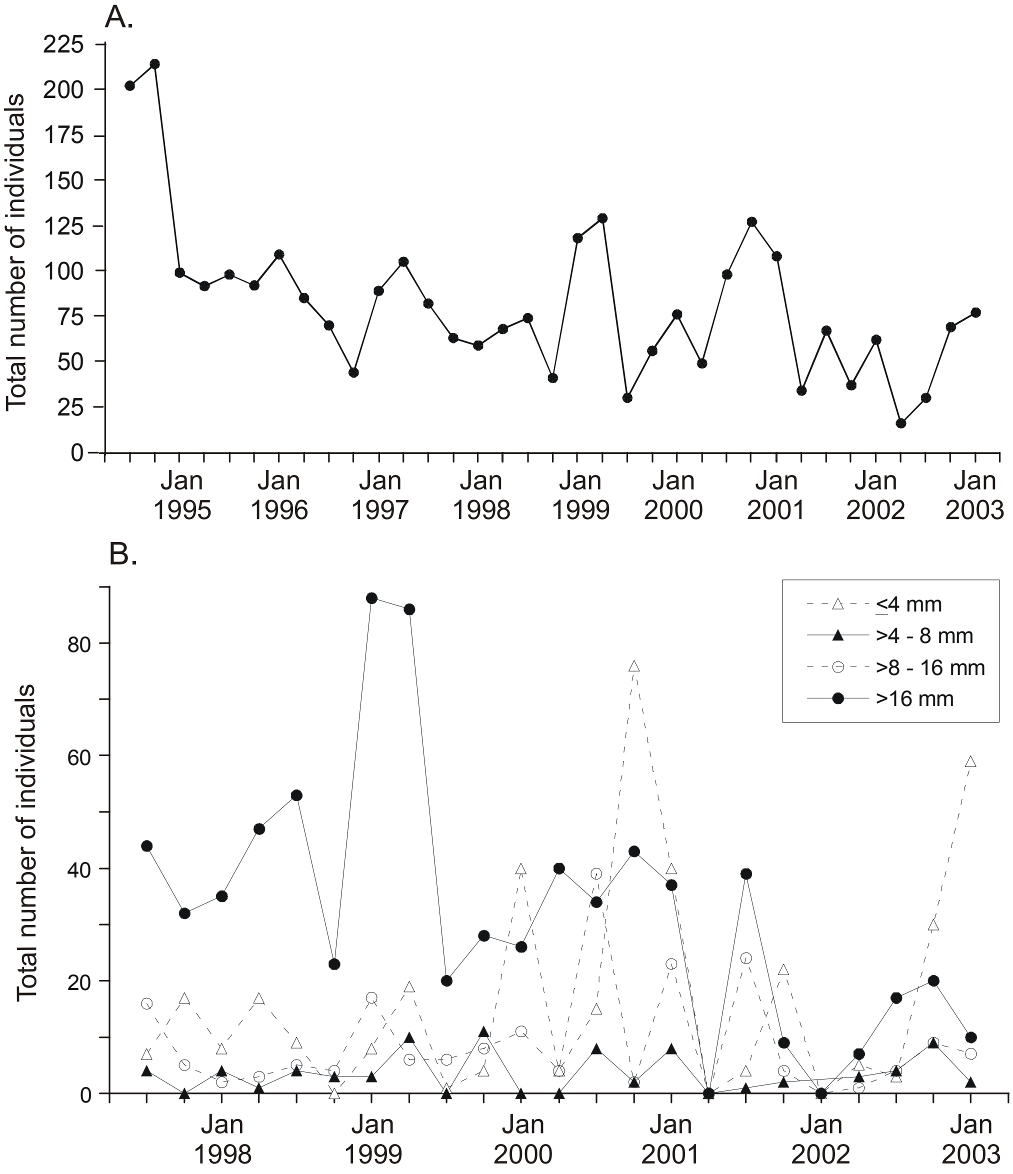

Figure 6: A. The total number of *Austrovenus stutchburyi* collected on each sampling occasion at Te Kapa Inlet, and B. The total number of individuals in each size class, from July 1997 onwards.

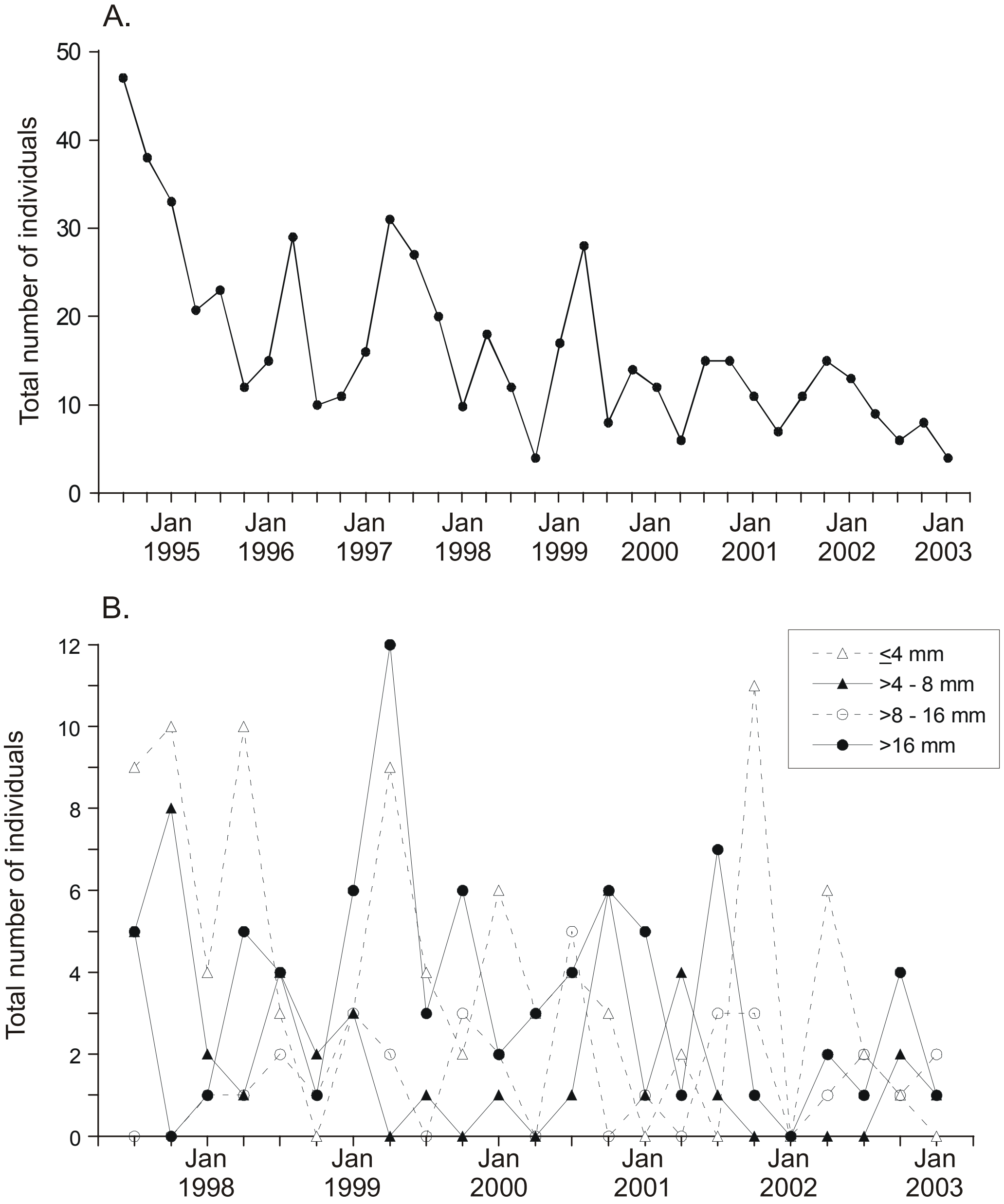

Figure 7: A. The total number of *Macomona liliana* collected on each sampling occasion at Te Kapa Inlet, and B. The total number of individuals in each size class, from July 1997 onwards.

Table 7: Magnitude of trends in abundance of intertidal taxa at each site detected using 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. Only taxa for which significant trends were detected are presented.

	July 1994 – January 2001	**July 1994 – January 2003**
Cowans Bay		
Austrovenus stutchburyi	0.127	
Polydorids	-0.421	-0.300
Hamilton Landing		
Aquilaspio aucklandica	(0.275)	0.348
Austrovenus stutchburyi	-4.71 (-5.48)	-3.672 (-3.456)
Cossura sp.	7.97	17.604
Heteromastus filiformis	11.26	11.196 (6.672)
Macomona liliana	-0.769	-0.708
Nemerteans		0.288
Nucula hartvigiana		-0.444
Oligochaetes		0.504
Perinereis nuntia		-0.096
Torridoharpinia hurleyi	0.166	
Jamieson Bay		
Aricidea sp.		0.408 (0.540)
Cossura sp.	-0.540	
Macomona liliana	-1.63	-1.236
Notoacmea helmsi	-1.410	0.180
Owenia fusiformis	-0.136	-0.108
Paracalliope novizelandiae		0.588
Polydorids	-14.51	-11.892 (-4.476)
Torridoharpinia hurleyi		-0.972
Mid Harbour		
Aonides oxycephala	-0.021	-0.012
Aricidea sp.		0.516
Arthritica bifurca		1.008
Cossura sp.	-3.32	-1.560
Heteromastus filiformis	-1.69	
Macomona liliana	-0.919 (-1.030)	-0.792
Nucula hartvigiana		(-6.828)

Table 7: (continued).

	July 1994 – January 2001	July 1994 – January 2003
Te Kapa Inlet		
Aonides oxycephala		.024
Austrovenus stutchburyi	-2.07	-2.208
Cossura sp.	7.77	13.644
Macomona liliana	-0.779 (-0.636)	-0.660 (-0.876)
Nemerteans	0.275	0.288
Notoacmea helmsi	-0.467 (ns)	
Nucula hartvigiana	-2.01	
Polydorids		-1.080 (-1.104)

3.1.3 Intertidal sites – general patterns

Sediment characteristics

The change in sediment grain size composition at the intertidal sites over the monitored period has been mentioned in previous reports (Cummings et al. 1999, 2001). Generally, there has been an increase in fine sand and a corresponding decrease in medium sand at each of the sites. This change occurred some time between the April 1996 and April 1997 sampling occasions, and the proportions of each of these fractions have remained relatively stable since this time. The changes in these fractions over the monitored period are clearly illustrated in Figure 8.

Populations showing trends in abundance

A total of 30 populations are showing trends in abundance over the monitored period. Sixteen of these populations are declining and fourteen are increasing (Table 7). Population trends have been detected at all sites, the most at Hamilton Landing (9 populations), and the least at Cowans Bay (1 population). Sites showed a combination of increasing and decreasing trends.

Nine bivalve populations exhibit trends in abundance. Decreasing trends were detected for *Macomona liliana* at all sites except Cowans Bay, and for *Austrovenus* *stutchburyi* and *Nucula hartvigiana* at two sites each (Hamilton Landing and Te Kapa Inlet, and Hamilton Landing and Mid Harbour, respectively). The tiny bivalve *Arthritca bifurca* has increased in abundance at Mid Harbour.

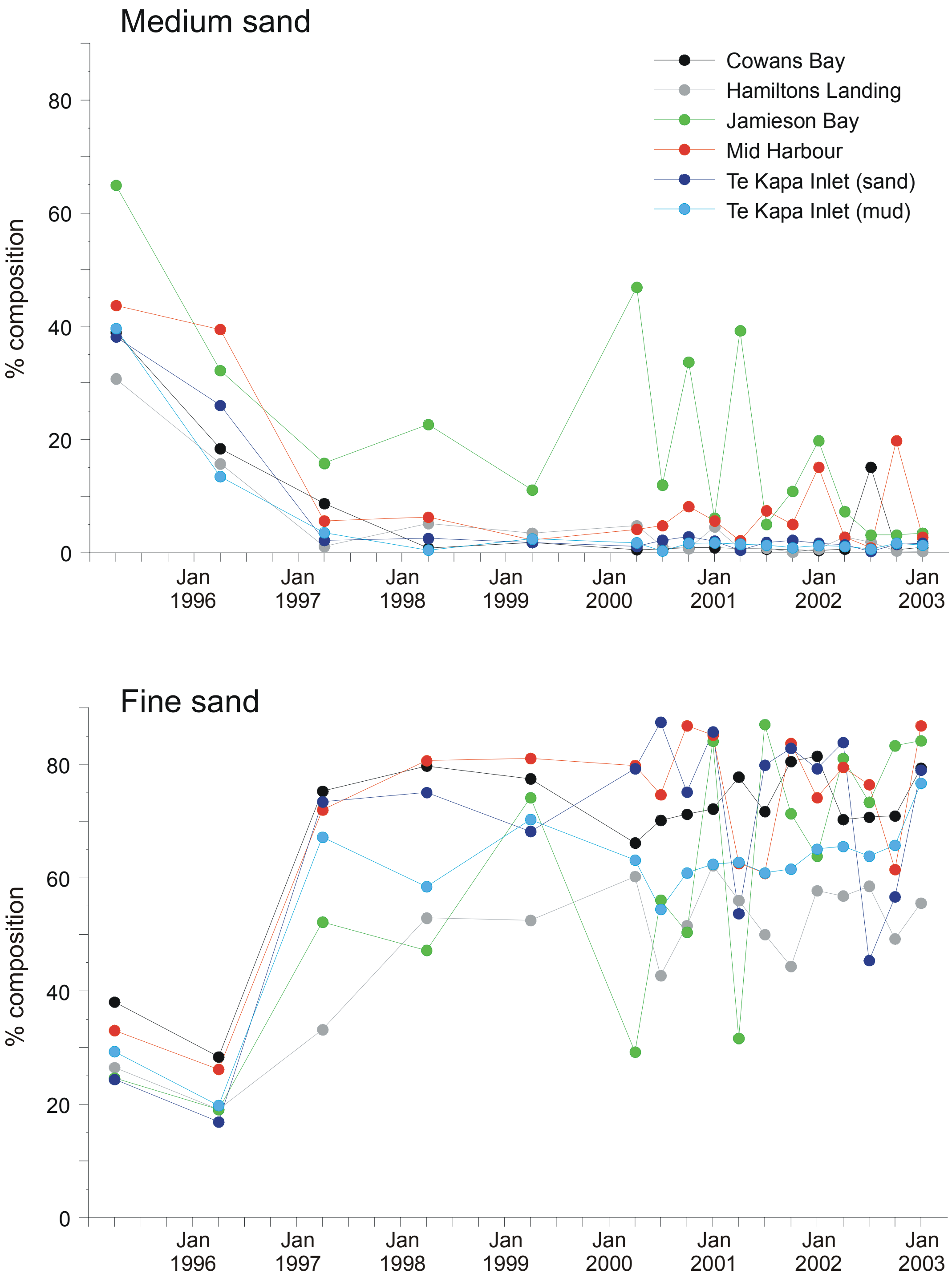

Figure 8: Changes in the proportions of the medium (250 –500 µm) and fine sand (62.5 – 250 µm) at each of the intertidal sites over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 1.

