Mahurangi Estuary Ecological Monitoring Programme:

Report on data collected from July 1994 to January 2011

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Mahurangi Estuary Monitoring Programme

Report on data collected from July 1994 to January 2011

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Prepared for
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Executive Summary

Populations and communities of the Mahurangi Estuary monitored macrofaunal taxa, and site sediment characteristics, have not changed markedly at the intertidal sites over the past two years of monitoring. The monitored macrofaunal communities at Hamilton Landing, Te Kapa Inlet and Cowans Bay are very similar to each other, as are the communities of Dyers Creek and Mid Harbour. The composition of the Jamieson Bay monitored community continues to exhibit considerable variability over time. The subtidal monitored communities of Sites A and C have been very similar to each other on all but the most recent sampling date, when the Site C community deviated from its previous temporal trajectory. A total of 24 intertidal populations have exhibited ecologically meaningful trends in abundance (increases or decreases); 10 of these are increasing trends and 14 are decreasing trends. All sites have populations that are exhibiting trends; most of these populations occur at Hamilton Landing and Te Kapa Inlet, and the least at Cowans Bay. Three subtidal populations have exhibited trends in abundance, all of which are increases.

Of most concern is that five intertidal species considered sensitive to increased sediment loading have continued to decline in abundance. Two important bivalve taxa, *Macomona* and *Austrovenus* have declined at two and four sites respectively. *Macomona* recruitment events have occurred at some of the sites showing declines; however, in most cases, these juvenile *Macomona* have not persisted in the population.

Numbers of the large horse mussel *Atrina zelandica* have been very low at both subtidal sites over the last two years, and no growth of existing individuals has been observed. These observations reflect the fact that these populations have aged and reached their maximum size. No new *Atrina* beds have been noted in the vicinity of our subtidal sites. Consequently, we see no value in continuing to monitor the *Atrina* at these sites, and suggest that mapping the populations of these important bivalves in the wider estuary, at less frequent intervals, would be more informative.

A new assessment of functional ‘health’ of the monitored community (NIWA-COBBII) revealed that Jamieson Bay has an extremely high ‘ecological functioning’ index, reflecting the heterogeneous nature of the environment and the high species diversity at this site. The indices for the four remaining intertidal sites were considerably lower, and those for the two subtidal sites were intermediate between these. Evaluation of benthic community ‘health’ using the Benthic Health Model indicated that assemblages at the sites were influenced more by sediment mud content than by metal contamination (i.e., by copper, lead and/or zinc).

Sediment contamination by metals and Polycyclic Aromatic Hydrocarbons (PAH) at the intertidal sites were assessed against management guidelines. Levels of all metals and PAH were below guidelines, with one exception: concentrations of arsenic were elevated at Te Kapa Inlet. Arsenic concentrations at all other intertidal sites but one (Dyers Creek) were also close to this threshold.

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. 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. Evidence of recruitment of juvenile bivalves is encouraging and highlights the potential for the recovery of some areas of the harbour should sediment control measures be effective. Unfortunately, these recruitment events have not yet translated to increases in numbers of large, spawning sized individuals, indicating the recruits did not remain at the site.

Additional analyses presented in this year's report have been useful in providing further understanding of the functional health of the Mahurangi Estuary communities and the potential influences of site environmental conditions on the monitored taxa. After 16.5 years of monitoring, we recommend that three sites, the intertidal site Cowans Bay, and subtidal sites A and C should be rotated out of the monitoring programme, using the same model currently used for the Manukau and Central Waitemata Harbour monitoring programmes. Resting these sites for five years will not compromise our ability to detect changes in the estuary's macrofauna or *Atrina* populations. We will re-evaluate this decision in light of changes in catchment development plans, or any other concerns which AC might have for this estuary in the future.

1 Introduction

In July 1994 a long-term ecological monitoring programme of the intertidal and subtidal benthic communities 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 (ARC) (Cummings et al. 1994).

This monitoring programme has now been running for 16.5 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. For cost effectiveness, monitoring is based on 19 intertidal taxa and 12 subtidal taxa which were selected for their community importance and to provide a range of responses to different anthropogenic impacts and environmental conditions (taxa listed in Appendix 1). This increases the ability of the monitoring programme to detect important community changes.

On the basis of trend and community analyses of the monitored taxa, we describe the current ecological status of the estuary and make recommendations for the future of this monitoring programme.

Since the MAP was established in 2004, the ARC and Rodney District Council have supported approximately $1,370,000 worth of work to reduce sediment loads to Mahurangi Estuary. Much of this work was undertaken in the Te Kapa and Dyers Creek catchments. This work has included:

- funding for 80 kilometres of stream and coastal edge fencing on private land;
- protection of 869 hectares of land through this fencing;
- planting of approximately 150,000 native seedlings;
- completion of 39 farm plans.

