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Report on Data Collected from July 1994 to January 2009

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Mahurangi Estuary Ecological Monitoring Programme – report on data collected from July 1994 to January 2009

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Prepared for
Auckland Regional Council

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1 Executive Summary

Populations and communities of the monitored macrofaunal taxa, and site sediment characteristics, have not changed markedly at the intertidal or subtidal sites over the past two years of monitoring. The monitored intertidal macrofaunal communities at Hamilton Landing, Te Kapa Inlet and Cowans Bay have continued to become more similar to each other, as have those of Jamieson Bay and Mid Harbour. The intertidal macrofaunal community at Dyers Creek exhibits strong similarilites with those of Jamieson Bay and Mid Harbour. The subtidal communities of Sites A and C are also very similar to each other.

A total of 19 intertidal populations are currently showing trends in abundance; 6 of these are increasing trends and 13 are decreasing trends. All sites have populations that are exhibiting ecologically significant trends; most of these populations occur at Hamilton Landing and Te Kapa Inlet, and the least at Mid Harbour. Five subtidal populations are exhibiting trends in abundance.

Of most concern is that three species considered sensitive to increased suspended sediment concentrations are continuing to exhibit declines in abundance at the intertidal sites (*Macomona liliana*, *Austrovenus stutchburyi*, *Scoloplos cylindrifer*). Two important bivalve taxa, *Macomona* and *Austrovenus* are declining at two sites each. The decline in abundance previously noted for *Macomona* is no longer apparent at some sites due to large recruitment events in the last three years. While this is encouraging, much of this apparent recovery is due to a couple of large recruitment events (<4 mm individuals) and the high abundances have not persisted.

In early 2000, the abundance of nine populations at multiple sites either increased or decreased in a significant way. In previous reports, if these one-off abundance changes persisted over time, the resulting change in abundance has been interpreted as a trend. However, we now consider these abundance changes to be 'step' changes in abundance, with mean abundances significantly different before and after this point. The lack of continued increases/decreases in abundance following the step change may not mean the environmental stressor has gone, as many of these populations were reduced to extremely low numbers in early 2000, therefore no further reduction is possible.

In contrast to Manukau Harbour, few of the intertidal or subtidal populations exhibit highly predictable cyclic abundance patterns, where peaks in abundance occur in the same monitoring month every year.

Numbers of the large horse mussel *Atrina zelandica* have been slightly higher at subtidal Site A than at Site C over the last two years. Sizes of *Atrina* are generally similar at the two sites. Numbers are low and the sizes of *Atrina* have not increased much over the past two years, probably reflecting the fact that the growth of these populations is slowing as the individuals age and reach their maximum size.

This monitoring programme has continued to provide very useful information on trends and cycles in monitored populations and sediment characteristics that can be used to guide and monitor the effectiveness of catchment management within Mahurangi

Estuary. We recommend two changes to the methodology of this monitoring programme. (i) we no longer consider measurement of the two smallest intertidal bivalves, *Nucula hartvigiana* and *Arthritica bifurca*, or the subtidal bivalve *Theora lubrica*, to be useful, as this data has not been useful to our interpretations over the past 14 years of monitoring. (ii) an initial survey of heavy metal concentrations at the sites should be conducted.

With two more years of data, our previous recommendations concerning the need to investigate and implement improved sediment controls still apply, as we are still detecting declines in abundance of taxa known to be sensitive to increased sediment loading. Recent evidence of recruitment of juvenile bivalve populations is encouraging and highlights the potential for the recovery of some areas of the harbour should sediment control measures be effective.

2 Introduction

In July 1994 a long-term ecological monitoring programme of the intertidal and subtidal benthic communties in Mahurangi Estuary commenced. 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 (Mahurangi Action Plan, MAP);
- 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 (Appendix 1) for this long-term monitoring programme were identified from a survey conducted in 1993, and recommended in a previous report to Auckland Regional Council (Cummings et al. 1994).

This monitoring programme has now been running for 14.5 years. In this report, we comment on the temporal variation in abundance of some monitored macrofaunal populations at the intertidal and subtidal sites, and on the temporal variation in abundance and size of the horse mussel, *Atrina zelandica*, at the subtidal sites. On the basis of trend and community analyses of the monitored taxa, we describe the current ecological status of the Harbour and make recommendations for the future of this monitoring programme.

3 Methods

3.1 Intertidal Sites

In July 1994, five permanent intertidal sites were established in locations predetermined from an initial survey of the estuary conducted in April 1993 (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.

In October 2005, an additional permanent intertidal site was established at Dyers Creek. The site was chosen and established by the ARC, in the approximate vicinity of the site initially surveyed by NIWA in 1993 (Cummings et al. 1994).

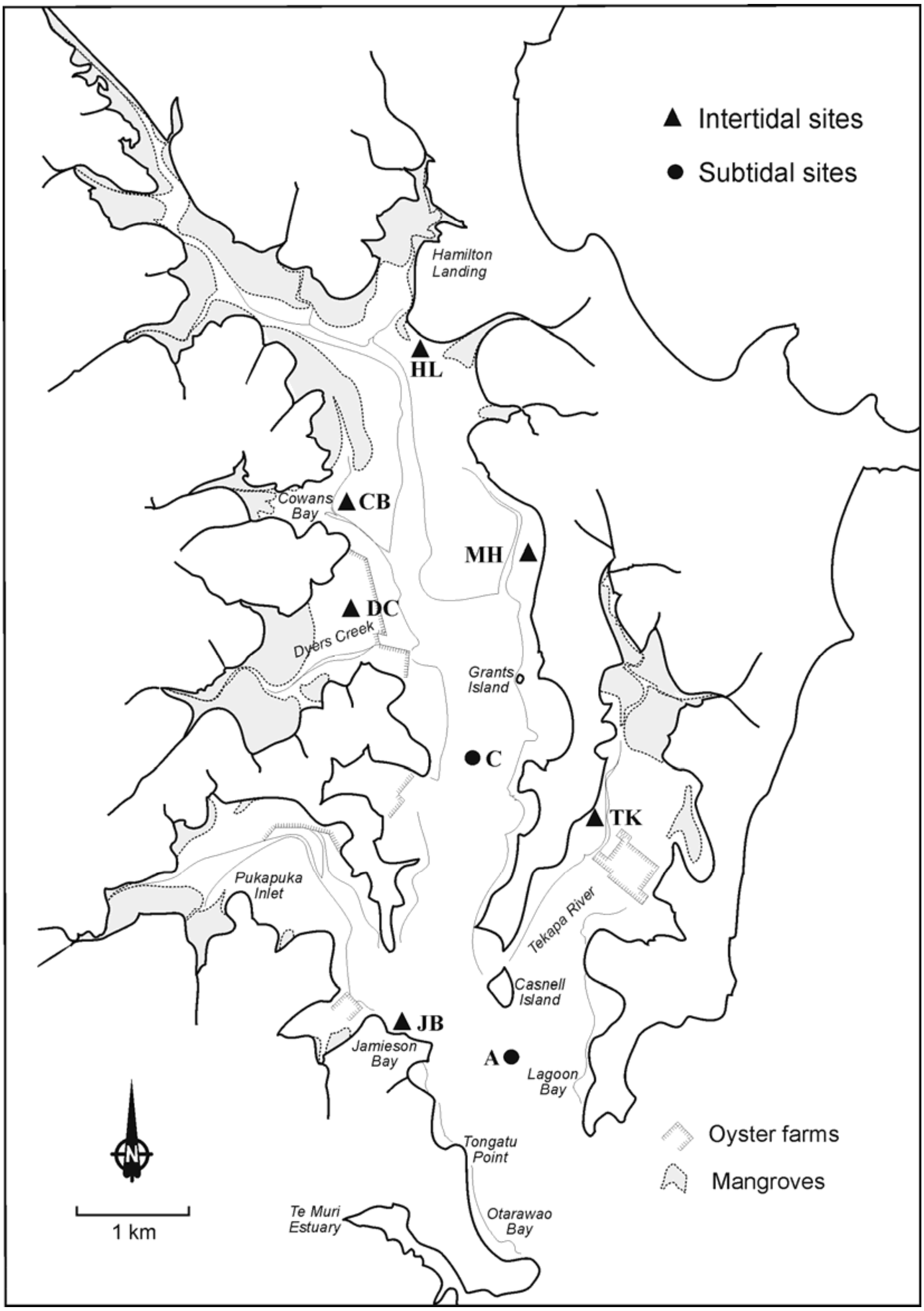
All six intertidal sites are sampled at three-monthly intervals.

3.1.1 Macrofauna

On each sampling occasion, core samples (13 cm diameter, 15 cm deep) are collected at 12 predetermined locations at each site. To provide adequate dispersion over the site, each site is 'divided' into 12 equal blocks and one core sample taken from a random location within each block. To reduce the influence of previous sampling activity and spatial autocorrelation (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 remaining material stained with rose bengal and preserved in 70% isopropyl alcohol. 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. Until 2007, monitored bivalves were individually measured (via callipers or digitising under a dissecting microscope) and the results summarised into the following size classes: ≤4 mm, ≥4-8 mm, ≥8 – 16 mm, ≥16 mm. However, in consultation with ARC, this methodology and the size classes used have been modified to enable direct comparison with the Manuaku and Waitemata ecological monitoring programmes. Individual bivalves are now allotted a size class under a dissecting microscope and large individuals are measured using electronic callipers. Size class groupings used are: ≤5 mm, ≥5-10 mm, ≥10 – 15 mm, ≥15 - 20 mm, ≥20 mm.

Figure 1.

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



3.1.2 Sediment characteristics

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

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

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

3.2 Subtidal Sites

Three permanent subtidal sites were established in locations predetermined from the initial survey of the estuary (Cummings et al. 1994). Following the recommendations made in our 2001 report (Cummings et al. 2001), the number of subtidal sites routinely monitored was reduced, with Sites A and C continuing to be monitored. Both of these sites are situated adjacent to the main estuary channel, in approximately 6 - 10 m of water (Figure 1). A 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 and GPS 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. The video footage is taken from a target height of 40 cm above the seafloor, resulting in a transect width of approximately 50 cm.General video footage at each site supplements the quadrat data and provides a visual archive of the communities associated with the horse mussel beds.

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

3.2.1 Macrofauna

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

3.2.2 Sediment characteristics

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

3.2.3 *Atrina zelandica*

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

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

3.3 Analyses of macrofaunal abundance

3.3.1 Biological interpretation of patterns

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

3.3.2 Trend analysis

To formally identify any suggested trends in the abundance of the monitored taxa at both the intertidal and subtidal sites, trend analyses were conducted. Autocorrelation in each time series was investigated using chi-square probabilities (SAS/ETS). Step trends were investigated using wilcoxon rank tests and, if autocorrelation was present, adjusting the degrees of freedom. Gradual changes were investigated by ordinary least squares regression unless autocorrelation was present. Where autocorrelation was indicated, increasing or decreasing trends were investigated by adjusting parameters and significance levels (AUTOREG procedure, SAS/ETS). Only linear trends were investigated as investigation of residual variability suggested no other responses.

Analyses were carried out on both the original time series and the basal population (i.e., when peak abundances occurred in a repeatable, cyclic pattern, they were removed, and the remaining 'basal' population analysed). Doing both analyses enables identification of trends that are due to changes in recruitment which may not (yet) be affecting basal abundances, and thus aids biological interpretation.

3.3.3 Community analysis

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

As ecological theory suggests that an early warning for abrupt degradative change may be increased temporal variability in community dynamics (Anderson et al. 2008; Carpenter & Brock 2006), potential changes between the start of the monitoring programme and the last 2 years were investiagted. Variability was assessed as the Bray-Curtis % dissimilarities (calculated for log transformed data). Averages of these were calculated both within and between years. The first 5 years of the monitoring programme were used as the baseline. Only the final 2 years of data were used for the comparison as the more years used, the less of an early warning signal it would be.

4 Results and Discussion

4.1 Intertidal sites

4.1.1 Sediment characteristics

The sediment grain size composition of the five original intertidal sites continues to contain a higher proportion of fine sand and a lower amount of medium sand compared with the first two years of monitoring (Figure 2, Appendix 2).

The organic and chlorophyll *a* content of the sediments at each site from July 2000 to January 2007 are provided in Appendix 3. The organic content is lowest at Dyers Creek (range 0.76-1.34% since monitoring began at this site in October 2005), and highest at Hamilton Landing (range 1.58-6.65%). While there is no predictable pattern in organic content over time that is consistent across all sites, there are similarities between Cowans Bay, Jamieson Bay and Te Kapa Inlet (Figure 3).

Chlorophyll *a* content of the sediments continues to be highest at Cowans Bay (10.66-23.08 μg g^{-1} sediment) and lowest at Jamieson Bay (1.76 - 6.76 μg g^{-1} sediment). Dyers Creek chlorophyll *a* levels are intermediate between these sites (5.16-9.17 μg g^{-1} sediment). There is no easily discernable temporal pattern in sediment chlorophyll *a* levels across the sites (Appendix 3).

Figure 2.
Changes in the proportions of mud (i.e., silt/clay; <63 µm), fine sand (62.5 – 250 µm), medium sand (250 –500 µm) and coarse sediment (>500 µm) content at each of the intertidal sites over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 2.

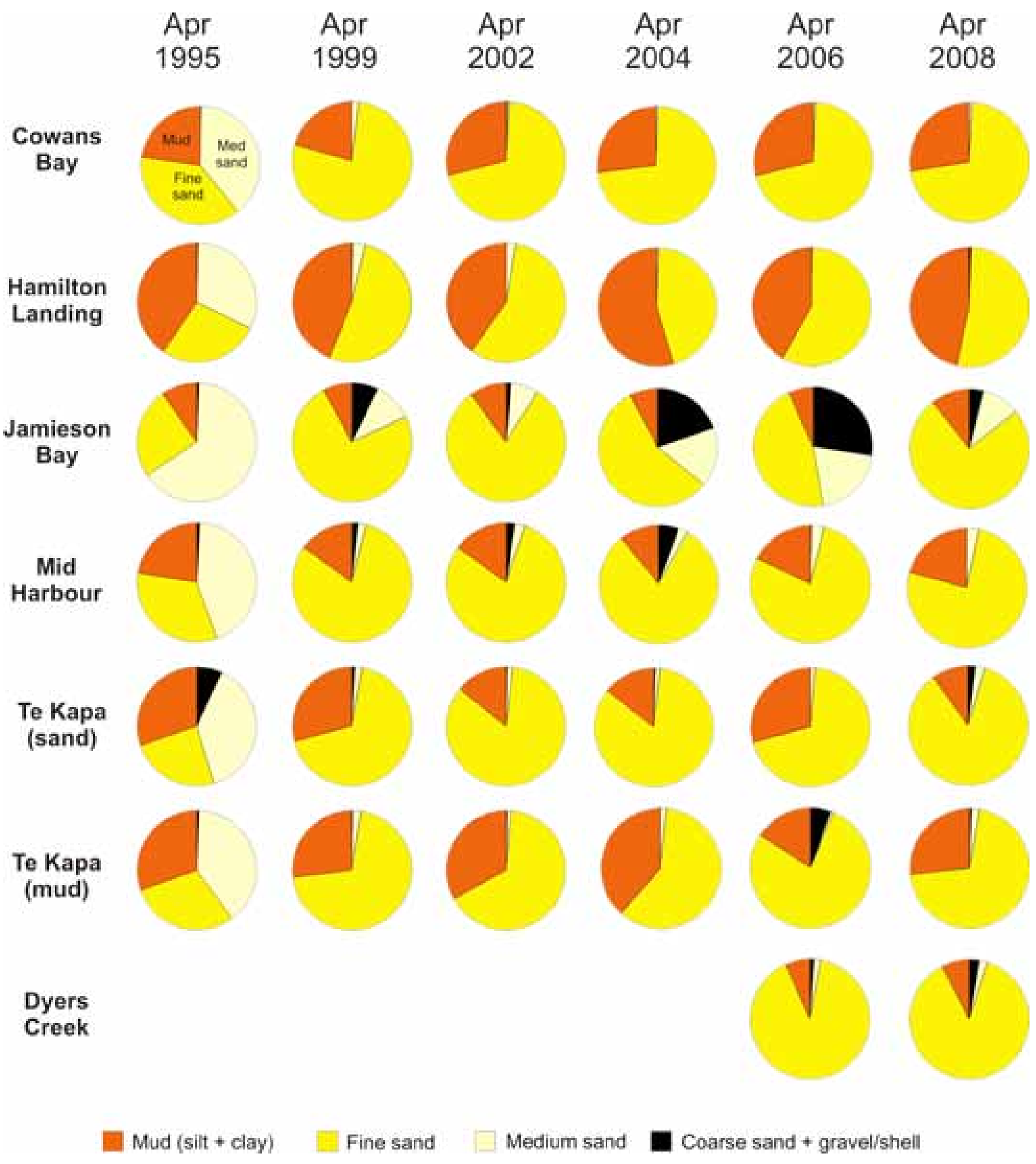
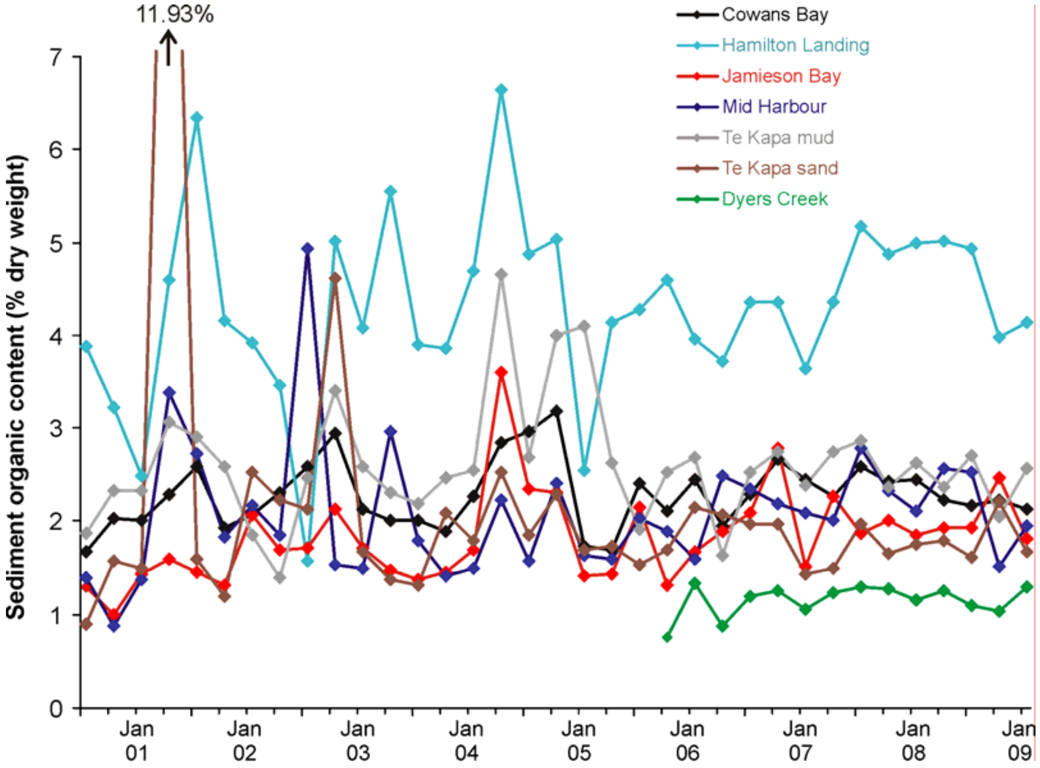


Figure 3.

Sediment organic content at the intertidal sites on each sampling occasion since July 2000



4.1.2 Macrofauna - comments on the abundance of common taxa

Throughout this report 'total' abundances (i.e., total numbers of individuals collected in 12 samples) of the monitored taxa are discussed. The abundances of all the intertidal monitored taxa collected at each site on each sampling date since the last report (i.e., from April 2005 to January 2009) are given in Appendix 4[1].

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 summary of trend analysis results is given at the end of this section (Table 7).

4.1.2.1 Cowans Bay

The polychaete *Cossura consimilis* has dominated this site on all but one occasion since monitoring began in July 1994 (Table 1), with 135 to 738 individuals found on each sampling date. Generally, the second most common taxa at Cowans Bay over the last two years was the polychaete *Heteromastus filiformis* (Table 1), with 10-68

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[1] *Aquilaspio aucklandica* is now referred to a *Prionospio aucklandica* following a taxonomic name change.

individuals found on each sampling occasion. The small bivalve *Arthritica bifurca* has featured amongst the dominant taxa on six of the eight most recent sampling dates. Numbers of *Torridoharpinia* were unusually high in January 2005, but this appeared to be a one off event (Cummings et al. 2005).

Table 1.

The three dominant taxa collected at Cowans Bay between July 1994 and January 2009. 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 consimilis*'

Jul 94	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 94	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 95	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Apr 95	Cossura consimilis	Arthritica bifurca	Nucula hartvigiana
Jul 95	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Oct 95	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Jan 96	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Apr 96	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 96	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 96	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 97	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Apr 97	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 97	Cossura consimilis	Torridoharpinia hurleyi	Arthritica bifurca
Oct 97	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 98	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Apr 98	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 98	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 98	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Jan 99	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Apr 99	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Jul 99	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 99	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 00	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis

Jul 94	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Apr 00	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 00	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 00	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 01	Cossura consimilis	Arthritica bifurca	Torridoharpinia hurleyi
Apr 01	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 01	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Oct 01	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Jan 02	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Apr 02	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 02	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 02	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 03	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Apr 03	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 03	Cossura consimilis	Heteromastus filiformis	Torridoharpinia hurleyi
Oct 03	Cossura consimilis	Heteromastus filiformis	Macomona liliana
Jan 04	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Apr 04	Cossura consimilis	Heteromastus filiformis	Torridoharpinia hurleyi
Jul 04	Cossura consimilis	Heteromastus filiformis	Torridoharpinia hurleyi
Oct 04	Cossura consimilis	Heteromastus filiformis	Torridoharpinia hurleyi
Jan 05	Torridoharpinia hurleyi	Cossura consimilis	Nucula hartvigiana
Apr 05	Cossura consimilis	Heteromastus filiformis	Polydorids
Jul 05	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 05	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Jan 06	Cossura consimilis	Nucula hartvigiana	Arthritica bifurca

Jul 94	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Apr 06	Cossura consimilis	Arthritica bifurca	Heteromastus filiformis
Jul 06	Cossura consimilis	Arthritica bifurca	Nucula hartvigiana
Oct 06	Cossura consimilis	Arthritica bifurca	Torridoharpinia hurleyi
Jan 07	Cossura consimilis	Torridoharpinia hurleyi	Arthritica bifurca
Apr 07	Cossura consimilis	Arthritica bifurca	Macomona liliana
Jul 07	Cossura consimilis	Heteromastus filiformis	Polydorids
Oct 07	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca / Polydorids
Jan 08	Cossura consimilis	Arthritica bifurca	Torridoharpinia hurleyi
Apr 08	Cossura consimilis	Heteromastus filiformis	Polydorids
Jul 08	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 08	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 09	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca

Populations showing cyclic abundance patterns

Nucula hartvigiana exhibits peaks in abundance in January of most years, except for 2002, 2003 and 2007 when peaks occurred in October (Figure 4). An increase in the size of recruitment peaks and baseline abundance reported in the 2007 report is no longer apparent with the addition of two more years of data. Similarly, the mud crab *Macrophthalmus hirtipes* is most abundant in January or October (Figure 5). *Heteromastus filiformis* numbers generally peak in July or October.

Figure 4.

Total number of *Nucula hartvigiana* collected on each sampling occasion at Cowans Bay. Peaks in abundance occur annually, most often in January months.

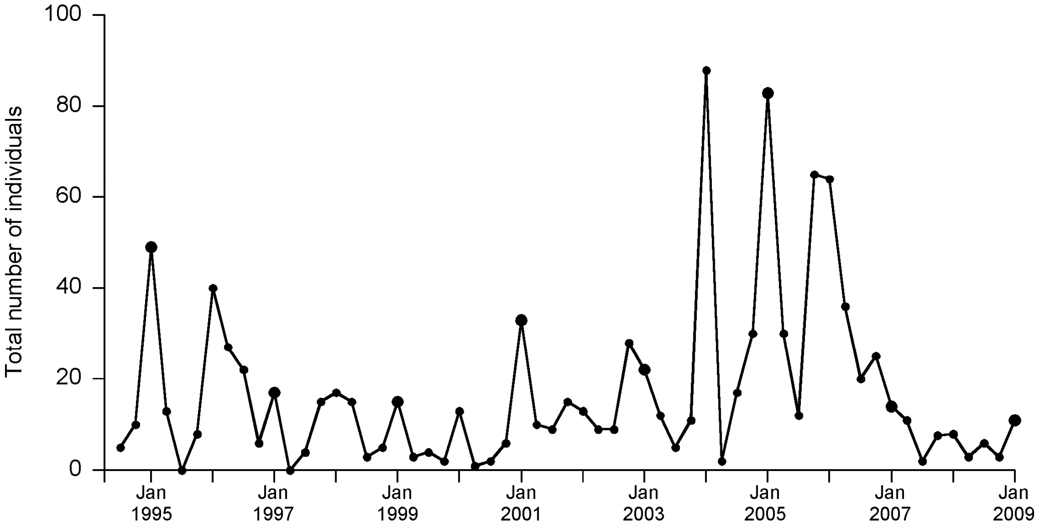
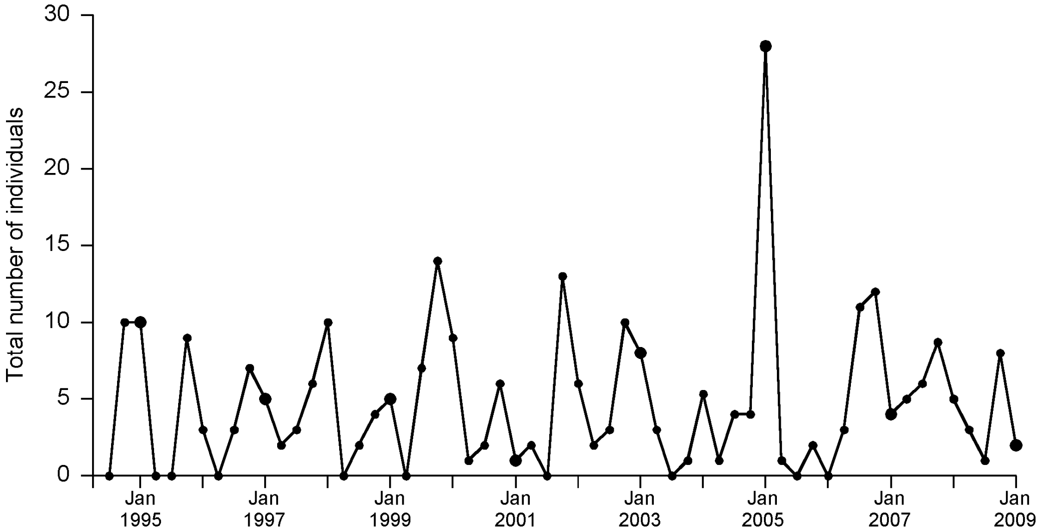


Figure 5.

Total number of *Macrophthalmus hirtipes* collected on each sampling occasion at Cowans Bay. Peaks in abundance of this crab occur annually, most often in January or October.



Populations showing trends in abundance

The decline in *Cossura consimilis* and nemerteans first detected in the 2007 report are still evident (Table 7). However, the other two emerging trends identified in the 2007 report (decline in *Prionospio aucklandica* abundance and increase in *Nucula hartvigiana*) have, with the addition of two more years of data, proven to be a function of occasional high abundances and are no longer apparent (Table 7).

Cossura is found in very high numbers at this site and, while there has been a decline in it's abundance over the last 9 years, numbers are no lower than they were in the first year (Figure 6). A small decreasing trend was also detected for nemerteans; this species has only been found in low numbers at this site in recent years (<10 individuals) (Figure 7).

While a statistically significant increasing trend in abundance was detected for *Paracalliope novizealandiae* in the 2007 report, the trend was of a very low magnitude and this amphipod was rarely found at this site. This trend is no longer apparent (Table 7).

Figure 6.

Total number of *Cossura consimilis* collected on each sampling occasion at Cowans Bay. While peaks in abundance of this polychaete have declined over the last few years, numbers are no lower than those found in the first year of monitoring.

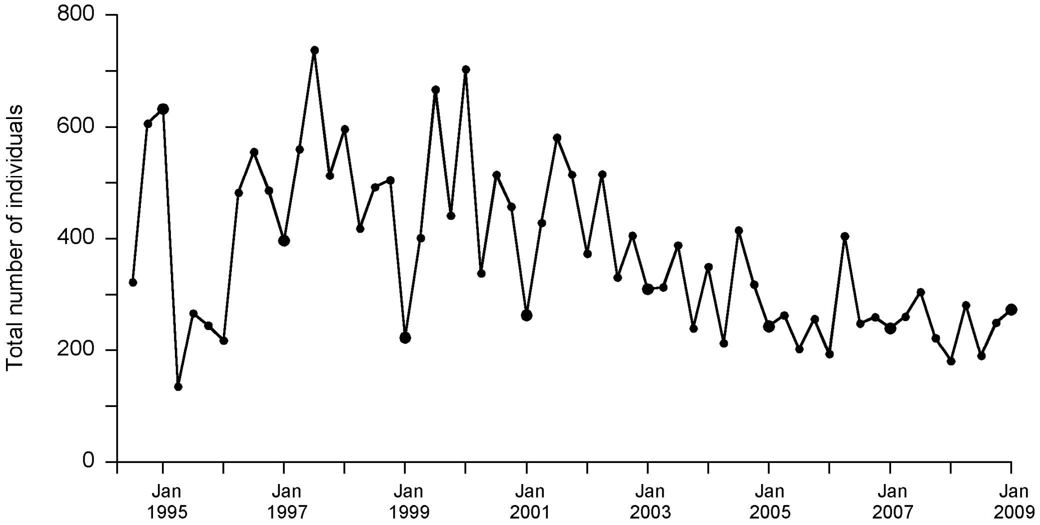


Figure 7.

Total number of nemerteans collected on each sampling occasion at Cowans Bay. A small decreasing trend in abundance has been detected in this taxa over the monitoring period.