Of major concern is the wedge shell, *Macomona liliana*, which is still exhibiting a decreasing trend in abundance at four of the five intertidal sites (Table 7). At three of these sites (Hamilton Landing, Mid Harbour and Te Kapa Inlet), numbers of >16 mm individuals have decreased (Figures 3B, 5B and 7B). Lack of these spawning sized individuals means recruitment at the site will rely on immigration of larval and juvenile stages from outside the site. At Mid Harbour, a high proportion of recruit-sized individuals were found in October 2002 (Figure 5B). At Jamieson Bay, while abundances of recruits have declined considerably, numbers of larger individuals have been relatively steady in the past year (Figure 4B).

Austrovenus stutchburyi exhibits decreasing trends at Hamilton Landing and Te Kapa Inlet (Table 7). At Hamilton Landing in the past two years, this bivalve has occurred in very low numbers, or has not been found at all (Figure 2). The only individuals found at this site are small (i.e., $\leq$4 mm). Conversely, large individuals are still found at Te Kapa Inlet (Figure 6). As mentioned in our last report, the physiological condition of *Austrovenus* in these very muddy habitats is often low. Eventually, their ability to survive and reproduce in such areas may be compromised, in which case the populations will only persist via supply of recruits from other areas.

The concern in Mahurangi is that the declines in the monitored bivalve species appears to be a harbour-wide phenomenon. While we have data for our monitored sites only, and therefore cannot state categorically that there are no good shellfish populations elsewhere in the harbour, these monitoring sites do provide a good geographical spread of the harbour and populations have declined at all but one of our sites. This means that the supply of recruits may even have to come from outside the harbour, which will reduce the chances of recolonisation occurring at a particular site. For a long time, marine populations (including those in estuaries) were considered to be 'open', implying high mobility of larvae and juveniles. However recent research is indicating that for many species broad-scale dispersal is not so common. Our research matching the transport of potential colonists to hydrodynamic conditions indicates that dispersal is limited and habitat dependent (Lundquist et al. submitted). The implications of these trends in scientific findings is that we should be very cautious in involving simple 'supply-side' and 'source-sink' models to support the persistence of populations.

Trend analysis detected declines in seven polychaete populations, and increases in seven (Table 7). *Cossura* sp., exhibited increases in abundance in the last half of the monitored period at Hamilton Landing and Te Kapa Inlet, while at Jamieson Bay their numbers declined. The *Heteromastus filiformis* population at Hamilton Landing, and the *Aricicea* sp. population at Mid Harbour, have both increased over the monitored period. All three of these taxa thrive in muddy, organically enriched habitats. Polydorids have declined at three sites (Cowans Bay, Jamieson Bay and Te Kapa Inlet). However, once more data have been collected we may find that these apparent decreases are actually part of greater than annual (i.e., 3 - 4 yearly) cyclic abundance patterns.

3.1.4 Multivariate analysis of intertidal macrofaunal communities

Figure 9 shows the relative composition of the monitored-taxa communities at each site, and the temporal change in these communities over the sampling period. The Cowans Bay community is very stable, and exhibits 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 closer in ordination space in January 2003. The monitored communities at Jamieson Bay and Mid Harbour have become more similar to each other.

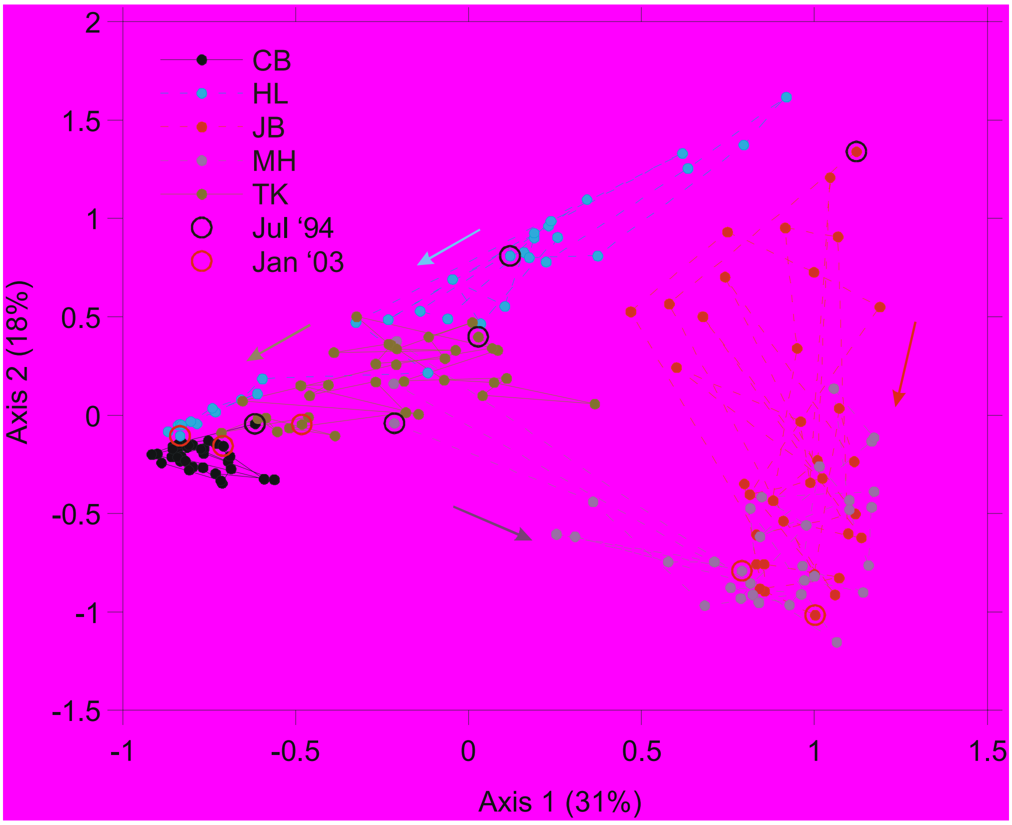

Figure 9: Correspondence analysis ordination plot, showing the temporal variation in the monitored community composition at each intertidal site over the monitored period. For each site, the positions of the community on the first (July 1994) and the most recent (January 2003) sampling occasions are 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.

3.2 Subtidal sites

3.2.1 Sediment Characteristics

The sediment grain size characteristics at the subtidal sites have not changed markedly in the past two years (Appendix 3). However, there has been an increase in the proportion of fine sand at both sites over the monitored period (Figure 10). This increase occurred, as noted for the intertidal sites, between the April 1996 and April 1997 sampling occasions. Unlike the intertidal sites, the % fine sand has been relatively low on a few occasions since this increase was noted. Also, the corresponding decrease in medium sand noted for the intertidal sites (see pg. 29, Figure 8) is not apparent at the subtidal sites (Figure 10).

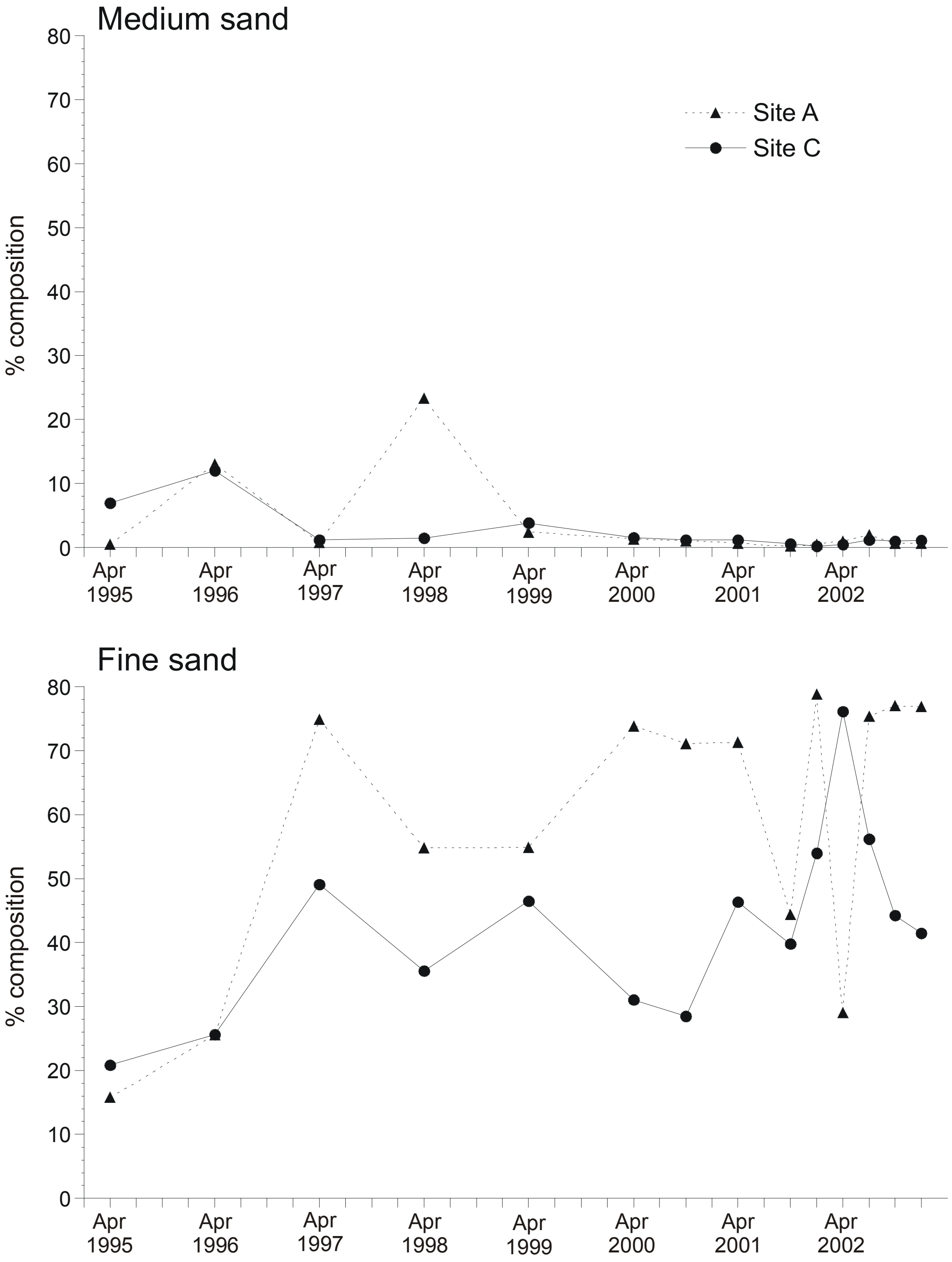

Figure 10: Changes in the proportions of the medium (250 –500 μm) and fine sand (62.5 – 250 μm) at the subtidal sites over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 3.

The organic and chlorophyll *a* contents of the subtidal sediments in October 2000 are shown in Table 8. The organic content of the subtidal sediments is less than 5% on all sampling dates (Table 8A). Sediment organic content was higher at the inner most harbour site, Site C, on all sampling dates except April 2002.

Unlike the sediment organic content, there was more chlorophyll *a* in Site A sediments on most sampling occasions (Table 8B). At both sites, highest chlorophyll *a* levels were recorded in April 2002.

Table 8: A. Organic content (% dry weight), and B. Chlorophyll *a* content (µg / g sediment) of sediments at the subtidal sites from October 2000.

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

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

3.2.2 *Atrina zelandica*

The decline in the abundance of live *Atrina* at both subtidal sites over the monitored period has continued (Figure 11). Numbers of live individuals were high at Site A until October 1995, after which time they declined considerably (Figure 11). The decrease in *Atrina* abundance further up the harbour at Site C was noted earlier, in October 1995 (Figure 11). On the most recent sampling date (January 2003), an average of 1.8 live *Atrina* (± 0.6 per 0.25 m^2 quadrat, SE) were found at Site A, and only 0.7 (± 0.4, SE) at Site C. This is consistent with the changes we may expect from increased suspended sediment concentrations (Ellis et al. 1999).

The mean sizes of these live individuals at Site C have increased slightly compared with the early stages of the monitoring programme (Figure 12). In April 2002, individuals were the largest ever recorded at this site (14.6 ± 0.5 cm shell width). Larger individuals have also been found later in the monitored period at Site A (i.e., 13.5 – 14.25 cm; January, April and July 2002).