Priority areas for future work under the MAP are the Dyers Creek, Duck Creek and Te Kapa catchments (Dr Megan Carbines, Auckland Council, pers comm., June 2011).

In 2004, Dr Greg Skilleter (University of Queensland, Australia) peer reviewed the Mahurangi Estuary monitoring programme for the Auckland Regional Council (ARC 2004a). His brief was to determine if the monitoring programme was sufficiently robust to support the conclusions made in the 2003 Mahurangi Estuary monitoring report (Cummings et al. 2003) that an ecologically significant decline in the condition of certain biota was occurring. Dr Skilleter was also asked to assess whether the available information supported the conclusion that sediment was the most likely cause of the observed ecological changes and, if so, whether management changes designed to reduce sediment loads in to the estuary would be sufficient to significantly improve the health of the resident biota.

Dr Skilleter concluded that there were (i) very, broad scale (estuary wide) declines in the abundance of some sedimentation-intolerant taxa, and (ii) general increases in the abundance of other groups, and that (iii) these changes are consistent with a model of large scale increases in sedimentation and benthic resuspension across the estuary (ARC 2004a).

2 Methods

2.1 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). The Jamieson Bay site also covers a greater tidal range than the other intertidal 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 a site initially surveyed by NIWA in 1993 (Cummings et al. 1994).

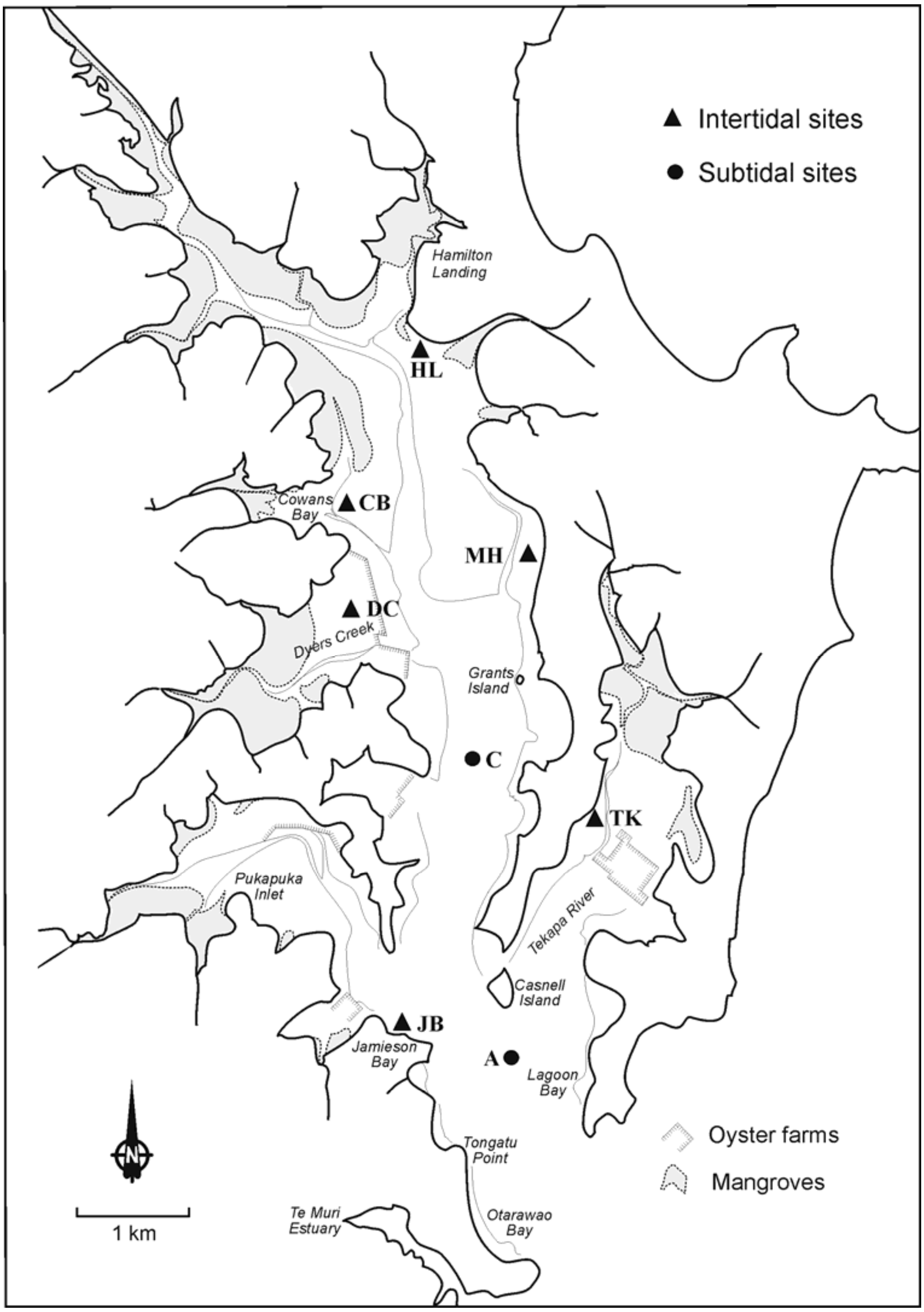
All six intertidal sites are sampled at three-monthly intervals.