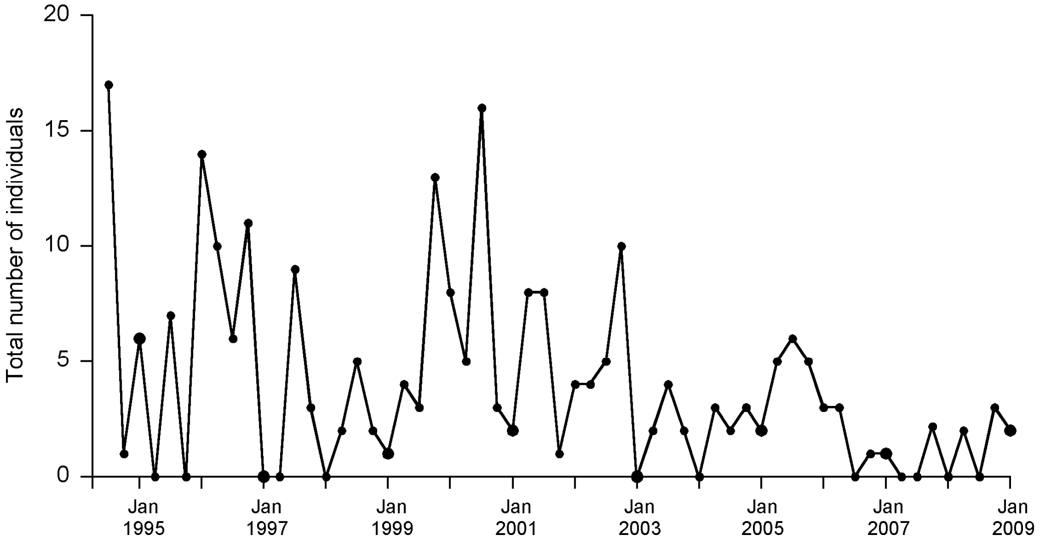
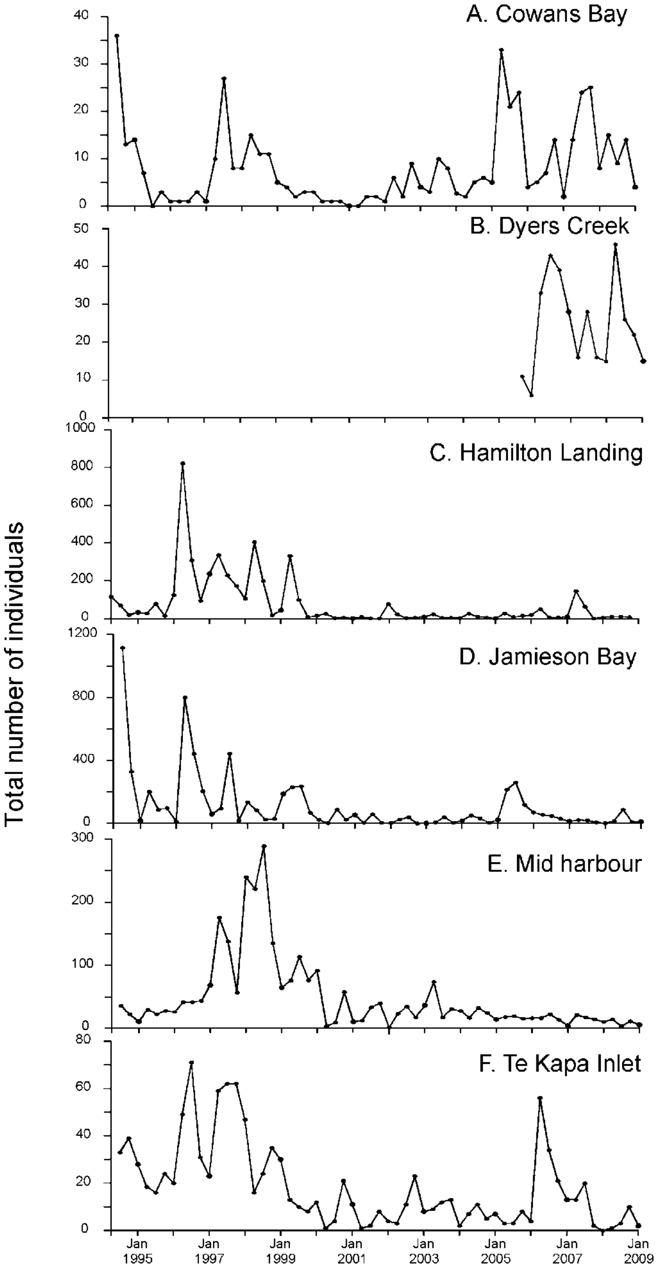


Figure 8.

Total number of polydorid polychaetes collected on each sampling occasion at the intertidal sites. Peaks in abundance of this polychaete occur annually at Dyers Creek, Hamilton Landing and Jamieson Bay, and approximately every two years at Te Kapa Inlet. Decreasing step trends in abundance were detected at Hamilton Landing, Jamieson Bay, Mid Harbour and Te Kapa Inlet. Total numbers of Polydorids were low at all sites from April 2000 to January 2004, numbers then recovered at Cowans Bay and to some extent at Te Kapa Inlet. This species exhibits 5 – 7 year abundance cycles in Manukau Harbour.



4.1.2.2 Dyers Creek

The Dyers Creek site was added as a long-term monitoring site in October 2005. Cummings (2007) provides a detailed description of the site and compares the fauna found in the October 2005 – January 2007 period with that found in the initial April 1993 survey of Mahurangi Estuary.

Dyers Creek is dominated by the bivalves *Nucula hartvigiana* (326-711 individuals) and *Austrovenus stutchburyi* (111-293 individuals). These were the first and second most abundant, respectively, of the monitored taxa collected from October 2005 to January 2009 (Table 2). *Heteromastus filiformis* was also common (3-119 individuals) and *Macomona liliana* has appeared amongst three dominant taxa on two occasions. *Macomona* is found consistently in low numbers (28-89 individuals) at this site. The limpet *Notoacmea helmsei,* which often attaches to the outside of *Austrovenus* shells, was one of the three dominant taxa on four occasions.

Table 2.
The three dominant taxa collected at Dyers Creek from October 2005 to January 2009. The most abundant taxa is on the left hand side of the table.

Oct 05	Nucula hartvigiana	Austrovenus stutchburyi	Macomona liliana
Jan 06	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Apr 06	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Jul 06	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Oct 06	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Jan 07	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Apr 07	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Jul 07	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Oct 07	Nucula hartvigiana	Austrovenus stutchburyi	Macomona liliana
Jan 08	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea helmsei
Apr 08	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Jul 08	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea helmsei
Oct 08	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea helmsei
Jan 09	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea helmsei

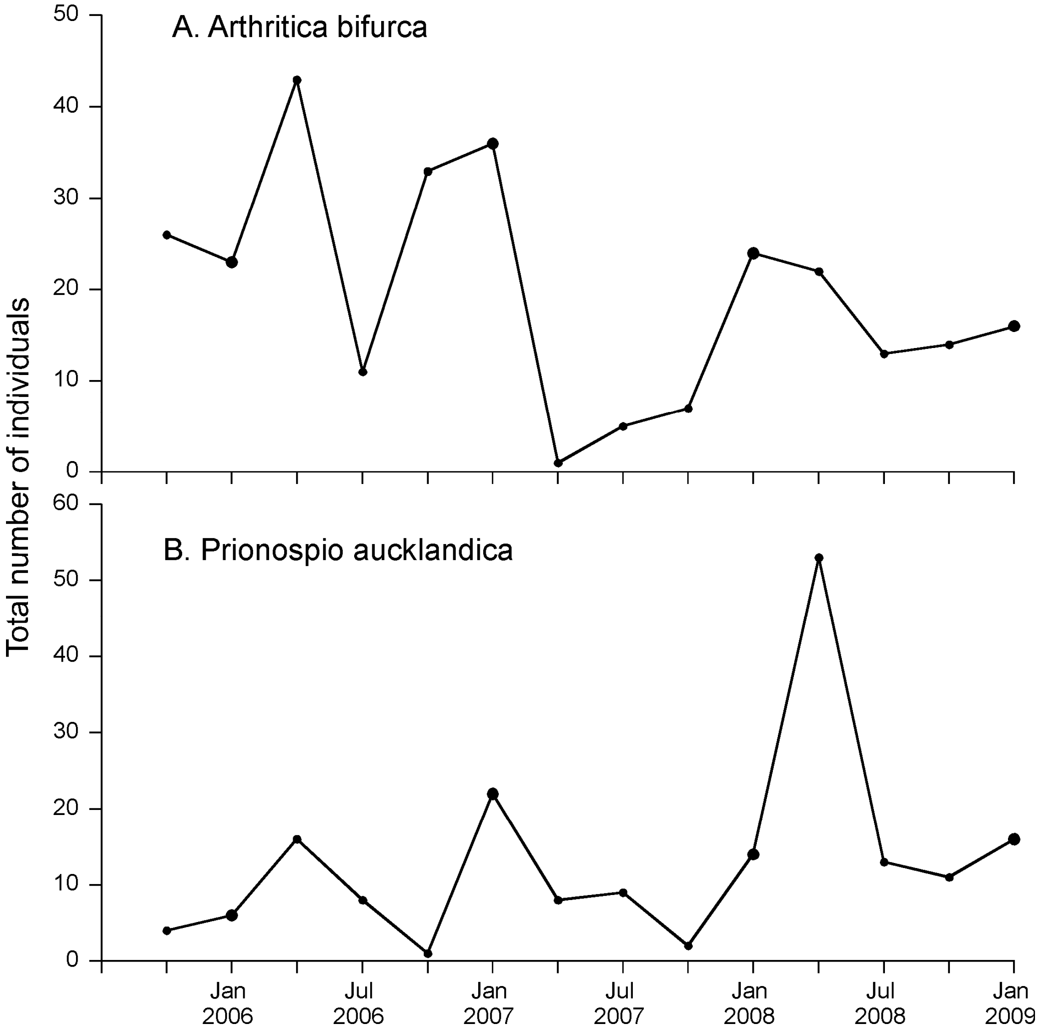
Populations showing cyclic abundance patterns

Cyclic abundance patterns identified with only 3.5 years of data should be treated as provisional. More data is required to confirm any cyclic patterns identified at this stage.

Four annual cyclic trends are suggested. The bivalve *Arthritica bifurca* and the polychaete *Prionospio aucklandica* both peak in abundance either in January or April each year (Figure 9). Polydorid polychaetes peak in abundance in July or April each year (Figure 8B).

Figure 9.

Total abundance of *Arthritica bifurca* and *Prionospio aucklandica* collected on each sampling occasion at Dyers Creek. Peaks in abundance of these species occur annually, in April or January.

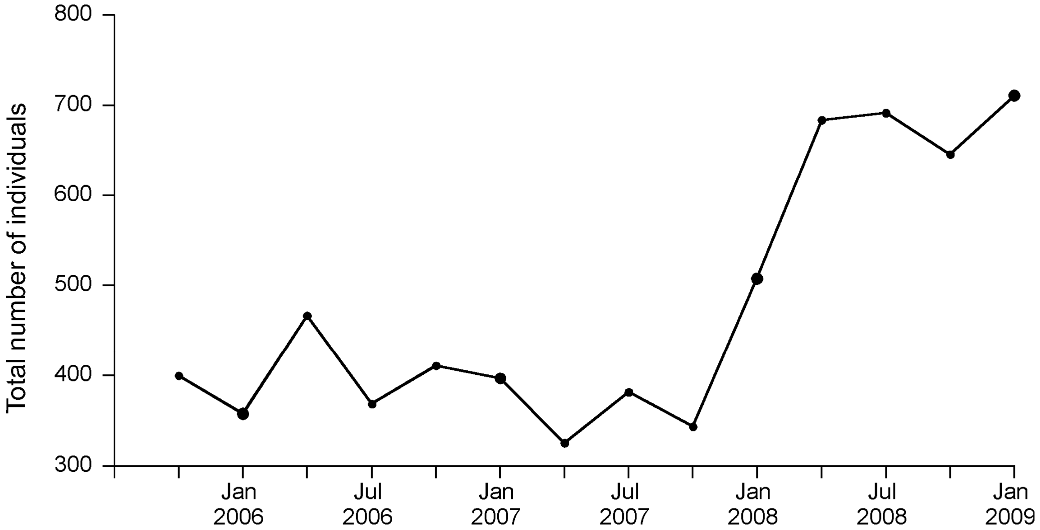


Populations showing trends in abundance

As with identification of annual cycles in abundance, abundance trends detected from only 3.5 years of data should be treated as provisional. Only one abundance trend has been identified in the monitored taxa at Dyers Creek; the total number of *Nucula hartivigiana* has increased considerably over the past year (Figure 10). More data will be required to confirm this trend.

Figure 10.

Total number of *Nucula hartvigiana* collected on each sampling occasion at Dyers Creek. Total abundance has increased over the last year (Jan 2008 – Jan 2009). Further data is required to confirm if this change is an abundance trend or part of a greater than annual cycle.



4.1.2.3 Hamilton Landing

Cossura consimilis and *Heteromastus filiformis* are still the first and second most abundant of the monitored species at Hamilton Landing and both continue to increase in abundance as the monitoring programme continues (Table 3). In the past two years *Aricidea* sp. and Polydorids have featured as the third most abundant monitored taxa at this site.

Table 3.

The three dominant taxa collected at Hamilton Landing between July 1994 and January 2009. 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 consimilis*'.

Jul 94	Austrovenus stutchburyi	Polydorids	Cossura consimilis
Oct 94	Austrovenus stutchburyi	Polydorids	Cossura consimilis
Jan 95	Austrovenus stutchburyi	Nucula hartvigiana	Arthritica bifurca/Cossura consimilis
Apr 95	Austrovenus stutchburyi	Cossura consimilis	Arthritica bifurca
Jul 95	Austrovenus stutchburyi	Cossura consimilis	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 consimilis
Oct 96	Polydorids	Heteromastus filiformis	Austrovenus stutchburyi
Jan 97	Polydorids	Austrovenus stutchburyi	Cossura consimilis
Apr 97	Polydorids	Cossura consimilis	Heteromastus filiformis

Jul 97	Polydorids	Heteromastus filiformis	Cossura consimilis
Oct 97	Polydorids	Heteromastus filiformis	Cossura consimilis
Jan 98	Heteromastus filiformis	Polydorids	Cossura consimilis
Apr 98	Austrovenus stutchburyi	Polydorids	Cossura consimilis
Jul 98	Polydorids	Austrovenus stutchburyi	Cossura consimilis
Oct 98	Polydorids	Heteromastus filiformis	Cossura consimilis
Jan 99	Austrovenus stutchburyi / Cossura consimilis		Arthritica bifurca / Polydorids
Apr 99	Heteromastus filiformis	Cossura consimilis	Austrovenus stutchburyi
Jul 99	Polydorids	Heteromastus filiformis	Cossura consimilis
Oct 99	Heteromastus filiformis	Polydorids	Cossura consimilis
Jan 00	Austrovenus stutchburyi	Heteromastus filiformis	Cossura consimilis
Apr 00	Heteromastus filiformis	Cossura consimilis	Torridoharpinia hurleyi
Jul 00	Heteromastus filiformis	Cossura consimilis	Oligochaetes
Oct 00	Heteromastus filiformis	Cossura consimilis	Arthritica bifurca
Jan 01	Cossura consimilis	Heteromastus filiformis	Nemerteans
Apr 01	Cossura consimilis	Heteromastus filiformis	Prionospio aucklandica
Jul 01	Cossura consimilis	Heteromastus filiformis	Polydorids
Oct 01	Cossura consimilis	Heteromastus filiformis	Nemerteans
Jan 02	Cossura consimilis	Heteromastus filiformis	Prionospio aucklandica
Apr 02	Cossura consimilis	Heteromastus filiformis	Polydorids
Jul 02	Heteromastus filiformis	Cossura consimilis	Arthritica bifurca
Oct 02	Cossura consimilis	Heteromastus filiformis	Macrophthalmus hirtipes
Jan 03	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Apr 03	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 03	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 03	Heteromastus filiformis	Cossura consimilis	Prionospio aucklandica
Jan 04	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 04	Cossura consimilis	Heteromastus filiformis	Prionospio aucklandica
Jul 04	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 04	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 05	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 05	Cossura consimilis	Heteromastus filiformis	Oligochaetes
Jul 05	Cossura consimilis	Heteromastus filiformis	Polydorids
Oct 05	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 06	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 06	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 06	Cossura consimilis	Heteromastus filiformis	Polydorids
Oct 06	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca

Jan 07	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 07	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 07	Cossura consimilis	Heteromastus filiformis	Oligochaetes
Oct 07	Cossura consimilis	Heteromastus filiformis	Polydorids
Jan 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 09	Cossura consimilis	Heteromastus filiformis	Prionospio aucklandica

Populations showing cyclic abundance patterns

The small bivalve *Arthritica bifurca* exhibits a greater than annual cycle in its abundance, with peaks in January or October. (Figure 11).

Polydorid polychaetes have exhibited peaks in abundance in January most years, except for 1995 and 2002 when these occurred in October and April, respectively. Numbers of polydorids have been considerably lower in the last half of the monitored period (i.e., since October 1999), but remain steady (Figure 8B).

The crab *Macrophthalmus hirtipes* and the polychaete *Heteromastus filiformis* exhibit peaks in abundance every year, and most often in October (Figures 12 and 13, respectively).

Figure 11.
Total number of *Arthritica bifurca* collected on each sampling occasion at Hamilton Landing. Peaks in abundance of this bivalve occur on a greater than annual cycle, in January or October months.

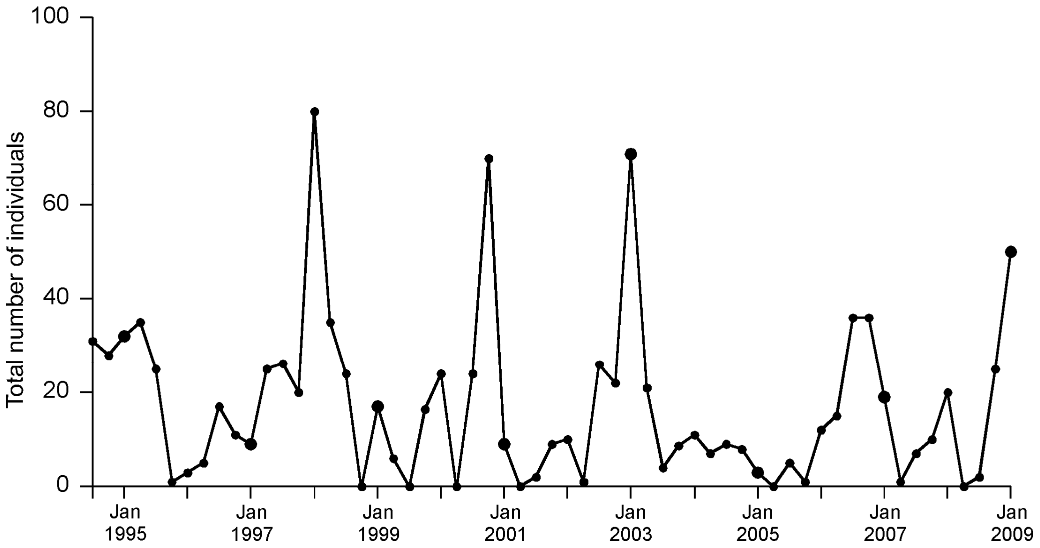


Figure 12.

Total number of *Macrophthalmus hirtipes* collected on each sampling occasion at Hamilton Landing. Peaks in abundance of this crab occur annually, most often in October months.

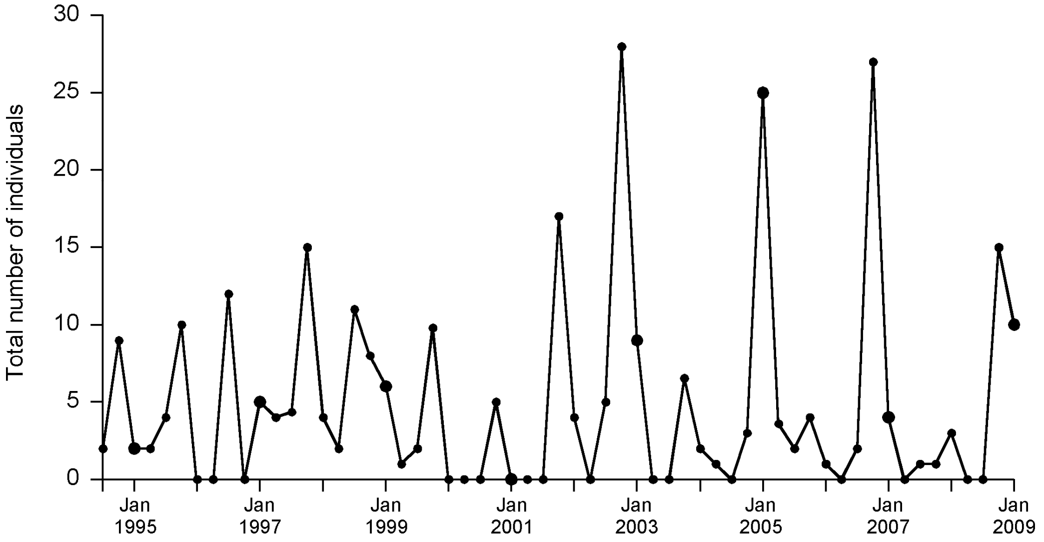
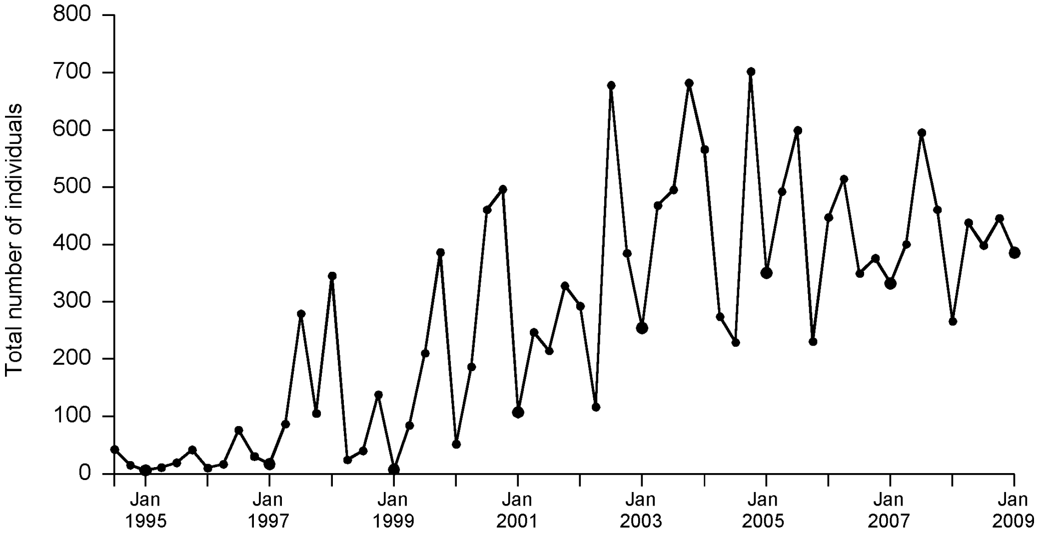


Figure 13.

Total number of *Heteromastus filiformis* collected on each sampling occasion at Hamilton Landing. Peaks in abundance of this polychaete occur annually, most often in October months. An increasing trend in overall and basal abundances was also detected.



Populations showing trends in abundance

Trends in abundance over the monitoring period were detected for 8 of the monitored populations at Hamilton Landing; all were noted in our last report (Table 7). Three populations exhibit increases in abundance, and five exhibit decreases.

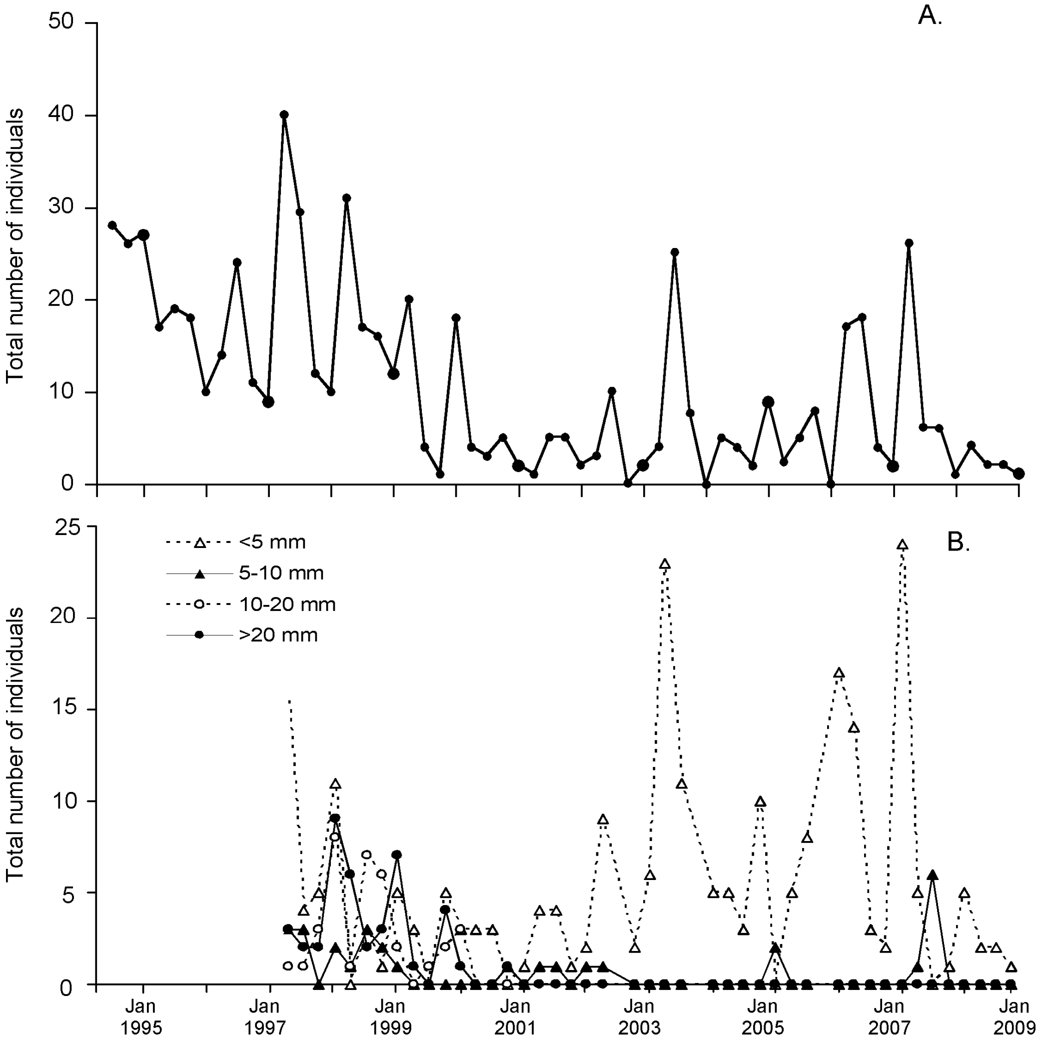
Six of these trends appear due to sudden 'step' changes in abundance, rather than gradual changes over time. An abrupt change in density occurred in several taxa in early 2000 (e.g., polydorids, see Figure 8C). The environmental event which lead to this change particularly affected the community at Hamilton Landing and, for several taxa, the resulting abundance changes have persisted.

- *Cossura consimilis* exhibited a step increase followed by a linear increasing trend in abundance.
- Overall baseline abundances of polydorids declined in a step manner in early 2000, and their densities have not returned to pre 2000 levels (Figure 8C, Table 7).
- The bivalves *Austrovenus stutchburyi* and *Macomona liliana* continue to exhibit statistically significant declines in abundance at Hamilton Landing, due to step changes in early 2000. Since January 2001, less than 6 individual *Austrovenus* have been found at this site per sampling occasion. *Macomona* abundance peaks were up around its pre 2000 high values in July 2003 (25 individuals) and April 2007 (26 individuals), and relatively high abundances occurred in April and July 2006 (17 and 18 individuals, respectively). However, the basal abundance has not returned to pre 2000 levels. Numbers of *Macomona* now appear to be steady at a new baseline abundance of 0-9 individuals (Figure 14A). The *Macomona* population at Hamilton Landing is now largely comprised of very small (<4 mm) individuals; no large, spawning sized individuals have been collected since January 2001 (Figure 14B). This indicates that juvenile *Macomona* are being supplied to this site from elsewhere in the harbour and that few are surviving to adulthood.
- Decreasing step trends were detected for *Scoloplos cylindrifer* and *Perinereis vallata*; these polychaetes have been scarce or absent at Hamilton Landing since early 2000.

Two polychaete populations also exhibit trends in abundance. A strong linear trend was detected for *Heteromastus filiformis* (Figure 13) from 1997 to 2003/4. Abundances of this species are now higher than they were initially, but are no longer increasing (Figure 13). A small increase in abundance was detected for *Aricidea* sp. (Table 7). The trends detected for Nemerteans and *Prionospio aucklandica* in previous reports now appear to have been due to multiyear cycles in their abundances.

Figure 14.

A. The total number of *Macomona liliana* collected on each sampling occasion at Hamilton Landing. A decreasing trend in overall abundance was detected for this bivalve. Numbers have stabilised since April 2000. B. The total number of individuals in each size class, from July 1997 onwards. Note only small (< 5mm shell length) individuals have been commonly found since April 2000.



4.1.2.4 Jamieson Bay

Nucula hartvigiana was the most abundant species at Jamieson Bay between April 2007 and January 2009 (Table 4), when 136-469 individuals were found. Oligochaetes, *Heteromastus filiformis* and *Aonides oxycephala* have also been the second or third most abundant taxa.

Table 4.

The three dominant taxa collected at Jamieson Bay between July 1994 and January 2009. The most abundant taxa is on the left hand side of the table.

Jul 94	Polydorids	Nucula hartvigiana	Macomona liliana
Oct 94	Polydorids	Nucula hartvigiana	Heteromastus filiformis
Jan 95	Nucula hartvigiana	Macomona liliana	Cossura consimilis
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 consimilis / 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 consimilis	Macomona liliana
Apr 02	Nucula hartvigiana	Paracalliope novizealandiae	Cossura consimilis
Jul 02	Nucula hartvigiana	Heteromastus filiformis	Polydorids
Oct 02	Nucula hartvigiana	Aricidea sp.	Heteromastus filiformis
Jan 03	Nucula hartvigiana	Cossura consimilis	Paracalliope novizealandiae
Apr 03	Nucula hartvigiana	Aonides oxycephala	Aricidea sp.
Jul 03	Nucula hartvigiana	Heteromastus filiformis	Oligochaete
Oct 03	Nucula hartvigiana	Aonides oxycephala	Heteromastus filiformis
Jan 04	Nucula hartvigiana	Heteromastus filiformis	Aonides oxycephala
Apr 04	Nucula hartvigiana	Polydorids	Aonides oxycephala
Jul 04	Nucula hartvigiana	Oligochaete	Aonides oxycephala
Oct 04	Nucula hartvigiana	Aricidea sp.	Heteromastus filiformis
Jan 05	Nucula hartvigiana	Torridoharpinia hurleyi	Paracalliope novizealandiae
Apr 05	Polydorids	Nucula hartvigiana	Heteromastus filiformis

Jul 05	Polydorids	Nucula hartvigiana	Heteromastus filiformis
Oct 05	Polydorids	Nucula hartvigiana	Paracalliope novizealandiae
Jan 06	Nucula hartvigiana	Aonides oxycephala	Polydorids
Apr 06	Nucula hartvigiana	Heteromastus filiformis	Macomona liliana
Jul 06	Nucula hartvigiana	Heteromastus filiformis	Oligochaete
Oct 06	Nucula hartvigiana	Macomona liliana	Polydorids
Jan 07	Nucula hartvigiana	Torridoharpinia hurleyi	Macomona liliana
Apr 07	*Nucula hartvigiana*	Polydorids	Cossura consimilis / Oligochaete
Jul 07	*Nucula hartvigiana*	Aonides oxycephala / Oligochaete	Polydorids
Oct 07	*Nucula hartvigiana*	Aonides oxycephala	Heteromastus filiformis
Jan 08	*Nucula hartvigiana*	Heteromastus filiformis	Torridoharpinia hurleyi
Apr08	*Nucula hartvigiana*	Macomona liliana	Austrovenus stutchburyi
Jul 08	*Nucula hartvigiana*	Polydorids	Aonides oxycephala
Oct 08	*Nucula hartvigiana*	Oligochaete	Heteromastus filiformis
Jan 09	*Nucula hartvigiana*	Oligochaete	Aricidea sp.

Populations showing cyclic abundance patterns

Three populations exhibit annual cyclic abundance patterns at Jamieson Bay: polydorids, *Aricidea* sp. and *Nucula hartvigiana*. Polydorids have highest numbers in July or April each year, although peaks have been lower since early 2000 (Figure 8C). *Aricidea* peak abundances occur in either July or October, while *Nucula* consistently exhibits its highest numbers in January or April.