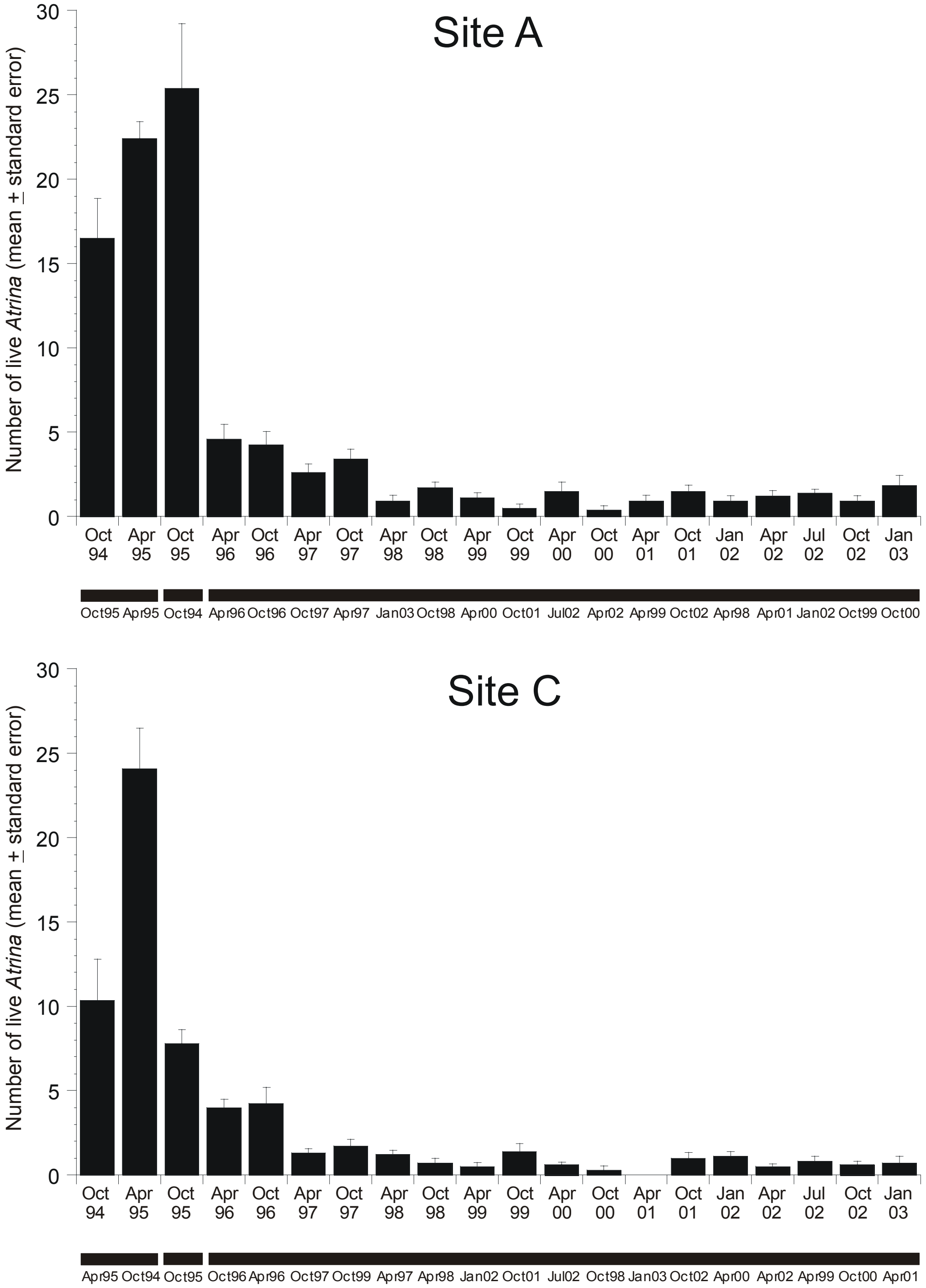

Figure 11: The number of live *Atrina zelandica* recorded in a 0.25 m^2 quadrat at the two subtidal sites on each sampling occasion. Also shown are the significant differences between sampling occasions: dates connected by the same line are not significantly different from each other.

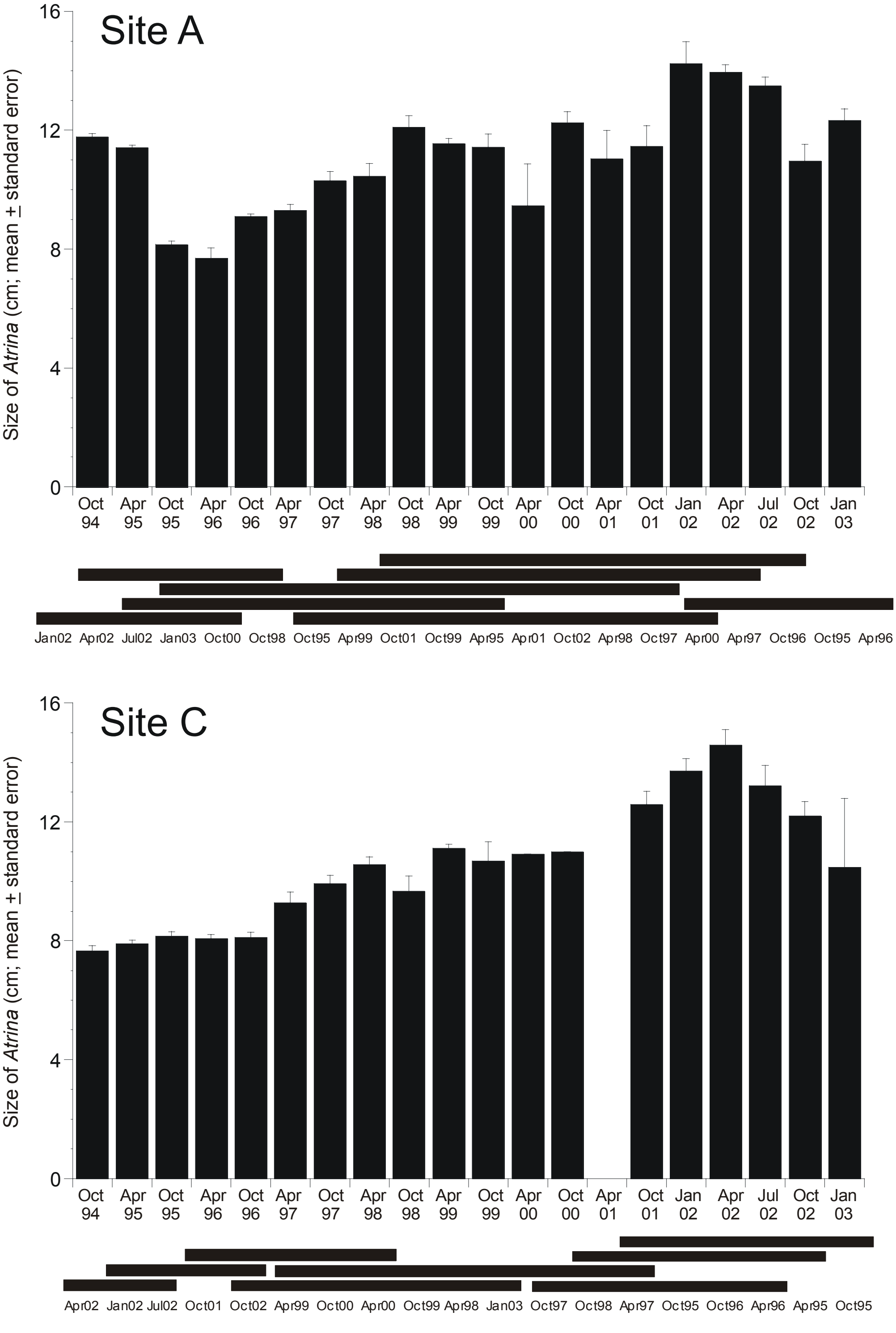

Figure 12: The mean size of live *Atrina zelandica* recorded in a 0.25 m^2 quadrat at the two subtidal sites on each sampling occasion. Also shown are the significant differences between sampling occasions: dates connected by the same line are not significantly different from each other.

3.2.3 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 2000 to January 2003) 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 at each site detected using regression analysis. Negative numbers indicate a decrease in abundance, while positive numbers indicate an increase. Only the results of analysis of each taxa using all data are presented here, as there were no significant trends detected using baseline data only. Only taxa for which significant trends were detected are presented.

	July 1994 – January 2001	**July 1994 – January 2003**
Site A		
Aricidea sp.	0.135	0.336
Cirratulids		0.456
Nucula hartvigiana	-0.378	
Theora lubrica	2.00	1.344
Site C		
Cirratulids		0.360
Corophidae-complex		0.288
Nucula hartvigiana	-0.433	
Oligochaetes	4.30	
Theora lubrica	3.13	3.180

Site A

The bivalve *Theora lubrica* continues to be the dominant taxa at this site (Table 10). Cirratulids, *Prionospio* sp. and *Torridoharpinia hurleyi* have been common in the past two years, while Polydorids, *Arthritica bifurca* and *Aricidea* sp. have all featured on 1 - 3 sampling dates.

Populations showing cyclic abundance patterns

Torridoharpinia hurleyi, as suggested in our last report, may be showing a greater than annual cycle in abundance. It has exhibited its highest numbers in April of 1995 and 1998, and October 2000. We had also suggested *Theora lubrica* had a greater than annual abundance cycle. However, with more data this does not appear to be the case.

Table 10: The three dominant taxa collected at subtidal Site A from October 1994 to January 2003. 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	*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*

Populations showing trends in abundance

Increasing trends in abundance have been detected for three taxa (*Aricidea* sp. Cirratulids 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 in the past two years, with 24 individuals collected in January 2003. Theora abundances have been higher in the second half of the monitored period. Prior to April 1999, between 7 and 46 individuals were found; however, from this time onwards 27 – 123 individuals have been collected (Figure 13). Cirratulid numbers have increased in the past year at this site. In the last report we noted a decline in numbers of *Nucula hartvigiana*; this trend is no longer apparent (Table 9; see below).

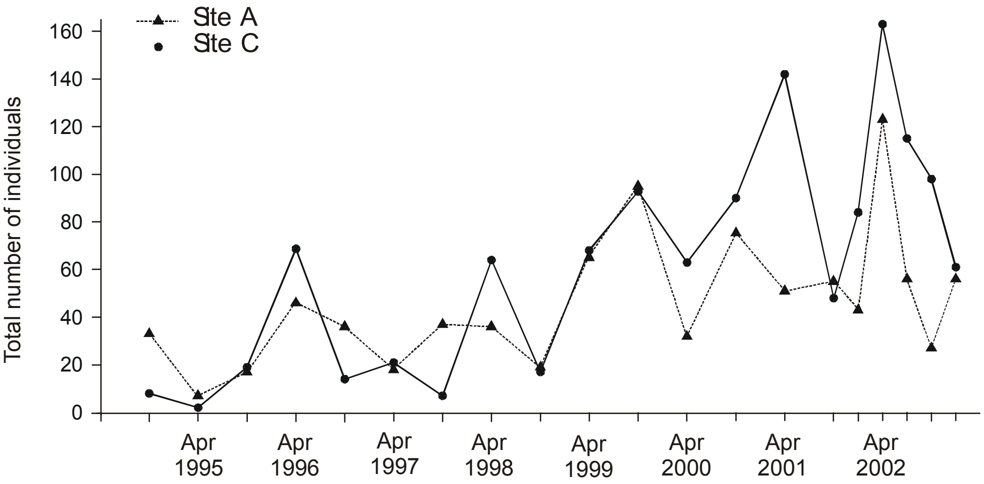

Figure 13: The total number of *Theora lubrica* collected on each sampling occasion at the subtidal sites.

Site C

Theora lubrica has been the first or second most abundant taxa at this site on all sampling dates in the past two years, while Oligochaetes have featured on all but the most recent occasion (January 2003). During this time period, Polydorids, Cirratulids and *Arthritica* have featured on 1 - 3 sampling dates (Table 11).

Populations showing cyclic abundance patterns

Arthritica bifurca is showing signs of a greater than annual cycle, with peak abundances recorded in April of 1998 and 2001.

Populations showing trends in abundance

Increasing trends were detected for *Theora lubrica*, Cirratulids and the amphipod Corophidae-complex (Table 9). *Theora* numbers prior to April 1999 ranged from 2 – 69 individuals. Since this time, 61 – 163 individuals have been collected on any one sampling date (Figure 13). A similar pattern has been noted for Cirratulids, with higher abundances after April 1999 (11 – 19 individuals) than before (0 – 13 individuals). Corophid amphipods were mostly absent from this site until October 2000, but have featured on all but 1 of the 9 sampling occasions since.

As for Site A, the decreasing trend noted for *Nucula hartvigiana* in the last report is no longer apparent (Table 9; see below).

Table 11: The three dominant taxa collected at subtidal Site C from October 1994 to January 2003. 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*

3.2.6 Multivariate analysis of subtidal macrofaunal communities

The monitored communities at Sites A and C have been separated in ordination space for the majority of the monitored period (Figure 14).