2.1.1 Macrofauna

On each sampling occasion, core samples (13 cm diameter, 15 cm deep) are collected at 12 predetermined locations at each site. To provide adequate dispersion over the site, each site is ‘divided’ into 12 equal blocks and one core sample taken from a random location within each block. To reduce the influence of previous sampling activity and spatial autocorrelation (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 Manukau and Waitemata ecological monitoring programs. 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 - 20 mm, >20 mm. In addition, while each monitored bivalve taxon was measured from 1997-2009, in July 2009 this list was reduced to the three major species, *Macomona liliana, Austrovenus stutchburyi* and *Theora lubrica* (Halliday & Cummings 2009).

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.



2.1.2 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 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.

2.2 Subtidal Sites

Three permanent subtidal sites were established in locations predetermined from the initial survey of the estuary (Cummings et al. 1994). Following the recommendations made in our 2001 report (Cummings et al. 2001), the number of subtidal sites routinely monitored was reduced to two, 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 randomly 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.

2.2.1 Macrofauna

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

2.2.2 Sediment characteristics

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

2.2.3 *Atrina zelandica*

Estimates of size and density of the *Atrina* are made at each subtidal site. Ten quadrats (0.25 m^2) are randomly 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.

2.3 Analyses of macrofaunal abundance

2.3.1 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.

2.3.2 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 and step trends were assessed 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.

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

To determine the relative functional health of each site, community compositions, including non-monitored taxa, from all sites in October 2010 were analysed using the NIWACOOBII index (Lohrer & Rodil 2011). The NIWACOOBII index was developed for the Auckland Council by NIWA to provide an understandable and scientifically defensible indicator of the ecological integrity of its estuarine and coastal areas. The index is based upon the richness of macrofaunal taxa in each of seven functional trait groups (e.g., organism size, mobility, feeding mode, position in the sediment, etc.). For the Mahurangi Estuary communities, the seven individual trait groups selected for use were those most sensitive to mud and metals. The index value ranges from 0 to 1, with 0 indicating highly degraded sites and 1 indicating the opposite. Declines in NIWACOOBII scores with increases in mud and heavy metal concentrations are interpreted as losses of functional redundancy. Habitats with high functional redundancy (i.e., many species present in each functional trait group) will tend to have higher inherent resistance and resilience in the face of environmental changes, as the higher numbers of species per functional group provide “insurance” for stochastic or stress-induced losses of particular species.

The NIWACOOBII index was calculated using the October 2010 data. This is the best taxonomically resolved data set each year and will allow comparison in future between Mahurangi sites and other Auckland State-of-the-Environment harbour monitoring sites. The list of taxa found in a particular set of samples (i.e., the 12 replicates from a specific site in October 2010) was matched to the functional traits database and a score was assigned. The scores were added together (SUMactual) and used in the formula below:

$$1 – (SUM_{max} – SUM_{actual})/SUM_{max}$$

The SUM_{max} used was 226.39, which is the maximum SUM score for 12 replicates calculated in Lohrer & Rodil (2011).

In response to a request by the Auckland Council, we also assessed whether any changes in species abundance at the intertidal sites were consistent with contamination by selected heavy metals or Polycyclic Aromatic Hydrocarbons (PAH). In November 2010, Auckland Council staff collected three replicate sediment samples from each intertidal site to determine the levels of copper, zinc and lead, and one sample per site to determine levels of arsenic, cadmium, chromium, mercury, nickel, within the >500 µm sediment fraction. Concentrations of copper, zinc and lead in the <63 µm sediment fraction were also determined. High molecular weight and total Polycyclic Aromatic Hydrocarbons (HMW PAH and Total PAH) concentrations were assessed in the >500µm sediment fraction at Jameson Bay and Hamilton Landing only. The samples were analysed by Hills Laboratory using standard procedures. Contaminant levels were then assessed against threshold levels provided by three guidelines (MacDonald et al. 1996, Long & Morgan 1990, ARC 2004b).