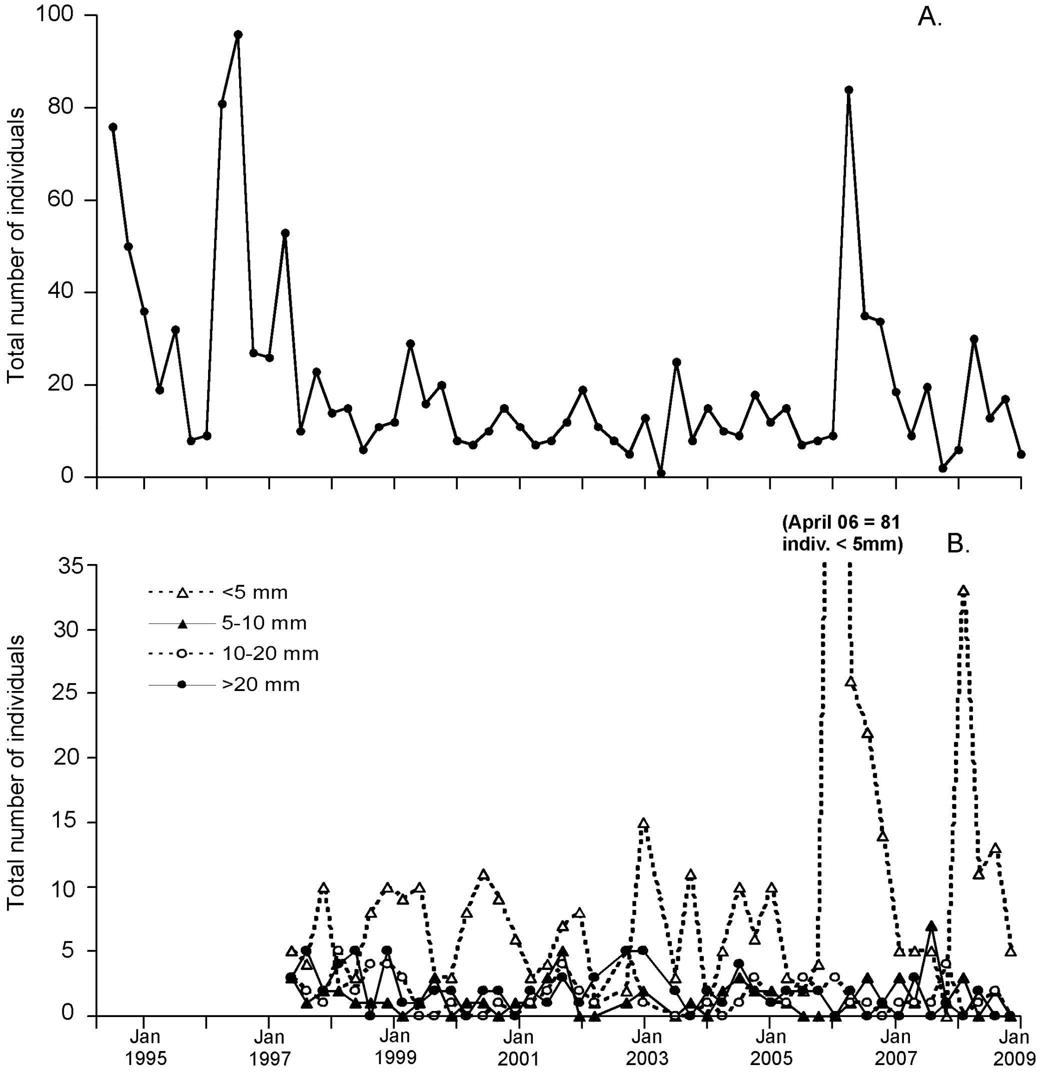
Populations showing trends in abundance

Statistically significant trends in abundance were detected in only one population at Jamieson Bay in this year's analyses, compared with five detected in the 2005 and 2007 reports (Table 7). Polydorids exhibited a step reduction in both overall and basal abundances in 2000 (Figure 8D). Abundance peaks for this polychaete in 2005 and 2008 show the potential for its recovery to pre 2000 levels.

The trends noted in our last report for *Arthritica bifurca* and *Aricidea* sp. (increases) and *Torridoharpinia hurleyi* and *Macomona liliana* (decreases) are no longer apparent with two more years of data (Table 7). The abundances of *Arthritica, Torridoharpinia* and *Aricidea* seem to fluctuate on greater than annual cycles. *Macomona* was abundant at this site for the first three years of monitoring, after which it's declined to around 10 individuals on average. While Figure 15A suggests that this decline has been reversed (with a large peak in abundance in April 2006 and moderate sized peaks since), these peaks were comprised almost entirely of <4 mm individuals (Figure 15B). As individual *Macomona* were not measured in the first three years of monitoring we can not tell if there has been a decline in the abundance of larger individuals.

Figure 15.

A. Total number of *Macomona liliana* collected on each sampling occasion at Jamieson Bay. A decreasing trend in overall abundance of this bivalve was detected in previous reports, however numbers have recovered in the last three years. B. The total number of individuals in each size class, from July 1997 onwards.



(April 06 = 81 indiv. < 5mm)

4.1.2.5 Mid Harbour

Nucula hartvigiana continues to dominate Mid Harbour (Table 5), with between 331 and 849 individuals collected on the last eight monitoring dates.

Table 5.
The three dominant taxa collected at Mid Harbour between July 1994 to January 2007. The most abundant taxa is on the left hand side of the table.

Jul 94	Heteromastus filiformis	Cossura consimilis	Nucula hartvigiana
Oct 94	Nucula hartvigiana	Cossura consimilis	Macomona liliana
Jan 95	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Apr 95	Nucula hartvigiana	Cossura consimilis	Polydorids
Jul 95	Nucula hartvigiana	Cossura consimilis	Macomona liliana
Oct 95	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Jan 96	Nucula hartvigiana	Cossura consimilis	Polydorids
Apr 96	Nucula hartvigiana	Polydorids	Cossura consimilis
Jul 96	Nucula hartvigiana	Polydorids	Cossura consimilis
Oct 96	Nucula hartvigiana	Polydorids	Cossura consimilis
Jan 97	Nucula hartvigiana	Polydorids	Cossura consimilis
Apr 97	Nucula hartvigiana	Polydorids	Cossura consimilis
Jul 97	Nucula hartvigiana	Polydorids	Cossura consimilis
Oct 97	Nucula hartvigiana	Polydorids	Cossura consimilis
Jan 98	Nucula hartvigiana	Polydorids	Cossura consimilis
Apr 98	Nucula hartvigiana	Polydorids	Cossura consimilis
Jul 98	Nucula hartvigiana	Polydorids	Austrovenus stutchburyi
Oct 98	Nucula hartvigiana	Polydorids	Cossura consimilis
Jan 99	Nucula hartvigiana	Polydorids	Cossura consimilis
Apr99	Nucula hartvigiana	Polydorids	Heteromastus filiformis
Jul 99	Nucula hartvigiana	Polydorids	Cossura consimilis
Oct 99	Nucula hartvigiana	Polydorids	Heteromastus filiformis
Jan 00	Nucula hartvigiana	Polydorids	Arthritica bifurca
Apr 00	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Jul 00	Nucula hartvigiana	Cossura consimilis	Heteromastus filiformis
Oct 00	Nucula hartvigiana	Polydorids	Arthritica bifurca
Jan 01	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Apr 01	Heteromastus filiformis	Prionospio 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

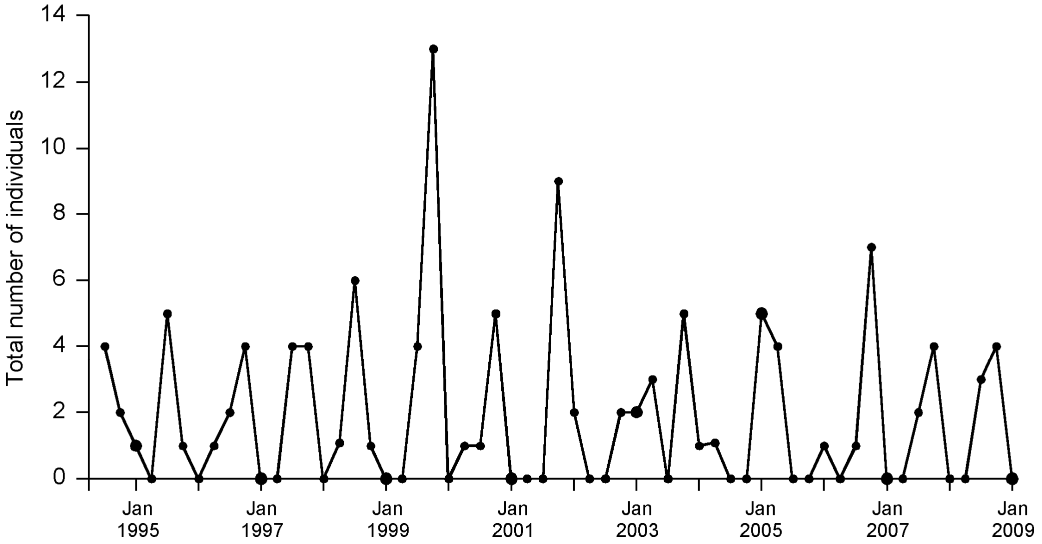
Jul 02	Nucula hartvigiana	Arthritica bifurca	Heteromastus filiformis
Oct 02	Nucula hartvigiana	Cossura consimilis	Heteromastus filiformis
Jan 03	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Apr 03	Nucula hartvigiana	Polydorids	Cossura consimilis
Jul 03	Nucula hartvigiana	Cossura consimilis	Heteromastus filiformis
Oct 03	Nucula hartvigiana	Heteromastus filiformis	Polydorids
Jan 04	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Apr 04	Nucula hartvigiana	Cossura consimilis	Heteromastus filiformis
Jul 04	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Oct 04	Nucula hartvigiana	Arthritica bifurca	Heteromastus filiformis
Jan 05	Nucula hartvigiana	Cossura consimilis	Macomona liliana
Apr 05	Nucula hartvigiana	Cossura consimilis	Heteromastus filiformis
Jul 05	Nucula hartvigiana	Heteromastus filiformis	Cossura consimilis
Oct 05	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Jan 06	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Apr 06	Nucula hartvigiana	Heteromastus filiformis	Arthritica bifurca
Jul 06	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Oct 06	Nucula hartvigiana	Arthritica bifurca	Heteromastus filiformis
Jan 07	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Apr 07	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca / Polydorids
Jul 07	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Oct 07	Nucula hartvigiana	Polydorids / Macomona liliana	Heteromastus filiformis
Jan 08	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Apr 08	Nucula hartvigiana	Arthritica bifurca	Aricidea sp.
Jul 08	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Oct 08	Nucula hartvigiana	Heteromastus filiformis	Arthritica bifurca
Jan 09	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis

Populations showing cyclic abundance patterns

Heteromastus filiformis and *Macrophthalmus hirtipes* (Figure 16) exhibit peaks in abundance every year at Mid Harbour, in July or October months. *Nucula hartvigiana* numbers are highest in January or October each year (except for 2003, 2004, and 2008, when peak abundances occurrred in April).

Figure 16.

Total number of *Macrophthalmus hirtipes* collected on each sampling occasion at Mid Harbour. Peaks in abundance of this crab occur annually, most often in July or October months.



Populations showing trends in abundance

Three populations exhibit trends in abundance at Mid Harbour: *Arthritica bifurca* and *Nucula hartvigiana* (increases) and *Macomona liliana* (a decrease) (Table 7).

Arthritica bifurca abundance fluctuates considerably, however their abundance has been generally higher in the last half of the monitoring period, possibly corresponding to changes occurring in early 2000. A large recruitment event (210 individuals) occurred on the most recent sampling occasion, January 2009.

An increasing trend was detected in the abundance of the small bivalve *Nucula hartvigiana,* mainly reflecting large recruitment events in January 2008 and 2009 (Figure 17). This is the first time an increasing abundance trend has been detected for *Nucula* at this site.

Although a decreasing trend was detected for *Macomona liliana* over the entire monitoring period, this taxa actually exhibits a greater than annual cyclic abundance pattern (Figure 18A). *Macomona* exhibited a decline in numbers in the middle of the monitoring programme, probably corresponding to the early 2000 shift in abundance noted at many sites. Peak abundances since 2003 are similar to those noted prior to this decline, and baseline abundances had been increasing until 2007 when they dipped again (Figure 18A). Since 2003 the population has comprised of individuals of a range of sizes (Figure 18B).

The increasing trends noted for *Paracalliope novizealandiae* and *Notoacmea helmsi* in our last report are no longer apparent with two more years of data (Table 7). Abundances of both species are sporadic and low at this site.

Figure 17.

Total number of *Nucula hartvigiana* collected on each sampling occasion at Mid Harbour. An increasing trend in abundance was detected for this bivalve.

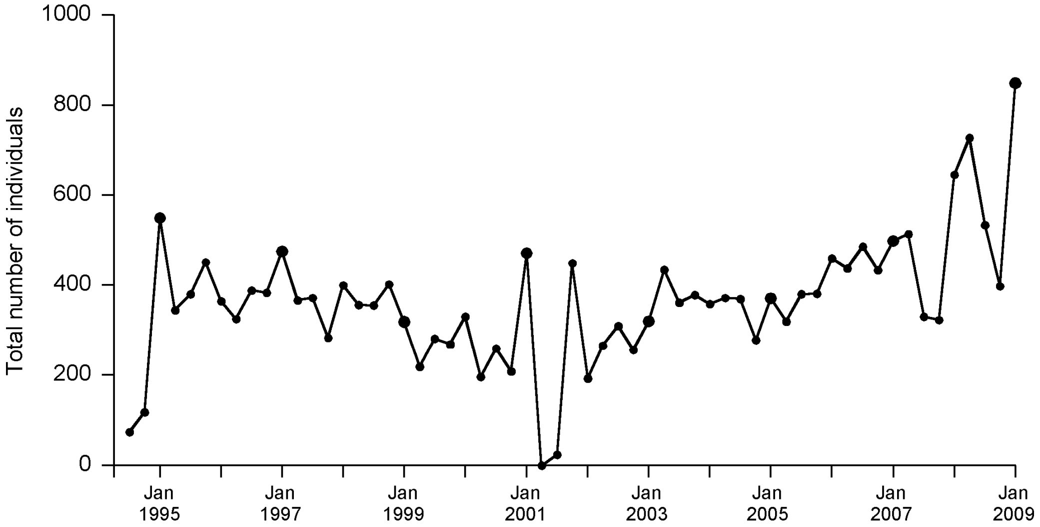
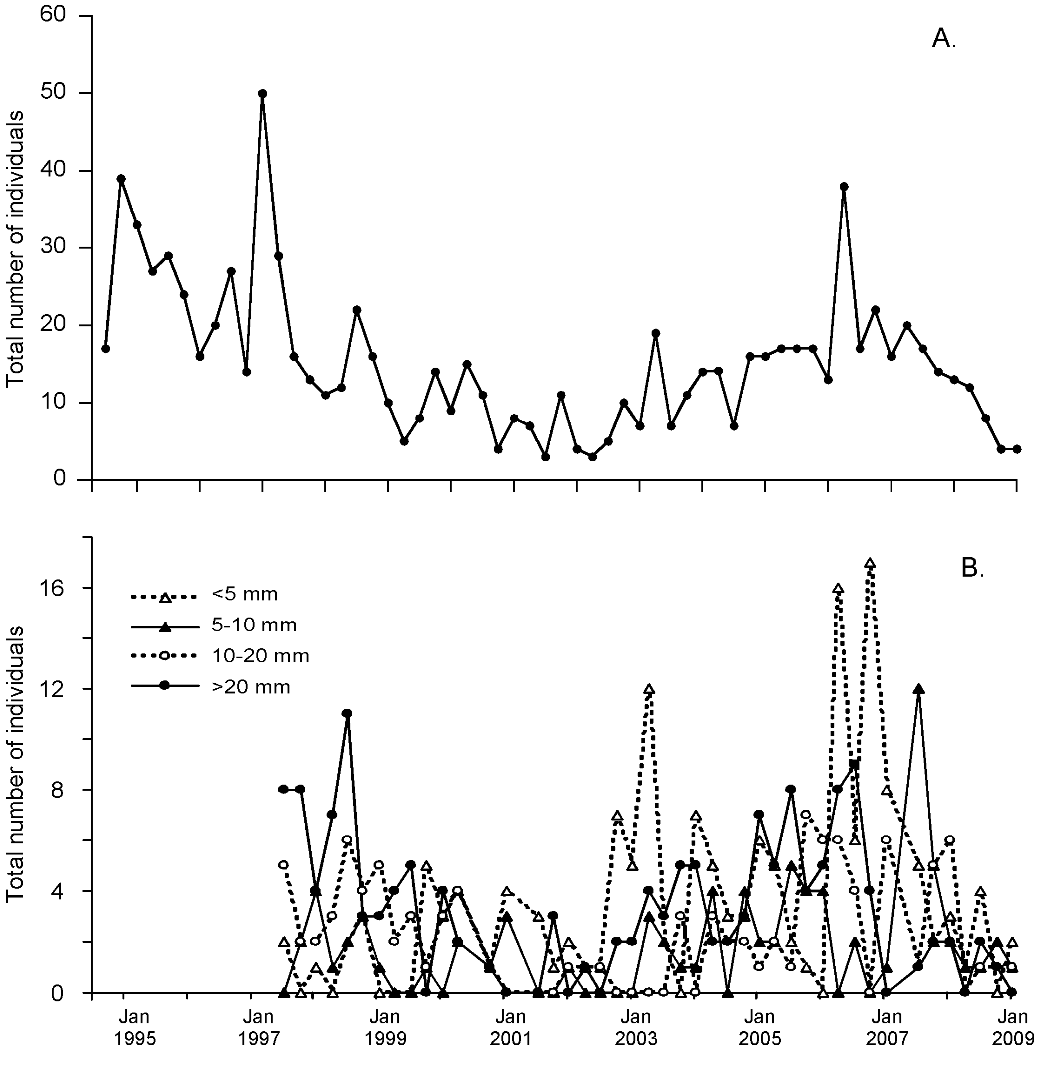


Figure 18.

A. Total number of *Macomona liliana* collected on each sampling occasion at Mid Harbour. Total abundance decreased over the first 7 years of monitoring, and now abundance is variable; however, a small decreasing trend is still apparent. B. Total number of individuals in each size class, from July 1997.



4.1.2.6 Te Kapa Inlet

The Te Kapa Inlet monitored community has been dominated by three taxa over the last two years of monitoring (Table 6). *Cossura consimilis* , the most abundant species, has continually been found in very high numbers (281-497 individuals) since the last report. *Heteromastus filiformis* (36-293 individuals) and *Aricidea* sp. (28-152 individuals) are also common. *Austrovenus stutchburyi* (7-49 individuals) was the third equal most commonly monitored taxa in October 2007. All four of these taxa have featured amongst the most dominant at this site over the course of the monitoring programme.

Table 6.

The three dominant taxa collected at Te Kapa Inlet between July 1994 to January 2007. 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 consimilis* '.

Jul 94	Austrovenus stutchburyi	Heteromastus filiformis	Aricidea sp.
Oct 94	Austrovenus stutchburyi	Heteromastus filiformis	Nucula hartvigiana
Jan 95	Heteromastus filiformis	Cossura consimilis	Nucula hartvigiana
Apr 95	Austrovenus stutchburyi	Nucula hartvigiana	Cossura consimilis
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 consimilis
Jul 96	Heteromastus filiformis	Cossura consimilis	Aricidea sp.
Oct 96	Heteromastus filiformis	Cossura consimilis	Aricidea sp.
Jan 97	Austrovenus stutchburyi	Prionospio aucklandica	Heteromastus filiformis
Apr 97	Heteromastus filiformis	Prionospio aucklandica	Aricidea sp.
Jul 97	Prionospio aucklandica	Aricidea sp.	Austrovenus stutchburyi
Oct 97	Heteromastus filiformis	Aricidea sp.	Cossura consimilis
Jan 98	Aricidea sp.	Prionospio aucklandica	Cossura consimilis
Apr 98	Cossura consimilis	Heteromastus filiformis	Prionospio aucklandica
Jul 98	Heteromastus filiformis	Aricidea sp.	Prionospio aucklandica
Oct 98	Aricidea sp.	Heteromastus filiformis	Cossura consimilis
Jan 99	Austrovenus stutchburyi	Cossura consimilis	Nucula hartvigiana
Apr99	Cossura consimilis	Austrovenus stutchburyi	Prionospio aucklandica
Jul 99	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 99	Cossura consimilis	Nucula hartvigiana	Austrovenus stutchburyi
Jan 00	Cossura consimilis	Prionospio aucklandica	Heteromastus filiformis
Apr 00	Cossura consimilis	Prionospio aucklandica	Austrovenus stutchburyi
Jul 00	Cossura consimilis	Heteromastus filiformis	Austrovenus stutchburyi
Oct 00	Cossura consimilis	Heteromastus filiformis	Prionospio aucklandica
Jan 01	Cossura consimilis	Nucula hartvigiana	Austrovenus stutchburyi

Apr 01	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Jul 01	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Oct 01	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 02	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Apr 02	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 02	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 02	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 03	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Apr 03	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 03	Cossura consimilis	Aricidea sp.	Heteromastus filiformis
Oct 03	Cossura consimilis	Heteromastus filiformis	Austrovenus stutchburyi
Jan 04	Cossura consimilis	Heteromastus filiformis	Austrovenus stutchburyi
Apr 04	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Jul 04	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 04	Cossura consimilis	Heteromastus filiformis	Austrovenus stutchburyi
Jan 05	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Apr 05	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 05	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 05	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 06	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 06	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 06	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 06	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 07	Cossura consimilis	Heteromastus filiformis	Nucula hartvigiana
Apr 07	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 07	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 07	Cossura consimilis	Heteromastus filiformis	Aricidea sp. / Austrovenus stutchburyi
Jan 08	Cossura consimilis	Nucula hartvigiana	Aricidea sp.
Apr 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 08	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 09	Cossura consimilis	Heteromastus filiformis	Aricidea sp.

Populations showing cyclic abundance patterns

All three of the populations exhibiting cyclic patterns in abundance in the 2007 report (i.e., *Aricidea* sp. and *Heteromastus filiformis* and polydorids) continue to do so with the addition of two years more data.

Aricidea sp. and *Heteromastus filiformis* exhibit peaks in abundance each year, but the timing of these peaks is not predictable. Polydorids show a greater than annual cycle in abundance; peaks have occurred every two years, and generally in July or October months, although two peaks occurred in April of 2006 & 2008 (Figure 8E).

Populations showing trends in abundance

Trends in abundance were detected for five populations at Te Kapa Inlet: one is an increasing trend and four are decreasing (Table 7).

Two of these trends are due to one off step changes in abundance (i.e., *Cossura consimilis* and polydorids). There was initially a large increase in numbers of *Cossura* at this site, abundances ranged from 1-367 prior to July 2000, and 143-810 since this time). While still higher than pre 2000, *Cossura* abundances now show signs of decreasing. Numbers of polydorids decreased in a step manner in early 2000 (Table 7). There has been some sign of recovery of this population, with a large abundance peak in in April 2006 and a smaller one in Oct 2008, but polydorids are still less frequently found at this site than in the initial years of monitoring (Figure 8F).

A decline in abundance of *Austrovenus stutchburyi* was again detected at this site (Table 7), and lowest ever numbers of this bivalve were recorded on the most recent sampling occasion (i.e., 7 individuals; Figure 19A). The proportion and abundance of medium and large-sized cockles has been lower over the last two years than previously (Figure 19B).

Numbers of *Prionospio aucklandica* and *Nucula hartvigiana* have continued to decline at Te Kapa Inlet, with abundances still generally lower than in the first few years of monitoring.

Several trends detected in our last report are now no longer apparent. *Heteromastus filiformis* abundances, although initially increasing after 2000, are now similar to those at the start of the monitoring programme. A new increasing trend was detected for *Arthritica bifurca* in the 2007 report. The increase in abundance of this small bivalve was due to the relatively high numbers found on two sampling dates in 2006/07 and, over the last two years, numbers have returned to pre-2006/07 levels. The trend previously detected for *Notoacmea helmsi* should be interpreted as a greater than annual abundance cycle rather than a steady shift in abundance. Nemerteans and *Scoloplos cylindrifer* are rarely found at this site. The *Macomona liliana* population at Te Kapa Inlet has not shown a statistically significant trend for the past 4 years. While this is encouraging, numbers of this bivalve remain low, particularly those of adult-sized individuals (Figure 20A and B).

Figure 19.

Total number of *Austrovenus stutchburyi* collected on each sampling occasion at Te Kapa Inlet. A decreasing trend in overall abundance of this bivalve was detected. B. The total number of individuals in each size class, from July 1997 onwards. Note, as well as a decline in the total abundance of *Austrovenus*, the proportion of large sized cockles has also decreased.

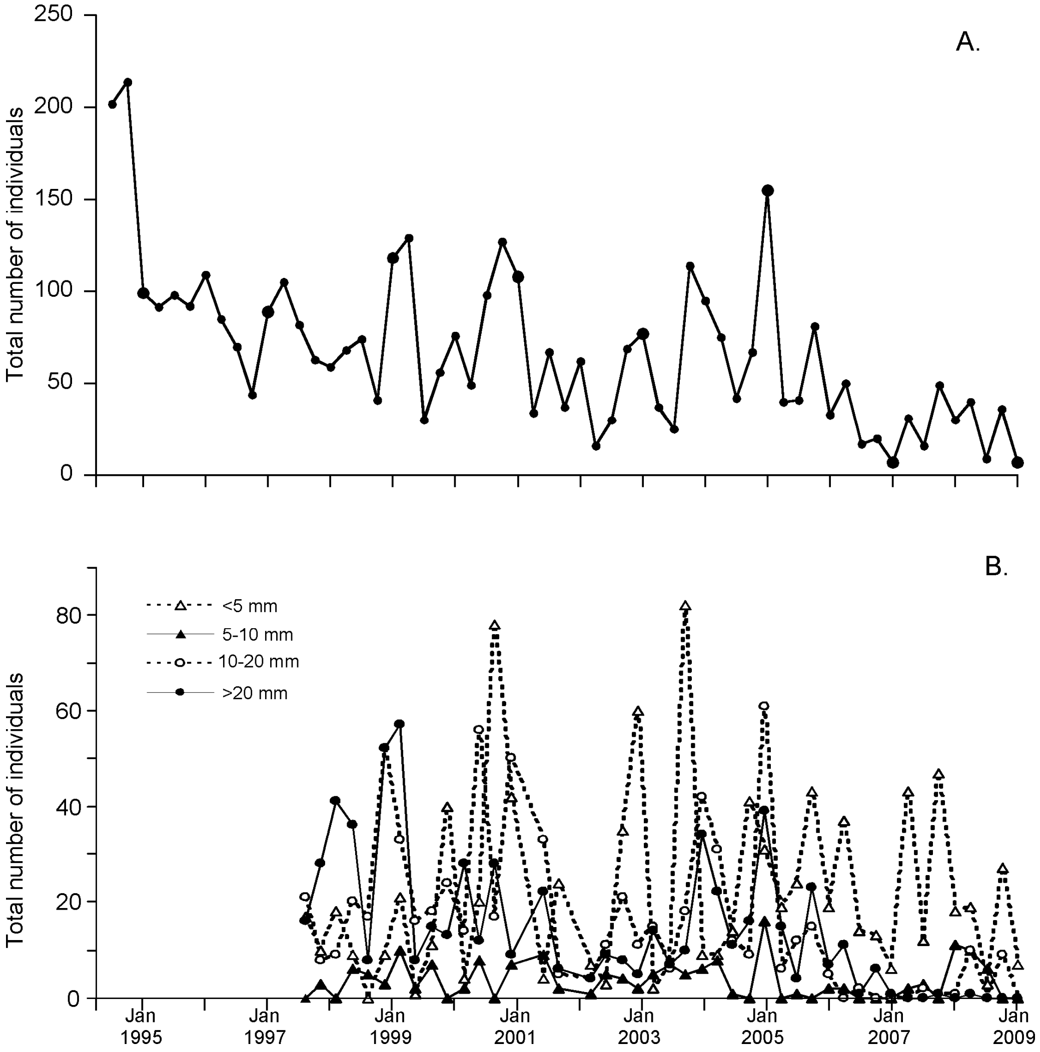


Figure 20.

Total number of *Macomona liliana* collected on each sampling occasion at Te Kapa Inlet. The decreasing trend in overall abundance of this bivalve detected in previous years is no longer apparent due to a large recruitment of juveniles in April 2006 and 2007. B. The total number of individuals in each size class, from July 1997 onwards.

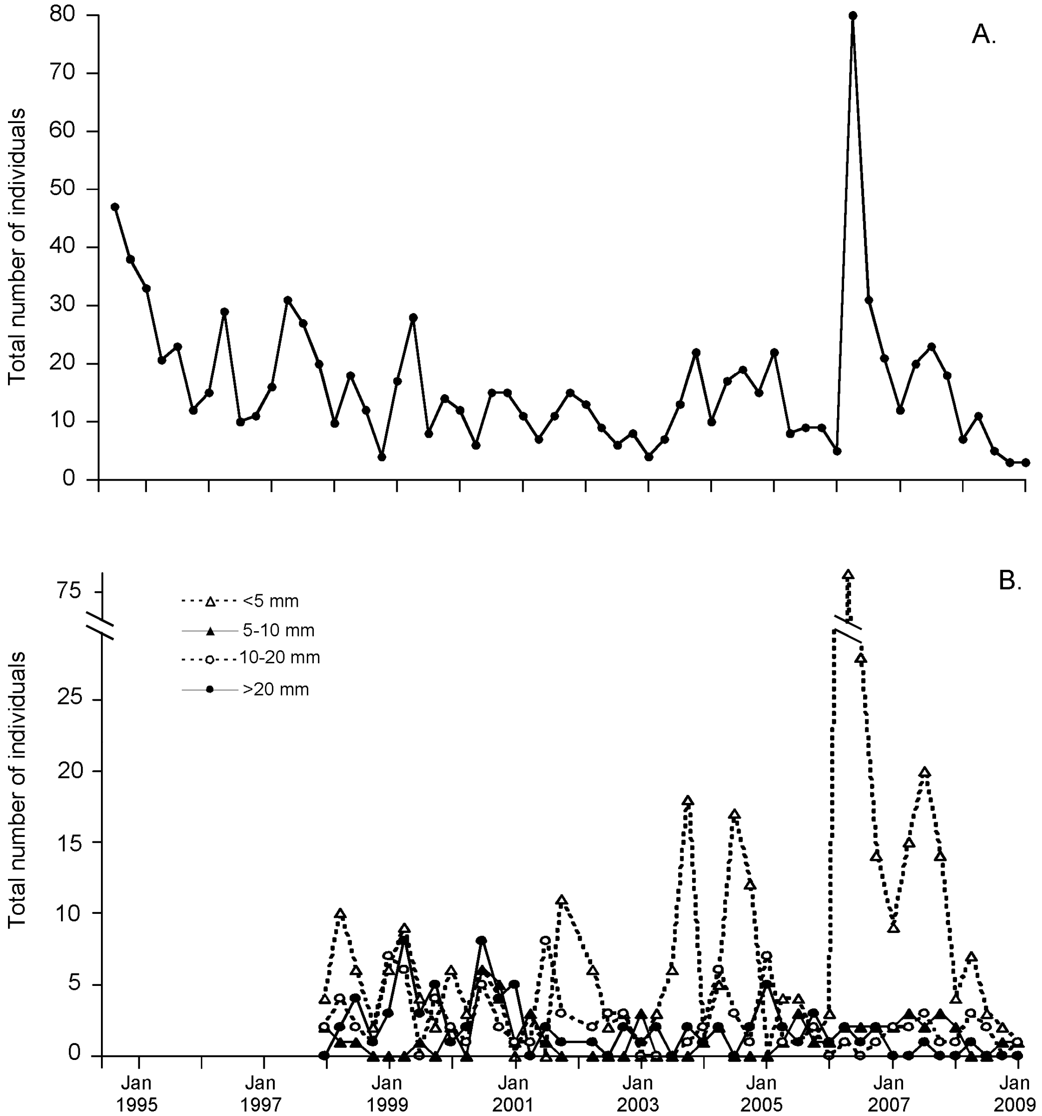


Table 7.

Statistically significant trends in abundance of intertidal taxa at each site. 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, if a repeatable cyclic abundance pattern was apparent, on basal data with peak abundances removed. Basal trends are shown in parentheses. Step changes are indicated by the word 'step' in parentheses. * trends that are unlikely to be ecologically significant due to low and/or sporadic occurrences of these taxa.