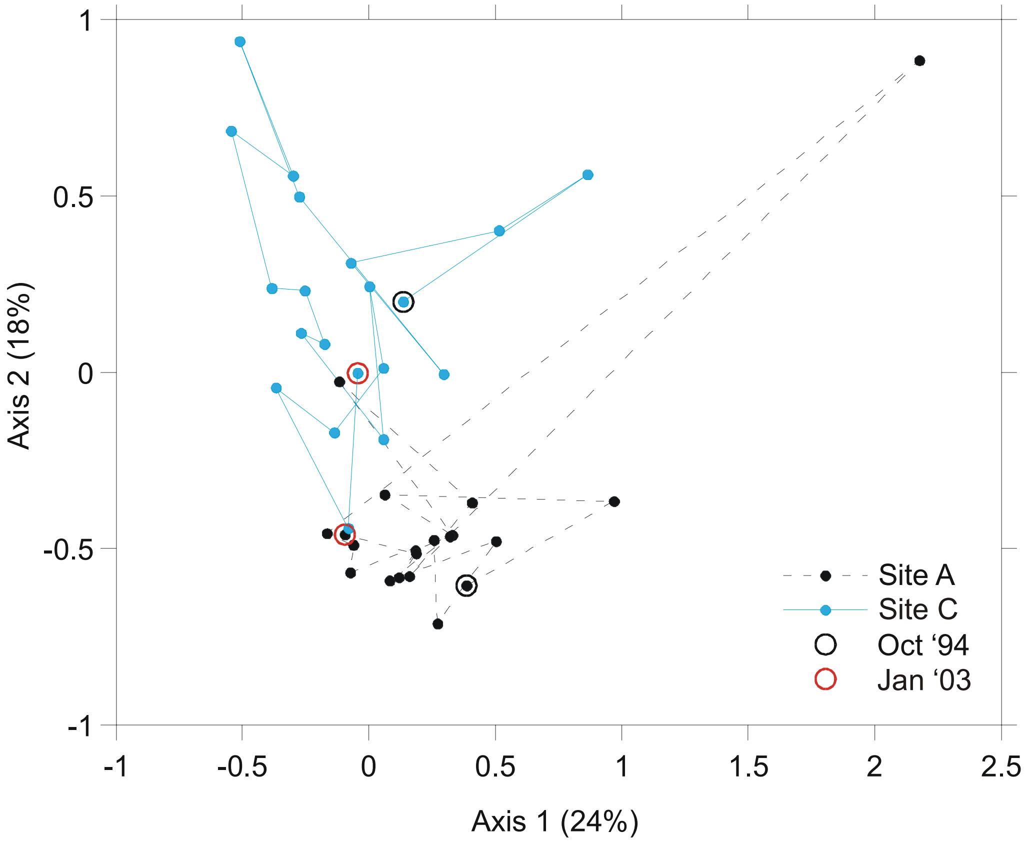

Figure 14: Correspondence analysis ordination plot, showing the temporal variation in the monitored community composition at the subtidal sites over the monitored period. For each site, the positions of the community on the first (October 1994) and most recent (January 2003) sampling occasions are highlighted. The percentage values associated with each axis indicate the % variance explained.

3.2.7 Subtidal sites – general patterns

Sediment characteristics

The change in sediment grain size composition noted at the intertidal sites over the monitored period has also occurred at the subtidal sites. Generally, there has been an increase in fine sand at each of the sites (Figure 10, Appendix 3). This change occurred some time between the April 1996 and April 1997 sampling occasions, and is more noticeable at Site A than Site C.

Atrina zelandica

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 11). Thus these declines cannot be a direct response to the increase in fine sand noted in the sediments at these sites between April of 1996 and 1997 (described above).

Macrofauna

Cirratulids have increased at both sites over the monitored period, as have *Theora lubrica*. *Theora* continues to show very similar temporal fluctuations in abundance at Site A and Site C (Figure 13).

Nucula showed a lack of recruitment peaks at both sites in 1999, and at Site A in 1998 and 2000. However, both populations have shown increases in the past year (Figure 15).

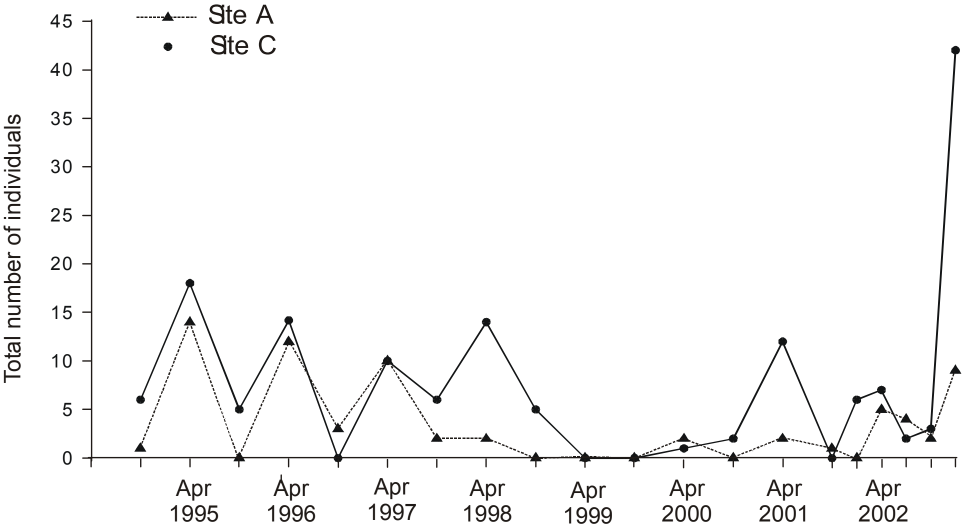

Figure 15: The total number of *Nucula hartvigiana* collected on each sampling occasion at the subtidal sites.

4. Conclusions and Recommendations

In our last report, we noted estuary-wide changes in abundance of macrofauna and horse mussels, and sediment characteristics over the monitored period (Cummings et al. 2001). These patterns in macrofaunal abundance were consistent with what we might expect to be associated with elevated levels of sedimentation and/or organic enrichment, giving us reason to be concerned (Cummings et al. 2001). With two more years of data now available, this situation has become much clearer.

Bivalves considered 'valuable' members of intertidal sandflat communities (*Macomona liliana* and *Austrovenus stutchburyi*) have all but disappeared from the uppermost intertidal site (Hamilton Landing) over the monitored period, and, due to its extremely muddy nature, any new recruits to this site are unlikely to persist. The Te Kapa Inlet site continues to provide an excellent (but unfortunate) example of changes in community structure which occur as a site becomes muddier. The Jamieson Bay site, which, with its coarser sediments and more exposed location, is the most 'coastal' example of all of the intertidal sites, is also showing signs of change. We strongly recommend that steps should be taken to mitigate any further change in the harbour.

While full scientific confidence can be had in the analysis of the time series, it also needs to be considered relative to the 'start' conditions. Given the trends reported in the time-series it is particularly important to ask *"how do you know that rather than things being in a state of decline, that they weren't previously in some uncharacteristically elevated condition and now they are returning to what is more normal for the Mahurangi?".* Of course the problem here is that we have no background ecological data. Certainly when we started working in Mahurangi there was plenty of mud, well developed mangrove habitats and turbid water. At the beginning of the monitoring programme the *Atrina* were abundant and encrusted with organisms, some of which are reasonably slow growing. We would expect to see these bivalves in a harbour like Mahurangi, and their size and encrusting community indicates that they had been in the harbour for a few years at least. These ecological observations lead us to consider that the harbour was not in an exceptionally pristine state when the monitoring programme was initiated. This is supported by sediment studies (Swales et al. 1997) that reveal a long history of sediment accumulation in the estuary.

We have noted an increase in the amount of fine sand at all sites, and a corresponding decrease in the amount of medium sand at the intertidal sites only. These changes occurred sometime between April 1996 and April 1997 and have persisted. We sampled the estuary on two occasions between these dates (July 1996 and January 1997), and did not see any evidence of a sedimentation 'event' (i.e., deposition of an obvious 'layer' of sediment) on those visits. We have not seen any obvious response to an apparent 'pulse' event by macrofauna, rather the declining or increasing trends are gradual. In addition, the changes in *Atrina* abundance at the subtidal sites occurred prior to this time.

This monitoring programme is designed to detect long-term and broad scale changes in the ecology of the harbour. When interpreting trends it is important to consider the scale of the physical process and that of the ecological response [Thrush, 1999 #4418]. We have conducted several experiments recently which involve depositing terrestrial sediments onto marine sediments (in Okura [Norkko et al. 1999], Whangapoua [Cummings et al. 2003; Hewitt et al. 2003], Whitianga [Thrush et al. in press], Whitford [Berkenbusch et al. 2001], and Mahurangi and Motuketekete [Lohrer et al. 2003]). These experiments all show a very consistent response: a rapid decline in macrofaunal abundance and diversity, and a very slow recovery. While we would only expect such 'saw-tooth' step trends to be apparent in the monitoring programme if the frequency of the monitoring matched, or exceeded, that of the ecological response, less frequent monitoring will still detect long-term negative trends in sensitive species. We consider it more likely that long-term negative trends in sensitive species reflect multiple (often small) events, and/or effects associated with changes in turbidity and the resuspension and transport of fine sediments around the estuary.

We are aware of only two long-term ecological monitoring programmes that have been operating in the Auckland region for sufficient time to enable long-term trends to be identified with any confidence. These are the monitoring programmes in Mahurangi and Manukau harbours. The natures of these two harbours differ substantially, meaning that any comparison between programmes needs to be done with caution. Nevertheless, many species are found in both harbours. However, none of these populations, at any of the three sites currently being monitored in Manukau (AA, CB, CH), show trends in abundance that are consistent with sediment loading (Funnell et al. 2003).

More generally, our observations while working in other estuaries indicate that sediment loading has probably influenced estuarine habitats and communities in Whitford, Okura, and the Upper Waitemata. A recent study comparing current benthic communities to decadal scale rates of sedimentation indicates that Pouhoi and Wairoa have been subject to high rates of sediment accumulation (Lundquist et al. submitted). During fieldwork in Kawau Bay we have observed very high levels of turbidity and plumes of sediment-laden water exiting the Matakana estuary after severe storms. However, we have only conducted a small amount of sampling in Matakana and we are not able to comment on the recent rate of sediment loading or changes in ecological condition relative to Mahurangi.

In our last report we 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). We recommend that this is followed through with appropriate actions to reduce the sediment loading to the harbour.

Future of the monitoring programme

We believe that monitoring two subtidal sites is still sufficient for the next couple of years. Despite the stability of the Cowans Bay site, the fact that it is distinctly different to the other intertidal sites and that other sites have become more similar to it in recent years (i.e., Hamilton Landing and Te Kapa Inlet) mean it provides useful comparison against which to assess harbour wide changes. Thus we recommend continuing to monitor all five of the intertidal sites.

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6. Appendices

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 (> 2000 µm)	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	2.40	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
Coarse sand (500 – 2000 µm)	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	1.33	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
Medium sand (250 – 500 µm)	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	2.74	7.32	2.78	1.42	1.11
		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

Fine Sand (62.5 – 250 µm)	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	70.34	56.77	81.13	79.56	83.94	65.59
		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	84.26	86.93	79.10	76.72
Silt (3.9 – 62.5 µm)	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	22.31	36.52	6.71	9.80	12.41	28.75
		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
Clay (< 3.9 µm)	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	6.53	3.87	3.35	5.28	1.82	4.23
		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

Appendix 2: Summary of temporal results[1] at the intertidal sites from April 2001(Time = 28) to January 2003 (Time = 35).

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Aonides oxycephala	CB	28	0	0	0	0.00
Aonides oxycephala	CB	29	0	0	0	0.00
Aonides oxycephala	CB	30	0	0	0	0.00
Aonides oxycephala	CB	31	0	0	0	0.00
Aonides oxycephala	CB	32	0	0	0	0.00
Aonides oxycephala	CB	33	0	0	0	0.00
Aonides oxycephala	CB	34	0	0	0	0.00
Aonides oxycephala	CB	35	0	0	0	0.00
Aonides oxycephala	HL	28	0	0	0	0.00
Aonides oxycephala	HL	29	0	0	0	0.00
Aonides oxycephala	HL	30	0	0	0	0.00
Aonides oxycephala	HL	31	0	0	0	0.00
Aonides oxycephala	HL	32	0	0	0	0.00
Aonides oxycephala	HL	33	0	0	0	0.00
Aonides oxycephala	HL	34	0	0	0	0.00
Aonides oxycephala	HL	35	0	0	0	0.00
Aonides oxycephala	JB	28	60	0	35	5.00
Aonides oxycephala	JB	29	47	0	47	3.92
Aonides oxycephala	JB	30	0	0	0	0.00
Aonides oxycephala	JB	31	0	0	0	0.00
Aonides oxycephala	JB	32	0	0	0	0.00
Aonides oxycephala	JB	33	1	0	1	0.08
Aonides oxycephala	JB	34	0	0	0	0.00
Aonides oxycephala	JB	35	4	0	1	0.33
Aonides oxycephala	MH	28	0	0	0	0.00
Aonides oxycephala	MH	29	0	0	0	0.00
Aonides oxycephala	MH	30	0	0	0	0.00
Aonides oxycephala	MH	31	0	0	0	0.00
Aonides oxycephala	MH	32	0	0	0	0.00
Aonides oxycephala	MH	33	0	0	0	0.00
Aonides oxycephala	MH	34	0	0	0	0.00
Aonides oxycephala	MH	35	0	0	0	0.00
Aonides oxycephala	TK	28	0	0	0	0.00
Aonides oxycephala	TK	29	2	0	2	0.17
Aonides oxycephala	TK	30	0	0	0	0.00
Aonides oxycephala	TK	31	0	0	0	0.00
Aonides oxycephala	TK	32	0	0	0	0.00
Aonides oxycephala	TK	33	0	0	0	0.00
Aonides oxycephala	TK	34	4	0	3	0.33
Aonides oxycephala	TK	35	0	0	0	0.00
Aquilaspio aucklandica	CB	28	1	0	1	0.08
Aquilaspio aucklandica	CB	29	5	0	2	0.42
Aquilaspio aucklandica	CB	30	4	0	1	0.33

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[1] Data are only given if the taxa occur at a site during this time period.
[2] Total number of individuals collected in 12 samples. Calculated by mean abundance*12.
[3] Range = between the 5th and 95th percentile.