The Benthic Health Model (BHM) was then used to assess the influence of mud content and contamination by metals (copper, lead and zinc only), on the October 2010 benthic communities (Anderson et al. 2006, Hewitt & Ellis 2010). The BHM was developed by the Auckland Council to provide a tool for classifying sites within the region according to categories of relative ecosystem health, based on community compositions and predicted responses to storm-water contamination. The model is based on canonical ordination of Principle Coordinates (CAP) using Bray-Curtis dissimilarities. Composition in relation to sediment muddiness was assessed at the intertidal and subtidal sites, and in relation to metal concentrations at the intertidal sites only.

3 Results and Discussion

3.1 Intertidal sites

3.1.1 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 early years of monitoring (April 1995; Figure 2, Appendix 2). Careful visual examination of the data has not revealed any long-term trends in any of the other sediment grain size components over the monitored period.

The organic and chlorophyll *a* content of the sediments at each site from July 2000 to January 2011 are provided in Appendix 3. The organic content is lowest at Dyers Creek (range 0.76-1.94% since monitoring began at this site in October 2005), and highest on average 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 strong 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 - 8.94 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 representative years of the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 2.

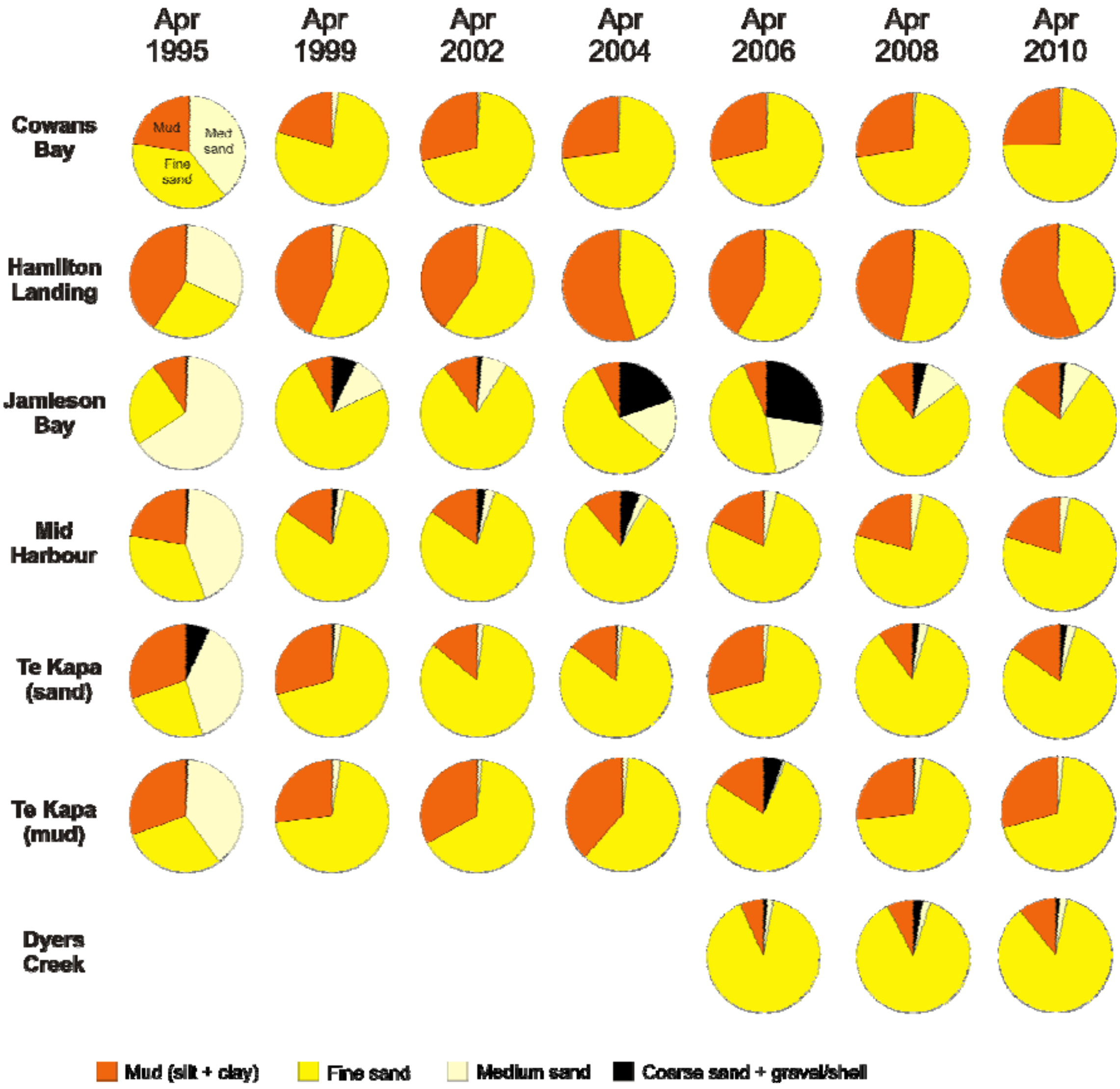
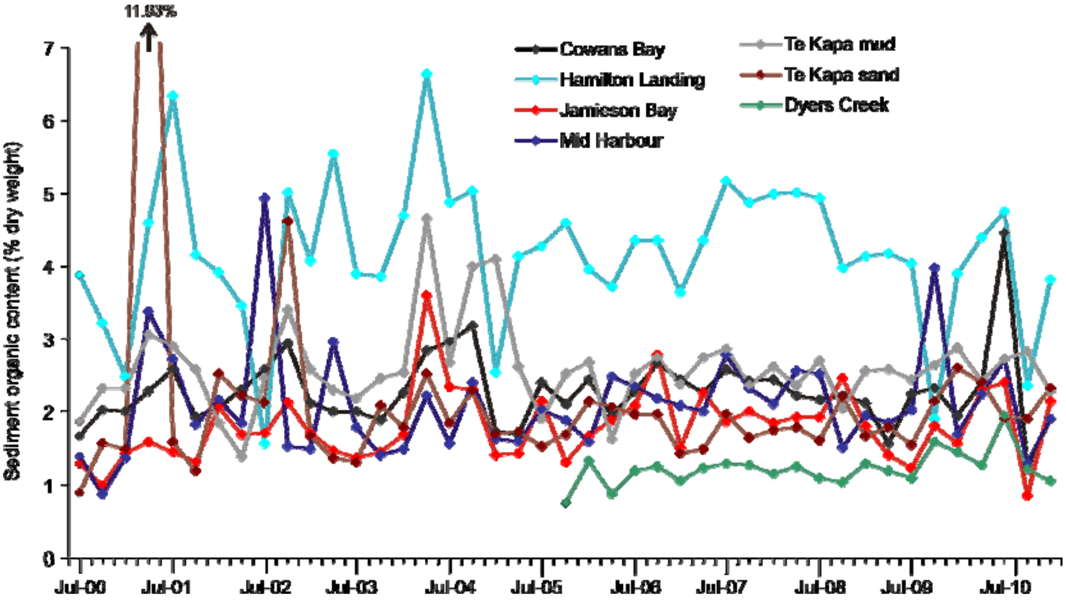