Monitored Taxa	2009	2007	2005	2003	2001
Cowans Bay					
Cossura consimilis	-4.47	-4.07	No trend	No trend	No trend
Nemerteans	-0.09	-0.08	No trend	No trend	No trend
Nucula hartvigiana	No trend	(0.41)	No trend	No trend	No trend
Paracalliope novizealandiae	No trend	0.02	0.05	No trend	No trend
Prionospio aucklandica	No trend	-0.04 (-0.04)	No trend	No trend	No trend
Hamilton Landing					
Aricidea sp.	0.86	0.66	0.86	No trend	No trend
Austrovenus stutchburyi	-1.76 (step)	-2.33	-2.82	-3.67 (-3.46)	-4.71 (-5.48)
Cossura consimilis	19.58 (step)	19.73	22.09	17.60	7.97
Heteromastus filiformis	8.70	10.36 (10.16)	12.37	11.20 (6.67)	11.26
Macomona liliana	-0.31 (step)	-0.39	-0.51	-0.71	-0.77
Nemerteans	No trend	0.18	0.30	0.288	No trend
Perinereis vallata*	-0.04 (step)	-0.06	No trend	-0.10	No trend
Polydorids	-3.41 (step)	-4.16 (-2.68)	-5.05	No trend	No trend
Prionospio aucklandica	No trend	0.28	0.52	0.35	0.28
Scoloplos cylindrifer	-0.23 (step)	-0.25	-0.30	No trend	No trend
Jamieson Bay					
Arthritica bifurca	No trend	0.17	0.16	No trend	No trend
Aricidea sp.	No trend	0.28 (0.32)	(0.36)	0.41 (0.54)	No trend
Polydorids	-5.05 (step)	-6.37 (-2.16)	-9.11 (-3.62)	-11.89 (-4.48)	-14.51
Macomona liliana	No trend	-0.48	-0.89	-1.24	-1.63
Torridoharpinia hurleyi	No trend	-0.41 (-0.42)	-0.58	-0.97	-1.41
Mid Harbour					
Arthritica bifurca	0.98	0.83	No trend	1.01	No trend
Macomona liliana	-0.20	No trend	-0.48	-0.79	-0.92 (-1.03)
Notoacmea helmsi	No trend	-0.01	No trend	No trend	No trend
Nucula hartvigiana	3.42	No trend	No trend	No trend	No trend
Paracalliope novizelandiae	No trend	0.08	No trend	No trend	No trend
Te Kapa Inlet					
Arthritica bifurca	No trend	0.40	No trend	No trend	No trend
Austrovenus stutchburyi	-1.51	-1.57	No trend	-2.21	-2.07
Cossura consimilis	8.39 (step)	9.76	14.90	13.64	7.77

Heteromastus filiformis	No trend	2.00	(4.58)	No trend	No trend
Notoacmea helmsi	No trend	-0.14	No trend	No trend	-0.47
Nucula hartvigiana	-0.85	-0.84	No trend	No trend	-2.01
Nemerteans	No trend	0.12	0.263	0.29	0.28
Polydorids	-0.54 (step)	-0.57	-0.91 (-1.09)	-1.08 (-1.10)	No trend
Prionospio aucklandica	-1.18	-1.18	-1.17	No trend	No trend
Scoloplos cylindrifer	No trend	0.05	No trend	No trend	No trend

4.1.3 Intertidal sites - general patterns

4.1.3.1 Harbour-wide patterns in intertidal macrofaunal populations

Populations showing cyclic abundance patterns

Nineteen taxa exhibit cyclic abundance patterns, including three provisionally identified from Dyers Creek (Table 8). Very few of these taxa exhibit highly predictable patterns, where peaks in abundance occur in the same monitoring month every year. This is not surprising as 2 monthly monitoring in the Manukau suggests that recruitment peaks may vary in timing from year to year by 2 – 3 months. The lower frequency of sampling in the Mahurangi would thus result in less capability to detect cyclic patterns. For the Dyers Creek monitored taxa, it is important to note that these cycles have been identified from only 3.5 years of data and that more data is required to confirm cyclical patterns in abundance.

Table 8.

Summary of monitored taxa currently exhibiting cyclic abundance patterns at the Mahurangi intertidal monitoring sites. * peaks occur annually but month of occurrence varies; > indicates a greater than annual abundance cycle. CB = Cowans Bay, DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet. Note that cyclic trends in abundance identified from the Dyers Creek site are only based on 3.5 years of data; more data are required to confirm these trends.

Taxa currently showing cyclic abundance patterns	CB	DC	HL	JB	MH	TK
Aricidea sp.				Jul/Oct		*
Arthritica bifurca	.	Jan/Apr	Jan/Oct (>)	.	.	.
Cossura consimilis	.		.	.	.	.
Heteromastus filiformis	Jul/Oct		Oct	.	Jul/Oct	*
Macrophthalmus hirtipes	Jan/Oct		Oct	.	Jul/Oct	.
Nucula hartvigiana	Jan		.	Jan/Apr	Jan/Oct	.
Polydorids	.	Jul/Apr	Jan	Jul/Apr	.	Jul/Oct (>)
Prionospio aucklandica		Jan/Apr				

Populations showing step abundance patterns

The abundance of a number of monitored populations at more than one site either increased or decreased in a step manner in early 2000. While many of these changes have been identified as long-term trends in abundance in previous reports, we now have sufficient data to test if the abundances prior and post the change are significantly different. A total of nine populations exhibit a significant step change in abundance occurring in early 2000 from which the population has not recovered (Table 9). Step changes reflect a quick event resulting in a long term change in the environment or the recruitment pool. Where a step response has resulted in a decrease in abundance, the population may have stabilised at or close to 0 individuals. This doesn’t necessarily mean that the impact-causing event is finished, but the species’ abundance has been reduced to a stage that no further response is observable. This is not the case with an increasing step response, where continued increases in abundance are expected following the step change if the environmental change persists (e.g., *Cossura consimilis* at Hamilton Landing, Figure 21). Another Hamilton Landing population (*Heteromastus filiformis*) increased in abundance to a new higher level between 1997 and 2003/4 (Figure 13).

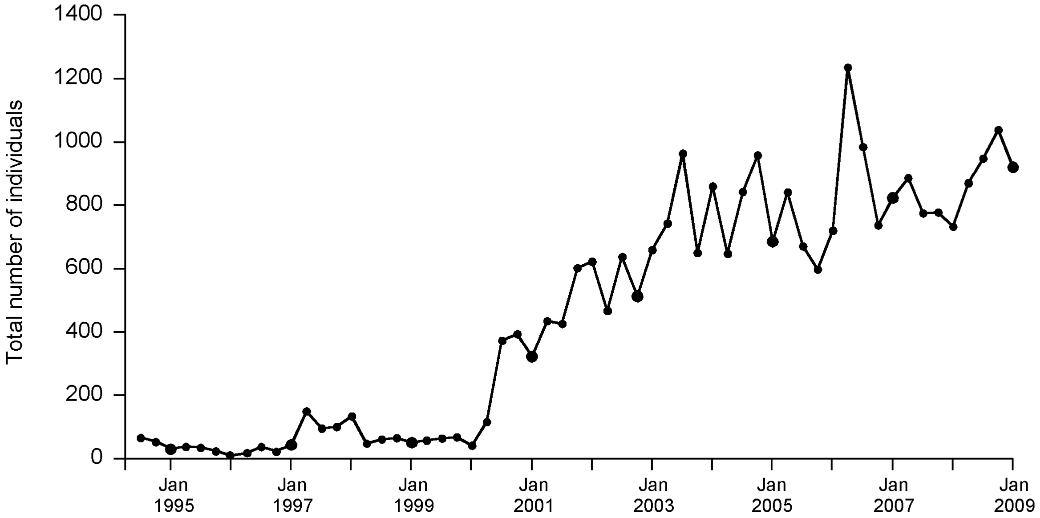
Table 9.

Summary of intertidal monitored taxa exhibiting persistent, ecologically significant step abundance changes in early 2000 . HL = Hamilton Landing, JB = Jamieson Bay, TK = Te Kapa Inlet. –ve= reduction in abundance, +ve = increase in abundance. No step abundance changes were detected for populations at Cowans Bay or Mid Harbour.

Taxa showing step abundance pattern	HL	JB	TK
Austrovenus stutchburyi	-ve		
Cossura consimilis	+ve		+ve
Macomona liliana	-ve		
Perinereis vallata	-ve		
Polydorids	-ve	-ve	-ve
Scoloplos cylindrifer	-ve		

Figure 21.

Total number of *Cossura consimilis* collected on each sampling occasion at Hamilton Landing. The abundance of *Cossura* increased in a step manner in early 2000, and has continued to increase since.



Populations showing trends in abundance

A total of 19 populations are currently showing ecologically significant trends in abundance (excluding Dyers Creek); 6 of these are increasing trends and 13 are decreasing trends (Table 10). All sites have populations that are exhibiting trends; most occur at Hamilton Landing (8 populations) and Te Kapa Inlet (5 populations), and the least at Jamieson Bay (1 population).

Three species considered sensitive to increased suspended sediment concentrations are exhibiting declines in abundance in Mahurangi Estuary (Table 10). Two important bivalve taxa, *Macomona liliana* and *Austrovenus stutchburyi* are declining at two sites each. The decline in abundance previously noted for *Macomona* is still apparent at Hamilton Landing, but not at Jamieson Bay due to large recruitment events in the last three years (Table 7). The pattern of change in *Macomona* abundance is similar at many sites, with an initial period of high abundance followed by a step decrease in early 2000, followed by low abundances for a number of years. Abundances have since increased at all sites except Hamilton Landing. However, much of this apparent recovery is due to a couple of large recruitment events (<4 mm individuals), the largest of which was in April 2006 (Figures 15, 18 & 20). The high abundances have not persisted at Cowans Bay, Mid Harbour, Jamieson Bay or Te Kapa Inlet over the last two years due to poor recruitment and retention at these sites. Very few adult sized individuals are found at these sites.

Austrovenus stutchburyi is exhibiting declines in abundance at Hamilton Landing and Te Kapa Inlet (Table 7). In our early monitoring reports we noted that the Te Kapa Inlet site was unusual in that the half closest to the inlet entrance had sandy substrate while the upper inlet half was muddy (Cummings et al. 1995). This muddy area has gradually expanded, and there is now only a small portion of the north-western corner of this site which is sandy (S. Edhouse, pers obs). This change is highly correlated with the decline in abundance of *Austrovenus* at this site. In our last report we noted that a considerable number of planting grants had been awarded to residents of the Te Kapa Inlet catchment as part of the MAP, which may have positive implications in reducing future sediment inputs to this monitoring site.

Scoloplos cylindrifer has declined markedly at Hamilton Landing over the monitored period. This polychaete is considered sensitive to increased suspended sediment concentrations. Prior to October 1999 between 0 and 54 individual *Scoloplos* were collected on any one sampling date, but it has since been found at this site in very low numbers (1-2 individuals) and on few occasions. Interestingly, the bivalve *Nucula hartvigiana*, which is also considered sensitive to increasing suspended sediment levels, is increasing in abundance at Mid Harbour. *Nucula* is found in a wide range of sediment types, including those comprised of up to 60% mud content; however their 'optimum' habitat (i.e., that in which they attain their highest densities) contains $\leq$5% mud (Gibbs and Hewitt 2004).

A number of trends were detected for species that show intermediate responses to increased suspended sediment concentrations (i.e., they prefer sediment containing some mud but not in high percentages). *Cossura consimilis* and *Aricidea* sp., both polychaete species that thrive in muddy, organically enriched sediments, are increasing in abundance at Hamilton Landing (both taxa) and Te Kapa Inlet (*Cossura* only). The increase in *Cossura* numbers at Te Kapa Inlet is likely to be a reflection of the continued growth of the muddy area at this site. Interestingly, *Cossura consimilis* is exhibiting a decline in peak abundances at Cowans Bay. Polydorid polychaete numbers are decreasing at Jamieson Bay, Te Kapa Inlet and Hamilton Landing, despite recruitment events at all three sites over the last four years (including a large one at Te Kapa Inlet in April 2006, Figure 8). The polychaete *Prionospio aucklandica* is decreasing at Te Kapa Inlet.

Table 10.

Summary of monitored taxa showing statistically and ecologically meaningful trends in abundance at the Mahurangi monitoring sites, and their sediment preferences (Sed Pref). Sites are arranged in order with the least sediment mud content on the left, and the muddiest on the right of the Table. Sediment preferences are derived from Tables 5 and 6 in Gibbs & Hewitt (2004) and from Norkko et al. (2001). S = prefers sand, I = prefers some mud but not in high percentages,. dec = decreasing trend, inc = increasing trend. (S) = step abundance trend, (S+) steady increase after a certain date, JB = Jamieson Bay, DC = Dyers Creek, MH = Mid Harbour, TK = Te Kapa Inlet, CB = Cowans Bay, HL = Hamilton Landing.

Sed pref	Taxa currently showing trends	JB (least muddy)	MH	TK	CB	HL (most muddy)
S	Austrovenus stutchburyi	.	.	dec	.	dec (S)
S	Macomona liliana	.	dec	.	.	dec (S)
S	Nucula hartvigiana	.	inc	dec	.	
S	Scoloplos cylindrifer	.	.	.	.	dec (S)
I	Aricidea sp.		.	.	.	inc
I	Arthritica bifurca		inc	.		.
I	Cossura consimilis	.	.	inc (S)	dec	inc (S+)
I	Heteromastus filiformis					inc
I	Nemerteans	.	.	.	dec	
I	Polydorids	dec (S)		dec (S)	.	dec (S)
I	Prionospio aucklandica	.	.	dec	.	

Heavy metal contamination

In response to a request by ARC, we also considered whether any changes in species abundance are consistent with increased contamination by heavy metals. Table 11 lists the monitored species and their degree of likely sensitivity to metal contamination. Only four of the populations for which we detected trends in abundance in Mahurangi are consistent with a response to potential increases in contamination (in particular copper). These are the decreases in abundance of *Austrovenus* at Hamilton Landing and Te Kapa Inlet and of *Macomona* at Hamilton Landing and Mid Harbour. The decreased abundance of *Austrovenus* at Te Kapa Inlet is unlikely to be related to heavy metal contamination as *Macomona* (a more sensitive species) is showing no such decrease in abundance at this site. In contrast, the decreases of both species at Hamilton Landing and the decrease of *Macomona* at Mid Harbour could be a response to heavy metal contamination, as no species that should be more sensitive actually occur at this site.

It is important to note that many of the species considered sensitive to heavy metal contamination are also sensitive to sedimentation. Without detailed monitoring of both parameters at our sites it would be very difficult to assign cause and effect to the responses we have detected. While sediment characteristics have been regularly monitored as part of this programme since its inception, heavy metal concentrations have not. Given the negative reponse of *Austrovenus* at Te Kapa Inlet, the location of the sites exhibting the decreasing abundances of *Macomona* and the response of other species at these sites, it is most likely that the overiding factor is that of sedimentation.

Table 11.

Monitored species in Mahurangi Harbour for which an EC50 (i.e., reduction in abundance) was predicted to occur below the sediment effect level guideline (TEL) for copper, lead and zinc. Taxa are listed in order of sensitivity with the most sensitive species first (Hewitt et al. in press).

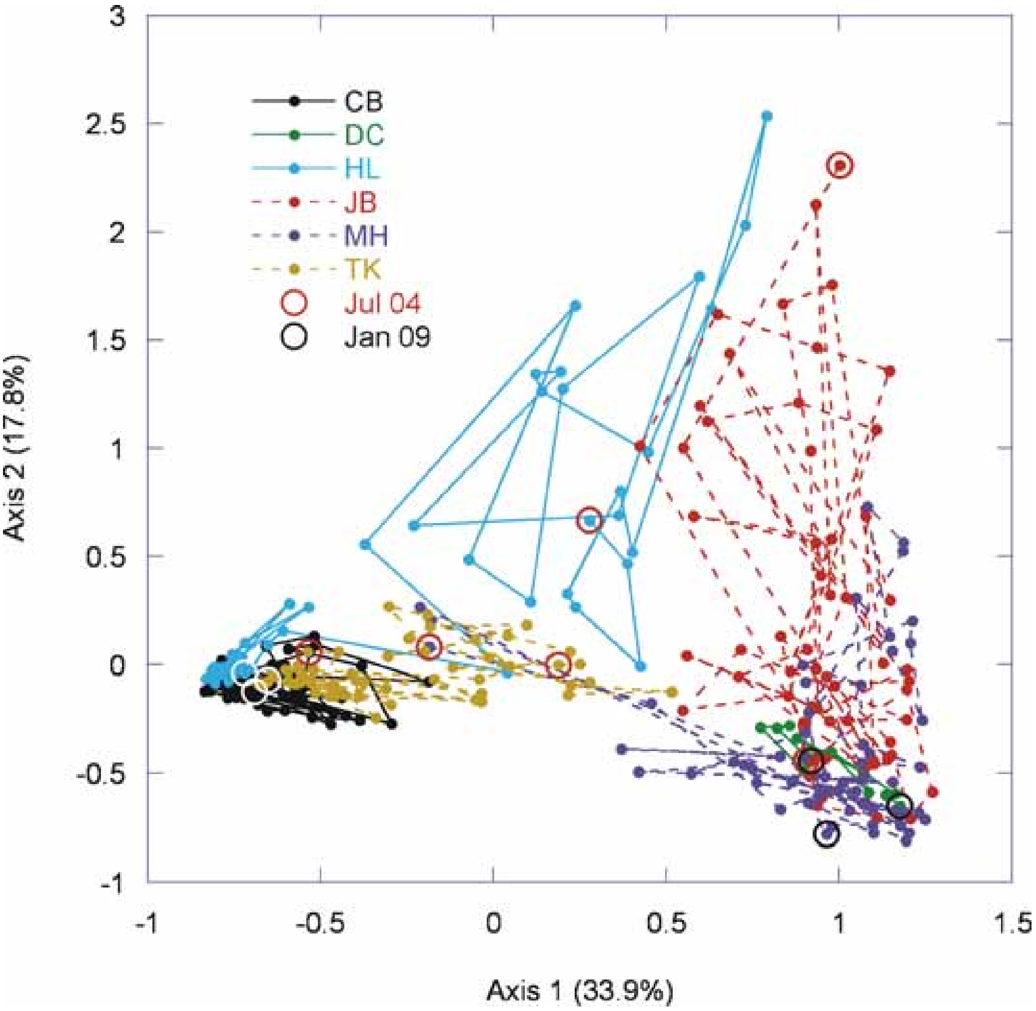
Copper	Lead	Zinc
Anthopleura aureoradiata	*Magelona dakini*	*Notoacmea helmsi*
Aonides trifida	*Waitangi brevirostris*	Orbinidae
Macroclymenella stewartensis	Polydoridae	
Macomona liliana	*Colurostylis lemurum*	
Austrovenus stutchburyi		
Prionospio aucklandica		
Nucula hartvigiana		
Glycinde trifida		

4.1.3.2 Intertidal macrofaunal community composition

Figure 22 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 has remained very stable since monitoring began, and continues to exhibit very little temporal variation in community composition relative to the other intertidal sites. The Hamilton Landing, Te Kapa Inlet and Cowans Bay sites have become more similar to each other in recent years, and are now situated more closely together in ordination space (e.g., see January 2009 symbols). A similar pattern is apparent for the monitored communities at Jamieson Bay and Mid Harbour. The monitored communities at Jamieson Bay, Mid Harbour and Dyers Creek are also similar to each other, as illustrated by their considerable overlap in ordination space. The Dyers Creek community has remained relatively stable since monitoring began 3.5 years ago.

Figure 22.

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 2009) sampling occasions are highlighted. To enable identification, a white symbol is used to denote the most recent sampling date for Cowans Bay, Te Kapa Inlet and Hamilton Landing. The percentage values associated with each axis indicate the % variance explained. CB = Cowans Bay, DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.



As ecological theory suggests that an early warning for abrupt degradative change may be increased temporal variability in community dynamics, within and between year variability at the start of the monitoring programme was compared with that of the last 2 years (Table 12). Changes in within-year similarity mainly involved small (less than 5%) increases in similarity (i.e., variability decreased). Between year variablity also decreased (%similarity between years was higher in the last two years). Thus, there are no signs in community temporal dynamics that an abrupt degradative change may be going to occur.

Table 12.

Changes in percent similarity within and between years at the 5 long-term monitored sites. Negative numbers would suggest sites are becoming more variable.

	Year	CB	HL	JB	MH	TK
within year	first 5 years	75.554	79.45	70.592	79.848	82.82
	last 2 years	75.585	80.71	74.54	80.605	86.385
	difference	0.031	1.26	3.948	0.757	3.565
between year	first 5 years	74.623	76.098	68.494	78.173	82.087
	last 2 years	77.81	80.71	73.74	79.59	83.03
	difference	3.187	4.612	5.246	1.417	0.943

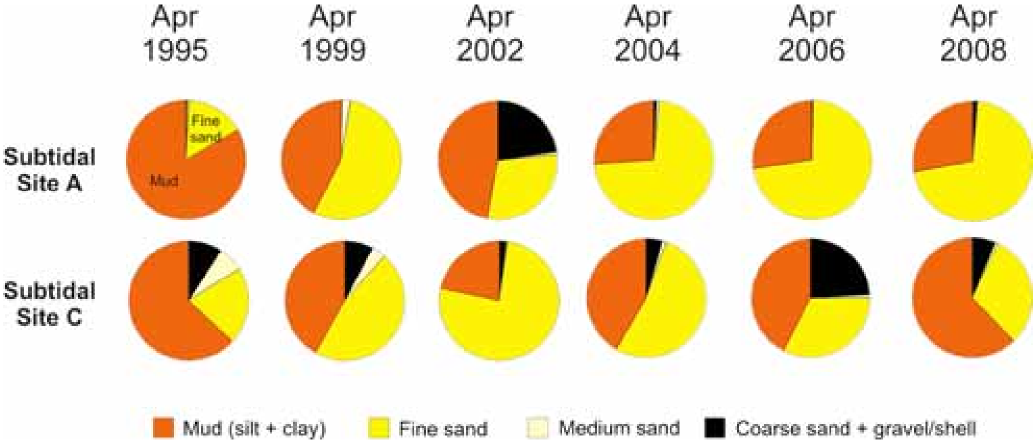
4.2 Subtidal sites

4.2.1 Sediment characteristics

The sediment grain size composition at both of the subtidal sites has been very consistent over the past two years of monitoring (Appendix 5). There is little medium sand at either of the sites and around twice as much fine sand at Site A than at Site C (i.e., a range of 67-75% cf. 31-41% over the past two years at Sites A and C, respectively). Site C sediments have a higher silt and clay (i.e., mud) content and more gravel/shell hash than those at Site A (Figure 23, Appendix 5).

Figure 23.

Changes in the proportions of the mud (i.e., silt + clay; <63 µm), fine sand (62.5 – 250 µm), medium sand (250 –500 µm) and coarse fractions (>500 µm) of the sediment at each of the subtidal sites over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 5.

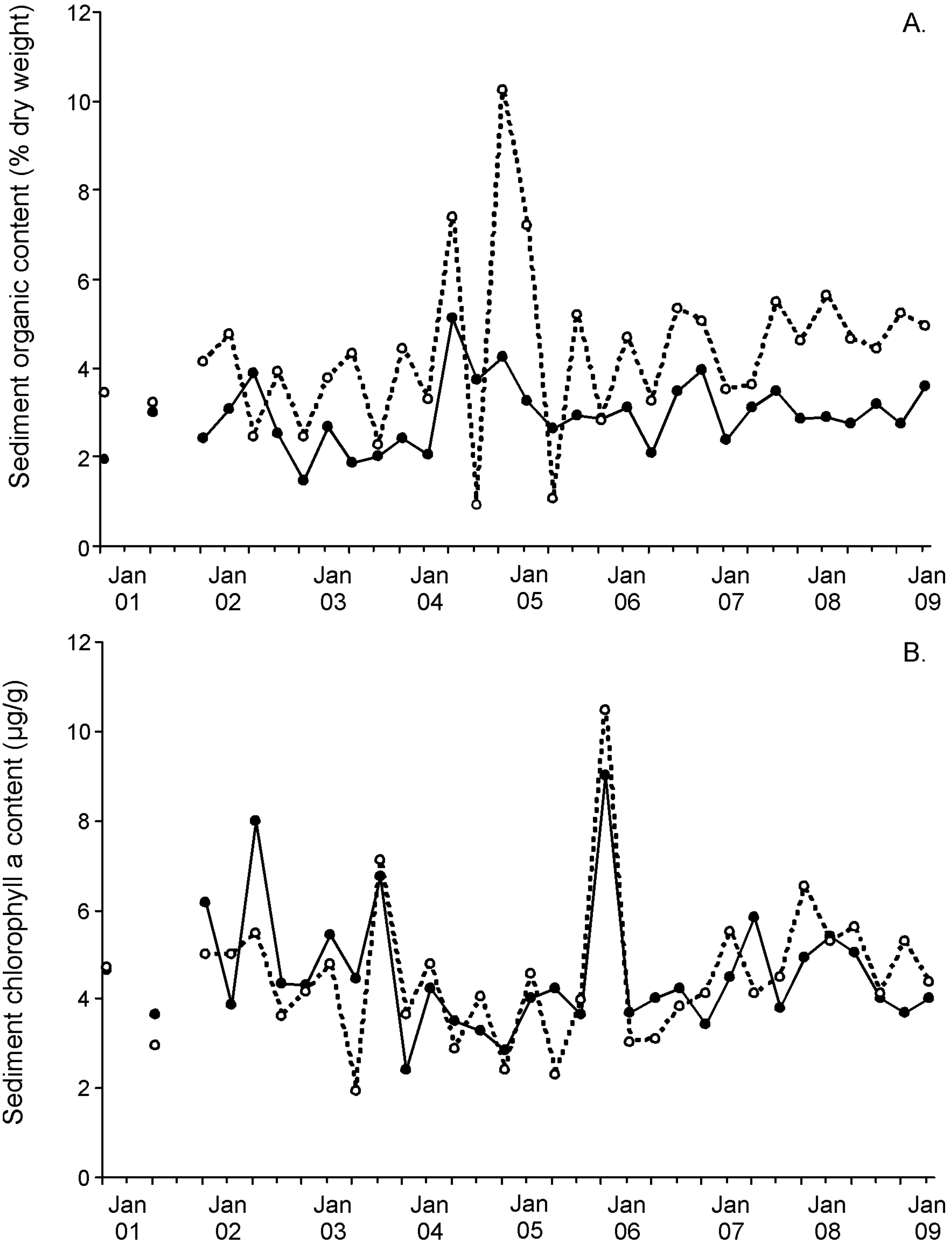


Organic content of the sediments is low and similar at both subtidal sites, although levels tend to be slightly higher at Site C on most occasions (Figure 24A; Appendix 6). As noted in previous reports, the sediment organic content was generally higher at both sites between January 2004 and January 2005 than on previous sampling dates and has remained slightly elevated since (Figure 24A).

Sediment chlorophyll *a* levels are also very similar at each site and follow similar temporal fluctuations (Figure 24B; Appendix 6). Despite this, there is no predictable relationship between high and low chlorophyll *a* levels and sampling month (season).

Figure 24.

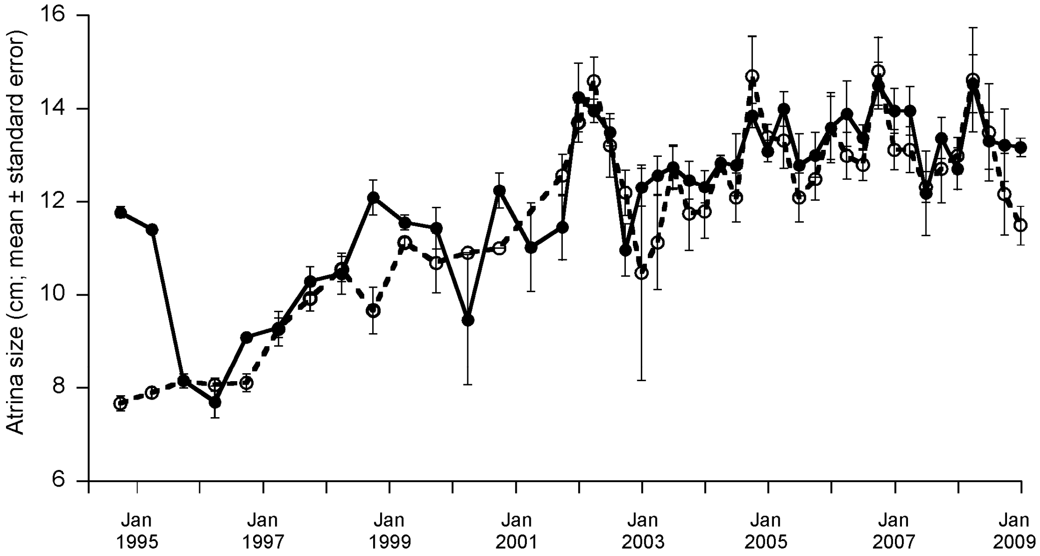
A. Sediment organic content, and B. sediment chlorophyll *a* content, at the subtidal sites. Site A = black symbols, Site C = white symbols.



4.2.2 *Atrina zelandica*

Numbers and sizes of *Atrina zelandica* are similar at both of the subtidal sites, although more live *Atrina* have been found at Site A over the last two years (0.9-2.3 individuals on average in each 0.25 m^2 quadrat) than previously (0.2-1 individuals quadrat^{-1}). The sizes of *Atrina* over the past two years have generally been similar at the two sites, and are similar to the sizes noted in our last report; this probably reflects the fact that the growth of these populations is slowing as the individuals age and reach their maximum size (Figure 25). We have not noted beds of smaller individuals in the vicinity of the areas targeted for monitoring, indicating there has been no recent recruitment to these sites.

Figure 25.
The mean size of live *Atrina zelandica* recorded in a 0.25 m^2 quadrat at the two subtidal sites on each sampling occasion. Site A = black symbols, Site C = white symbols.



4.2.3 Macrofauna - comments on the abundance of common taxa

The abundances of subtidal monitored taxa collected at each site on each sampling date since the last report (i.e., from April 2007 to January 2009) are given in Appendix 7.

The following are site descriptions of the monitored macrofauna and 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 (see Table 15).

4.2.3.1 Site A

Eight taxa have comprised the dominant three at Site A over the past two years of monitoring: the bivalves *Theora lubrica* (2-267 individuals), *Nucula hartvigiana* (0-13 individuals) and *Arthritica bifurca* (0-11 individuals), the polychaetes *Aricidea* sp. (2-20 individuals), cirratulids (2-23 individuals), *Prionospio* sp. (3-14 individuals) and polydorids (0-17 individuals), and the amphipod *Torridoharpinia hurleyi* (1-27 individuals) (Table 13).

Populations showing cyclic abundance patterns

Three populations exhibit greater than annual abundance cycles at Site A. The polychaete *Armandia maculata* has large peaks in April, and smaller ones in October months. *Torridoharpinia hurleyi* also generally peaked in abundance in April or October months. *Theora lubrica* generally exhibits peak abundances in April (Figure 26). Oligochaetes exhibit a greater than annual cyclic abundance pattern; it's numbers have peaked in October of 1996 and 2000 and in April of 2002, 2004, 2006 and 2008. All of these patterns were also noted in the 2007 report.

Figure 26.

The total number of *Theora lubrica* collected on each sampling occasion at the subtidal sites. Site A = black symbols, Site C = white symbols.