Taxa	**Site**	**Time**	**Total**^{2}	**Median**	**Range**^{3}	**Mean**
Aquilaspio aucklandica	CB	31	1	0	1	0.08
Aquilaspio aucklandica	CB	32	1	0	1	0.08
Aquilaspio aucklandica	CB	33	0	0	0	0.00
Aquilaspio aucklandica	CB	34	1	0	1	0.08
Aquilaspio aucklandica	CB	35	0	0	0	0.00
Aquilaspio aucklandica	HL	28	17	2	3	1.42
Aquilaspio aucklandica	HL	29	5	0	2	0.42
Aquilaspio aucklandica	HL	30	18	1.5	4	1.50
Aquilaspio aucklandica	HL	31	19	1.5	4	1.58
Aquilaspio aucklandica	HL	32	6	0.5	1	0.50
Aquilaspio aucklandica	HL	33	9	0.5	4	0.75
Aquilaspio aucklandica	HL	34	6	0	2	0.50
Aquilaspio aucklandica	HL	35	27	2.5	5	2.25
Aquilaspio aucklandica	JB	28	1	0	1	0.08
Aquilaspio aucklandica	JB	29	2	0	1	0.17
Aquilaspio aucklandica	JB	30	1	0	1	0.08
Aquilaspio aucklandica	JB	31	4	0	3	0.33
Aquilaspio aucklandica	JB	32	3	0	1	0.25
Aquilaspio aucklandica	JB	33	2	0	1	0.17
Aquilaspio aucklandica	JB	34	0	0	0	0.00
Aquilaspio aucklandica	JB	35	4	0	2	0.33
Aquilaspio aucklandica	MH	28	37	2	11	3.08
Aquilaspio aucklandica	MH	29	5	0	3	0.42
Aquilaspio aucklandica	MH	30	0	0	0	0.00
Aquilaspio aucklandica	MH	31	1	0	1	0.08
Aquilaspio aucklandica	MH	32	2	0	1	0.17
Aquilaspio aucklandica	MH	33	0	0	0	0.00
Aquilaspio aucklandica	MH	34	0	0	0	0.00
Aquilaspio aucklandica	MH	35	0	0	0	0.00
Aquilaspio aucklandica	TK	28	32	1.5	11	2.67
Aquilaspio aucklandica	TK	29	33	2	9	2.75
Aquilaspio aucklandica	TK	30	18	1	5	1.50
Aquilaspio aucklandica	TK	31	37	3	8	3.08
Aquilaspio aucklandica	TK	32	34	2.5	6	2.83
Aquilaspio aucklandica	TK	33	16	1	3	1.33
Aquilaspio aucklandica	TK	34	31	1.5	11	2.58
Aquilaspio aucklandica	TK	35	50	3	12	4.17
Aricidea sp.	CB	28	3	0	1	0.25
Aricidea sp.	CB	29	6	0	2	0.50
Aricidea sp.	CB	30	6	0	2	0.50
Aricidea sp.	CB	31	3	0	1	0.25
Aricidea sp.	CB	32	3	0	2	0.25
Aricidea sp.	CB	33	5	0	2	0.42
Aricidea sp.	CB	34	6	0	3	0.50
Aricidea sp.	CB	35	18	0	6	1.50
Aricidea sp.	HL	28	5	0	2	0.42
Aricidea sp.	HL	29	7	0	3	0.58
Aricidea sp.	HL	30	4	0	2	0.33
Aricidea sp.	HL	31	7	0	2	0.58
Aricidea sp.	HL	32	21	1	5	1.75

Taxa	**Site**	**Time**	**Total**^{2}	**Median**	**Range**^{3}	**Mean**
Aricidea sp.	HL	33	14	1	3	1.17
Aricidea sp.	HL	34	6	0.5	1	0.50
Aricidea sp.	HL	35	15	1	4	1.25
Aricidea sp.	JB	28	14	0	5	1.17
Aricidea sp.	JB	29	32	2	8	2.67
Aricidea sp.	JB	30	28	1	11	2.33
Aricidea sp.	JB	31	13	0	6	1.08
Aricidea sp.	JB	32	7	0	4	0.58
Aricidea sp.	JB	33	0	0	0	0.00
Aricidea sp.	JB	34	44	0.5	19	3.67
Aricidea sp.	JB	35	17	0	6	1.42
Aricidea sp.	MH	28	28	2	7	2.33
Aricidea sp.	MH	29	49	3.5	8	4.08
Aricidea sp.	MH	30	10	0.5	3	0.83
Aricidea sp.	MH	31	48	3.5	12	4.00
Aricidea sp.	MH	32	6	0	3	0.50
Aricidea sp.	MH	33	21	1.5	6	1.75
Aricidea sp.	MH	34	11	1	3	0.92
Aricidea sp.	MH	35	6	0	2	0.50
Aricidea sp.	TK	28	24	1	7	2.00
Aricidea sp.	TK	29	70	4.5	14	5.83
Aricidea sp.	TK	30	148	13	23	12.33
Aricidea sp.	TK	31	93	9	11	7.75
Aricidea sp.	TK	32	79	5.5	16	6.58
Aricidea sp.	TK	33	90	7.5	14	7.50
Aricidea sp.	TK	34	126	8.5	20	10.50
Aricidea sp.	TK	35	86	3	40	7.17
Arthritica bifurca	CB	28	67	6	12	5.58
Arthritica bifurca	CB	29	203	18.5	42	16.92
Arthritica bifurca	CB	30	236	16.5	54	19.67
Arthritica bifurca	CB	31	131	10	25	10.92
Arthritica bifurca	CB	32	36	2	11	3.00
Arthritica bifurca	CB	33	88	7	19	7.33
Arthritica bifurca	CB	34	157	14	19	13.08
Arthritica bifurca	CB	35	43	3	7	3.58
Arthritica bifurca	HL	28	0	0	0	0.00
Arthritica bifurca	HL	29	2	0	1	0.17
Arthritica bifurca	HL	30	9	0	5	0.75
Arthritica bifurca	HL	31	10	0	7	0.83
Arthritica bifurca	HL	32	1	0	1	0.08
Arthritica bifurca	HL	33	26	1.5	10	2.17
Arthritica bifurca	HL	34	22	1.5	5	1.83
Arthritica bifurca	HL	35	71	5	17	5.92
Arthritica bifurca	JB	28	7	0	3	0.58
Arthritica bifurca	JB	29	16	0.5	11	1.33
Arthritica bifurca	JB	30	4	0	2	0.33
Arthritica bifurca	JB	31	3	0	3	0.25
Arthritica bifurca	JB	32	13	0	11	1.08
Arthritica bifurca	JB	33	6	0	5	0.50
Arthritica bifurca	JB	34	1	0	1	0.08

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Arthritica bifurca	JB	35	3	0	1	0.25
Arthritica bifurca	MH	28	11	0	6	0.92
Arthritica bifurca	MH	29	48	3	10	4.00
Arthritica bifurca	MH	30	98	8	17	8.17
Arthritica bifurca	MH	31	63	3.5	24	5.25
Arthritica bifurca	MH	32	87	5.5	17	7.25
Arthritica bifurca	MH	33	59	4.5	13	4.92
Arthritica bifurca	MH	34	73	5.5	16	6.08
Arthritica bifurca	MH	35	40	2	14	3.33
Arthritica bifurca	TK	28	8	0	2	0.67
Arthritica bifurca	TK	29	6	0	3	0.50
Arthritica bifurca	TK	30	19	1.5	4	1.58
Arthritica bifurca	TK	31	23	1	10	1.92
Arthritica bifurca	TK	32	6	0	3	0.50
Arthritica bifurca	TK	33	5	0	3	0.42
Arthritica bifurca	TK	34	7	0.5	2	0.58
Arthritica bifurca	TK	35	26	1	8	2.17
Austrovenus stutchburyi	CB	28	0	0	0	0.00
Austrovenus stutchburyi	CB	29	0	0	0	0.00
Austrovenus stutchburyi	CB	30	1	0	1	0.08
Austrovenus stutchburyi	CB	31	1	0	1	0.08
Austrovenus stutchburyi	CB	32	1	0	1	0.08
Austrovenus stutchburyi	CB	33	0	0	0	0.00
Austrovenus stutchburyi	CB	34	0	0	0	0.00
Austrovenus stutchburyi	CB	35	1	0	1	0.08
Austrovenus stutchburyi	HL	28	1	0	1	0.08
Austrovenus stutchburyi	HL	29	2	0	1	0.17
Austrovenus stutchburyi	HL	30	5	0	2	0.42
Austrovenus stutchburyi	HL	31	2	0	2	0.17
Austrovenus stutchburyi	HL	32	2	0	1	0.17
Austrovenus stutchburyi	HL	33	1	0	1	0.08
Austrovenus stutchburyi	HL	34	2	0	1	0.17
Austrovenus stutchburyi	HL	35	2	0	1	0.17
Austrovenus stutchburyi	JB	28	12	0	10	1.00
Austrovenus stutchburyi	JB	29	4	0	2	0.33
Austrovenus stutchburyi	JB	30	3	0	2	0.25
Austrovenus stutchburyi	JB	31	2	0	2	0.17
Austrovenus stutchburyi	JB	32	1	0	1	0.08
Austrovenus stutchburyi	JB	33	2	0	2	0.17
Austrovenus stutchburyi	JB	34	0	0	0	0.00
Austrovenus stutchburyi	JB	35	10	0	6	0.83
Austrovenus stutchburyi	MH	28	2	0	1	0.17
Austrovenus stutchburyi	MH	29	4	0	1	0.33
Austrovenus stutchburyi	MH	30	1	0	1	0.08
Austrovenus stutchburyi	MH	31	0	0	0	0.00
Austrovenus stutchburyi	MH	32	0	0	0	0.00
Austrovenus stutchburyi	MH	33	0	0	0	0.00
Austrovenus stutchburyi	MH	34	1	0	1	0.08
Austrovenus stutchburyi	MH	35	0	0	0	0.00
Austrovenus stutchburyi	TK	28	34	0	30	2.83

Taxa	**Site**	**Time**	**Total**[2]	**Median**	**Range**[3]	**Mean**
Austrovenus stutchburyi	TK	29	67	0	40	5.58
Austrovenus stutchburyi	TK	30	37	1	20	3.08
Austrovenus stutchburyi	TK	31	62	1	30	5.17
Austrovenus stutchburyi	TK	32	16	0	11	1.33
Austrovenus stutchburyi	TK	33	30	0	25	2.50
Austrovenus stutchburyi	TK	34	69	3.5	33	5.75
Austrovenus stutchburyi	TK	35	77	1.5	36	6.42
Cossura sp.	CB	28	429	32	55	35.75
Cossura sp.	CB	29	582	49	40	48.50
Cossura sp.	CB	30	515	40.5	38	42.92
Cossura sp.	CB	31	374	30.5	44	31.17
Cossura sp.	CB	32	516	44.5	39	43.00
Cossura sp.	CB	33	331	24	49	27.58
Cossura sp.	CB	34	406	32.5	39	33.83
Cossura sp.	CB	35	310	23.5	39	25.83
Cossura sp.	HL	28	435	29	87	36.25
Cossura sp.	HL	29	427	30	86	35.58
Cossura sp.	HL	30	601	51	61	50.08
Cossura sp.	HL	31	622	49	48	51.83
Cossura sp.	HL	32	467	23.5	109	38.92
Cossura sp.	HL	33	637	57	83	53.08
Cossura sp.	HL	34	513	38	73	42.75
Cossura sp.	HL	35	659	52	77	54.92
Cossura sp.	JB	28	23	0.5	9	1.92
Cossura sp.	JB	29	30	1.5	8	2.50
Cossura sp.	JB	30	11	0	4	0.92
Cossura sp.	JB	31	27	0.5	8	2.25
Cossura sp.	JB	32	40	2	12	3.33
Cossura sp.	JB	33	0	0	0	0.00
Cossura sp.	JB	34	16	1	4	1.33
Cossura sp.	JB	35	27	0.5	13	2.25
Cossura sp.	MH	28	16	0	10	1.33
Cossura sp.	MH	29	42	2	16	3.50
Cossura sp.	MH	30	14	1	7	1.17
Cossura sp.	MH	31	27	2	10	2.25
Cossura sp.	MH	32	23	1	6	1.92
Cossura sp.	MH	33	31	1.5	11	2.58
Cossura sp.	MH	34	114	2.5	41	9.50
Cossura sp.	MH	35	41	4	7	3.42
Cossura sp.	TK	28	238	16	68	19.83
Cossura sp.	TK	29	378	32.5	73	31.50
Cossura sp.	TK	30	494	33.5	95	41.17
Cossura sp.	TK	31	559	36	123	46.58
Cossura sp.	TK	32	323	30	61	26.92
Cossura sp.	TK	33	671	65.5	95	55.92
Cossura sp.	TK	34	483	37.5	117	40.25
Cossura sp.	TK	35	430	35.5	79	35.83
Heteromastus filiformis	CB	28	112	8.5	15	9.33
Heteromastus filiformis	CB	29	186	15	18	15.50
Heteromastus filiformis	CB	30	131	10.5	10	10.92

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Heteromastus filiformis	CB	31	79	7	10	6.58
Heteromastus filiformis	CB	32	132	10.5	13	11.00
Heteromastus filiformis	CB	33	193	16	32	16.08
Heteromastus filiformis	CB	34	177	13	19	14.75
Heteromastus filiformis	CB	35	130	8	23	10.83
Heteromastus filiformis	HL	28	248	20.5	37	20.67
Heteromastus filiformis	HL	29	215	18.5	30	17.92
Heteromastus filiformis	HL	30	329	28.5	40	27.42
Heteromastus filiformis	HL	31	294	27	21	24.50
Heteromastus filiformis	HL	32	117	8.5	27	9.75
Heteromastus filiformis	HL	33	679	50.5	70	56.58
Heteromastus filiformis	HL	34	385	28	69	32.08
Heteromastus filiformis	HL	35	255	20.5	23	21.25
Heteromastus filiformis	JB	28	12	1	3	1.00
Heteromastus filiformis	JB	29	31	2	9	2.58
Heteromastus filiformis	JB	30	11	0	5	0.92
Heteromastus filiformis	JB	31	17	1	6	1.42
Heteromastus filiformis	JB	32	36	2	6	3.00
Heteromastus filiformis	JB	33	44	4	9	3.67
Heteromastus filiformis	JB	34	38	3	10	3.17
Heteromastus filiformis	JB	35	24	2	7	2.00
Heteromastus filiformis	MH	28	48	3.5	10	4.00
Heteromastus filiformis	MH	29	119	7.5	22	9.92
Heteromastus filiformis	MH	30	41	3	5	3.42
Heteromastus filiformis	MH	31	90	7	20	7.50
Heteromastus filiformis	MH	32	50	4.5	8	4.17
Heteromastus filiformis	MH	33	42	2.5	9	3.50
Heteromastus filiformis	MH	34	92	7.5	13	7.67
Heteromastus filiformis	MH	35	38	2.5	8	3.17
Heteromastus filiformis	TK	28	56	4.5	9	4.67
Heteromastus filiformis	TK	29	143	13	22	11.92
Heteromastus filiformis	TK	30	165	12.5	21	13.75
Heteromastus filiformis	TK	31	184	14	27	15.33
Heteromastus filiformis	TK	32	119	7.5	20	9.92
Heteromastus filiformis	TK	33	115	8.5	20	9.58
Heteromastus filiformis	TK	34	160	14	14	13.33
Heteromastus filiformis	TK	35	110	8.5	16	9.17
Macomona liliana	CB	28	4	0	1	0.33
Macomona liliana	CB	29	4	0	1	0.33
Macomona liliana	CB	30	8	0.5	3	0.67
Macomona liliana	CB	31	3	0	1	0.25
Macomona liliana	CB	32	4	0	1	0.33
Macomona liliana	CB	33	4	0	1	0.33
Macomona liliana	CB	34	1	0	1	0.08
Macomona liliana	CB	35	1	0	1	0.08
Macomona liliana	HL	28	1	0	1	0.08
Macomona liliana	HL	29	5	0	2	0.42
Macomona liliana	HL	30	5	0	2	0.42
Macomona liliana	HL	31	2	0	1	0.17
Macomona liliana	HL	32	3	0	2	0.25