Figure 3

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



3.1.2 Macrofauna - comments on the abundance of common taxa

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

3.1.2.1 Cowans Bay

Prior to 2009, the polychaete *Cossura consimilis* was the dominant taxa at Cowans Bay on all but one occasion (135-738 individuals; Appendix 5). In the last two years of sampling *Cossura* has remained common (132 – 200 individuals); but is now generally ranked the second most common taxon (Appendix 5). Another polychaete, *Heteromastus filiformis,* was the dominant taxon at this site on four of the eight sampling dates in the past two years, and was the second or third most commonly ranked taxon on the other four occasions (96-180 individuals; Appendix 5). The small

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[1] *Macropthalmus hirtipes* is now referred to as *Hemiplax hirtipes* and *Aquilaspio aucklandica* is referred to as *Prionospio aucklandica* following a taxonomic name changes. Also *Aonides oxycephala* has changed its name to *Aonides trifida* since the beginning of the monitoring programme.

bivalve *Arthritica bifurca* has featured amongst the dominant taxa on six of the eight most recent sampling dates. In January 2011, it was the most abundant taxon (152 individuals). The amphipod *Torriodoharpinia hurleyi* was the third most common taxon on one occasion in recent years.

Populations showing cyclic abundance patterns

The nut shell *Nucula hartvigiana* exhibits peaks in abundance in either January or October of most years (Figure 4). An increase in the size of recruitment peaks and baseline abundance of this bivalve reported in the 2007 report is no longer apparent with the addition of four more years of data. The mud crab *Hemiplax hirtipes* is also most abundant in October or January, although its 2010 peak occurrences were found in July (Figure 5). *Heteromastus filiformis* numbers generally peak in July or October (Figure not shown).