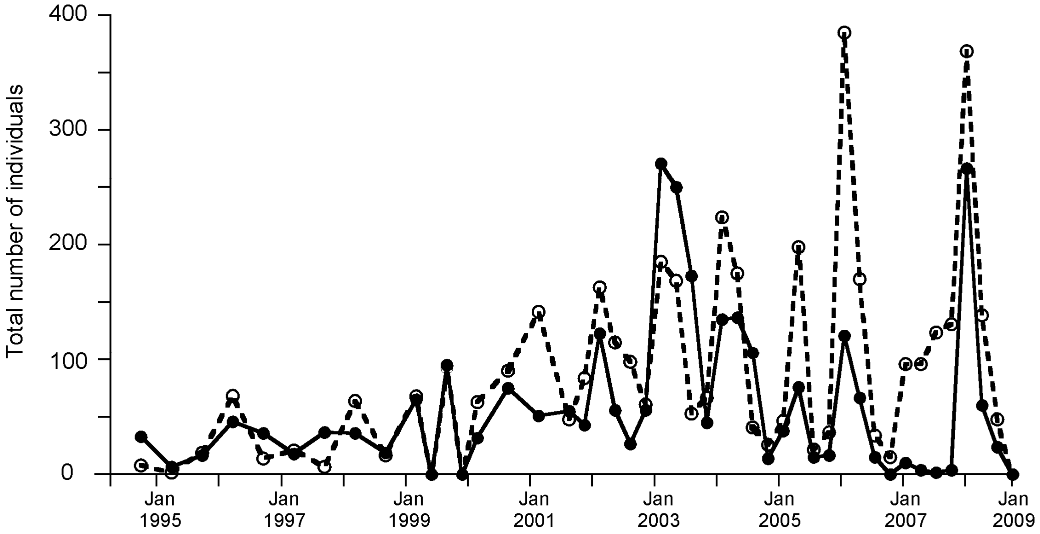


Table 13.

The three dominant taxa collected at subtidal Site A between October 1994 and January 2009. 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 consimilis '*.

Oct 94	Prionospio spp.	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 spp.
Oct 97	Theora lubrica	Cirratulids / Prionospio spp.	
Apr 98	Polydorids	Torridoharpinia hurleyi	Theora lubrica
Oct 98	Theora lubrica	Cirratulids	Oligochaetes / Prionospio spp.
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 spp.
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 spp.
Oct 02	Theora lubrica	Prionospio spp.	Cirratulids
Jan 03	Theora lubrica	Aricidea sp.	Arthritica bifurca
Apr 03	Theora lubrica	Arthritica bifurca / Torridoharpinia hurleyi	
Jul 03	Theora lubrica	Aricidea sp.	Polydorids
Oct 03	Theora lubrica	Arthritica bifurca	Cirratulids
Jan 04	Theora lubrica	Polydorids	Aricidea sp.
Apr 04	Theora lubrica	Cirratulids	Arthritica bifurca
Jul 04	Theora lubrica	Arthritica bifurca	Cirratulids
Oct 04	Theora lubrica	Torridoharpinia hurleyi	Arthritica bifurca
Jan 05	Theora lubrica	Polydorids	Aricidea sp.
Apr 05	Polydorids	Theora lubrica	Torridoharpinia hurleyi

Jul 05	Polydorids	Theora lubrica	Cirratulids
Oct 05	Aricidea sp.	Theora lubrica	Polydorids
Jan 06	Torridoharpinia hurleyi	Polydorids	Theora lubrica
Apr 06	Theora lubrica	Arthritica bifurca	Cirratulids / Torridoharpinia hurleyi
Jul 06	Theora lubrica	Aricidea sp.	Arthritica bifurca / Cirratulids
Oct 06	Nucula hartvigiana	Aricidea sp.	Theora lubrica
Jan 07	Torridoharpinia hurleyi	Arthritica bifurca	Corophidae-complex
Apr 07	Nucula hartvigiana	Theora lubrica	Cirratulids
Jul 07	Cirratulids	Polydorids	Theora lubrica / Prionospio sp.
Oct 07	Aricidea sp.	Cirratulids	Torridoharpinia hurleyi
Jan 08	Aricidea sp.	Torridoharpinia hurleyi	Arthritica bifurca
Apr 08	Theora lubrica	Polydorids	Aricidea sp.
Jul 08	Theora lubrica	Aricidea sp. / Cirratulids	Arthritica bifurca
Oct 08	Theora lubrica	Aricidea sp	Torridoharpinia hurleyi
Jan 09	Torridoharpinia hurleyi	Cirratulids	Aricidea sp.

Populations showing trends in abundance

Two polychaete populations, cirratulids (Figure 27) and *Aricidea* sp. (Figure 28), have increased in abundance at subtidal Site A over the duration of the monitoring programme (Table 15). The increasing abundance trend noted for cirratulids appears to be due to a step change in early 2000; since this time multiyear cycles have dominated the temporal dynamics (Figure 27). This pattern is also apparent for cirratulids at Site C (see below). The increasing trend in *Aricidea* sp. also appears to be due to a step change at the same period (Table 15, Figure 28). The increasing trend in *Arthritica bifurca* abundance noted in our 2007 report is no longer apparent (Table 14).

Figure 27.

The total number of cirratulids collected on each sampling occasion at the subtidal sites. Site A = black symbols, Site C = white symbols.

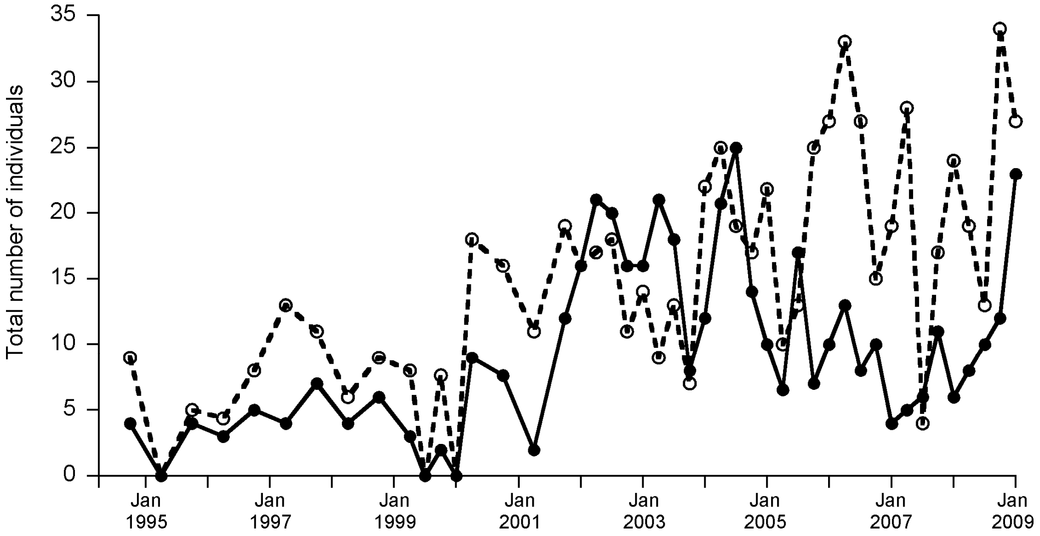
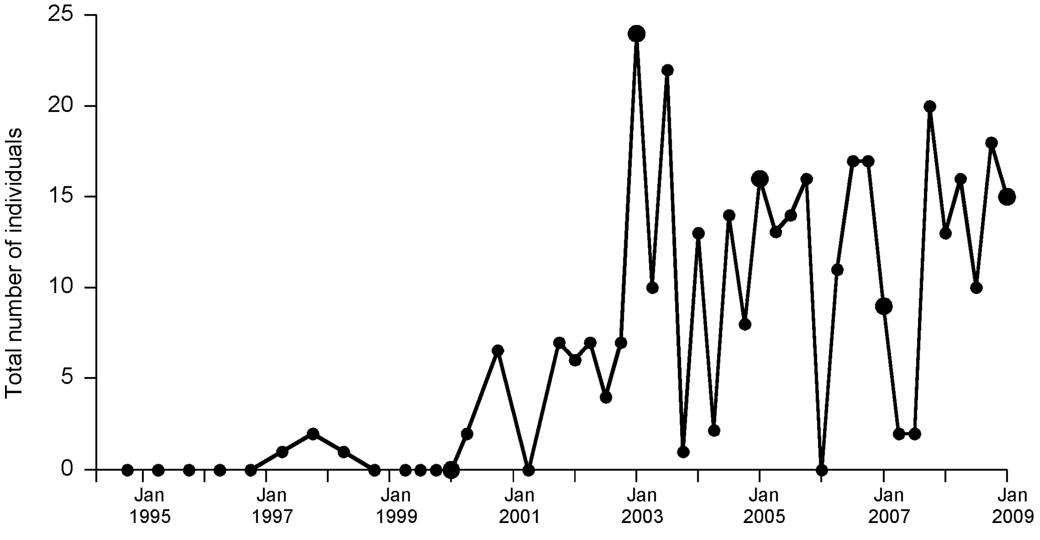


Figure 28.

The total number of *Aricidea* sp. collected on each sampling occasion at subtidal Site A.



4.2.3.2 Site C

Theora lubrica (0-369 individuals) was the first or second most abundant monitored taxa at Site C over the last two years, except in January 2009 when none were found. Oligochaetes, cirratulids and polydorids (19-93, 4-34 and 2-37 individuals, respectively) were also common (Table 14). *Aricidea sp.* (0-21 individuals) and *Torridoharphina* *hurleyi* (4-24 individuals) were the third most abundant taxa on one occasion each. These species have all featured amongst the dominant taxa at this site over the monitored period (Table 14).

Populations showing cyclic abundance patterns

Theora lubrica exhibits an annual cyclic abundance pattern at Site C, with peaks occurring in April of each year, except for 1999 (October) and 2005 (July) (Figure 26). Cirratulids and corophidae-complex both exhibit complex cyclic patterns.

Table 14.

The three dominant taxa collected at subtidal Site C between October 1994 and January 2007. The most abundant taxa is on the left hand side of the table.

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

Oct 04	Torridoharpinia hurleyi	Theora lubrica	Oligochaetes
Jan 05	Oligochaetes	Theora lubrica	Torridoharpinia hurleyi
Apr 05	Theora lubrica	Oligochaetes	Torridoharpinia hurleyi
Jul 05	Theora lubrica	Polydorids	Oligochaetes
Oct 05	Cirratulids	Theora lubrica	Oligochaetes
Jan 06	Theora lubrica	Oligochaetes	Cirratulids
Apr 06	Theora lubrica	Cirratulids	Oligochaetes
Jul 06	Theora lubrica	Oligochaetes	Cirratulids
Oct 06	Oligochaetes	Theora lubrica	Arthritica bifurca
Jan 07	Torridoharpinia hurleyi	Cirratulids	Oligochaetes
Apr 07	Theora lubrica	Oligochaetes	Cirratulids
Jul 08	Theora lubrica	Oligochaetes	Torridoharpinia hurleyi
Oct 08	Theora lubrica	Oligochaetes	Polydorids
Jan 08	Theora lubrica	Cirratulids	Oligochaetes
Apr 08	Theora lubrica	Oligochaetes	Cirratulids
Jul 08	Theora lubrica	Oligochaetes	Aricidea sp.
Oct 08	Oligochaetes	Theora lubrica	Cirratulids
Jan 09	Oligochaetes	Polydorids	Cirratulids

Populations showing trends in abundance

Three populations are exhibiting trends in abundance at Site C, and all of these were detected previously (Table 15). *Arthritica bifurca* is less common at this site than it was originally (9-101 individuals in the first four years of monitoring) although lowest numbers occurred in 2003. Peak abundances of *Theora lubrica* are still increasing; basal abundances have remained steady for a number of years (Figure 26). A step trend was detected for cirratulid polychaetes, with numbers significantly higher post 1999. It's abundances continue to increase, although low densities still occur every couple of years (Figures 27). The increasing trend noted for Corophidae-complex amphipods in previous reports is no longer apparent.

Table 15.

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. Significant step changes are indicated by the word 'step' in parentheses.

Monitored taxa	2009	2007	2005	2003	2001
Site A					
Arthritica bifurca	No trend	0.29	0.40	No trend	No trend
Aricidea sp.	0.30 (step)	0.34	0.36 (0.18)	0.34	0.14
Cirratulids	0.28 (step)	0.21	0.44	0.46	No trend
Site C					
Arthritica bifurca	-0.60	-0.75	-0.97	No trend	No trend
Cirratulids	0.35 (step)	0.38	0.36	0.36	No trend
Corophidae-complex	No trend	0.14	0.23	0.29	No trend
Theora lubrica	2.17	2.67	2.96 (1.32)	3.18	3.13

4.2.4 Subtidal sites - general patterns

4.2.4.1 Harbour-wide patterns in subtidal macrofaunal populations

Populations showing cyclic abundance patterns

Four of the monitored taxa populations exhibit cyclic patterns in abundance at the subtidal sites (Table16). *Theora lubrica* exhibits peak abundances in April each year at both subtidal sites.

Table 16.

Summary of monitored taxa currently exhibiting cyclic abundance patterns at the Mahurangi subtidal monitoring sites. > indicates a greater than annual abundance cycle.

Taxa currently showing a cyclic abundance pattern	Site A	Site C
Armandia maculata	Apr/Oct	
Oligochaetes	Apr/Oct (>)	.
Theora lubrica	Apr	Apr
Torridoharpinia hurleyi	Apr/Oct	.

Populations showing trends in abundance

A total of five subtidal populations and four different taxa are exhibiting trends in abundance at the Mahurangi Estuary subtidal sites (Table 17). Cirratulid polychaetes are increasing in abundance at both sites, following a step change in early 2000 and 1999, respectively. *Aricidea* sp. is increasing in abundance at Site A only, and *Theora lubrica* is increasing at Site C. *Arthritica bifurca* is decreasing in abundance at Site C. All of these taxa are known to prefer some mud content in the sediment but not high proportions (Gibbs & Hewitt 2004). Unfortunately we have no information on the sensitivity of these species to heavy metal concentrations.

Table 17.

Summary of monitored taxa showing trends in abundance at the Mahurangi subtidal monitoring sites. dec = decreasing trend, inc = increasing trend. Significant step changes are indicated by the word 'step' in parentheses.

Taxa currently showing trends	Site A	Site C
Aricidea sp.	inc (step)	.
Arthritica bifurca	.	dec
Cirratulids	inc (step)	inc (step)
Theora lubrica	.	inc

4.2.4.2 Subtidal macrofaunal community composition

As noted in our previous reports, while the monitored communities at Sites A and C have exhibited considerable fluctuations over the monitored period, they are currently very similar both to one another, and to the communities observed at the start of the monitoring programme (Figure 29).

Again we considered whether there was any increase in temporal variability of community dynamics between the start of the monitored period and the last two years (Table 18). As for the intertidal sites, changes in within-year similarity were all for increased similarity (decreased variability) although they were somewhat higher (6-8% cf. less than 5% for the intertidal sites). Between year variablity also decreased (%similarity between years was higher in the last two years)

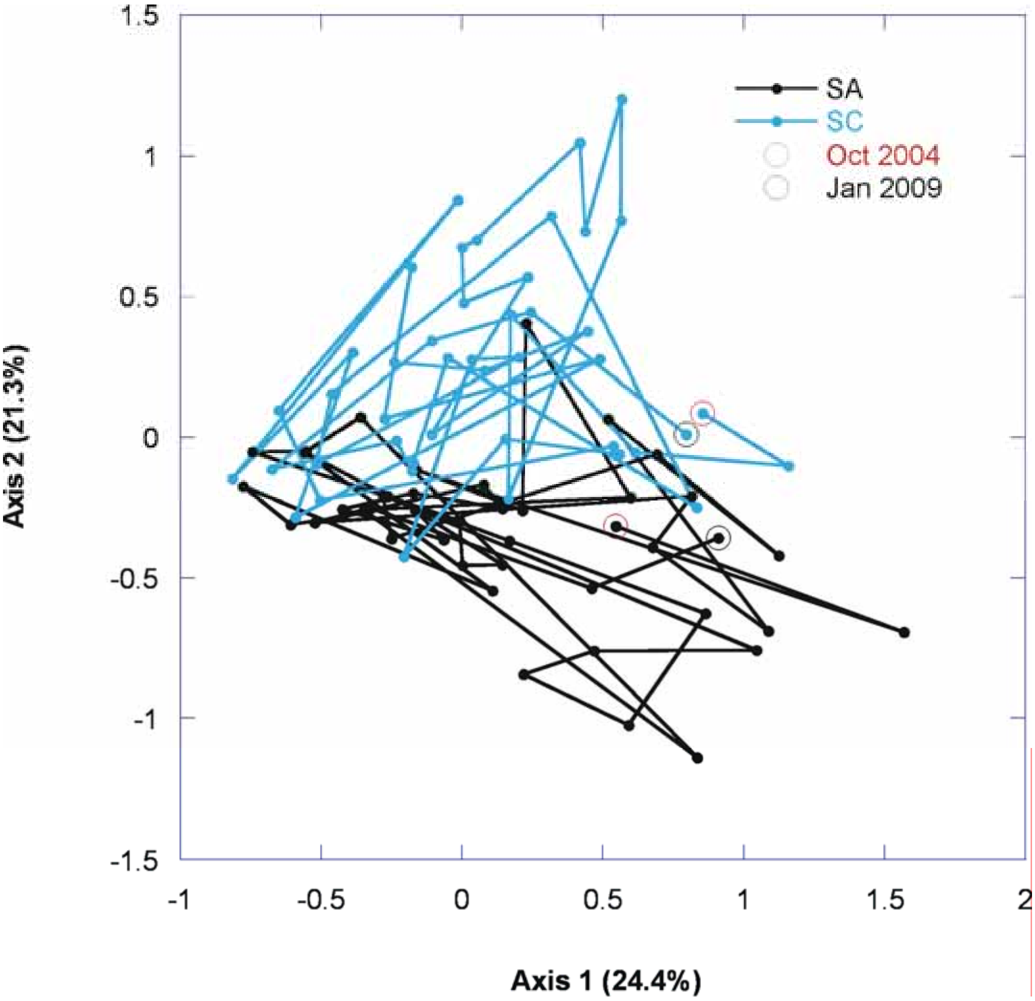
Table 18:

Changes in similarity within and between years at the 5 long-term monitored sites. Negative numbers would suggest sites are becoming more variable.

	Period	Site A	Site C
within year	first 5 years	63.756	70.948
	last 2 years	70.72	78.055
	difference	6.964	7.107
between year	first 5 years	63.138	67.855
	last 2 years	73.24	76.47
	difference	10.102	8.615

Figure 29.

Correspondence analysis ordination plot, showing the temporal variation in the monitored community composition at the subtidal sites over the monitored period. For each site, the positions of the community on the first (July 1994) and the most recent (January 2009) sampling occasions are highlighted. The percentage values associated with each axis indicate the % variance explained.



5 Summary & recommendations

5.1 Summary

The populations of a selected range of invertebrate taxa have been monitored at intertidal and subtidal sites in Mahurangi Estuary since 1994. Estuary-wide changes in the abundance of some macrofaunal taxa and the horse mussel *Atrina zelandica*, and increases in the proportion of fine sand present in the sediments, were noted over the initial 6 years of monitoring (Cummings et al. 2001). The sediment composition changes occurred sometime between April 1996 and April 1997 and have persisted. Some of the patterns in the abundance of the monitored species are consistent with those that may be associated with elevated levels of sedimentation and/or organic enrichment. Consequently, we recommended a desktop study be conducted to consider any changes in catchment land use and hydrology over that time period, to help identify potential reasons for these changes (Cummings et al. 2001, 2003). A major joint project between ARC and the Rodney District Council was initiated (i.e., the Mahurangi Action Plan, MAP). The aims of this project are to protect and enhance the existing values of Mahurangi Estuary and, especially to 'halt, slow or reverse the adverse effects of sedimentation' on its health (see http://www.arc.govt.nz/arc/environment for details).

Populations and communities of the monitored macrofaunal taxa, and sediment characteristics have not changed markedly at the intertidal or subtidal sites over the past two years of monitoring. The monitored macrofaunal communities at Hamilton Landing, Te Kapa Inlet and Cowans Bay have continued to become more similar to each other, as have those of Jamieson Bay and Mid Harbour (Figure 22). The monitored macrofaunal community at Dyers Creek continues to be very similar to those of Jamieson Bay and Mid Harbour (Figure 18). The communities at subtidal Sites A and C are also currently very similar to each other (Figure 29).

A total of 19 intertidal populations are currently showing ecologically significant trends in abundance; 6 are increasing trends and 13 are decreasing trends. All sites have populations that are exhibiting ecologically significant trends; most occur at Hamilton Landing and Te Kapa Inlet (8 and 5 populations each, respectively), and the least at Jamieson Bay (1 population). Five subtidal populations are exhibiting ecologically significant trends in abundance, and all but one of these are increasing (Table 17). All of these subtidal taxa are known to prefer some mud but not high percentages (Gibbs & Hewitt 2004). Only one taxa show trends at both subtidal sites: cirratulid polychaetes are increasing in abundance.

Several of the monitored populations exhibiting trends in abundance appear to show a 'step' increase or decrease in numbers part way through the monitored period (i.e., early 2000). As this pattern was observed in several taxa at five sites (Hamilton Landing, Jamieson Bay, Te Kapa Inlet, subtidal Sites A and C) it could not have been a localised event. We have hypothesed in our previous reports that these changes could have been due to a lagged response to an increase in muddiness of sediments that occurred in 1996/7, or as a result of larger than annual cyclic abundance patterns in some taxa. If these one-off abundance changes persisted over time, the resulting change in abundance has been interpreted as a trend in past reports. However, these abundance changes now generally appear to be step changes, where the mean abundances before and after the event are significantly different.

Of most concern is that three species considered sensitive to increased suspended sediment concentrations are exhibiting declines in abundance in Mahurangi Estuary (*Macomona liliana*, *Austrovenus stutchburyi*, *Scoloplos cylindrifer*, Table 10). All three continue to decline in abundance at the muddiest site, Hamilton Landing. Decreasing trends were also detected for *Austrovenus* and the nut shell, *Nucula hartvigiana*, at Te Kapa Inlet, and for *Macomona* at Mid Harbour. These declines at Te Kapa Inlet are likely to be correlated with the continued expansion of the muddy portion of this site noted over the monitored period. The decline in abundance previously noted for *Macomona* is no longer apparent at some sites due to large recruitment events in the last three years (Table 7). While this is encouraging, much of this apparent recovery is due to a couple of large recruitment events (<4 mm individuals) and the high abundances have not persisted, and there are very few adult-sized individuals present.

In response to a request by ARC, we also considered whether any changes in species abundance are consistent with increased contamination by heavy metals. Three of the populations for which we detected trends in abundance in Mahurangi are showing changes consistent with a response to potential increases in copper concentrations (decreases in abundance of *Austrovenus* at Hamilton Landing and of *Macomona* at Hamilton Landing and Mid Harbour). Unfortunately many of the species considered sensitive to heavy metal contamination are also sensitive to sedimentation. Without detailed monitoring of both parameters at our sites it would be very difficult to assign cause and effect to the responses we have detected. While we believe that the overiding factor here is sedimentation, we recommend that an initial survey of heavy metal concentrations at each of the sites should be conducted. Depending on the results of this survey, it may be useful to incorporate monitoring of heavy metals into this monitoring programme or to incorporate some Mahurangi sites into the Regional Discharges Monitoring Programme.

Very few of the intertidal populations exhibit highly predictable cyclic abundance patterns, where peaks in abundance occur in the same monitoring month every year. Only four of the subtidal monitored populations exhibit cyclic patterns in abundance (Table 16). This is not surprising given that these populations are only sampled at 3 monthly intervals. Long-term data from the Manukau Harbour ecological monitoring programme, where sites are sampled every 2 months frequently shows offsets in recruitment by 2- 3 months (Hewitt & Thrush 2007).

Numbers of horse mussels (*Atrina zelandica*) continue to be low at both subtidal sites, with 0-2 live individuals on average found in a 0.25 m^2 quadrat on any one sampling date. Numbers of live *Atrina* have however been slightly higher at subtidal Site A than Site C over the last two years. The sizes of *Atrina* have not increased much over the past two years, probably reflecting the fact that the growth of these populations has slowed as the individuals age and reach their maximum size (Figure 25).

Dyers Creek and Te Kapa Inlet subcatchments are both being targeted for remedial work under the Mahurangi Action Plan. In response to this, an additional intertidal monitoring site was established at Dyers Creek in October 2005, so that any changes over time in its ecology may be able to be linked to these changes in catchment management. Only one provisional trend has been identified from Dyers Creek, an increase in the number of nut shells, *Nucula hartvigiana* over the last year. More than 3.5 years of data is required to identify population trends and cycles with any certainty so we will re-evaluate this trend in our next report; note however, that the magnitude of this increase is considerable (Figure 10).

Fluctuations in abundance of invertebrate populations is to be expected, and we must document and understand this natural variability to enable identification of 'unusual' increases or decreases that may be due to some environmental stressor (e.g., sedimentation). Similarly, this baseline information is also needed to be able to document recovery of impacted populations. In addition, populations that are under stress tend to exhibit more variability in their abundance, so we might not expect to see a simple linear response in all populations. Indeed Hewitt & Thrush (2009) have documented increasing spatial variance in the abundance of species sensitive to sediment mud content along the intertidal gradient in Mahurangi. Interpretations of trends and patterns in abundance of Mahurangi populations is done with knowledge of information on populations of the same taxa from Manukau (in particular) and Waitemata Harbours, where there is currently no sedimentation issue affecting the ecology of intertidal sandflats.

This monitoring programme has continued to provide very useful information on trends and cycles in monitored taxa populations and sediment characteristics that can be used to guide and monitor the effectiveness of catchment management within Mahurangi Estuary. With two more years of data our previous recommendations concerning the need to investigate and implement improved sediment controls still apply, as we are still detecting declines in abundance of taxa known to be sensitive to increased sediment loading. Recent evidence of recruitment of juvenile bivalves to some of the intertidal populations is encouraging, as this highlights the potential for the recovery of some areas of the harbour should these control measures be effective.

5.2 Recommendations for the monitoring programme

The change in the bivalve measuring protocol (noted in methods) has not impacted on our ability to interpret abundance changes in monitored bivalve taxa. However, we no longer consider measurement of the two smallest intertidal bivalves, *Nucula hartvigiana* and *Arthritica bifurca*, or the subtidal bivalve *Theora lubrica*, to be useful, as this data has not been useful to our interpretations over the past 14 years of monitoring. Consequently, we recommend that these measurements are not made in future years.

Finally, in response to a request by ARC we also considered whether any changes in species abundance are consistent with increased contamination by heavy metals (many of the species considered sensitive to heavy metal contamination are also sensitive to sedimentation). While we believe that the overiding factor here is sedimentation, we recommend that an initial survey of heavy metal concentrations at each site should be conducted, and the results of this survey analysed to determine whether heavy metal monitoring should be incorporated into this monitoring programme in future.

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8 Appendices

8.1 Appendix 1

The taxa monitored at the intertidal and subtidal sites.

Intertidal	Subtidal
Aonides trifida	Aricidea sp.
Aricidea sp.	Armandia maculata
Arthritica bifurca	Arthritica bifurca
Austrovenus stutchburyi	Cirratulids
Cossura consimilis	Corophidae-complex
Heteromastus filiformis	Nucula hartvigiana
Macomona liliana	Oligochaetes
Macrophthalmus hirtipes	Polydorids
Nemerteans	Prionospio spp.
Notoacmea helmsi	Tawera spissa
Nucula hartvigiana	Theora lubrica
Oligochaetes	Torridoharpinia hurleyi
Owenia fusiformis	
Paracalliope novizealandiae	
Perinereis vallata	
Prionospio aucklandica	
Polydorids	
Scoloplos cylindrifer	
Torridoharpinia hurleyi	

8.2 Appendix 2

Results of grain size analysis for the intertidal sites. CB = Cowans Bay, DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
Gravel/ Shell hash	1995	Apr	0.07	0.04	0.37	0.64	3.50	0.24	
	1996	Apr	0.00	0.00	0.00	0.00	0.00	0.00	
	1997	Apr	0.02	0.00	21.42	6.56	10.14	0.00	
	1998	Apr	0.02	1.16	16.08	1.78	1.94	0.01	
	1999	Apr	0.03	0.00	5.04	1.50	0.83	0.12	
	2000	Apr	0.02	0.18	8.61	0.67	0.43	0.00	
		Jul	0.07	0.00	18.96	0.00	3.72	0.00	
		Oct	0.05	0.00	7.98	0.10	1.79	0.00	
	2001	Jan	0.43	0.04	0.65	0.19	1.60	0.00	
		Apr	0.00	0.00	8.5	0.33	0.00	0.04	
		Jul	0.00	0.00	0.13	0.46	0.06	0.00	
		Oct	0.00	0.00	3.27	0.43	0.68	0.00	
	2002	Jan	0.00	0.00	1.79	0.02	1.58	0.00	
		Apr	0.02	0.00	0.17	2.38	0.32	0.25	
		Jul	1.63	7.34	0.26	0.35	0.00	0.00	
		Oct	0.00	0.06	0.02	4.02	31.18	0.16	
	2003	Jan	0.00	0.01	0.51	0.07	0.76	0.40	
		Apr	0.02	0.00	0.19	1.80	0.46	0.29	
		Jul	0.00	0.00	2.88	0.19	0.09	0.07	
		Oct	0.00	0.00	19.72	0.16	0.50	0.03	
	2004	Jan	0.00	0.00	17.17	0.43	3.93	0.00	
		Apr	0.00	0.00	12.01	4.99	0.35	0.00	
		Jul	0.00	0.00	5.34	0.51	0.34	1.95	
		Oct	0.02	0.02	8.03	0.56	0.65	0.00	
	2005	Jan	0.00	0.00	2.83	0.97	2.70	0.00	
		Apr	0.00	0.00	3.04	0.79	0.00	0.00	
		Jul	0.00	0.00	5.70	0.97	1.04	0.00	
		Oct	0.00	0.00	7.14	0.11	21.57	0.00	1.83
	2006	Jan	0.00	0.00	9.30	0.50	0.55	0.00	0.28
		Apr	0.00	0.00	17.44	0.09	0.00	5.12	0.25
		Jul	0.00	0.39	2.64	0.10	5.38	0.00	0.78
		Oct	0.00	0.00	22.54	0.00	0.62	0.00	1.51
	2007	Jan	0.00	0.00	8.72	0.68	4.36	0.62	1.46
		Apr	0.00	0.00	4.20	0.10	1.20	0.07	0.67
		Jul	0.00	0.00	18.05	0.48	0.85	0.00	0.41
		Oct	0.02	0.00	10.93	0.48	1.00	0.00	2.22
	2008	Jan	0.24	0.09	6.34	0.65	0.79	0.12	1.03
		Apr	0.00	0.00	0.79	0.00	1.30	0.19	2.56
		Jul	0.01	0.00	15.09	0.05	1.33	0.00	0.46
					18.04	0.27	14.38	0.02	0.19