Taxa	**Site**	**Time**	**Total**[2]	**Median**	**Range**[3]	**Mean**
Macomona liliana	HL	33	10	1	2	0.83
Macomona liliana	HL	34	0	0	0	0.00
Macomona liliana	HL	35	2	0	1	0.17
Macomona liliana	JB	28	7	0	2	0.58
Macomona liliana	JB	29	8	0.5	2	0.67
Macomona liliana	JB	30	12	1	3	1.00
Macomona liliana	JB	31	19	1	8	1.58
Macomona liliana	JB	32	11	1	4	0.92
Macomona liliana	JB	33	8	0.5	2	0.67
Macomona liliana	JB	34	5	0	2	0.42
Macomona liliana	JB	35	13	1	3	1.08
Macomona liliana	MH	28	7	0	2	0.58
Macomona liliana	MH	29	3	0	1	0.25
Macomona liliana	MH	30	11	0	7	0.92
Macomona liliana	MH	31	4	0	2	0.33
Macomona liliana	MH	32	3	0	1	0.25
Macomona liliana	MH	33	5	0	1	0.42
Macomona liliana	MH	34	10	1	3	0.83
Macomona liliana	MH	35	7	0.5	2	0.58
Macomona liliana	TK	28	7	0	2	0.58
Macomona liliana	TK	29	11	0	5	0.92
Macomona liliana	TK	30	15	0.5	5	1.25
Macomona liliana	TK	31	13	0.5	5	1.08
Macomona liliana	TK	32	9	0	4	0.75
Macomona liliana	TK	33	6	0	2	0.50
Macomona liliana	TK	34	8	0	3	0.67
Macomona liliana	TK	35	4	0	2	0.33
Macrophthalmus hirtipes	CB	28	2	0	1	0.17
Macrophthalmus hirtipes	CB	29	0	0	0	0.00
Macrophthalmus hirtipes	CB	30	13	1	5	1.08
Macrophthalmus hirtipes	CB	31	6	0.5	1	0.50
Macrophthalmus hirtipes	CB	32	2	0	2	0.17
Macrophthalmus hirtipes	CB	33	3	0	2	0.25
Macrophthalmus hirtipes	CB	34	10	1	2	0.83
Macrophthalmus hirtipes	CB	35	8	0	3	0.67
Macrophthalmus hirtipes	HL	28	0	0	0	0.00
Macrophthalmus hirtipes	HL	29	0	0	0	0.00
Macrophthalmus hirtipes	HL	30	17	1	4	1.42
Macrophthalmus hirtipes	HL	31	4	0	1	0.33
Macrophthalmus hirtipes	HL	32	0	0	0	0.00
Macrophthalmus hirtipes	HL	33	5	0	2	0.42
Macrophthalmus hirtipes	HL	34	28	2	7	2.33
Macrophthalmus hirtipes	HL	35	9	0	4	0.75
Macrophthalmus hirtipes	JB	28	0	0	0	0.00
Macrophthalmus hirtipes	JB	29	0	0	0	0.00
Macrophthalmus hirtipes	JB	30	10	1	3	0.83
Macrophthalmus hirtipes	JB	31	0	0	0	0.00
Macrophthalmus hirtipes	JB	32	0	0	0	0.00
Macrophthalmus hirtipes	JB	33	0	0	0	0.00
Macrophthalmus hirtipes	JB	34	0	0	0	0.00

Taxa	**Site**	**Time**	**Total**[2]	**Median**	**Range**[3]	**Mean**
Macrophthalmus hirtipes	JB	35	2	0	1	0.17
Macrophthalmus hirtipes	MH	28	0	0	0	0.00
Macrophthalmus hirtipes	MH	29	0	0	0	0.00
Macrophthalmus hirtipes	MH	30	9	0.5	3	0.75
Macrophthalmus hirtipes	MH	31	2	0	1	0.17
Macrophthalmus hirtipes	MH	32	0	0	0	0.00
Macrophthalmus hirtipes	MH	33	0	0	0	0.00
Macrophthalmus hirtipes	MH	34	2	0	2	0.17
Macrophthalmus hirtipes	MH	35	2	0	1	0.17
Macrophthalmus hirtipes	TK	28	1	0	1	0.08
Macrophthalmus hirtipes	TK	29	0	0	0	0.00
Macrophthalmus hirtipes	TK	30	3	0	1	0.25
Macrophthalmus hirtipes	TK	31	1	0	1	0.08
Macrophthalmus hirtipes	TK	32	1	0	1	0.08
Macrophthalmus hirtipes	TK	33	0	0	0	0.00
Macrophthalmus hirtipes	TK	34	6	0	2	0.50
Macrophthalmus hirtipes	TK	35	1	0	1	0.08
Nemerteans	CB	28	8	1	1	0.67
Nemerteans	CB	29	8	0	3	0.67
Nemerteans	CB	30	1	0	1	0.08
Nemerteans	CB	31	4	0	3	0.33
Nemerteans	CB	32	4	0	1	0.33
Nemerteans	CB	33	5	0	1	0.42
Nemerteans	CB	34	10	1	4	0.83
Nemerteans	CB	35	0	0	0	0.00
Nemerteans	HL	28	13	1	3	1.08
Nemerteans	HL	29	6	0	3	0.50
Nemerteans	HL	30	19	1	4	1.58
Nemerteans	HL	31	4	0	2	0.33
Nemerteans	HL	32	22	0	9	1.83
Nemerteans	HL	33	11	0	5	0.92
Nemerteans	HL	34	7	0	3	0.58
Nemerteans	HL	35	10	0	5	0.83
Nemerteans	JB	28	1	0	1	0.08
Nemerteans	JB	29	17	1	6	1.42
Nemerteans	JB	30	6	0	2	0.50
Nemerteans	JB	31	14	0.5	5	1.17
Nemerteans	JB	32	17	1.5	3	1.42
Nemerteans	JB	33	9	0.5	2	0.75
Nemerteans	JB	34	0	0	0	0.00
Nemerteans	JB	35	0	0	0	0.00
Nemerteans	MH	28	28	2	9	2.33
Nemerteans	MH	29	27	2	4	2.25
Nemerteans	MH	30	7	0	2	0.58
Nemerteans	MH	31	1	0	1	0.08
Nemerteans	MH	32	17	1.5	5	1.42
Nemerteans	MH	33	8	1	2	0.67
Nemerteans	MH	34	2	0	1	0.17
Nemerteans	MH	35	4	0	2	0.33
Nemerteans	TK	28	5	0	2	0.42

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Nemerteans	TK	29	13	1	3	1.08
Nemerteans	TK	30	18	1	8	1.50
Nemerteans	TK	31	5	0	2	0.42
Nemerteans	TK	32	14	0.5	5	1.17
Nemerteans	TK	33	17	1	5	1.42
Nemerteans	TK	34	11	0	4	0.92
Nemerteans	TK	35	10	1	3	0.83
Notoacmea helmsi	CB	28	0	0	0	0.00
Notoacmea helmsi	CB	29	0	0	0	0.00
Notoacmea helmsi	CB	30	0	0	0	0.00
Notoacmea helmsi	CB	31	0	0	0	0.00
Notoacmea helmsi	CB	32	0	0	0	0.00
Notoacmea helmsi	CB	33	1	0	1	0.08
Notoacmea helmsi	CB	34	0	0	0	0.00
Notoacmea helmsi	CB	35	1	0	1	0.08
Notoacmea helmsi	HL	28	0	0	0	0.00
Notoacmea helmsi	HL	29	0	0	0	0.00
Notoacmea helmsi	HL	30	0	0	0	0.00
Notoacmea helmsi	HL	31	0	0	0	0.00
Notoacmea helmsi	HL	32	0	0	0	0.00
Notoacmea helmsi	HL	33	0	0	0	0.00
Notoacmea helmsi	HL	34	1	0	1	0.08
Notoacmea helmsi	HL	35	0	0	0	0.00
Notoacmea helmsi	JB	28	1	0	1	0.08
Notoacmea helmsi	JB	29	1	0	1	0.08
Notoacmea helmsi	JB	30	0	0	0	0.00
Notoacmea helmsi	JB	31	0	0	0	0.00
Notoacmea helmsi	JB	32	27	0	26	2.25
Notoacmea helmsi	JB	33	0	0	0	0.00
Notoacmea helmsi	JB	34	11	0	6	0.92
Notoacmea helmsi	JB	35	3	0	2	0.25
Notoacmea helmsi	MH	28	0	0	0	0.00
Notoacmea helmsi	MH	29	0	0	0	0.00
Notoacmea helmsi	MH	30	0	0	0	0.00
Notoacmea helmsi	MH	31	0	0	0	0.00
Notoacmea helmsi	MH	32	0	0	0	0.00
Notoacmea helmsi	MH	33	0	0	0	0.00
Notoacmea helmsi	MH	34	0	0	0	0.00
Notoacmea helmsi	MH	35	0	0	0	0.00
Notoacmea helmsi	TK	28	0	0	0	0.00
Notoacmea helmsi	TK	29	13	0	12	1.08
Notoacmea helmsi	TK	30	8	0	7	0.67
Notoacmea helmsi	TK	31	8	0	8	0.67
Notoacmea helmsi	TK	32	3	0	3	0.25
Notoacmea helmsi	TK	33	1	0	1	0.08
Notoacmea helmsi	TK	34	6	0	5	0.50
Notoacmea helmsi	TK	35	2	0	2	0.17
Nucula hartvigiana	CB	28	10	1	4	0.83
Nucula hartvigiana	CB	29	9	1	2	0.75
Nucula hartvigiana	CB	30	15	1	3	1.25

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Nucula hartvigiana	CB	31	13	1	4	1.08
Nucula hartvigiana	CB	32	9	1	3	0.75
Nucula hartvigiana	CB	33	9	0	4	0.75
Nucula hartvigiana	CB	34	28	2	4	2.33
Nucula hartvigiana	CB	35	22	2	5	1.83
Nucula hartvigiana	HL	28	0	0	0	0.00
Nucula hartvigiana	HL	29	0	0	0	0.00
Nucula hartvigiana	HL	30	1	0	1	0.08
Nucula hartvigiana	HL	31	2	0	2	0.17
Nucula hartvigiana	HL	32	0	0	0	0.00
Nucula hartvigiana	HL	33	4	0	1	0.33
Nucula hartvigiana	HL	34	1	0	1	0.08
Nucula hartvigiana	HL	35	1	0	1	0.08
Nucula hartvigiana	JB	28	289	18	55	24.08
Nucula hartvigiana	JB	29	189	4.5	54	15.75
Nucula hartvigiana	JB	30	179	4.5	45	14.92
Nucula hartvigiana	JB	31	236	20.5	62	19.67
Nucula hartvigiana	JB	32	306	19	60	25.50
Nucula hartvigiana	JB	33	353	34	65	29.42
Nucula hartvigiana	JB	34	270	16.5	81	22.50
Nucula hartvigiana	JB	35	378	28.5	47	31.50
Nucula hartvigiana	MH	28	1	0	1	0.08
Nucula hartvigiana	MH	29	24	1	9	2.00
Nucula hartvigiana	MH	30	449	36.5	46	37.42
Nucula hartvigiana	MH	31	193	16	46	16.08
Nucula hartvigiana	MH	32	266	16	28	22.17
Nucula hartvigiana	MH	33	310	26.5	45	25.83
Nucula hartvigiana	MH	34	257	23	37	21.42
Nucula hartvigiana	MH	35	320	28.5	34	26.67
Nucula hartvigiana	TK	28	39	1	30	3.25
Nucula hartvigiana	TK	29	119	0	61	9.92
Nucula hartvigiana	TK	30	45	0.5	38	3.75
Nucula hartvigiana	TK	31	94	4.5	45	7.83
Nucula hartvigiana	TK	32	30	0	25	2.50
Nucula hartvigiana	TK	33	36	0	34	3.00
Nucula hartvigiana	TK	34	93	3	44	7.75
Nucula hartvigiana	TK	35	91	3	37	7.58
Oligochaetes	CB	28	1	0	1	0.08
Oligochaetes	CB	29	0	0	0	0.00
Oligochaetes	CB	30	1	0	1	0.08
Oligochaetes	CB	31	2	0	1	0.17
Oligochaetes	CB	32	0	0	0	0.00
Oligochaetes	CB	33	2	0	1	0.17
Oligochaetes	CB	34	0	0	0	0.00
Oligochaetes	CB	35	16	0.5	5	1.33
Oligochaetes	HL	28	1	0	1	0.08
Oligochaetes	HL	29	0	0	0	0.00
Oligochaetes	HL	30	0	0	0	0.00
Oligochaetes	HL	31	2	0	1	0.17
Oligochaetes	HL	32	44	3.5	10	3.67