Figure 4

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

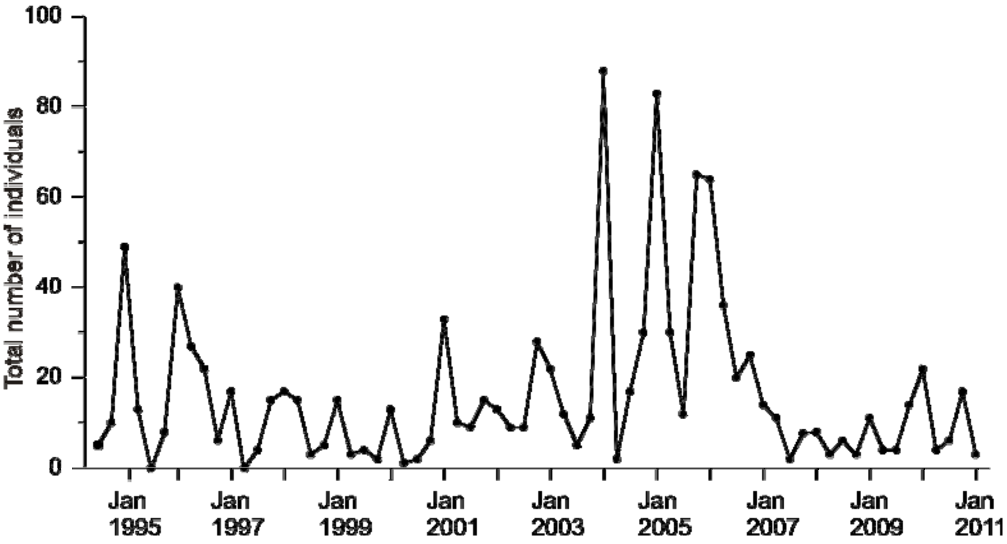
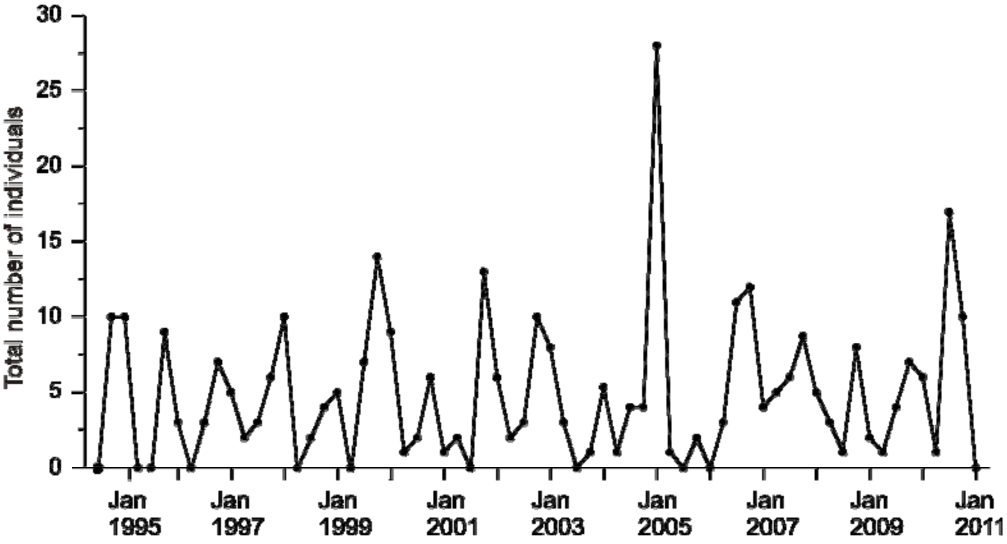