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
		Oct	0.00	0.00	3.32	0.62	0.49	0.01	0.99
	2009	Jan	0.01	0.00					
Coarse sand	1995	Apr	0.08	0.17	0.27	0.20	3.58	0.22	
	1996	Apr	0.54	1.47	21.11	6.17	5.99	1.73	
	1997	Apr	0.06	0.34	6.02	1.43	0.18	0.03	
	1998	Apr	0.06	0.93	11.36	0.34	0.62	0.15	
	1999	Apr	0.05	0.21	2.06	0.17	0.08	0.07	
	2000	Apr	0.07	0.32	14.01	0.33	0.24	0.14	
		Jul	0.07	0.23	9.33	0.13	0.29	0.10	
		Oct	0.06	0.08	4.37	0.62	0.23	0.16	
	2001	Jan	0.14	0.17	0.65	0.34	0.07	0.09	
		Apr	0.06	0.06	18.88	0.05	0.35	0.21	
		Jul	0.51	0.15	0.30	0.54	0.09	0.34	
		Oct	0.00	0.00	2.80	0.05	0.07	0.00	
	2002	Jan	0.02	0.00	7.48	0.00	0.14	0.00	
		Apr	0.14	0.10	1.32	0.18	0.09	0.07	
		Jul	4.70	3.06	0.14	0.96	0.09	0.04	
		Oct	0.06	0.06	0.11	7.86	0.13	0.16	
	2003	Jan	0.06	0.12	0.49	0.12	0.49	0.17	
		Apr	0.13	0.09	1.50	0.13	0.17	0.08	
		Jul	0.07	0.26	2.27	0.20	0.31	0.07	
		Oct	0.02	0.12	10.22	0.05	0.09	0.09	
	2004	Jan	0.00	0.00	12.67	0.26	1.09	0.15	
		Apr	0.00	0.12	7.69	0.54	0.19	0.08	
		Jul	0.00	0.02	10.69	0.24	0.41	0.05	
		Oct	0.06	0.22	7.54	0.19	0.37	0.14	
	2005	Jan	0.00	0.07	7.74	0.00	0.37	0.14	
		Apr	0.07	0.00	11.18	0.31	0.53	0.48	
		Jul	0.08	0.10	5.78	0.07	0.06	0.04	
		Oct	0.10	0.21	16.07	0.33	0.16	0.08	0.24
	2006	Jan	0.04	0.08	11.48	0.25	0.19	0.08	0.28
		Apr	0.07	0.11	10.14	0.32	0.11	0.30	0.25
		Jul	0.04	0.07	4.78	0.12	0.31	0.06	0.14
		Oct	0.00	0.12	5.83	0.19	0.04	0.00	0.12
	2007	Jan	0.04	0.04	12.73	0.21	0.10	0.01	0.15
		Apr	0.01	0.16	0.04	6.69	0.14	2.41	0.18
		Jul	0.00	0.00	12.22	0.10	0.45	0.06	0.36
		Oct	0.03	0.00	7.95	0.28	0.25	0.08	0.30
	2008	Jan	0.22	0.12	7.27	0.42	0.24	0.15	0.32
		Apr	0.04	0.14	3.08	0.09	0.59	0.35	0.25
		Jul	0.03	0.11	6.31	0.18	0.27	0.13	0.25
		Oct	0.03	0.06	5.59	0.06	0.28	0.02	0.14
	2009	Jan	0.04	0.17	3.03	0.20	0.75	0.08	0.24
Medium	1995	Apr	38.94	30.74	64.93	43.64	38.15	39.60	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
sand	1996	Apr	18.37	15.71	32.19	39.50	26.03	13.42	
	1997	Apr	8.71	1.08	15.78	5.63	2.19	3.56	
	1998	Apr	0.78	5.18	22.67	6.29	2.48	0.50	
	1999	Apr	1.84	3.43	11.08	2.26	1.82	2.43	
	2000	Apr	0.52	4.81	46.93	4.19	1.10	1.72	
		Jul	0.60	1.08	11.94	4.80	2.24	0.33	
		Oct	0.90	0.74	33.67	8.10	2.83	1.66	
	2001	Jan	0.83	4.52	6.08	5.64	2.05	1.73	
		Apr	0.72	0.70	39.23	2.08	0.48	1.50	
		Jul	0.67	0.81	5.01	7.4	1.83	1.38	
		Oct	0.57	0.13	10.89	5.04	2.17	0.88	
	2002	Jan	0.43	0.61	19.77	15.08	1.65	1.28	
		Apr	0.66	2.70	7.28	2.75	1.42	1.10	
		July	15.14	1.85	3.16	0.90	0.20	0.61	
		Oct	0.52	0.34	3.11	19.76	1.53	1.69	
	2003	Jan	0.95	0.26	3.44	2.75	1.66	1.34	
		Apr	0.65	2.41	8.30	2.08	0.94	1.29	
		Jul	0.44	0.53	26.98	2.25	2.93	1.45	
		Oct	0.49	0.25	18.79	3.91	1.17	0.77	
	2004	Jan	0.69	0.23	20.72	4.51	1.67	1.78	
		Apr	0.56	0.35	16.03	2.72	1.32	1.57	
		Jul	0.38	0.30	24.34	7.73	1.67	1.10	
		Oct	0.61	0.37	15.02	3.27	1.66	1.41	
	2005	Jan	0.92	0.23	18.71	3.43	1.63	1.73	
		Apr	0.40	0.86	33.90	4.03	1.60	1.29	
		Jul	0.93	0.38	15.21	3.43	1.51	1.52	
		Oct	0.70	0.47	30.88	3.65	1.72	1.61	1.65
	2006	Jan	0.59	0.32	22.64	3.69	0.60	0.90	2.08
		Apr	0.40	0.27	19.59	3.38	1.32	1.06	2.07
		Jul	0.54	0.24	13.44	3.12	1.53	1.49	2.16
		Oct	0.70	0.24	13.25	3.67	1.26	1.41	1.97
	2007	Jan	0.67	0.34	21.34	3.82	1.22	1.24	1.25
		Apr	0.60	0.29	27.39	3.02	1.58	1.23	1.80
		Jul	0.61	0.28	21.59	6.33	3.02	1.34	2.92
		Oct	0.80	1.27	14.94	3.42	2.44	1.62	1.91
	2008	Jan	1.09	0.55	13.55	4.78	2.03	1.74	2.42
		Apr	0.74	0.38	10.52	3.26	2.83	2.37	2.31
		Jul	0.41	0.41	15.11	2.77	1.41	1.33	2.34
		Oct	0.49	0.19	16.73	3.24	2.04	0.60	2.07
	2009	Jan	0.60	0.48	12.56	2.86	3.03	1.16	2.44
Fine sand	1995	Apr	38.04	26.50	24.65	33.05	24.41	29.34	
	1996	Apr	28.40	19.08	19.11	26.16	16.90	19.79	
	1997	Apr	75.34	33.23	52.17	72.05	73.46	67.23	
	1998	Apr	79.76	52.91	47.18	80.72	75.12	58.41	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
	1999	Apr	77.54	52.55	74.14	81.09	68.21	70.32	
	2000	Apr	66.19	60.20	29.26	79.84	79.29	63.18	
		Jul	70.18	42.73	56.13	74.69	87.48	54.48	
		Oct	71.24	51.56	50.38	86.93	75.16	60.85	
	2001	Jan	72.19	62.16	84.19	85.25	85.81	62.42	
		Apr	77.79	56.02	31.69	62.62	53.70	62.77	
		July	71.76	50.02	87.15	60.77	79.95	60.87	
		Oct	80.53	44.40	71.37	83.77	82.89	61.61	
	2002	Jan	81.51	57.74	63.83	74.17	79.31	65.13	
		Apr	69.70	55.98	80.65	78.88	83.52	64.96	
		Jul	70.72	58.54	73.40	76.53	45.41	63.87	
		Oct	70.99	49.23	83.39	61.47	56.65	65.82	
	2003	Jan	79.42	55.57	84.20	86.93	79.10	76.72	
		Apr	69.19	49.97	92.01	59.49	77.47	76.09	
		Jul	71.03	47.82	58.73	74.61	82.82	64.66	
		Oct	71.70	48.10	45.71	87.08	77.57	57.06	
	2004	Jan	67.38	43.87	42.37	86.83	82.64	63.57	
		Apr	72.59	45.03	56.77	80.87	83.56	59.64	
		Jul	68.43	50.00	54.36	84.43	89.73	58.56	
		Oct	68.08	54.08	62.39	86.23	88.12	63.54	
	2005	Jan	71.24	57.91	62.94	88.30	86.59	60.75	
		Apr	70.70	55.64	46.57	82.99	85.16	60.63	
		Jul	71.32	48.36	64.64	82.74	87.18	62.11	
		Oct	70.78	57.06	42.74	87.60	67.63	62.70	88.03
	2006	Jan	67.69	51.57	50.78	86.95	79.99	58.34	89.15
		Apr	70.70	57.74	46.08	78.40	69.60	77.61	90.25
		Jul	71.78	51.92	69.24	81.99	76.93	62.65	89.10
		Oct	69.95	51.85	47.61	81.14	84.42	64.19	89.37
	2007	Jan	71.11	59.35	51.26	83.41	82.07	63.86	79.48
		Apr	71.77	53.82	54.71	80.46	87.11	60.80	90.65
		Jul	73.95	49.34	41.09	76.39	84.50	61.78	91.60
		Oct	77.18	49.86	58.84	82.30	88.53	71.85	91.71
	2008	Jan	74.57	55.20	64.84	82.33	88.25	70.71	91.83
		Apr	71.75	52.75	74.92	75.91	85.39	70.45	87.25
		Jul	68.76	48.40	56.12	73.99	82.61	61.39	90.71
		Oct	70.58	47.58	50.84	85.00	73.90	41.98	92.24
	2009	Jan	74.06	50.32	73.07	81.88	86.26	67.21	90.14
Silt	1995	Apr	17.42	34.03	6.44	18.37	27.38	23.63	
	1996	Apr	38.08	46.32	19.30	19.69	33.01	48.03	
	1997	Apr	11.12	39.04	4.09	7.78	7.27	21.66	
	1998	Apr	12.74	29.06	2.38	6.71	12.75	29.93	
	1999	Apr	8.24	27.77	7.56	8.73	17.98	19.41	
	2000	Apr	24.61	20.37	0.30	9.94	12.50	27.58	
		Jul	29.01	54.62	3.79	17.36	4.27	34.20	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
		Oct	22.02	41.08	3.06	3.88	16.76	19.14	
	2001	Jan	22.22	28.10	8.00	7.10	7.93	29.95	
		Apr	18.98	40.19	0.04	31.70	36.64	29.83	
		Jul	26.93	47.46	7.36	30.22	17.02	35.93	
		Oct	7.84	48.63	11.09	3.31	11.83	32.13	
	2002	Jan	17.60	35.24	6.75	8.09	14.72	29.48	
		Apr	22.81	37.26	7.05	10.28	12.78	29.32	
		Jul	5.68	17.34	20.52	14.17	30.34	26.90	
		Oct	23.51	38.81	9.88	4.14	7.88	25.73	
	2003	Jan	15.15	35.03	8.66	6.75	7.20	12.82	
		Apr	23.21	27.12	20.00	19.50	26.00	26.15	
		Jul	22.25	45.58	7.53	15.59	9.23	32.11	
		Oct	23.60	47.52	2.78	5.28	11.00	32.54	
	2004	Jan	22.54	54.95	6.70	4.16	4.57	26.93	
		Apr	15.66	33.74	3.70	3.11	9.72	31.33	
		Jul	23.17	44.03	3.36	3.86	4.58	36.34	
		Oct	24.99	33.05	4.82	5.85	4.60	28.56	
	2005	Jan	18.56	31.90	3.59	3.13	6.66	23.01	
		Apr	23.39	29.00	4.25	6.99	6.35	29.43	
		Jul	19.60	33.36	4.34	7.10	6.50	26.86	
		Oct	22.96	22.14	1.06	0.00	6.69	22.66	5.25
	2006	Jan	24.70	38.42	3.12	5.33	9.72	31.56	5.18
		Apr	23.39	33.00	4.70	13.50	21.65	10.97	3.62
		Jul	20.17	33.06	6.85	9.77	9.90	27.60	5.85
		Oct	21.86	32.49	3.32	9.29	8.19	24.36	5.37
	2007	Jan	22.66	31.68	3.78	6.16	8.01	27.30	12.79
		Apr	20.79	25.01	3.71	7.56	6.35	24.71	2.55
		Jul	18.63	35.03	4.02	13.50	8.49	29.11	2.36
		Oct	15.51	40.92	3.67	7.37	3.89	19.40	2.08
	2008	Jan	18.45	36.59	5.46	6.82	5.56	21.10	0.34
		Apr	19.64	36.91	9.16	18.60	8.14	17.24	4.48
		Jul	22.68	36.01	1.47	13.07	9.40	29.03	2.84
		Oct	22.05	45.36	5.86	6.43	5.65	36.78	2.68
	2009	Jan	21.08	41.05	5.10	10.67	6.15	24.82	2.89
Clay	1995	Apr	5.45	4.96	3.34	4.10	2.98	6.98	
	1996	Apr	14.61	17.42	8.29	8.48	18.07	17.03	
	1997	Apr	4.75	26.33	0.51	6.54	6.76	7.52	
	1998	Apr	6.64	10.77	0.32	4.18	7.09	11.00	
	1999	Apr	12.31	16.05	0.14	6.25	11.09	7.65	
	2000	Apr	8.60	14.12	0.90	5.03	6.43	7.37	
		Jul	0.08	1.34	0.11	3.01	2.00	10.89	
		Oct	5.74	6.54	0.53	0.37	3.22	18.19	
	2001	Jan	4.19	5.02	0.45	1.47	2.55	5.82	
		Apr	2.45	3.04	1.67	3.23	8.83	5.65	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
		Jul	0.13	1.55	0.05	0.62	1.06	1.49	
		Oct	11.05	6.83	0.58	7.40	2.35	5.38	
	2002	Jan	0.44	6.41	0.37	2.64	2.61	4.11	
		Apr	6.68	3.95	3.53	5.53	1.88	4.31	
		Jul	2.13	11.87	2.52	7.09	23.95	8.59	
		Oct	4.92	11.50	3.49	2.76	2.63	6.43	
	2003	Jan	4.43	9.01	2.64	3.38	10.79	8.55	
		Apr	6.79	2.88	10.00	10.50	4.00	3.85	
		Jul	6.21	5.82	1.61	7.16	4.62	1.63	
		Oct	4.19	4.00	2.78	3.52	9.68	9.52	
	2004	Jan	9.39	0.95	0.37	3.81	6.09	7.57	
		Apr	11.19	20.77	3.74	7.77	4.86	7.37	
		Jul	8.02	5.64	1.92	3.22	3.27	1.98	
		Oct	6.25	12.24	2.19	3.90	4.60	6.35	
	2005	Jan	9.28	9.90	4.19	4.17	2.05	14.38	
		Apr	5.44	14.50	1.06	4.89	6.35	8.17	
		Jul	8.07	17.79	4.34	5.68	3.71	9.48	
		Oct	5.47	20.13	2.12	8.32	2.23	12.95	3.00
	2006	Jan	6.97	9.61	2.68	3.28	7.95	9.12	3.19
		Apr	5.44	8.88	2.06	4.32	7.42	4.94	3.01
		Jul	7.47	14.33	3.05	4.89	5.94	8.20	1.95
		Oct	7.51	15.29	7.46	5.71	5.46	10.03	1.65
	2007	Jan	5.51	8.58	2.16	5.72	4.24	6.97	4.87
		Apr	6.82	20.84	3.30	8.69	3.59	13.04	4.18
		Jul	6.80	15.37	3.02	3.20	2.68	7.72	2.36
		Oct	6.46	7.96	3.67	6.14	3.89	7.05	1.78
	2008	Jan	5.43	7.45	2.55	5.00	3.13	6.17	4.06
		Apr	7.86	9.84	1.53	2.15	1.75	9.40	3.15
		Jul	8.10	15.07	5.90	9.93	4.98	8.13	3.40
		Oct	6.84	6.80	2.93	5.00	3.76	20.60	2.68
	2009	Jan	4.22	7.98	2.91	3.76	3.31	6.71	3.30

8.3 Appendix 3

A. Organic content (% dry weight), and B. Chlorophyll a content (µg g^{-1} sediment) of sediments at the intertidal sites on each sampling occasion since July 2000. * = highest recorded value at a particular site.

A. Organic content

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Jul00	1.67	3.87	1.29	1.40	1.87	0.90	
Oct00	2.03	3.22	1.00	0.88	2.32	1.57	
Jan01	2.00	2.49	1.44	1.38	2.33	1.49	
Apr01	2.28	4.60	1.59	3.38	3.06	11.93*	
Jul01	2.58	6.35	1.45	2.72	2.90	1.59	
Oct01	1.92	4.16	1.32	1.83	2.58	1.20	
Jan02	2.06	3.92	2.06	2.17	1.84	2.53	
Apr02	2.30	3.47	1.70	1.84	1.40	2.22	
Jul02	2.58	1.58	1.71	4.94*	2.46	2.13	
Oct02	2.94	5.02	2.13	1.53	3.41	4.62	
Jan03	2.13	4.07	1.72	1.50	2.59	1.68	
Apr03	2.01	5.54	1.48	2.96	2.31	1.37	
Jul03	2.00	3.89	1.38	1.79	2.18	1.32	
Oct03	1.88	3.85	1.45	1.42	2.46	2.08	
Jan04	2.27	4.69	1.70	1.49	2.54	1.79	
Apr04	2.85	6.65*	3.59*	2.23	4.66*	2.53	
Jul04	2.97	4.87	2.34	1.57	2.69	1.85	
Oct04	3.18*	5.04	2.31	2.40	3.99	2.29	
Jan05	1.74	2.55	1.41	1.63	4.10	1.70	
Apr05	1.70	4.13	1.44	1.59	2.63	1.73	
Jul05	2.40	4.27	2.15	2.02	1.91	1.54	
Oct05	2.11	4.60	1.31	1.88	2.53	1.70	0.76
Jan06	2.45	3.95	1.68	1.60	2.68	2.14	1.34*
Apr06	1.95	3.72	1.89	2.48	1.63	2.06	0.88
Jul06	2.29	4.35	2.08	2.34	2.52	1.96	1.20
Oct06	2.66	4.35	2.78	2.19	2.75	1.97	1.25
Jan07	2.45	3.64	1.52	2.09	2.39	1.43	1.05
Apr07	2.26	4.35	2.26	2.00	2.74	1.48	1.24
Jul07	2.58	5.17	1.86	2.78	2.87	1.98	1.29
Oct07	2.42	4.87	2	2.32	2.36	1.66	1.27
Jan08	2.45	4.99	1.84	2.11	2.62	1.75	1.16

Apr08	2.22	5.02	1.94	2.57	2.36	1.79	1.25
Jul08	2.16	4.94	1.92	2.54	2.70	1.61	1.10
Oct08	2.23	3.98	2.47	1.52	2.05	2.21	1.03
Jan09	2.13	4.14	1.81	1.95	2.56	1.68	1.29

B. Chlorophyll *a*

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Jul00	17.81	12.14	4.59	10.03	14.74	6.35	
Oct00	23.08*	11.32	3.97	7.33	8.40	15.39	
Jan01	12.40	10.04	3.44	6.54	5.94	9.62	
Apr01	15.54	12.63	1.76	10.38	13.11	ns	
Jul01	21.21	16.74*	6.76*	10.46	17.41*	9.99	
Oct01	14.01	8.32	3.65	6.55	12.63	5.22	
Jan02	12.23	8.21	2.75	4.53	9.15	5.23	
Apr02	18.07	13.13	6.15	9.76	14.32	6.30	
Jul02	15.52	6.41	4.58	10.99	14.16	6.14	
Oct02	14.02	7.27	3.14	8.59	9.91	6.48	
Jan03	12.63	10.07	5.04	9.02	11.38	7.32	
Apr03	12.72	5.93	3.66	7.05	9.11	7.60	
Jul03	13.08	6.19	3.50	3.09	9.65	6.76	
Oct03	14.04	7.70	5.50	8.98	9.06	5.50	
Jan04	10.66	10.78	3.09	8.49	6.07	17.43*	
Apr04	16.65	12.35	2.86	10.67	5.96	9.85	
Jul04	15.13	10.86	3.38	7.05	7.22	14.10	
Oct04	11.02	7.62	3.23	2.53	4.03	7.62	
Jan05	12.28	8.48	4.61	10.93	6.90	9.05	
Apr05	10.80	6.62	3.74	9.13	11.03	7.30	
Jul05	13.57	12.82	4.76	7.43	6.82	13.89	
Oct05	10.82	10.94	2.71	8.42	6.46	9.66	8.10
Jan06	11.05	9.87	3.09	7.33	6.06	9.23	7.36
Apr06	13.98	9.50	4.13	8.36	5.73	3.20	7.23
Jul06	13.76	6.44	3.38	8.71	8.48	4.76	5.22
Oct06	13.53	8.60	3.21	6.65	10.77	4.93	5.16
Jan07	15.24	10.78	3.10	7.80	11.46	5.39	6.99
Apr07	13.42	11.69	4.47	11.35*	12.04	5.50	8.14
Jul07	14.22	11.47	2.58	9.51	11.92	6.53	7.56
Oct07	13.52	10.54	6.76*	7.56	11.00	4.93	7.10
Jan08	12.15	12.03	3.78	7.22	9.40	7.11	7.68

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Apr08	14.90	10.43	5.04	7.22	10.55	5.50	8.94
Jul08	15.36	10.20	4.24	7.79	12.72	7.11	9.06
Oct08	14.10	9.63	4.24	5.85	8.83	6.19	6.99
Jan09	14.44	9.97	4.58	9.86	10.55	6.19	9.17*

8.4 Appendix 4

Summary of temporal results at the intertidal sites from April 2007 (Time = 52) to January 2009 (Time = 59). CB = Cowans Bay, DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Aonides trifida	CB	52	0	0	0	0.00
Aonides trifida	CB	53	0	0	0	0.00
Aonides trifida	CB	54	0	0	0	0.00
Aonides trifida	CB	55	0	0	0	0.00
Aonides trifida	CB	56	0	0	0	0.00
Aonides trifida	CB	57	1	0	1	0.08
Aonides trifida	CB	58	0	0	0	0.00
Aonides trifida	CB	59	0	0	0	0.00
Aonides trifida	DC	53	1	0	1	0.08
Aonides trifida	DC	54	1	0	1	0.08
Aonides trifida	DC	55	1	0	1	0.08
Aonides trifida	DC	57	3	0	3	0.25
Aonides trifida	HL	52	0	0	0	0.00
Aonides trifida	HL	53	1	0	1	0.08
Aonides trifida	HL	54	0	0	0	0.00
Aonides trifida	HL	55	0	0	0	0.00
Aonides trifida	HL	56	0	0	0	0.00
Aonides trifida	HL	57	0	0	0	0.00
Aonides trifida	HL	58	0	0	0	0.00
Aonides trifida	HL	59	0	0	0	0.00
Aonides trifida	JB	52	15	0	11	1.25
Aonides trifida	JB	53	28.4	0	15	2.36
Aonides trifida	JB	54	32	0	20	2.67
Aonides trifida	JB	55	9	0	7	0.75
Aonides trifida	JB	56	15	0	9	1.25
Aonides trifida	JB	57	36	0.5	15	3.00
Aonides trifida	JB	58	15	0	11	1.25
Aonides trifida	JB	59	1	0	1	0.08
Aonides trifida	MH	52	0	0	0	0.00
Aonides trifida	MH	53	0	0	0	0.00
Aonides trifida	MH	54	0	0	0	0.00
Aonides trifida	MH	55	0	0	0	0.00

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[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
Aonides trifida	MH	56	0	0	0	0.00
Aonides trifida	MH	57	1	0	1	0.08
Aonides trifida	MH	58	1	0	1	0.08
Aonides trifida	MH	59	0	0	0	0.00
Aonides trifida	TK	52	0	0	0	0.00
Aonides trifida	TK	53	1	0	1	0.08
Aonides trifida	TK	54	0	0	0	0.00
Aonides trifida	TK	55	0	0	0	0.00
Aonides trifida	TK	56	1	0	1	0.08
Aonides trifida	TK	57	0	0	0	0.00
Aonides trifida	TK	58	0	0	0	0.00
Aonides trifida	TK	59	0	0	0	0.00
Aricidea sp.	CB	52	2	0	1	0.17
Aricidea sp.	CB	53	2	0	2	0.17
Aricidea sp.	CB	54	0	0	0	0.00
Aricidea sp.	CB	55	4	0	3	0.33
Aricidea sp.	CB	56	0	0	0	0.00
Aricidea sp.	CB	57	2	0	1	0.17
Aricidea sp.	CB	58	9	0	4	0.75
Aricidea sp.	CB	59	0	0	0	0.00
Aricidea sp.	DC	52	8	0	3	0.67
Aricidea sp.	DC	53	21	1.5	6	1.75
Aricidea sp.	DC	54	6	0	3	0.50
Aricidea sp.	DC	55	7	0	2	0.58
Aricidea sp.	DC	56	15	1	3	1.25
Aricidea sp.	DC	57	13	1	4	1.08
Aricidea sp.	DC	58	7	0	3	0.58
Aricidea sp.	DC	59	18	0.5	4	1.50
Aricidea sp.	HL	52	34	2	8	2.83
Aricidea sp.	HL	53	70	5	8	5.83
Aricidea sp.	HL	54	28	2.5	7	2.33
Aricidea sp.	HL	55	43	2.5	10	3.58
Aricidea sp.	HL	56	57	4.5	11	4.75
Aricidea sp.	HL	57	83	6.5	15	6.92
Aricidea sp.	HL	58	57	4.5	9	4.75
Aricidea sp.	HL	59	73	6	9	6.08
Aricidea sp.	JB	52	17	0	6	1.42
Aricidea sp.	JB	53	16.4	2	3	1.36
Aricidea sp.	JB	54	6	0	4	0.50

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Aricidea sp.	JB	55	6	0	2	0.50
Aricidea sp.	JB	56	10	1	2	0.83
Aricidea sp.	JB	57	12	0	5	1.00
Aricidea sp.	JB	58	30	2	6	2.50
Aricidea sp.	JB	59	16	1	6	1.33
Aricidea sp.	MH	52	1	0	1	0.08
Aricidea sp.	MH	53	17	1	3	1.42
Aricidea sp.	MH	54	5	0	2	0.42
Aricidea sp.	MH	55	3	0	2	0.25
Aricidea sp.	MH	56	42	2.5	16	3.50
Aricidea sp.	MH	57	18	0	5	1.50
Aricidea sp.	MH	58	13	1	4	1.08
Aricidea sp.	MH	59	8	0	4	0.67
Aricidea sp.	TK	52	78	2.5	36	6.50
Aricidea sp.	TK	53	142	10	53	11.83
Aricidea sp.	TK	54	49	3	14	4.08
Aricidea sp.	TK	55	37	2	7	3.08
Aricidea sp.	TK	56	110	9.5	25	9.17
Aricidea sp.	TK	57	36	3	8	3.00
Aricidea sp.	TK	58	152	7	36	12.67
Aricidea sp.	TK	59	28	1	13	2.33
Arthritica bifurca	CB	52	22	0.5	7	1.83
Arthritica bifurca	CB	53	13	1	4	1.08
Arthritica bifurca	CB	54	25.1	1	5	2.09
Arthritica bifurca	CB	55	50	3.5	9	4.17
Arthritica bifurca	CB	56	4	0	3	0.33
Arthritica bifurca	CB	57	15	1	6	1.25
Arthritica bifurca	CB	58	44	3	9	3.67
Arthritica bifurca	CB	59	35	2.5	9	2.92
Arthritica bifurca	DC	52	1	0	1	0.08
Arthritica bifurca	DC	53	5	0	2	0.42
Arthritica bifurca	DC	54	7	0	6	0.58
Arthritica bifurca	DC	55	24	0.5	10	2.00
Arthritica bifurca	DC	56	22	1.5	7	1.83
Arthritica bifurca	DC	57	13	0	5	1.08
Arthritica bifurca	DC	58	14	0	11	1.17
Arthritica bifurca	DC	59	16	0.5	6	1.33
Arthritica bifurca	HL	52	1	0	1	0.08
Arthritica bifurca	HL	53	7	0	4	0.58

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Arthritica bifurca	HL	54	10	0	5	0.83
Arthritica bifurca	HL	55	20	0	7	1.67
Arthritica bifurca	HL	56	0	0	0	0.00
Arthritica bifurca	HL	57	2	0	1	0.17
Arthritica bifurca	HL	58	25	1	9	2.08
Arthritica bifurca	HL	59	50	3	17	4.17
Arthritica bifurca	JB	52	1	0	1	0.08
Arthritica bifurca	JB	53	0	0	0	0.00
Arthritica bifurca	JB	54	0	0	0	0.00
Arthritica bifurca	JB	55	8	0	4	0.67
Arthritica bifurca	JB	56	3	0	1	0.25
Arthritica bifurca	JB	57	4	0	3	0.33
Arthritica bifurca	JB	58	11	0	6	0.92
Arthritica bifurca	JB	59	0	0	0	0.00
Arthritica bifurca	MH	52	21	1	7	1.75
Arthritica bifurca	MH	53	79	6	14	6.58
Arthritica bifurca	MH	54	5	0	2	0.42
Arthritica bifurca	MH	55	100	7.5	25	8.33
Arthritica bifurca	MH	56	79	4	18	6.58
Arthritica bifurca	MH	57	25	2	7	2.08
Arthritica bifurca	MH	58	47	3.5	11	3.92
Arthritica bifurca	MH	59	210	19	29	17.50
Arthritica bifurca	TK	52	16	1	7	1.33
Arthritica bifurca	TK	53	16	1	5	1.33
Arthritica bifurca	TK	54	10	0	5	0.83
Arthritica bifurca	TK	55	20	1	5	1.67
Arthritica bifurca	TK	56	10	0	5	0.83
Arthritica bifurca	TK	57	4	0	2	0.33
Arthritica bifurca	TK	58	19	0.5	11	1.58
Arthritica bifurca	TK	59	16	1.5	4	1.33
Austrovenus stutchburyi	CB	52	2	0	1	0.17
Austrovenus stutchburyi	CB	53	0	0	0	0.00
Austrovenus stutchburyi	CB	54	0	0	0	0.00
Austrovenus stutchburyi	CB	55	0	0	0	0.00
Austrovenus stutchburyi	CB	56	1	0	1	0.08
Austrovenus stutchburyi	CB	57	0	0	0	0.00
Austrovenus stutchburyi	CB	58	1	0	1	0.08
Austrovenus stutchburyi	CB	59	1	0	1	0.08
Austrovenus stutchburyi	DC	52	111	10.5	15	9.25

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Austrovenus stutchburyi	DC	53	135	10.5	19	11.25
Austrovenus stutchburyi	DC	54	125	11	18	10.42
Austrovenus stutchburyi	DC	55	142	11	18	11.83
Austrovenus stutchburyi	DC	56	220	14.5	38	18.33
Austrovenus stutchburyi	DC	57	157	15	24	13.08
Austrovenus stutchburyi	DC	58	178	12.5	30	14.83
Austrovenus stutchburyi	DC	59	168	13.5	23	14.00
Austrovenus stutchburyi	HL	52	3	0	1	0.25
Austrovenus stutchburyi	HL	53	1	0	1	0.08
Austrovenus stutchburyi	HL	54	1	0	1	0.08
Austrovenus stutchburyi	HL	55	2	0	1	0.17
Austrovenus stutchburyi	HL	56	1	0	1	0.08
Austrovenus stutchburyi	HL	57	1	0	1	0.08
Austrovenus stutchburyi	HL	58	3	0	1	0.25
Austrovenus stutchburyi	HL	59	0	0	0	0.00
Austrovenus stutchburyi	JB	52	0	0	0	0.00
Austrovenus stutchburyi	JB	53	1.1	0	1	0.09
Austrovenus stutchburyi	JB	54	1	0	1	0.08
Austrovenus stutchburyi	JB	55	16	0.5	6	1.33
Austrovenus stutchburyi	JB	56	18	1	5	1.50
Austrovenus stutchburyi	JB	57	9	0	4	0.75
Austrovenus stutchburyi	JB	58	3	0	2	0.25
Austrovenus stutchburyi	JB	59	1	0	1	0.08
Austrovenus stutchburyi	MH	52	0	0	0	0.00
Austrovenus stutchburyi	MH	53	0	0	0	0.00
Austrovenus stutchburyi	MH	54	0	0	0	0.00
Austrovenus stutchburyi	MH	55	0	0	0	0.00
Austrovenus stutchburyi	MH	56	0	0	0	0.00
Austrovenus stutchburyi	MH	57	0	0	0	0.00
Austrovenus stutchburyi	MH	58	0	0	0	0.00
Austrovenus stutchburyi	MH	59	4	0	2	0.33
Austrovenus stutchburyi	TK	52	31	2	8	2.58
Austrovenus stutchburyi	TK	53	16	0.5	5	1.33
Austrovenus stutchburyi	TK	54	49	2	19	4.08
Austrovenus stutchburyi	TK	55	30	0.5	14	2.50
Austrovenus stutchburyi	TK	56	40	1	19	3.33
Austrovenus stutchburyi	TK	57	9	0	8	0.75
Austrovenus stutchburyi	TK	58	36	0.5	14	3.00
Austrovenus stutchburyi	TK	59	7	0	3	0.58