Taxa	**Site**	**Time**	**Total[2]**	**Median**	**Range[3]**	**Mean**
Oligochaetes	HL	33	23	2	6	1.92
Oligochaetes	HL	34	3	0	2	0.25
Oligochaetes	HL	35	10	0	4	0.83
Oligochaetes	JB	28	2	0	1	0.17
Oligochaetes	JB	29	0	0	0	0.00
Oligochaetes	JB	30	0	0	0	0.00
Oligochaetes	JB	31	7	0	5	0.58
Oligochaetes	JB	32	6	0	3	0.50
Oligochaetes	JB	33	0	0	0	0.00
Oligochaetes	JB	34	4	0	2	0.33
Oligochaetes	JB	35	1	0	1	0.08
Oligochaetes	MH	28	0	0	0	0.00
Oligochaetes	MH	29	0	0	0	0.00
Oligochaetes	MH	30	0	0	0	0.00
Oligochaetes	MH	31	1	0	1	0.08
Oligochaetes	MH	32	8	0.5	3	0.67
Oligochaetes	MH	33	1	0	1	0.08
Oligochaetes	MH	34	19	0	19	1.58
Oligochaetes	MH	35	1	0	1	0.08
Oligochaetes	TK	28	1	0	1	0.08
Oligochaetes	TK	29	0	0	0	0.00
Oligochaetes	TK	30	0	0	0	0.00
Oligochaetes	TK	31	2	0	1	0.17
Oligochaetes	TK	32	1	0	1	0.08
Oligochaetes	TK	33	8	0	3	0.67
Oligochaetes	TK	34	0	0	0	0.00
Oligochaetes	TK	35	1	0	1	0.08
Owenia fusiformis	CB	28	0	0	0	0.00
Owenia fusiformis	CB	29	0	0	0	0.00
Owenia fusiformis	CB	30	0	0	0	0.00
Owenia fusiformis	CB	31	0	0	0	0.00
Owenia fusiformis	CB	32	0	0	0	0.00
Owenia fusiformis	CB	33	0	0	0	0.00
Owenia fusiformis	CB	34	0	0	0	0.00
Owenia fusiformis	CB	35	0	0	0	0.00
Owenia fusiformis	HL	28	0	0	0	0.00
Owenia fusiformis	HL	29	0	0	0	0.00
Owenia fusiformis	HL	30	0	0	0	0.00
Owenia fusiformis	HL	31	0	0	0	0.00
Owenia fusiformis	HL	32	0	0	0	0.00
Owenia fusiformis	HL	33	0	0	0	0.00
Owenia fusiformis	HL	34	0	0	0	0.00
Owenia fusiformis	HL	35	0	0	0	0.00
Owenia fusiformis	JB	28	0	0	0	0.00
Owenia fusiformis	JB	29	0	0	0	0.00
Owenia fusiformis	JB	30	0	0	0	0.00
Owenia fusiformis	JB	31	0	0	0	0.00
Owenia fusiformis	JB	32	2	0	1	0.17
Owenia fusiformis	JB	33	3	0	2	0.25
Owenia fusiformis	JB	34	0	0	0	0.00

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Owenia fusiformis	JB	35	0	0	0	0.00
Owenia fusiformis	MH	28	0	0	0	0.00
Owenia fusiformis	MH	29	0	0	0	0.00
Owenia fusiformis	MH	30	0	0	0	0.00
Owenia fusiformis	MH	31	0	0	0	0.00
Owenia fusiformis	MH	32	0	0	0	0.00
Owenia fusiformis	MH	33	0	0	0	0.00
Owenia fusiformis	MH	34	0	0	0	0.00
Owenia fusiformis	MH	35	0	0	0	0.00
Owenia fusiformis	TK	28	0	0	0	0.00
Owenia fusiformis	TK	29	0	0	0	0.00
Owenia fusiformis	TK	30	0	0	0	0.00
Owenia fusiformis	TK	31	0	0	0	0.00
Owenia fusiformis	TK	32	0	0	0	0.00
Owenia fusiformis	TK	33	0	0	0	0.00
Owenia fusiformis	TK	34	0	0	0	0.00
Owenia fusiformis	TK	35	0	0	0	0.00
Paracalliope novizealandiae	CB	28	0	0	0	0.00
Paracalliope novizealandiae	CB	29	0	0	0	0.00
Paracalliope novizealandiae	CB	30	0	0	0	0.00
Paracalliope novizealandiae	CB	31	0	0	0	0.00
Paracalliope novizealandiae	CB	32	0	0	0	0.00
Paracalliope novizealandiae	CB	33	0	0	0	0.00
Paracalliope novizealandiae	CB	34	0	0	0	0.00
Paracalliope novizealandiae	CB	35	1	0	1	0.08
Paracalliope novizealandiae	HL	28	1	0	1	0.08
Paracalliope novizealandiae	HL	29	0	0	0	0.00
Paracalliope novizealandiae	HL	30	0	0	0	0.00
Paracalliope novizealandiae	HL	31	0	0	0	0.00
Paracalliope novizealandiae	HL	32	0	0	0	0.00
Paracalliope novizealandiae	HL	33	0	0	0	0.00
Paracalliope novizealandiae	HL	34	0	0	0	0.00
Paracalliope novizealandiae	HL	35	0	0	0	0.00
Paracalliope novizealandiae	JB	28	31	2	7	2.58
Paracalliope novizealandiae	JB	29	0	0	0	0.00
Paracalliope novizealandiae	JB	30	4	0	2	0.33
Paracalliope novizealandiae	JB	31	1	0	1	0.08
Paracalliope novizealandiae	JB	32	77	3.5	33	6.42
Paracalliope novizealandiae	JB	33	0	0	0	0.00
Paracalliope novizealandiae	JB	34	13	0	7	1.08
Paracalliope novizealandiae	JB	35	25	1	7	2.08
Paracalliope novizealandiae	MH	28	0	0	0	0.00
Paracalliope novizealandiae	MH	29	2	0	1	0.17
Paracalliope novizealandiae	MH	30	0	0	0	0.00
Paracalliope novizealandiae	MH	31	0	0	0	0.00
Paracalliope novizealandiae	MH	32	0	0	0	0.00
Paracalliope novizealandiae	MH	33	0	0	0	0.00
Paracalliope novizealandiae	MH	34	0	0	0	0.00
Paracalliope novizealandiae	MH	35	2	0	1	0.17
Paracalliope novizealandiae	TK	28	5	0	2	0.42

Taxa	**Site**	**Time**	**Total**[2]	**Median**	**Range**[3]	**Mean**
Paracalliope novizealandiae	TK	29	0	0	0	0.00
Paracalliope novizealandiae	TK	30	1	0	1	0.08
Paracalliope novizealandiae	TK	31	0	0	0	0.00
Paracalliope novizealandiae	TK	32	0	0	0	0.00
Paracalliope novizealandiae	TK	33	0	0	0	0.00
Paracalliope novizealandiae	TK	34	0	0	0	0.00
Paracalliope novizealandiae	TK	35	0	0	0	0.00
Perinereis nuntia	CB	28	0	0	0	0.00
Perinereis nuntia	CB	29	0	0	0	0.00
Perinereis nuntia	CB	30	0	0	0	0.00
Perinereis nuntia	CB	31	0	0	0	0.00
Perinereis nuntia	CB	32	0	0	0	0.00
Perinereis nuntia	CB	33	0	0	0	0.00
Perinereis nuntia	CB	34	0	0	0	0.00
Perinereis nuntia	CB	35	0	0	0	0.00
Perinereis nuntia	HL	28	0	0	0	0.00
Perinereis nuntia	HL	29	0	0	0	0.00
Perinereis nuntia	HL	30	0	0	0	0.00
Perinereis nuntia	HL	31	0	0	0	0.00
Perinereis nuntia	HL	32	0	0	0	0.00
Perinereis nuntia	HL	33	0	0	0	0.00
Perinereis nuntia	HL	34	0	0	0	0.00
Perinereis nuntia	HL	35	0	0	0	0.00
Perinereis nuntia	JB	28	1	0	1	0.08
Perinereis nuntia	JB	29	0	0	0	0.00
Perinereis nuntia	JB	30	0	0	0	0.00
Perinereis nuntia	JB	31	0	0	0	0.00
Perinereis nuntia	JB	32	0	0	0	0.00
Perinereis nuntia	JB	33	1	0	1	0.08
Perinereis nuntia	JB	34	0	0	0	0.00
Perinereis nuntia	JB	35	0	0	0	0.00
Perinereis nuntia	MH	28	6	0	2	0.50
Perinereis nuntia	MH	29	0	0	0	0.00
Perinereis nuntia	MH	30	0	0	0	0.00
Perinereis nuntia	MH	31	0	0	0	0.00
Perinereis nuntia	MH	32	0	0	0	0.00
Perinereis nuntia	MH	33	0	0	0	0.00
Perinereis nuntia	MH	34	0	0	0	0.00
Perinereis nuntia	MH	35	0	0	0	0.00
Perinereis nuntia	TK	28	0	0	0	0.00
Perinereis nuntia	TK	29	0	0	0	0.00
Perinereis nuntia	TK	30	0	0	0	0.00
Perinereis nuntia	TK	31	0	0	0	0.00
Perinereis nuntia	TK	32	0	0	0	0.00
Perinereis nuntia	TK	33	1	0	1	0.08
Perinereis nuntia	TK	34	0	0	0	0.00
Perinereis nuntia	TK	35	0	0	0	0.00
Polydorids	CB	28	0	0	0	0.00
Polydorids	CB	29	2	0	2	0.17
Polydorids	CB	30	2	0	1	0.17

Taxa	**Site**	**Time**	**Total[2]**	**Median**	**Range[3]**	**Mean**
Polydorids	CB	31	1	0	1	0.08
Polydorids	CB	32	6	0	2	0.50
Polydorids	CB	33	2	0	1	0.17
Polydorids	CB	34	9	0	3	0.75
Polydorids	CB	35	4	0	3	0.33
Polydorids	HL	28	0	0	0	0.00
Polydorids	HL	29	9	0.5	3	0.75
Polydorids	HL	30	2	0	1	0.17
Polydorids	HL	31	0	0	0	0.00
Polydorids	HL	32	77	3	20	6.42
Polydorids	HL	33	23	2	4	1.92
Polydorids	HL	34	3	0	1	0.25
Polydorids	HL	35	6	0	2	0.50
Polydorids	JB	28	4	0	1	0.33
Polydorids	JB	29	61	3	20	5.08
Polydorids	JB	30	6	0	2	0.50
Polydorids	JB	31	3	0	2	0.25
Polydorids	JB	32	25	1.5	5	2.08
Polydorids	JB	33	41	0.5	19	3.42
Polydorids	JB	34	1	0	1	0.08
Polydorids	JB	35	2	0	1	0.17
Polydorids	MH	28	12	0.5	3	1.00
Polydorids	MH	29	34	1	10	2.83
Polydorids	MH	30	40	3	9	3.33
Polydorids	MH	31	1	0	1	0.08
Polydorids	MH	32	23	1.5	6	1.92
Polydorids	MH	33	35	3	9	2.92
Polydorids	MH	34	17	1.5	4	1.42
Polydorids	MH	35	37	2	8	3.08
Polydorids	TK	28	1	0	1	0.08
Polydorids	TK	29	2	0	1	0.17
Polydorids	TK	30	8	0	2	0.67
Polydorids	TK	31	4	0	2	0.33
Polydorids	TK	32	3	0	1	0.25
Polydorids	TK	33	11	0.5	6	0.92
Polydorids	TK	34	23	0	10	1.92
Polydorids	TK	35	8	0	2	0.67
Scoloplos cylindrifer	CB	28	0	0	0	0.00
Scoloplos cylindrifer	CB	29	0	0	0	0.00
Scoloplos cylindrifer	CB	30	0	0	0	0.00
Scoloplos cylindrifer	CB	31	0	0	0	0.00
Scoloplos cylindrifer	CB	32	0	0	0	0.00
Scoloplos cylindrifer	CB	33	0	0	0	0.00
Scoloplos cylindrifer	CB	34	0	0	0	0.00
Scoloplos cylindrifer	CB	35	0	0	0	0.00
Scoloplos cylindrifer	HL	28	0	0	0	0.00
Scoloplos cylindrifer	HL	29	0	0	0	0.00
Scoloplos cylindrifer	HL	30	0	0	0	0.00
Scoloplos cylindrifer	HL	31	0	0	0	0.00
Scoloplos cylindrifer	HL	32	2	0	2	0.17