Figure 5

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

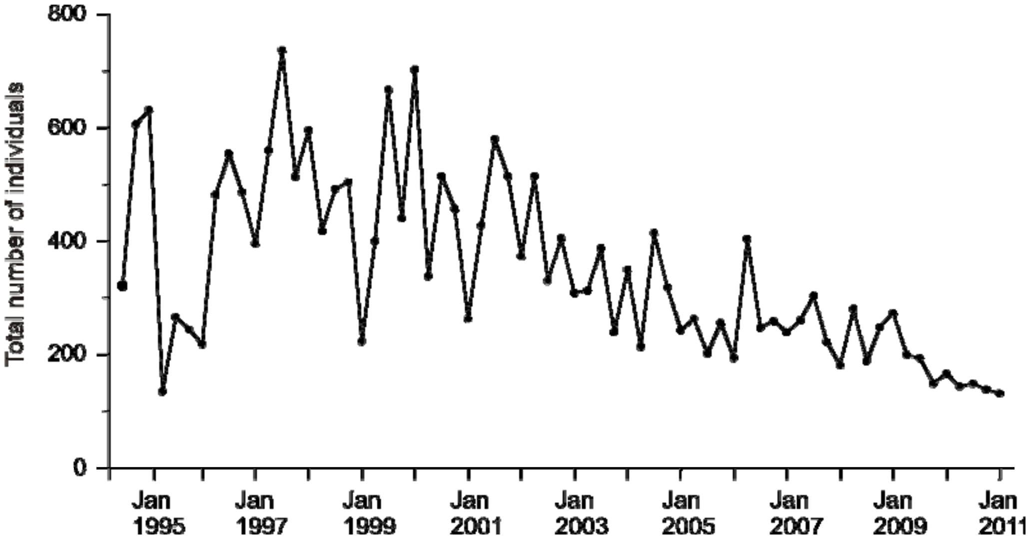


Populations showing trends in abundance

Only one taxon exhibits a trend in abundance at Cowans Bay. The decline in *Cossura consimilis* first detected in our 2009 report is still evident (Table 1), reflecting the fact that this polychaete is no longer the most abundant taxa at this site. *Cossura* has always been found in very high numbers at this site and, while abundances are still very high; numbers are now the lowest they have been since monitoring began (Figure 6). The emerging trend identified in the 2009 report, a small decline in nemertean abundance, is no longer apparent, and with the addition of two more years of data this has proven to be a function of poor recruitment between 2006 and 2008 (Table 1).

Figure 6

Total number of *Cossura consimilis* collected on each sampling occasion at Cowans Bay showing a decreasing trend in abundance. While peaks in abundance of this polychaete have declined over the last few years, numbers are now lower than those found in the first year of monitoring.



3.1.2.2 Dyers Creek

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

Dyers Creek is dominated by the bivalves *Nucula hartvigiana* (18-346 individuals) and *Austrovenus stutchburyi* (180-336 individuals) (Appendix 6). The polychaete *Prionospio aucklandica* (45-94 individuals) was the second or third most dominant taxon on six occasions over the past two years. This taxon has not been recorded amongst the three most dominant taxa listed previously. *Heteromastus filiformis,* which had been common in 2006–2007, is no longer one of the more dominant taxa, reflecting its decline in abundance over the last two years. In contrast, the bivalve *Macomona liliana* and the limpet *Notoacmea helmsei* have recently appeared amongst the three dominant taxa. *Macomona* is found consistently in low numbers (31-61 individuals) at this site. *Notoacmea helmsei*, which often attaches to the outside of *Austrovenus* shells, also occurs in low numbers (1-22 individuals).

Populations showing cyclic abundance patterns

Cyclic abundance patterns identified with only 5.5 years of data should be treated as provisional, and more data are required to confirm any patterns identified at this stage.

Three annual cyclic trends are suggested. Polydorid polychaetes peak in abundance in July or April (Figure 7B), the bivalve *Arthritica bifurca* either in January (or April 2006 only) (Figure 8), and the limpet *Notoacmea scapha* in July or October each year (Figure not shown).

Figure 7

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 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, and in the last year, have increased at Jamieson Bay. This species exhibits 5 – 7 year abundance cycles in Manukau Harbour.