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Cossura consimilis	CB	52	261	19.5	38	21.75
Cossura consimilis	CB	53	305	22	40	25.42
Cossura consimilis	CB	54	222.5	15	19	18.55
Cossura consimilis	CB	55	181	12.5	32	15.08
Cossura consimilis	CB	56	282	23	26	23.50
Cossura consimilis	CB	57	190	15	23	15.83
Cossura consimilis	CB	58	250	18	24	20.83
Cossura consimilis	CB	59	274	23	30	22.83
Cossura consimilis	DC	52	0	0	0	0.00
Cossura consimilis	DC	53	2	0	1	0.17
Cossura consimilis	DC	54	0	0	0	0.00
Cossura consimilis	DC	55	0	0	0	0.00
Cossura consimilis	DC	56	3	0	2	0.25
Cossura consimilis	DC	57	5	0	2	0.42
Cossura consimilis	DC	58	2	0	1	0.17
Cossura consimilis	DC	59	2	0	1	0.17
Cossura consimilis	HL	52	884	68.5	78	73.67
Cossura consimilis	HL	53	774	67	85	64.50
Cossura consimilis	HL	54	777	62	61	64.75
Cossura consimilis	HL	55	731	61.5	47	60.92
Cossura consimilis	HL	56	868	75.5	89	72.33
Cossura consimilis	HL	57	947	76	109	78.92
Cossura consimilis	HL	58	1037	86	102	86.42
Cossura consimilis	HL	59	919	67.5	67	76.58
Cossura consimilis	JB	52	19	0	6	1.58
Cossura consimilis	JB	53	1.1	0	1	0.09
Cossura consimilis	JB	54	2	0	1	0.17
Cossura consimilis	JB	55	7	0	3	0.58
Cossura consimilis	JB	56	4	0	4	0.33
Cossura consimilis	JB	57	4	0	2	0.33
Cossura consimilis	JB	58	12	0	5	1.00
Cossura consimilis	JB	59	14	1	3	1.17
Cossura consimilis	MH	52	25	1.5	6	2.08
Cossura consimilis	MH	53	58	2.5	20	4.83
Cossura consimilis	MH	54	12	1	4	1.00
Cossura consimilis	MH	55	14	1	3	1.17
Cossura consimilis	MH	56	33	3	5	2.75
Cossura consimilis	MH	57	43	3.5	5	3.58
Cossura consimilis	MH	58	34	3	4	2.83

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Cossura consimilis	MH	59	78	5	26	6.50
Cossura consimilis	TK	52	497	33.5	119	41.42
Cossura consimilis	TK	53	455	35.5	123	37.92
Cossura consimilis	TK	54	400	32	67	33.33
Cossura consimilis	TK	55	281	23	51	23.42
Cossura consimilis	TK	56	324	34	45	27.00
Cossura consimilis	TK	57	401	37	64	33.42
Cossura consimilis	TK	58	353	28.5	63	29.42
Cossura consimilis	TK	59	305	28.5	56	25.42
Heteromastus filiformis	CB	52	10	1	2	0.83
Heteromastus filiformis	CB	53	41	3	7	3.42
Heteromastus filiformis	CB	54	38.2	3	7	3.18
Heteromastus filiformis	CB	55	10	0.5	3	0.83
Heteromastus filiformis	CB	56	48	4	8	4.00
Heteromastus filiformis	CB	57	23	1	8	1.92
Heteromastus filiformis	CB	58	68	4.5	16	5.67
Heteromastus filiformis	CB	59	50	3	13	4.17
Heteromastus filiformis	DC	52	59	1.5	31	4.92
Heteromastus filiformis	DC	53	83	8.5	16	6.92
Heteromastus filiformis	DC	54	23	2	4	1.92
Heteromastus filiformis	DC	55	28	2	7	2.33
Heteromastus filiformis	DC	56	62	1	22	5.17
Heteromastus filiformis	DC	57	18	0.5	8	1.50
Heteromastus filiformis	DC	58	16	0	4	1.33
Heteromastus filiformis	DC	59	3	0	1	0.25
Heteromastus filiformis	HL	52	401	30	44	33.42
Heteromastus filiformis	HL	53	596	44.5	53	49.67
Heteromastus filiformis	HL	54	461	40.5	52	38.42
Heteromastus filiformis	HL	55	267	24.5	19	22.25
Heteromastus filiformis	HL	56	439	34.5	39	36.58
Heteromastus filiformis	HL	57	399	35	28	33.25
Heteromastus filiformis	HL	58	446	39.5	41	37.17
Heteromastus filiformis	HL	59	386	36.5	43	32.17
Heteromastus filiformis	JB	52	13	0	6	1.08
Heteromastus filiformis	JB	53	15.3	1	8	1.27
Heteromastus filiformis	JB	54	22	0.5	7	1.83
Heteromastus filiformis	JB	55	26	1	13	2.17
Heteromastus filiformis	JB	56	9	0.5	3	0.75
Heteromastus filiformis	JB	57	22	0	11	1.83

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Heteromastus filiformis	JB	58	45	2	14	3.75
Heteromastus filiformis	JB	59	12	1	4	1.00
Heteromastus filiformis	MH	52	8	0	4	0.67
Heteromastus filiformis	MH	53	27	1	8	2.25
Heteromastus filiformis	MH	54	13	1	3	1.08
Heteromastus filiformis	MH	55	6	0	2	0.50
Heteromastus filiformis	MH	56	25	1	6	2.08
Heteromastus filiformis	MH	57	21	1	5	1.75
Heteromastus filiformis	MH	58	48	3.5	12	4.00
Heteromastus filiformis	MH	59	28	2	5	2.33
Heteromastus filiformis	TK	52	155	13.5	37	12.92
Heteromastus filiformis	TK	53	177	12	28	14.75
Heteromastus filiformis	TK	54	180	14.5	17	15.00
Heteromastus filiformis	TK	55	36	2.5	12	3.00
Heteromastus filiformis	TK	56	150	11.5	42	12.50
Heteromastus filiformis	TK	57	108	7	19	9.00
Heteromastus filiformis	TK	58	293	19.5	46	24.42
Heteromastus filiformis	TK	59	113	9	17	9.42
Macomona liliana	CB	52	20	1.5	6	1.67
Macomona liliana	CB	53	15	1	5	1.25
Macomona liliana	CB	54	12	1	2	1.00
Macomona liliana	CB	55	4	0	2	0.33
Macomona liliana	CB	56	1	0	1	0.08
Macomona liliana	CB	57	4	0	1	0.33
Macomona liliana	CB	58	1	0	1	0.08
Macomona liliana	CB	59	1	0	1	0.08
Macomona liliana	DC	52	37	3	4	3.08
Macomona liliana	DC	53	41	3	7	3.42
Macomona liliana	DC	54	37	3	5	3.08
Macomona liliana	DC	55	28	2	4	2.33
Macomona liliana	DC	56	61	6	4	5.08
Macomona liliana	DC	57	40	3	5	3.33
Macomona liliana	DC	58	48	3.5	6	4.00
Macomona liliana	DC	59	47	4	6	3.92
Macomona liliana	HL	52	26	2	6	2.17
Macomona liliana	HL	53	6	0	2	0.50
Macomona liliana	HL	54	6	0	2	0.50
Macomona liliana	HL	55	1	0	1	0.08
Macomona liliana	HL	56	4	0	2	0.33

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Macomona liliana	HL	57	2	0	1	0.17
Macomona liliana	HL	58	2	0	1	0.17
Macomona liliana	HL	59	1	0	1	0.08
Macomona liliana	JB	52	9	1	2	0.75
Macomona liliana	JB	53	19.6	1	5	1.64
Macomona liliana	JB	54	2	0	2	0.17
Macomona liliana	JB	55	6	0	2	0.50
Macomona liliana	JB	56	30	3	6	2.50
Macomona liliana	JB	57	13	0.5	4	1.08
Macomona liliana	JB	58	17	1.5	4	1.42
Macomona liliana	JB	59	5	0	2	0.42
Macomona liliana	MH	52	20	1	4	1.67
Macomona liliana	MH	53	17	1	3	1.42
Macomona liliana	MH	54	14	1	3	1.17
Macomona liliana	MH	55	13	1	4	1.08
Macomona liliana	MH	56	12	1	3	1.00
Macomona liliana	MH	57	8	1	2	0.67
Macomona liliana	MH	58	4	0	2	0.33
Macomona liliana	MH	59	4	0	1	0.33
Macomona liliana	TK	52	20	1	5	1.67
Macomona liliana	TK	53	23	2	6	1.92
Macomona liliana	TK	54	18	1	5	1.50
Macomona liliana	TK	55	7	0	3	0.58
Macomona liliana	TK	56	11	0.5	5	0.92
Macomona liliana	TK	57	5	0	2	0.42
Macomona liliana	TK	58	3	0	2	0.25
Macomona liliana	TK	59	3	0	2	0.25
Macrophthalmus hirtipes	CB	52	5	0	2	0.42
Macrophthalmus hirtipes	CB	53	6	0	2	0.50
Macrophthalmus hirtipes	CB	54	8.7	0	3	0.73
Macrophthalmus hirtipes	CB	55	5	0	2	0.42
Macrophthalmus hirtipes	CB	56	3	0	1	0.25
Macrophthalmus hirtipes	CB	57	1	0	1	0.08
Macrophthalmus hirtipes	CB	58	8	1	2	0.67
Macrophthalmus hirtipes	CB	59	2	0	1	0.17
Macrophthalmus hirtipes	DC	52	2	0	1	0.17
Macrophthalmus hirtipes	DC	53	3	0	1	0.25
Macrophthalmus hirtipes	DC	54	0	0	0	0.00
Macrophthalmus hirtipes	DC	55	1	0	1	0.08

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Macrophthalmus hirtipes	DC	56	0	0	0	0.00
Macrophthalmus hirtipes	DC	57	0	0	0	0.00
Macrophthalmus hirtipes	DC	58	4	0	1	0.33
Macrophthalmus hirtipes	DC	59	2	0	1	0.17
Macrophthalmus hirtipes	HL	52	0	0	0	0.00
Macrophthalmus hirtipes	HL	53	1	0	1	0.08
Macrophthalmus hirtipes	HL	54	1	0	1	0.08
Macrophthalmus hirtipes	HL	55	3	0	1	0.25
Macrophthalmus hirtipes	HL	56	0	0	0	0.00
Macrophthalmus hirtipes	HL	57	0	0	0	0.00
Macrophthalmus hirtipes	HL	58	15	1	4	1.25
Macrophthalmus hirtipes	HL	59	10	0	5	0.83
Macrophthalmus hirtipes	JB	52	0	0	0	0.00
Macrophthalmus hirtipes	JB	53	0	0	0	0.00
Macrophthalmus hirtipes	JB	54	0	0	0	0.00
Macrophthalmus hirtipes	JB	55	2	0	1	0.17
Macrophthalmus hirtipes	JB	56	0	0	0	0.00
Macrophthalmus hirtipes	JB	57	0	0	0	0.00
Macrophthalmus hirtipes	JB	58	9	0	5	0.75
Macrophthalmus hirtipes	JB	59	0	0	0	0.00
Macrophthalmus hirtipes	MH	52	0	0	0	0.00
Macrophthalmus hirtipes	MH	53	2	0	1	0.17
Macrophthalmus hirtipes	MH	54	4	0	2	0.33
Macrophthalmus hirtipes	MH	55	0	0	0	0.00
Macrophthalmus hirtipes	MH	56	0	0	0	0.00
Macrophthalmus hirtipes	MH	57	3	0	1	0.25
Macrophthalmus hirtipes	MH	58	4	0	2	0.33
Macrophthalmus hirtipes	MH	59	0	0	0	0.00
Macrophthalmus hirtipes	TK	52	1	0	1	0.08
Macrophthalmus hirtipes	TK	53	1	0	1	0.08
Macrophthalmus hirtipes	TK	54	0	0	0	0.00
Macrophthalmus hirtipes	TK	55	0	0	0	0.00
Macrophthalmus hirtipes	TK	56	0	0	0	0.00
Macrophthalmus hirtipes	TK	57	3	0	2	0.25
Macrophthalmus hirtipes	TK	58	4	0	1	0.33
Macrophthalmus hirtipes	TK	59	1	0	1	0.08
Nemerteans	CB	52	0	0	0	0.00
Nemerteans	CB	53	0	0	0	0.00
Nemerteans	CB	54	2.2	0	1	0.18

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Nemerteans	CB	55	0	0	0	0.00
Nemerteans	CB	56	2	0	1	0.17
Nemerteans	CB	57	0	0	0	0.00
Nemerteans	CB	58	3	0	1	0.25
Nemerteans	CB	59	2	0	1	0.17
Nemerteans	DC	52	3	0	1	0.25
Nemerteans	DC	53	17	0.5	6	1.42
Nemerteans	DC	54	2	0	1	0.17
Nemerteans	DC	55	2	0	1	0.17
Nemerteans	DC	56	14	0.5	4	1.17
Nemerteans	DC	57	2	0	1	0.17
Nemerteans	DC	58	6	0	2	0.50
Nemerteans	DC	59	4	0	2	0.33
Nemerteans	HL	52	3	0	1	0.25
Nemerteans	HL	53	16	1	4	1.33
Nemerteans	HL	54	24	2	4	2.00
Nemerteans	HL	55	2	0	1	0.17
Nemerteans	HL	56	11	1	2	0.92
Nemerteans	HL	57	4	0	1	0.33
Nemerteans	HL	58	9	1	2	0.75
Nemerteans	HL	59	7	0	2	0.58
Nemerteans	JB	52	1	0	1	0.08
Nemerteans	JB	53	0	0	0	0.00
Nemerteans	JB	54	3	0	2	0.25
Nemerteans	JB	55	3	0	2	0.25
Nemerteans	JB	56	3	0	3	0.25
Nemerteans	JB	57	4	0	1	0.33
Nemerteans	JB	58	4	0	3	0.33
Nemerteans	JB	59	0	0	0	0.00
Nemerteans	MH	52	0	0	0	0.00
Nemerteans	MH	53	7	0	3	0.58
Nemerteans	MH	54	2	0	2	0.17
Nemerteans	MH	55	3	0	2	0.25
Nemerteans	MH	56	5	0	1	0.42
Nemerteans	MH	57	6	0	2	0.50
Nemerteans	MH	58	2	0	1	0.17
Nemerteans	MH	59	2	0	2	0.17
Nemerteans	TK	52	12	0	4	1.00
Nemerteans	TK	53	2	0	1	0.17

Taxa	Site	Time	Total^2	Median	Range^3	Mean
Nemerteans	TK	54	8	0	2	0.67
Nemerteans	TK	55	3	0	1	0.25
Nemerteans	TK	56	19	1	5	1.58
Nemerteans	TK	57	2	0	1	0.17
Nemerteans	TK	58	4	0	3	0.33
Nemerteans	TK	59	3	0	1	0.25
Notoacmea helmsi	CB	52	0	0	0	0.00
Notoacmea helmsi	CB	53	0	0	0	0.00
Notoacmea helmsi	CB	54	0	0	0	0.00
Notoacmea helmsi	CB	55	1	0	1	0.08
Notoacmea helmsi	CB	56	0	0	0	0.00
Notoacmea helmsi	CB	57	0	0	0	0.00
Notoacmea helmsi	CB	58	0	0	0	0.00
Notoacmea helmsi	CB	59	0	0	0	0.00
Notoacmea helmsi	DC	52	29	1	7	2.42
Notoacmea helmsi	DC	53	29	2	9	2.42
Notoacmea helmsi	DC	54	12	1	2	1.00
Notoacmea helmsi	DC	55	29	2	7	2.42
Notoacmea helmsi	DC	56	45	3.5	8	3.75
Notoacmea helmsi	DC	57	83	6.5	14	6.92
Notoacmea helmsi	DC	58	72	4.5	16	6.00
Notoacmea helmsi	DC	59	57	4.5	12	4.75
Notoacmea helmsi	HL	52	0	0	0	0.00
Notoacmea helmsi	HL	53	0	0	0	0.00
Notoacmea helmsi	HL	54	0	0	0	0.00
Notoacmea helmsi	HL	55	0	0	0	0.00
Notoacmea helmsi	HL	56	0	0	0	0.00
Notoacmea helmsi	HL	57	0	0	0	0.00
Notoacmea helmsi	HL	58	0	0	0	0.00
Notoacmea helmsi	HL	59	0	0	0	0.00
Notoacmea helmsi	JB	52	1	0	1	0.08
Notoacmea helmsi	JB	53	2.2	0	2	0.18
Notoacmea helmsi	JB	54	2	0	2	0.17
Notoacmea helmsi	JB	55	5	0	3	0.42
Notoacmea helmsi	JB	56	4	0	3	0.33
Notoacmea helmsi	JB	57	0	0	0	0.00
Notoacmea helmsi	JB	58	29	0	23	2.42
Notoacmea helmsi	JB	59	1	0	1	0.08
Notoacmea helmsi	MH	52	0	0	0	0.00

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Notoacmea helmsi	MH	53	0	0	0	0.00
Notoacmea helmsi	MH	54	0	0	0	0.00
Notoacmea helmsi	MH	55	0	0	0	0.00
Notoacmea helmsi	MH	56	0	0	0	0.00
Notoacmea helmsi	MH	57	0	0	0	0.00
Notoacmea helmsi	MH	58	1	0	1	0.08
Notoacmea helmsi	MH	59	0	0	0	0.00
Notoacmea helmsi	TK	52		0	0	0.00
Notoacmea helmsi	TK	53		0	0	0.00
Notoacmea helmsi	TK	54	1	0	1	0.08
Notoacmea helmsi	TK	55	0	0	0	0.00
Notoacmea helmsi	TK	56	0	0	0	0.00
Notoacmea helmsi	TK	57	0	0	0	0.00
Notoacmea helmsi	TK	58	0	0	0	0.00
Notoacmea helmsi	TK	59	0	0	0	0.00
Nucula hartvigiana	CB	52	11	0.5	4	0.92
Nucula hartvigiana	CB	53	2	0	1	0.17
Nucula hartvigiana	CB	54	7.6	0	3	0.64
Nucula hartvigiana	CB	55	8	0	4	0.67
Nucula hartvigiana	CB	56	3	0	1	0.25
Nucula hartvigiana	CB	57	6	0	2	0.50
Nucula hartvigiana	CB	58	3	0	1	0.25
Nucula hartvigiana	CB	59	11	0	5	0.92
Nucula hartvigiana	DC	52	326	27.5	43	27.17
Nucula hartvigiana	DC	53	382	31	48	31.83
Nucula hartvigiana	DC	54	344	26	37	28.67
Nucula hartvigiana	DC	55	508	40	36	42.33
Nucula hartvigiana	DC	56	684	56	37	57.00
Nucula hartvigiana	DC	57	692	60	48	57.67
Nucula hartvigiana	DC	58	646	50.5	39	53.83
Nucula hartvigiana	DC	59	711	61	33	59.25
Nucula hartvigiana	HL	52	0	0	0	0.00
Nucula hartvigiana	HL	53	4	0	3	0.33
Nucula hartvigiana	HL	54	5	0	3	0.42
Nucula hartvigiana	HL	55	10	0.5	4	0.83
Nucula hartvigiana	HL	56	1	0	1	0.08
Nucula hartvigiana	HL	57	2	0	2	0.17
Nucula hartvigiana	HL	58	2	0	1	0.17
Nucula hartvigiana	HL	59	6	0	2	0.50

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Nucula hartvigiana	JB	52	149	5.5	37	12.42
Nucula hartvigiana	JB	53	136.4	8	51	11.36
Nucula hartvigiana	JB	54	159	12.5	38	13.25
Nucula hartvigiana	JB	55	469	45	93	39.08
Nucula hartvigiana	JB	56	419	28	104	34.92
Nucula hartvigiana	JB	57	440	26	96	36.67
Nucula hartvigiana	JB	58	387	33.5	57	32.25
Nucula hartvigiana	JB	59	166	2.5	45	13.83
Nucula hartvigiana	MH	52	514	45	45	42.83
Nucula hartvigiana	MH	53	331	27.5	24	27.58
Nucula hartvigiana	MH	54	323	25	40	26.92
Nucula hartvigiana	MH	55	646	44.5	90	53.83
Nucula hartvigiana	MH	56	729	62	72	60.75
Nucula hartvigiana	MH	57	534	41	47	44.50
Nucula hartvigiana	MH	58	398	31.5	28	33.17
Nucula hartvigiana	MH	59	849	68	107	70.75
Nucula hartvigiana	TK	52	44	1.5	26	3.67
Nucula hartvigiana	TK	53	30	0.5	19	2.50
Nucula hartvigiana	TK	54	24	0.5	11	2.00
Nucula hartvigiana	TK	55	80	6.5	12	6.67
Nucula hartvigiana	TK	56	53	0.5	42	4.42
Nucula hartvigiana	TK	57	29	0	25	2.42
Nucula hartvigiana	TK	58	30	1	23	2.50
Nucula hartvigiana	TK	59	19	0	7	1.58
Oligochaetes	CB	52	1	0	1	0.08
Oligochaetes	CB	53	4	0	1	0.33
Oligochaetes	CB	54	1.1	0	1	0.09
Oligochaetes	CB	55	11	1	2	0.92
Oligochaetes	CB	56	0	0	0	0.00
Oligochaetes	CB	57	4	0	2	0.33
Oligochaetes	CB	58	2	0	2	0.17
Oligochaetes	CB	59	1	0	1	0.08
Oligochaetes	DC	52	1	0	1	0.08
Oligochaetes	DC	53	2	0	1	0.17
Oligochaetes	DC	54	0	0	0	0.00
Oligochaetes	DC	55	0	0	0	0.00
Oligochaetes	DC	56	5	0	2	0.42
Oligochaetes	DC	57	2	0	1	0.17
Oligochaetes	DC	58	5	0	4	0.42

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Oligochaetes	DC	59	0	0	0	0.00
Oligochaetes	HL	52	15	0	7	1.25
Oligochaetes	HL	53	270	18.5	46	22.50
Oligochaetes	HL	54	4	0	2	0.33
Oligochaetes	HL	55	0	0	0	0.00
Oligochaetes	HL	56	27	1.5	10	2.25
Oligochaetes	HL	57	35	2	7	2.92
Oligochaetes	HL	58	2	0	1	0.17
Oligochaetes	HL	59	82	4	22	6.83
Oligochaetes	JB	52	19	0	11	1.58
Oligochaetes	JB	53	28.4	0	14	2.36
Oligochaetes	JB	54	1	0	1	0.08
Oligochaetes	JB	55	0	0	0	0.00
Oligochaetes	JB	56	0	0	0	0.00
Oligochaetes	JB	57	28	0.5	11	2.33
Oligochaetes	JB	58	68	1	27	5.67
Oligochaetes	JB	59	19	0	15	1.58
Oligochaetes	MH	52	2	0	1	0.17
Oligochaetes	MH	53	3	0	2	0.25
Oligochaetes	MH	54	1	0	1	0.08
Oligochaetes	MH	55	1	0	1	0.08
Oligochaetes	MH	56	0	0	0	0.00
Oligochaetes	MH	57	5	0	2	0.42
Oligochaetes	MH	58	1	0	1	0.08
Oligochaetes	MH	59	9	0	4	0.75
Oligochaetes	TK	52	4	0	1	0.33
Oligochaetes	TK	53	3	0	3	0.25
Oligochaetes	TK	54	2	0	1	0.17
Oligochaetes	TK	55	0	0	0	0.00
Oligochaetes	TK	56	0	0	0	0.00
Oligochaetes	TK	57	13	0	5	1.08
Oligochaetes	TK	58	6	0	3	0.50
Oligochaetes	TK	59	25	0	11	2.08
Owenia fusiformis	CB	52	0	0	0	0.00
Owenia fusiformis	CB	53	0	0	0	0.00
Owenia fusiformis	CB	54	0	0	0	0.00
Owenia fusiformis	CB	55	0	0	0	0.00
Owenia fusiformis	CB	56	0	0	0	0.00
Owenia fusiformis	CB	57	0	0	0	0.00

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Owenia fusiformis	CB	58	0	0	0	0.00
Owenia fusiformis	CB	59	1	0	1	0.08
Owenia fusiformis	DC	52	0	0	0	0.00
Owenia fusiformis	DC	53	0	0	0	0.00
Owenia fusiformis	DC	54	0	0	0	0.00
Owenia fusiformis	DC	55	0	0	0	0.00
Owenia fusiformis	DC	56	0	0	0	0.00
Owenia fusiformis	DC	57	0	0	0	0.00
Owenia fusiformis	DC	58	0	0	0	0.00
Owenia fusiformis	DC	59	1	0	1	0.08
Owenia fusiformis	HL	52	0	0	0	0.00
Owenia fusiformis	HL	53	0	0	0	0.00
Owenia fusiformis	HL	54	0	0	0	0.00
Owenia fusiformis	HL	55	0	0	0	0.00
Owenia fusiformis	HL	56	0	0	0	0.00
Owenia fusiformis	HL	57	0	0	0	0.00
Owenia fusiformis	HL	58	0	0	0	0.00
Owenia fusiformis	HL	59	0	0	0	0.00
Owenia fusiformis	JB	52	0	0	0	0.00
Owenia fusiformis	JB	53	1.1	0	1	0.09
Owenia fusiformis	JB	54	0	0	0	0.00
Owenia fusiformis	JB	55	9	0	7	0.75
Owenia fusiformis	JB	56	8	0	2	0.67
Owenia fusiformis	JB	57	8	0	3	0.67
Owenia fusiformis	JB	58	3	0	2	0.25
Owenia fusiformis	JB	59	1	0	1	0.08
Owenia fusiformis	MH	52	0	0	0	0.00
Owenia fusiformis	MH	53	0	0	0	0.00
Owenia fusiformis	MH	54	0	0	0	0.00
Owenia fusiformis	MH	55	2	0	1	0.17
Owenia fusiformis	MH	56	1	0	1	0.08
Owenia fusiformis	MH	57	0	0	0	0.00
Owenia fusiformis	MH	58	0	0	0	0.00
Owenia fusiformis	MH	59	0	0	0	0.00
Owenia fusiformis	TK	52	1	0	1	0.08
Owenia fusiformis	TK	53	0	0	0	0.00
Owenia fusiformis	TK	54	0	0	0	0.00
Owenia fusiformis	TK	55	0	0	0	0.00
Owenia fusiformis	TK	56	1	0	1	0.08

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Owenia fusiformis	TK	57	0	0	0	0.00
Owenia fusiformis	TK	58	0	0	0	0.00
Owenia fusiformis	TK	59	0	0	0	0.00
Paracalliope novizelandiae	CB	52	0	0	0	0.00
Paracalliope novizelandiae	CB	53	0	0	0	0.00
Paracalliope novizelandiae	CB	54	0	0	0	0.00
Paracalliope novizelandiae	CB	55	0	0	0	0.00
Paracalliope novizelandiae	CB	56	0	0	0	0.00
Paracalliope novizelandiae	CB	57	0	0	0	0.00
Paracalliope novizelandiae	CB	58	0	0	0	0.00
Paracalliope novizelandiae	CB	59	0	0	0	0.00
Paracalliope novizelandiae	DC	52	0	0	0	0.00
Paracalliope novizelandiae	DC	53	0	0	0	0.00
Paracalliope novizelandiae	DC	54	0	0	0	0.00
Paracalliope novizelandiae	DC	55	0	0	0	0.00
Paracalliope novizelandiae	DC	56	4	0	1	0.33
Paracalliope novizelandiae	DC	57	7	0.5	2	0.58
Paracalliope novizelandiae	DC	58	1	0	1	0.08
Paracalliope novizelandiae	DC	59	7	0	6	0.58
Paracalliope novizelandiae	HL	52	0	0	0	0.00
Paracalliope novizelandiae	HL	53	1	0	1	0.08
Paracalliope novizelandiae	HL	54	0	0	0	0.00
Paracalliope novizelandiae	HL	55	0	0	0	0.00
Paracalliope novizelandiae	HL	56	0	0	0	0.00
Paracalliope novizelandiae	HL	57	0	0	0	0.00
Paracalliope novizelandiae	HL	58	0	0	0	0.00
Paracalliope novizelandiae	HL	59	2	0	1	0.17
Paracalliope novizelandiae	JB	52	13	0	7	1.08
Paracalliope novizelandiae	JB	53	14.2	0	8	1.18
Paracalliope novizelandiae	JB	54	7	0	3	0.58
Paracalliope novizelandiae	JB	55	6	0	6	0.50
Paracalliope novizelandiae	JB	56	10	0.5	3	0.83
Paracalliope novizelandiae	JB	57	3	0	1	0.25
Paracalliope novizelandiae	JB	58	11	0	8	0.92
Paracalliope novizelandiae	JB	59	0	0	0	0.00
Paracalliope novizelandiae	MH	52	3	0	3	0.25
Paracalliope novizelandiae	MH	53	0	0	0	0.00
Paracalliope novizelandiae	MH	54	0	0	0	0.00
Paracalliope novizelandiae	MH	55	0	0	0	0.00

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Paracalliope novizelandiae	MH	56	1	0	1	0.08
Paracalliope novizelandiae	MH	57	0	0	0	0.00
Paracalliope novizelandiae	MH	58	1	0	1	0.08
Paracalliope novizelandiae	MH	59	1	0	1	0.08
Paracalliope novizelandiae	TK	52	1	0	1	0.08
Paracalliope novizelandiae	TK	53	0	0	0	0.00
Paracalliope novizelandiae	TK	54	0	0	0	0.00
Paracalliope novizelandiae	TK	55	0	0	0	0.00
Paracalliope novizelandiae	TK	56	0	0	0	0.00
Paracalliope novizelandiae	TK	57	0	0	0	0.00
Paracalliope novizelandiae	TK	58	0	0	0	0.00
Paracalliope novizelandiae	TK	59	0	0	0	0.00
Perinereis nuntia	CB	52	0	0	0	0.00
Perinereis nuntia	CB	53	0	0	0	0.00
Perinereis nuntia	CB	54	0	0	0	0.00
Perinereis nuntia	CB	55	0	0	0	0.00
Perinereis nuntia	CB	56	0	0	0	0.00
Perinereis nuntia	CB	57	0	0	0	0.00
Perinereis nuntia	CB	58	0	0	0	0.00
Perinereis nuntia	CB	59	0	0	0	0.00
Perinereis nuntia	DC	52	0	0	0	0.00
Perinereis nuntia	DC	53	0	0	0	0.00
Perinereis nuntia	DC	54	0	0	0	0.00
Perinereis nuntia	DC	55	0	0	0	0.00
Perinereis nuntia	DC	56	4	0	1	0.33
Perinereis nuntia	DC	57	1	0	1	0.08
Perinereis nuntia	DC	58	0	0	0	0.00
Perinereis nuntia	DC	59	1	0	1	0.08
Perinereis nuntia	HL	52	1	0	1	0.08
Perinereis nuntia	HL	53	3	0	1	0.25
Perinereis nuntia	HL	54	0	0	0	0.00
Perinereis nuntia	HL	55	1	0	1	0.08
Perinereis nuntia	HL	56	0	0	0	0.00
Perinereis nuntia	HL	57	0	0	0	0.00
Perinereis nuntia	HL	58	0	0	0	0.00
Perinereis nuntia	HL	59	0	0	0	0.00
Perinereis nuntia	JB	52	0	0	0	0.00
Perinereis nuntia	JB	53	3.3	0	2	0.27
Perinereis nuntia	JB	54	2	0	1	0.17

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Perinereis nuntia	JB	55	1	0	1	0.08
Perinereis nuntia	JB	56	1	0	1	0.08
Perinereis nuntia	JB	57	1	0	1	0.08
Perinereis nuntia	JB	58	9	0	4	0.75
Perinereis nuntia	JB	59	0	0	0	0.00
Perinereis nuntia	MH	52	0	0	0	0.00
Perinereis nuntia	MH	53	0	0	0	0.00
Perinereis nuntia	MH	54	0	0	0	0.00
Perinereis nuntia	MH	55	0	0	0	0.00
Perinereis nuntia	MH	56	0	0	0	0.00
Perinereis nuntia	MH	57	0	0	0	0.00
Perinereis nuntia	MH	58	0	0	0	0.00
Perinereis nuntia	MH	59	0	0	0	0.00
Perinereis nuntia	TK	52	1	0	1	0.08
Perinereis nuntia	TK	53	2	0	1	0.17
Perinereis nuntia	TK	54	0	0	0	0.00
Perinereis nuntia	TK	55	0	0	0	0.00
Perinereis nuntia	TK	56	0	0	0	0.00
Perinereis nuntia	TK	57	0	0	0	0.00
Perinereis nuntia	TK	58	0	0	0	0.00
Perinereis nuntia	TK	59	1	0	1	0.08
Polydorids	CB	52	14	1	4	1.17
Polydorids	CB	53	24	2	5	2.00
Polydorids	CB	54	25.1	2	6	2.09
Polydorids	CB	55	8	0.5	2	0.67
Polydorids	CB	56	15	1	4	1.25
Polydorids	CB	57	9	1	2	0.75
Polydorids	CB	58	14	1	2	1.17
Polydorids	CB	59	4	0	2	0.33
Polydorids	DC	52	16	1	6	1.33
Polydorids	DC	53	28	1.5	8	2.33
Polydorids	DC	54	16	1	4	1.33
Polydorids	DC	55	15	1	5	1.25
Polydorids	DC	56	46	3	16	3.83
Polydorids	DC	57	26	1.5	9	2.17
Polydorids	DC	58	22	2	5	1.83
Polydorids	DC	59	15	1	6	1.25
Polydorids	HL	52	8	0.5	3	0.67
Polydorids	HL	53	145	11.5	28	12.08