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Scoloplos cylindrifer	HL	33	0	0	0	0.00
Scoloplos cylindrifer	HL	34	0	0	0	0.00
Scoloplos cylindrifer	HL	35	0	0	0	0.00
Scoloplos cylindrifer	JB	28	1	0	1	0.08
Scoloplos cylindrifer	JB	29	1	0	1	0.08
Scoloplos cylindrifer	JB	30	2	0	2	0.17
Scoloplos cylindrifer	JB	31	0	0	0	0.00
Scoloplos cylindrifer	JB	32	0	0	0	0.00
Scoloplos cylindrifer	JB	33	0	0	0	0.00
Scoloplos cylindrifer	JB	34	1	0	1	0.08
Scoloplos cylindrifer	JB	35	0	0	0	0.00
Scoloplos cylindrifer	MH	28	0	0	0	0.00
Scoloplos cylindrifer	MH	29	0	0	0	0.00
Scoloplos cylindrifer	MH	30	0	0	0	0.00
Scoloplos cylindrifer	MH	31	0	0	0	0.00
Scoloplos cylindrifer	MH	32	0	0	0	0.00
Scoloplos cylindrifer	MH	33	0	0	0	0.00
Scoloplos cylindrifer	MH	34	0	0	0	0.00
Scoloplos cylindrifer	MH	35	0	0	0	0.00
Scoloplos cylindrifer	TK	28	1	0	1	0.08
Scoloplos cylindrifer	TK	29	0	0	0	0.00
Scoloplos cylindrifer	TK	30	2	0	1	0.17
Scoloplos cylindrifer	TK	31	0	0	0	0.00
Scoloplos cylindrifer	TK	32	0	0	0	0.00
Scoloplos cylindrifer	TK	33	0	0	0	0.00
Scoloplos cylindrifer	TK	34	0	0	0	0.00
Scoloplos cylindrifer	TK	35	0	0	0	0.00
Torridoharpinia hurleyi	CB	28	6	0	5	0.50
Torridoharpinia hurleyi	CB	29	11	1	3	0.92
Torridoharpinia hurleyi	CB	30	32	2	5	2.67
Torridoharpinia hurleyi	CB	31	0	0	0	0.00
Torridoharpinia hurleyi	CB	32	11	1	2	0.92
Torridoharpinia hurleyi	CB	33	48	3.5	8	4.00
Torridoharpinia hurleyi	CB	34	41	1	11	3.42
Torridoharpinia hurleyi	CB	35	8	0	3	0.67
Torridoharpinia hurleyi	HL	28	6	0.5	1	0.50
Torridoharpinia hurleyi	HL	29	2	0	1	0.17
Torridoharpinia hurleyi	HL	30	0	0	0	0.00
Torridoharpinia hurleyi	HL	31	0	0	0	0.00
Torridoharpinia hurleyi	HL	32	2	0	1	0.17
Torridoharpinia hurleyi	HL	33	0	0	0	0.00
Torridoharpinia hurleyi	HL	34	7	0	4	0.58
Torridoharpinia hurleyi	HL	35	1	0	1	0.08
Torridoharpinia hurleyi	JB	28	14	0	5	1.17
Torridoharpinia hurleyi	JB	29	6	0	2	0.50
Torridoharpinia hurleyi	JB	30	8	0.5	3	0.67
Torridoharpinia hurleyi	JB	31	0	0	0	0.00
Torridoharpinia hurleyi	JB	32	7	0	4	0.58
Torridoharpinia hurleyi	JB	33	10	0	10	0.83
Torridoharpinia hurleyi	JB	34	3	0	2	0.25

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Torridoharpinia hurleyi	JB	35	1	0	1	0.08
Torridoharpinia hurleyi	MH	28	3	0	1	0.25
Torridoharpinia hurleyi	MH	29	2	0	1	0.17
Torridoharpinia hurleyi	MH	30	13	1	4	1.08
Torridoharpinia hurleyi	MH	31	0	0	0	0.00
Torridoharpinia hurleyi	MH	32	7	1	1	0.58
Torridoharpinia hurleyi	MH	33	9	1	3	0.75
Torridoharpinia hurleyi	MH	34	7	0	4	0.58
Torridoharpinia hurleyi	MH	35	5	0	3	0.42
Torridoharpinia hurleyi	TK	28	9	1	2	0.75
Torridoharpinia hurleyi	TK	29	5	0	4	0.42
Torridoharpinia hurleyi	TK	30	7	0	3	0.58
Torridoharpinia hurleyi	TK	31	0	0	0	0.00
Torridoharpinia hurleyi	TK	32	5	0	2	0.42
Torridoharpinia hurleyi	TK	33	13	1	4	1.08
Torridoharpinia hurleyi	TK	34	3	0	1	0.25
Torridoharpinia hurleyi	TK	35	1	0	1	0.08

Appendix 3: Results of grain size analysis for the subtidal sites.

% sediment composition	Year	Month	SITE A	SITE C
Gravel/shell hash (> 2000 µm)	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
Coarse sand (500 – 2000 µm)	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
Medium sand (250 – 500 µm)	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

Fine sand (62.5 – 250 µm)	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
Silt (3.9 – 62.5 µm)	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
Clay (< 3.9 µm)	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

Appendix 4: Summary of the temporal results[1] at the subtidal sites from April 2001 (Time = 28) to January 2003 (Time = 35).

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Athritica bifurca	SA	28	2	0	2	0.17
Athritica bifurca	SA	30	6	0	2	0.50
Athritica bifurca	SA	31	0	0	0	0.00
Athritica bifurca	SA	32	2	0	1	0.17
Athritica bifurca	SA	33	0	0	0	0.00
Athritica bifurca	SA	34	3	0	2	0.25
Athritica bifurca	SA	35	19	0.5	7	1.58
Athritica bifurca	SB	28	55	3.5	16	4.58
Athritica bifurca	SC	28	40	2.5	7	3.33
Athritica bifurca	SC	30	23	2	7	1.92
Athritica bifurca	SC	31	4	0	1	0.33
Athritica bifurca	SC	32	17	0	10	1.42
Athritica bifurca	SC	33	0	0	0	0.00
Athritica bifurca	SC	34	3	0	1	0.25
Athritica bifurca	SC	35	31	2	8	2.58
Aricidea sp.	SA	28	0	0	0	0.00
Aricidea sp.	SA	30	7	1	1	0.58
Aricidea sp.	SA	31	6	0	2	0.50
Aricidea sp.	SA	32	7	0	2	0.58
Aricidea sp.	SA	33	4	0	2	0.33
Aricidea sp.	SA	34	7	0	2	0.58
Aricidea sp.	SA	35	24	2	8	2.00
Aricidea sp.	SB	28	2	0	1	0.17
Aricidea sp.	SC	28	9	0	3	0.75
Aricidea sp.	SC	30	0	0	0	0.00
Aricidea sp.	SC	31	5	0	2	0.42
Aricidea sp.	SC	32	5	0	1	0.42
Aricidea sp.	SC	33	1	0	1	0.08
Aricidea sp.	SC	34	2	0	1	0.17
Aricidea sp.	SC	35	4	0	1	0.33
Armandia maculata	SA	28	6	0	4	0.50
Armandia maculata	SA	30	2	0	1	0.17
Armandia maculata	SA	31	0	0	0	0.00
Armandia maculata	SA	32	0	0	0	0.00
Armandia maculata	SA	33	0	0	0	0.00
Armandia maculata	SA	34	4	0	1	0.33
Armandia maculata	SA	35	0	0	0	0.00
Armandia maculata	SB	28	1	0	1	0.08
Armandia maculata	SC	28	4	0	2	0.33
Armandia maculata	SC	30	4	0	3	0.33
Armandia maculata	SC	31	4	0	2	0.33
Armandia maculata	SC	32	1	0	1	0.08
Armandia maculata	SC	33	0	0	0	0.00

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[1] Data are only given if the taxa occur at a site during this time period.
[2] Total number of individuals collected in 12 samples. Calculated by mean abundance*12.
[3] Range = between the 5th and 95th percentile.

Armandia maculata	SC	34	2	0	2	0.17
Armandia maculata	SC	35	3	0	2	0.25
Cirratulids	SA	28	2	0	1	0.17
Cirratulids	SA	30	12	1	4	1.00
Cirratulids	SA	31	16	1	3	1.33
Cirratulids	SA	32	21	1	6	1.75
Cirratulids	SA	33	20	1.5	5	1.67
Cirratulids	SA	34	16	1	3	1.33
Cirratulids	SA	35	16	1	4	1.33
Cirratulids	SB	28	24	1.5	5	2.00
Cirratulids	SC	28	11	0	3	0.92
Cirratulids	SC	30	19	1.5	4	1.58
Cirratulids	SC	31	16	1	3	1.33
Cirratulids	SC	32	17	1	4	1.42
Cirratulids	SC	33	18	1.5	5	1.50
Cirratulids	SC	34	11	1	2	0.92
Cirratulids	SC	35	14	0.5	4	1.17
Corophidae-complex	SA	28	0	0	0	0.00
Corophidae-complex	SA	30	0	0	0	0.00
Corophidae-complex	SA	31	0	0	0	0.00
Corophidae-complex	SA	32	4	0	3	0.33
Corophidae-complex	SA	33	0	0	0	0.00
Corophidae-complex	SA	34	0	0	0	0.00
Corophidae-complex	SA	35	5	0	2	0.42
Corophidae-complex	SB	28	1	0	1	0.08
Corophidae-complex	SC	28	2	0	1	0.17
Corophidae-complex	SC	30	0	0	0	0.00
Corophidae-complex	SC	31	7	0	7	0.58
Corophidae-complex	SC	32	5	0	5	0.42
Corophidae-complex	SC	33	7	0	4	0.58
Corophidae-complex	SC	34	1	0	1	0.08
Corophidae-complex	SC	35	29	0.5	12	2.42
Nucula hartvigiana	SA	28	2	0	1	0.17
Nucula hartvigiana	SA	30	1	0	1	0.08
Nucula hartvigiana	SA	31	0	0	0	0.00
Nucula hartvigiana	SA	32	5	0	2	0.42
Nucula hartvigiana	SA	33	4	0	2	0.33
Nucula hartvigiana	SA	34	2	0	1	0.17
Nucula hartvigiana	SA	35	9	0	3	0.75
Nucula hartvigiana	SB	28	2	0	1	0.17
Nucula hartvigiana	SC	28	12	0.5	4	1.00
Nucula hartvigiana	SC	30	0	0	0	0.00
Nucula hartvigiana	SC	31	6	0	3	0.50
Nucula hartvigiana	SC	32	7	0	2	0.58
Nucula hartvigiana	SC	33	2	0	1	0.17
Nucula hartvigiana	SC	34	3	0	1	0.25
Nucula hartvigiana	SC	35	42	2.5	14	3.50
Owenia fusiformis	SA	28	0	0	0	0.00
Owenia fusiformis	SA	30	1	0	1	0.08
Owenia fusiformis	SA	31	4	0	2	0.33
Owenia fusiformis	SA	32	7	0	3	0.58

Owenia fusiformis	SA	33	4	0	1	0.33
Owenia fusiformis	SA	34	1	0	1	0.08
Owenia fusiformis	SA	35	2	0	2	0.17
Owenia fusiformis	SB	28	24	1.5	7	2.00
Owenia fusiformis	SC	28	21	1	5	1.75
Owenia fusiformis	SC	30	64	1	21	5.33
Owenia fusiformis	SC	31	60	4.5	14	5.00
Owenia fusiformis	SC	32	66	5	11	5.50
Owenia fusiformis	SC	33	95	5.5	23	7.92
Owenia fusiformis	SC	34	24	1	10	2.00
Owenia fusiformis	SC	35	30	1	13	2.50
Prionospio sp.	SA	28	12	1	4	1.00
Prionospio sp.	SA	30	5	0	1	0.42
Prionospio sp.	SA	31	3	0	1	0.25
Prionospio sp.	SA	32	2	0	2	0.17
Prionospio sp.	SA	33	15	0	9	1.25
Prionospio sp.	SA	34	17	1.5	3	1.42
Prionospio sp.	SA	35	3	0	1	0.25
Prionospio sp.	SB	28	1	0	1	0.08
Prionospio sp.	SC	28	7	0	2	0.58
Prionospio sp.	SC	30	3	0	1	0.25
Prionospio sp.	SC	31	13	1	3	1.08
Prionospio sp.	SC	32	14	1	4	1.17
Prionospio sp.	SC	33	16	1	4	1.33
Prionospio sp.	SC	34	10	0	4	0.83
Prionospio sp.	SC	35	4	0	1	0.33
Polydorids	SA	28	5	0	2	0.42
Polydorids	SA	30	1	0	1	0.08
Polydorids	SA	31	7	0	5	0.58
Polydorids	SA	32	14	0	8	1.17
Polydorids	SA	33	4	0	1	0.33
Polydorids	SA	34	2	0	1	0.17
Polydorids	SA	35	0	0	0	0.00
Polydorids	SB	28	1	0	1	0.08
Polydorids	SC	28	12	0	6	1.00
Polydorids	SC	30	8	0	3	0.67
Polydorids	SC	31	16	1	6	1.33
Polydorids	SC	32	11	0	6	0.92
Polydorids	SC	33	3	0	1	0.25
Polydorids	SC	34	1	0	1	0.08
Polydorids	SC	35	0	0	0	0.00
Theora lubrica	SA	28	51	3.5	9	4.25
Theora lubrica	SA	30	55	4	13	4.58
Theora lubrica	SA	31	43	2.5	12	3.58
Theora lubrica	SA	32	123	10.5	18	10.25
Theora lubrica	SA	33	56	3.5	10	4.67
Theora lubrica	SA	34	27	2	4	2.25
Theora lubrica	SA	35	56	5	9	4.67
Theora lubrica	SB	28	155	11.5	17	12.92
Theora lubrica	SC	28	142	12	14	11.83
Theora lubrica	SC	30	48	4	9	4.00

Theora lubrica	SC	31	84	8	13	7.00
Theora lubrica	SC	32	163	13.5	24	13.58
Theora lubrica	SC	33	115	8.5	16	9.58
Theora lubrica	SC	34	98	8	20	8.17
Theora lubrica	SC	35	61	4.5	11	5.08
Torridoharpinia hurleyi	SA	28	24	1.5	6	2.00
Torridoharpinia hurleyi	SA	30	11	0	5	0.92
Torridoharpinia hurleyi	SA	31	11	0	6	0.92
Torridoharpinia hurleyi	SA	32	3	0	2	0.25
Torridoharpinia hurleyi	SA	33	4	0	1	0.33
Torridoharpinia hurleyi	SA	34	5	0	2	0.42
Torridoharpinia hurleyi	SA	35	3	0	2	0.25
Torridoharpinia hurleyi	SB	28	15	1	5	1.25
Torridoharpinia hurleyi	SC	28	13	1	5	1.08
Torridoharpinia hurleyi	SC	30	43	3	9	3.58
Torridoharpinia hurleyi	SC	31	13	1	3	1.08
Torridoharpinia hurleyi	SC	32	2	0	1	0.17
Torridoharpinia hurleyi	SC	33	0	0	0	0.00
Torridoharpinia hurleyi	SC	34	12	1	3	1.00
Torridoharpinia hurleyi	SC	35	23	2	5	1.92