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Polydorids	HL	54	63	3	26	5.25
Polydorids	HL	55	0	0	0	0.00
Polydorids	HL	56	6	0	2	0.50
Polydorids	HL	57	11	1	3	0.92
Polydorids	HL	58	11	1	3	0.92
Polydorids	HL	59	8	1	2	0.67
Polydorids	JB	52	22	1	11	1.83
Polydorids	JB	53	20.7	0	8	1.73
Polydorids	JB	54	8	0	3	0.67
Polydorids	JB	55	3	0	2	0.25
Polydorids	JB	56	16	0	13	1.33
Polydorids	JB	57	88	0.5	77	7.33
Polydorids	JB	58	12	0	5	1.00
Polydorids	JB	59	11	0	5	0.92
Polydorids	MH	52	21	1.5	6	1.75
Polydorids	MH	53	17	1	4	1.42
Polydorids	MH	54	14	1	4	1.17
Polydorids	MH	55	10	0	3	0.83
Polydorids	MH	56	14	0	4	1.17
Polydorids	MH	57	3	0	2	0.25
Polydorids	MH	58	11	1	3	0.92
Polydorids	MH	59	5	0	2	0.42
Polydorids	TK	52	13	0	5	1.08
Polydorids	TK	53	20	1	7	1.67
Polydorids	TK	54	2	0	1	0.17
Polydorids	TK	55	0	0	0	0.00
Polydorids	TK	56	1	0	1	0.08
Polydorids	TK	57	3	0	1	0.25
Polydorids	TK	58	10	0	5	0.83
Polydorids	TK	59	2	0	1	0.17
Prionospio aucklandica	CB	52	0	0	0	0.00
Prionospio aucklandica	CB	53	3	0	2	0.25
Prionospio aucklandica	CB	54	0	0	0	0.00
Prionospio aucklandica	CB	55	0	0	0	0.00
Prionospio aucklandica	CB	56	1	0	1	0.08
Prionospio aucklandica	CB	57	5	0	2	0.42
Prionospio aucklandica	CB	58	0	0	0	0.00
Prionospio aucklandica	CB	59	3	0	1	0.25
Prionospio aucklandica	DC	52	8	0	7	0.67

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Prionospio aucklandica	DC	53	9	0.5	3	0.75
Prionospio aucklandica	DC	54	2	0	1	0.17
Prionospio aucklandica	DC	55	14	1	6	1.17
Prionospio aucklandica	DC	56	53	1	14	4.42
Prionospio aucklandica	DC	57	13	1	2	1.08
Prionospio aucklandica	DC	58	11	0.5	3	0.92
Prionospio aucklandica	DC	59	16	0.5	8	1.33
Prionospio aucklandica	HL	52	16	1	4	1.33
Prionospio aucklandica	HL	53	13	1	4	1.08
Prionospio aucklandica	HL	54	2	0	1	0.17
Prionospio aucklandica	HL	55	31	1.5	8	2.58
Prionospio aucklandica	HL	56	27	2	6	2.25
Prionospio aucklandica	HL	57	18	1	4	1.50
Prionospio aucklandica	HL	58	33	3	6	2.75
Prionospio aucklandica	HL	59	125	9	13	10.42
Prionospio aucklandica	JB	52	0	0	0	0.00
Prionospio aucklandica	JB	53	0	0	0	0.00
Prionospio aucklandica	JB	54	0	0	0	0.00
Prionospio aucklandica	JB	55	5	0	2	0.42
Prionospio aucklandica	JB	56	3	0	2	0.25
Prionospio aucklandica	JB	57	2	0	1	0.17
Prionospio aucklandica	JB	58	8	0	4	0.67
Prionospio aucklandica	JB	59	5	0	2	0.42
Prionospio aucklandica	MH	52	3	0	1	0.25
Prionospio aucklandica	MH	53	1	0	1	0.08
Prionospio aucklandica	MH	54	0	0	0	0.00
Prionospio aucklandica	MH	55	1	0	1	0.08
Prionospio aucklandica	MH	56	6	0.5	1	0.50
Prionospio aucklandica	MH	57	4	0	1	0.33
Prionospio aucklandica	MH	58	4	0	3	0.33
Prionospio aucklandica	MH	59	0	0	0	0.00
Prionospio aucklandica	TK	52	31	1.5	10	2.58
Prionospio aucklandica	TK	53	20	1	6	1.67
Prionospio aucklandica	TK	54	10	0	3	0.83
Prionospio aucklandica	TK	55	22	1	9	1.83
Prionospio aucklandica	TK	56	51	3	11	4.25
Prionospio aucklandica	TK	57	9	1	3	0.75
Prionospio aucklandica	TK	58	16	0	8	1.33
Prionospio aucklandica	TK	59	8	0	4	0.67

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Scoloplos cylindrifer	CB	52	0	0	0	0.00
Scoloplos cylindrifer	CB	53	2	0	1	0.17
Scoloplos cylindrifer	CB	54	7.6	1	2	0.64
Scoloplos cylindrifer	CB	55	0	0	0	0.00
Scoloplos cylindrifer	CB	56	0	0	0	0.00
Scoloplos cylindrifer	CB	57	0	0	0	0.00
Scoloplos cylindrifer	CB	58	0	0	0	0.00
Scoloplos cylindrifer	CB	59	0	0	0	0.00
Scoloplos cylindrifer	DC	52	19	0	7	1.58
Scoloplos cylindrifer	DC	53	22	0	13	1.83
Scoloplos cylindrifer	DC	54	5	0	2	0.42
Scoloplos cylindrifer	DC	55	7	0	7	0.58
Scoloplos cylindrifer	DC	56	31	0	20	2.58
Scoloplos cylindrifer	DC	57	16	0	9	1.33
Scoloplos cylindrifer	DC	58	5	0	4	0.42
Scoloplos cylindrifer	DC	59	5	0	4	0.42
Scoloplos cylindrifer	HL	52	0	0	0	0.00
Scoloplos cylindrifer	HL	53	0	0	0	0.00
Scoloplos cylindrifer	HL	54	0	0	0	0.00
Scoloplos cylindrifer	HL	55	0	0	0	0.00
Scoloplos cylindrifer	HL	56	0	0	0	0.00
Scoloplos cylindrifer	HL	57	1	0	1	0.08
Scoloplos cylindrifer	HL	58	0	0	0	0.00
Scoloplos cylindrifer	HL	59	0	0	0	0.00
Scoloplos cylindrifer	JB	52	0	0	0	0.00
Scoloplos cylindrifer	JB	53	0	0	0	0.00
Scoloplos cylindrifer	JB	54	0	0	0	0.00
Scoloplos cylindrifer	JB	55	0	0	0	0.00
Scoloplos cylindrifer	JB	56	0	0	0	0.00
Scoloplos cylindrifer	JB	57	6	0	5	0.50
Scoloplos cylindrifer	JB	58	0	0	0	0.00
Scoloplos cylindrifer	JB	59	1	0	1	0.08
Scoloplos cylindrifer	MH	52	0	0	0	0.00
Scoloplos cylindrifer	MH	53	0	0	0	0.00
Scoloplos cylindrifer	MH	54	0	0	0	0.00
Scoloplos cylindrifer	MH	55	0	0	0	0.00
Scoloplos cylindrifer	MH	56	3	0	3	0.25
Scoloplos cylindrifer	MH	57	0	0	0	0.00
Scoloplos cylindrifer	MH	58	0	0	0	0.00

Taxa	Site	Time	Total[2]	Median	Range[3]	Mean
Scoloplos cylindrifer	MH	59	1	0	1	0.08
Scoloplos cylindrifer	TK	52	1	0	1	0.08
Scoloplos cylindrifer	TK	53	0	0	0	0.00
Scoloplos cylindrifer	TK	54	1	0	1	0.08
Scoloplos cylindrifer	TK	55	0	0	0	0.00
Scoloplos cylindrifer	TK	56	0	0	0	0.00
Scoloplos cylindrifer	TK	57	0	0	0	0.00
Scoloplos cylindrifer	TK	58	0	0	0	0.00
Scoloplos cylindrifer	TK	59	0	0	0	0.00
Torridoharpinia hurleyi	CB	52	0	0	0	0.00
Torridoharpinia hurleyi	CB	53	14	0.5	5	1.17
Torridoharpinia hurleyi	CB	54	15.3	1	4	1.27
Torridoharpinia hurleyi	CB	55	14	1	4	1.17
Torridoharpinia hurleyi	CB	56	0	0	0	0.00
Torridoharpinia hurleyi	CB	57	0	0	0	0.00
Torridoharpinia hurleyi	CB	58	34	3	7	2.83
Torridoharpinia hurleyi	CB	59	18	1	6	1.50
Torridoharpinia hurleyi	DC	52	0	0	0	0.00
Torridoharpinia hurleyi	DC	53	0	0	0	0.00
Torridoharpinia hurleyi	DC	54	0	0	0	0.00
Torridoharpinia hurleyi	DC	55	3	0	2	0.25
Torridoharpinia hurleyi	DC	56	4	0	1	0.33
Torridoharpinia hurleyi	DC	57	1	0	1	0.08

8.5 Appendix 5

Results of grain size analysis for the subtidal sites.

% Sediment composition	Year	Month	Site A	Site C
Gravel/shell hash	1995	Apr	0.17	7.10
	1996	Apr	0.00	0.00
	1997	Apr	0.20	3.01
	1998	Apr	0.08	5.22
	1999	Apr	0.05	5.23
	2000	Apr	0.74	14.77
		Oct	0.25	21.47
	2001	Apr	3.88	5.35
		Oct	0.07	1.56
	2002	Jan	0.08	1.47
		Apr	19.08	1.32
		Jul	0.00	0.35
		Oct	1.70	0.27
	2003	Jan	0.68	13.63
		Apr	20.12	1.58
		Jul	0.41	0.01
		Oct	0.00	0.00
	2004	Jan	0.09	11.17
		Apr	0.41	3.46
		Jul	0.80	5.16
		Oct	0.00	2.09
	2005	Jan	2.03	4.74
		Apr	10.76	9.14
		Jul	0.73	3.73
		Oct	0.96	0.15
	2006	Jan	0.36	20.49
		Apr	0.07	20.44
		Jul	0.00	3.39
		Oct	0.27	9.97
	2007	Jan	0.00	10.78
		Apr	0.19	8.77
		Jul	0.22	6.66
		Oct	0.61	9.89
	2008	Jan	1.06	4.42
		Apr	0.46	4.38
		Jul	0.11	0.92
		Oct	0.20	5.47
	2009	Jan	0.00	8.35

% Sediment composition	Year	Month	Site A	Site C
Coarse sand	1995	Apr	0.17	2.10
	1996	Apr	0.04	0.05
	1997	Apr	0.48	1.65
	1998	Apr	0.17	4.57
	1999	Apr	0.12	2.53
	2000	Apr	0.47	5.29
		Oct	0.48	4.26
	2001	Apr	0.76	2.70
		Oct	0.11	0.67
	2002	Jan	0.27	1.43
		Apr	3.57	0.53
		Jul	0.15	0.11
		Oct	1.05	0.92
	2003	Jan	0.99	2.95
		Apr	3.76	0.64
		Jul	0.45	0.13
		Oct	0.26	0.04
	2004	Jan	0.37	1.76
		Apr	0.52	0.90
		Jul	0.21	1.87
		Oct	0.44	1.69
	2005	Jan	0.00	2.42
		Apr	5.72	3.39
		Jul	0.34	0.64
		Oct	0.75	0.79
	2006	Jan	0.42	3.04
		Apr	0.26	3.59
		Jul	0.05	1.47
		Oct	0.32	1.21
	2007	Jan	0.34	1.49
		Apr	0.44	2.41
		Jul	0.24	3.24
		Oct	0.46	1.55
	2008	Jan	0.48	1.94
		Apr	0.62	2.09
		Jul	0.66	3.15
		Oct	0.33	4.18
	2009	Jan	0.21	1.80
Medium sand	1995	Apr	0.51	6.98
	1996	Apr	13.07	12.01
	1997	Apr	0.79	1.20
	1998	Apr	23.31	1.47
	1999	Apr	2.35	3.84
	2000	Apr	1.29	1.53

% Sediment composition	Year	Month	Site A	Site C
		Oct	1.04	1.22
	2001	Apr	0.65	1.19
		Oct	0.25	0.57
	2002	Jan	0.49	0.23
		Apr	0.96	0.51
		Jul	1.95	1.21
		Oct	0.63	1.00
	2003	Jan	0.64	1.11
		Apr	0.01	0.62
		Jul	0.79	0.20
		Oct	0.41	0.61
	2004	Jan	0.39	0.57
		Apr	0.64	1.25
		Jul	0.28	0.80
		Oct	0.73	0.81
	2005	Jan	0.68	0.29
		Apr	5.45	1.12
		Jul	0.56	0.90
		Oct	0.75	1.39
	2006	Jan	0.35	0.89
		Apr	0.29	1.07
		Jul	0.16	0.35
		Oct	0.76	0.54
	2007	Jan	0.48	0.64
		Apr	0.39	0.82
		Jul	0.42	1.11
		Oct	0.36	0.71
	2008	Jan	0.55	0.75
		Apr	0.30	0.72
		Jul	0.39	1.21
		Oct	0.33	1.19
	2009	Jan	0.27	0.62
Fine sand	1995	Apr	15.83	20.87
	1996	Apr	25.58	25.67
	1997	Apr	74.86	49.10
	1998	Apr	54.79	35.58
	1999	Apr	54.89	46.46
	2000	Apr	73.83	31.02
		Oct	71.15	28.51
	2001	Apr	71.34	46.34
		Oct	44.40	39.82
	2002	Jan	78.85	53.98
		Apr	29.04	76.10
		Jul	75.38	56.23

% Sediment composition	Year	Month	Site A	Site C
		Oct	77.04	44.27
	2003	Jan	76.85	41.51
		Apr	30.62	91.30
		Jul	73.89	71.53
		Oct	86.30	38.66
	2004	Jan	72.83	32.71
		Apr	72.27	52.60
		Jul	69.68	37.27
		Oct	69.26	34.18
	2005	Jan	75.60	39.01
		Apr	42.61	38.84
		Jul	71.62	29.54
		Oct	71.57	26.54
	2006	Jan	72.87	27.54
		Apr	71.76	32.34
		Jul	67.74	33.77
		Oct	66.23	33.82
	2007	Jan	76.03	32.84
		Apr	74.60	41.00
		Jul	70.56	39.44
		Oct	73.03	31.38
	2008	Jan	69.14	34.56
		Apr	70.43	30.54
		Jul	66.53	35.88
		Oct	74.85	35.37
	2009	Jan	68.51	35.78
Silt	1995	Apr	73.72	55.41
	1996	Apr	41.96	40.91
	1997	Apr	18.13	42.85
	1998	Apr	16.13	46.06
	1999	Apr	29.39	39.47
	2000	Apr	15.37	30.09
		Oct	23.11	37.01
	2001	Apr	20.18	36.55
		Oct	21.31	45.77
	2002	Jan	17.85	35.53
		Apr	14.95	16.15
		Jul	15.76	32.51
		Oct	10.60	34.23
	2003	Jan	12.65	16.32
		Apr	9.47	22.50
		Jul	17.46	18.46
		Oct	12.34	41.61
	2004	Jan	17.69	35.58

% Sediment composition	Year	Month	Site A	Site C
		Apr	13.08	23.89
		Jul	27.24	52.63
		Oct	19.71	43.74
	2005	Jan	19.72	49.71
		Apr	17.73	34.27
		Jul	16.72	42.51
		Oct	12.30	47.43
	2006	Jan	18.83	36.21
		Apr	20.72	30.61
		Jul	23.23	42.71
		Oct	20.53	34.39
	2007	Jan	17.02	32.91
		Apr	18.06	37.26
		Jul	19.73	33.54
		Oct	14.90	43.34
	2008	Jan	20.07	47.07
		Apr	19.32	45.66
		Jul	18.92	38.61
		Oct	15.18	28.96
	2009	Jan	20.67	40.54

% Sediment composition	Year	Month	Site A	Site C
Clay	1995	Apr	9.61	7.48
	1996	Apr	19.35	21.36
	1997	Apr	5.53	2.19
	1998	Apr	5.52	7.11
	1999	Apr	13.20	2.46
	2000	Apr	8.30	17.30
		Oct	3.97	7.52
	2001	Apr	3.19	7.86
		Oct	3.98	11.59
	2002	Jan	2.46	7.37
		Apr	32.40	5.38
		Jul	6.75	9.59
		Oct	8.97	15.32
	2003	Jan	8.18	24.47
		Apr	20.53	7.50
		Jul	6.99	9.67
		Oct	0.69	19.07
	2004	Jan	8.62	18.20
		Apr	13.08	17.91
		Jul	1.79	2.27
		Oct	9.85	17.50
	2005	Jan	1.97	3.82
		Apr	17.73	13.24
		Jul	10.03	22.67
		Oct	12.30	23.71
	2006	Jan	7.17	11.84
		Apr	6.91	11.95
		Jul	8.81	18.31
		Oct	11.88	20.06
	2007	Jan	6.13	21.34
		Apr	6.32	9.74
		Jul	8.83	16.01
		Oct	10.64	13.13
	2008	Jan	8.70	11.26
		Apr	8.86	16.61
		Jul	13.40	20.23
		Oct	9.11	24.83
	2009	Jan	10.34	12.90

8.6 Appendix 6

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

A. Organic content

Sampling date	Site A	Site C
Oct00	1.93	3.43
Apr01	2.99	3.23
Oct01	2.42	4.15
Jan02	3.07	4.77
Apr02	3.86	2.44
Jul02	2.53	3.93
Oct02	1.46	2.44
Jan03	2.66	3.76
Apr03	1.85	4.33
July03	2.01	2.27
Oct03	2.40	4.41
Jan04	2.05	3.30
Apr04	5.13*	7.39
Jul04	3.72	0.93
Oct04	4.26	10.24*
Jan05	3.27	7.19
Apr05	2.64	1.07
July05	2.93	5.18
Oct05	2.86	2.81
Jan06	3.12	4.69
Apr06	2.08	3.26
Jul06	3.46	5.35
Oct06	3.95	5.06
Jan07	2.39	3.51
Apr-07	3.11	3.64
Jul-07	3.48	5.48
Oct-07	2.85	4.61
Jan-08	2.90	5.63
Apr-08	2.76	4.63
Jul-08	3.19	4.44
Oct-08	2.74	5.25
Jan-09	3.58	4.95
range	1.46 - 5.13	0.93 - 10.24

B. Chlorophyll *a*

Sampling date	Site A	Site C
Oct00	4.64	4.71
Apr01	3.66	2.97
Oct01	6.17	5.01
Jan02	3.87	4.99
Apr02	8.00	5.46
Jul02	4.35	3.62
Oct02	4.32	4.17
Jan03	5.44	4.78
Apr03	4.45	1.94
July03	6.73	7.11
Oct03	2.41	3.64
Jan04	4.23	4.79
Apr04	3.51	2.87
Jul04	3.28	4.06
Oct04	2.86	2.41
Jan05	4.00	4.57
Apr05	4.24	2.28
July05	3.66	3.99
Oct05	9.01*	10.48*
Jan06	3.68	3.02
Apr06	4.01	3.09
Jul06	4.24	3.84
Oct06	3.44	4.13
Jan07	4.47	5.50
Apr-07	5.85	4.13
Jul-07	3.78	4.47
Oct-07	4.93	6.53
Jan-08	5.39	5.27
Apr-08	5.04	5.62
Jul-08	4.01	4.13
Oct-08	3.67	5.27
Jan-09	4.01	4.36
range	2.41 - 9.01	1.94 - 10.48

8.7 Appendix 7

Summary of the temporal results at the subtidal sites from April 2007 (Time = 52) to January 2009 (Time = 59). SA = Site A, SC = Site C.

Taxa	Site	Time	Total[4]	Median	Range[5]	Mean
Aricidea sp.	SA	52	2	0	1	0.17
Aricidea sp.	SA	53	2	0	1	0.17
Aricidea sp.	SA	54	20	1	5	1.67
Aricidea sp.	SA	55	13	1	2	1.08
Aricidea sp.	SA	56	16	1	4	1.33
Aricidea sp.	SA	57	10	5	4	0.83
Aricidea sp.	SA	58	18	1	4	1.50
Aricidea sp.	SA	59	15	1	4	1.25
Aricidea sp.	SC	52	0	0	0	0.00
Aricidea sp.	SC	53	0	0	0	0.00
Aricidea sp.	SC	54	10	5	4	0.83
Aricidea sp.	SC	55	3	0	1	0.25
Aricidea sp.	SC	56	0	0	0	0.00
Aricidea sp.	SC	57	21	2	4	1.75
Aricidea sp.	SC	58	8	0	4	0.67
Aricidea sp.	SC	59	3	0	2	0.25
Armandia maculata	SA	52	0	0	0	0.00
Armandia maculata	SA	53	0	0	0	0.00
Armandia maculata	SA	55	0	0	0	0.00
Armandia maculata	SA	56	12	0	8	1.00
Armandia maculata	SA	57	0	0	0	0.00
Armandia maculata	SA	58	0	0	0	0.00
Armandia maculata	SA	59	0	0	0	0.00
Armandia maculata	SC	52	1	0	1	0.08
Armandia maculata	SC	53	0	0	0	0.00
Armandia maculata	SC	54	1	0	1	0.08
Armandia maculata	SC	55	0	0	0	0.00
Armandia maculata	SC	56	2	0	1	0.17
Armandia maculata	SC	57	0	0	0	0.00

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

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

Taxa	Site	Time	Total[4]	Median	Range[5]	Mean
Armandia maculata	SC	58	0	0	0	0.00
Armandia maculata	SC	59	0	0	0	0.00
Arthritica bifurca	SA	52	2	0	1	0.17
Arthritica bifurca	SA	53	0	0	0	0.00
Arthritica bifurca	SA	54	7	0	2	0.58
Arthritica bifurca	SA	55	11	5	4	0.92
Arthritica bifurca	SA	56	11	1	5	0.92
Arthritica bifurca	SA	57	7	0	3	0.58
Arthritica bifurca	SA	58	5	0	2	0.42
Arthritica bifurca	SA	59	3	0	1	0.25
Arthritica bifurca	SC	52	25	1	9	2.08
Arthritica bifurca	SC	53	9	0	3	0.75
Arthritica bifurca	SC	54	5	0	4	0.42
Arthritica bifurca	SC	55	13	5	4	1.08
Arthritica bifurca	SC	56	9	0	4	0.75
Arthritica bifurca	SC	57	6	0	4	0.50
Arthritica bifurca	SC	58	5	0	2	0.42
Arthritica bifurca	SC	59	0	0	0	0.00
Cirratulids	SA	52	5	0	1	0.42
Cirratulids	SA	53	6	0	2	0.50
Cirratulids	SA	54	11	5	3	0.92
Cirratulids	SA	55	6	0	2	0.50
Cirratulids	SA	56	8	0	2	0.67
Cirratulids	SA	57	10	5	3	0.83
Cirratulids	SA	58	12	1	2	1.00
Cirratulids	SA	59	23	2	5	1.92
Cirratulids	SC	52	28	205	5	2.33
Cirratulids	SC	53	4	0	2	0.33
Cirratulids	SC	54	17	105	4	1.42
Cirratulids	SC	55	24	2	5	2.00
Cirratulids	SC	56	19	1	6	1.58
Cirratulids	SC	57	13	1	3	1.08
Cirratulids	SC	58	34	2	9	2.83
Cirratulids	SC	59	27	205	6	2.25
Corophidae-complex	SA	52	3	0	2	0.25
Corophidae-complex	SA	53	0	0	0	0.00
Corophidae-complex	SA	54	1	0	1	0.08
Corophidae-complex	SA	55	2	0	2	0.17
Corophidae-complex	SA	56	1	0	1	0.08

Taxa	Site	Time	Total[4]	Median	Range[5]	Mean
Corophidae-complex	SA	57	0	0	0	0.00
Corophidae-complex	SA	58	6	0	5	0.50
Corophidae-complex	SA	59	3	0	3	0.25
Corophidae-complex	SC	52	2	0	1	0.17
Corophidae-complex	SC	53	8	0	5	0.67
Corophidae-complex	SC	54	3	0	3	0.25
Corophidae-complex	SC	55	4	0	3	0.33
Corophidae-complex	SC	56	4	0	1	0.33
Corophidae-complex	SC	57	4	0	3	0.33
Corophidae-complex	SC	58	0	0	0	0.00
Corophidae-complex	SC	59	6	0	2	0.50
Nucula hartvigiana	SA	52	13	1	3	1.08
Nucula hartvigiana	SA	53	0	0	0	0.00
Nucula hartvigiana	SA	54	0	0	0	0.00
Nucula hartvigiana	SA	55	3	0	2	0.25
Nucula hartvigiana	SA	56	0	0	0	0.00
Nucula hartvigiana	SA	57	0	0	0	0.00
Nucula hartvigiana	SA	58	0	0	0	0.00
Nucula hartvigiana	SA	59	1	0	1	0.08
Nucula hartvigiana	SC	52	11	5	3	0.92
Nucula hartvigiana	SC	53	1	0	1	0.08
Nucula hartvigiana	SC	54	0	0	0	0.00
Nucula hartvigiana	SC	55	0	0	0	0.00
Nucula hartvigiana	SC	56	2	0	1	0.17
Nucula hartvigiana	SC	57	6	0	2	0.50
Nucula hartvigiana	SC	58	0	0	0	0.00
Nucula hartvigiana	SC	59	0	0	0	0.00
Oligochaetes	SA	52	1	0	1	0.08
Oligochaetes	SA	53	2	0	1	0.17
Oligochaetes	SA	54	3	0	1	0.25
Oligochaetes	SA	55	3	0	1	0.25
Oligochaetes	SA	56	6	0	3	0.50
Oligochaetes	SA	57	2	0	1	0.17
Oligochaetes	SA	58	1	0	1	0.08
Oligochaetes	SA	59	5	0	3	0.42
Oligochaetes	SC	52	41	2	15	3.42
Oligochaetes	SC	53	19	5	7	1.58
Oligochaetes	SC	54	38	105	12	3.17
Oligochaetes	SC	55	23	0	8	1.92

Taxa	Site	Time	Total[4]	Median	Range[5]	Mean
Oligochaetes	SC	56	27	105	7	2.25
Oligochaetes	SC	57	93	505	22	7.75
Oligochaetes	SC	58	74	305	20	6.17
Oligochaetes	SC	59	51	305	15	4.25
Polydorids	SA	52	1	0	1	0.08
Polydorids	SA	53	5	0	2	0.42
Polydorids	SA	54	4	0	1	0.33
Polydorids	SA	55	0	0	0	0.00
Polydorids	SA	56	17	0	8	1.42
Polydorids	SA	57	3	0	2	0.25
Polydorids	SA	58	10	0	8	0.83
Polydorids	SA	59	1	0	1	0.08
Polydorids	SC	52	10	1	2	0.83
Polydorids	SC	53	12	5	6	1.00
Polydorids	SC	54	31	0	18	2.58
Polydorids	SC	55	2	0	1	0.17
Polydorids	SC	56	8	0	2	0.67
Polydorids	SC	57	13	0	10	1.08
Polydorids	SC	58	11	0	7	0.92
Polydorids	SC	59	37	105	15	3.08
Prionospio spp.	SA	52	3	0	1	0.25
Prionospio spp.	SA	53	5	0	4	0.42
Prionospio spp.	SA	54	5	0	2	0.42
Prionospio spp.	SA	55	7	0	3	0.58
Prionospio spp.	SA	56	14	0	5	1.17
Prionospio spp.	SA	57	5	0	3	0.42
Prionospio spp.	SA	58	10	5	3	0.83
Prionospio spp.	SA	59	9	0	3	0.75
Prionospio spp.	SC	52	6	0	3	0.50
Prionospio spp.	SC	53	5	0	2	0.42
Prionospio spp.	SC	54	1	0	1	0.08
Prionospio spp.	SC	55	10	0	4	0.83
Prionospio spp.	SC	56	11	0	4	0.92
Prionospio spp.	SC	57	5	0	4	0.42
Prionospio spp.	SC	58	16	1	7	1.33
Prionospio spp.	SC	59	9	1	2	0.75
Tawera spissa	SA	52	0	0	0	0.00
Tawera spissa	SA	53	0	0	0	0.00
Tawera spissa	SA	54	0	0	0	0.00

Taxa	Site	Time	Total[4]	Median	Range[5]	Mean
Tawera spissa	SA	55	4	0	2	0.33
Tawera spissa	SA	56	5	0	1	0.42
Tawera spissa	SA	57	3	0	2	0.25
Tawera spissa	SA	58	0	0	0	0.00
Tawera spissa	SA	59	0	0	0	0.00
Tawera spissa	SC	52	0	0	0	0.00
Tawera spissa	SC	53	0	0	0	0.00
Tawera spissa	SC	54	0	0	0	0.00
Tawera spissa	SC	55	2	0	1	0.17
Tawera spissa	SC	56	4	0	1	0.33
Tawera spissa	SC	57	1	0	1	0.08
Tawera spissa	SC	58	1	0	1	0.08
Tawera spissa	SC	59	0	0	0	0.00
Theora lubrica	SA	52	10	0	4	0.83
Theora lubrica	SA	53	4	0	2	0.33
Theora lubrica	SA	54	2	0	2	0.17
Theora lubrica	SA	55	4	0	1	0.33
Theora lubrica	SA	56	267	18	53	22.25
Theora lubrica	SA	57	60	305	13	5.00
Theora lubrica	SA	58	24	105	5	2.00
Theora lubrica	SA	59	0	0	0	0.00
Theora lubrica	SC	52	96	905	19	8.00
Theora lubrica	SC	53	96	7	16	8.00
Theora lubrica	SC	54	124	8	21	10.33
Theora lubrica	SC	55	131	905	20	10.92
Theora lubrica	SC	56	369	3405	43	30.75
Theora lubrica	SC	57	139	1105	19	11.58
Theora lubrica	SC	58	48	305	9	4.00
Theora lubrica	SC	59	0	0	0	0.00
Torridoharpinia hurleyi	SA	52	1	0	1	0.08
Torridoharpinia hurleyi	SA	53	23	2	5	1.92
Torridoharpinia hurleyi	SA	54	8	0	5	0.67
Torridoharpinia hurleyi	SA	55	12	5	3	1.00
Torridoharpinia hurleyi	SA	56	10	1	3	0.83
Torridoharpinia hurleyi	SA	57	2	0	1	0.17
Torridoharpinia hurleyi	SA	58	17	1	4	1.42
Torridoharpinia hurleyi	SA	59	27	2	5	2.25
Torridoharpinia hurleyi	SC	52	4	0	1	0.33
Torridoharpinia hurleyi	SC	53	14	5	3	1.17

Taxa	Site	Time				Mean
			Total[4]	Median	Range[5]	
Torridoharpinia hurleyi	SC	54	10	5	4	0.83
Torridoharpinia hurleyi	SC	55	19	1	4	1.58
Torridoharpinia hurleyi	SC	56	6	0	2	0.50
Torridoharpinia hurleyi	SC	57	10	5	4	0.83
Torridoharpinia hurleyi	SC	58	15	1	4	1.25
Torridoharpinia hurleyi	SC	59	24	1	11	2.00