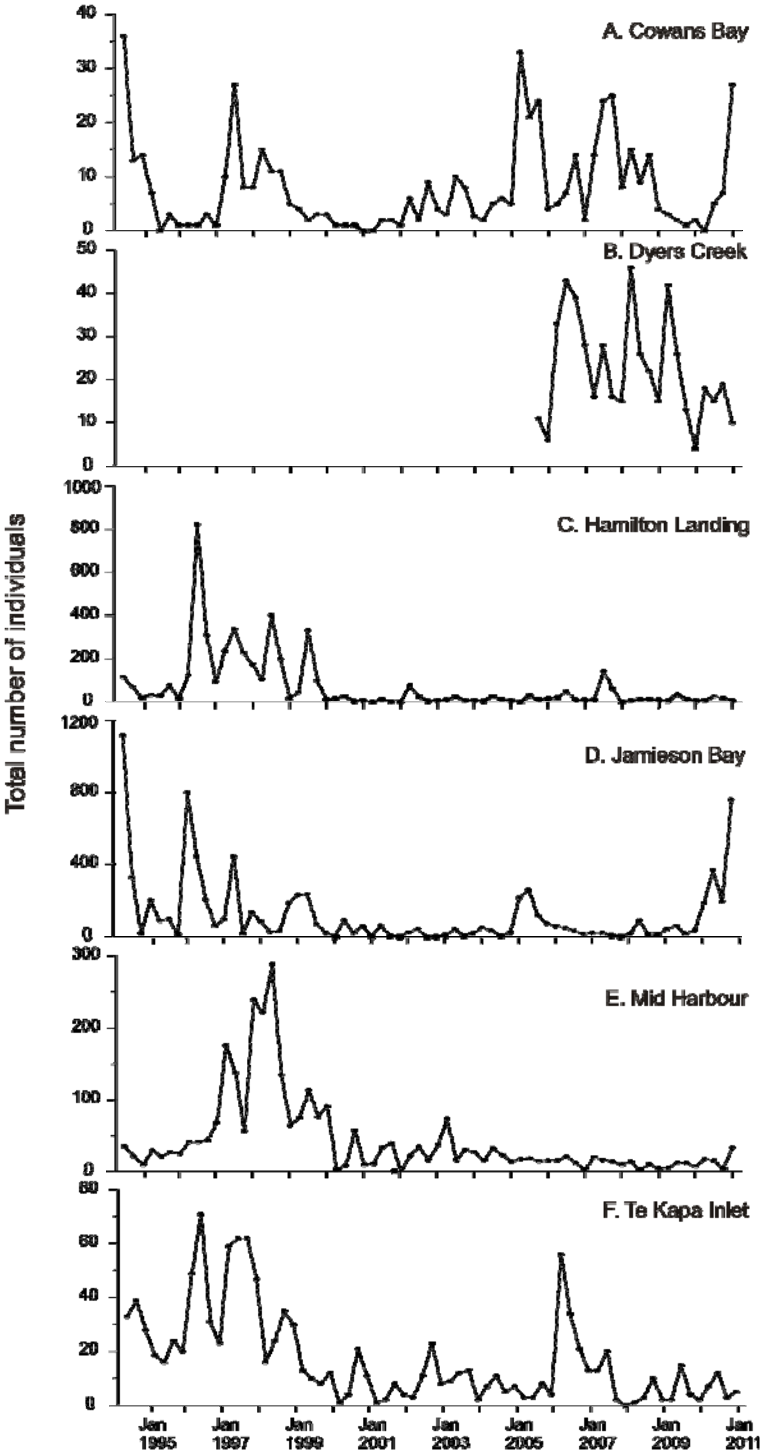
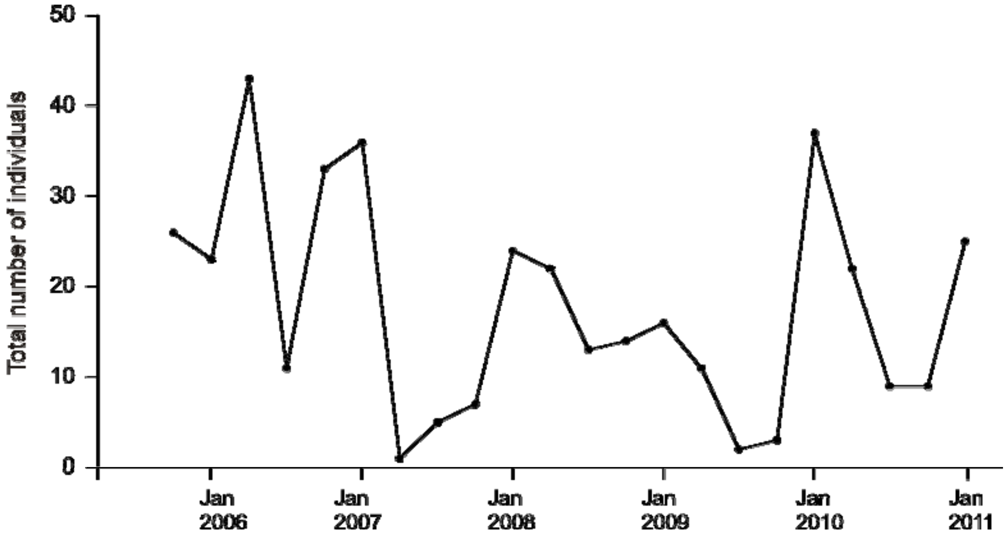


Figure 8

Total abundance of *Arthritica bifurca* collected on each sampling occasion at Dyers Creek. Peaks in abundance of these species occur annually, mostly in January.



Populations showing trends in abundance

As with identification of annual cycles in abundance, any abundance trends detected from only 5.5 years of data should also be treated as provisional. Four abundance trends have been identified in the monitored taxa at Dyers Creek (Table 1). Numbers of *Heteromastus filiformis* have decreased significantly over the monitoring period and has remained low for the past two years (Figure 9). In contrast an increasing trend has been detected in the abundance of *Prionospio aucklandica*, due to a large increase since January 2009.

The two remaining trends were detected in rarely occurring taxa: the crab *Hemiplax hirtipes* and oligochaetes, both of which are driven by single large recruitment events. Although these small positive trends are statistically significant, they are unlikely to be ecologically meaningful due to the low densities of these taxa.

The decline in *Nucula hartvigiana* abundance noted (but not formally tested for) in the 2009 report has proven, with the addition of 2 more years of data, to be part of a multiyear cycle of abundance.

As noted above, more data will be required to confirm these apparent trends.

Figure 9

Total abundance of *Heteromastus filiformis* collected on each sampling occasion at Dyers Creek, showing an apparent increasing trend in abundance.

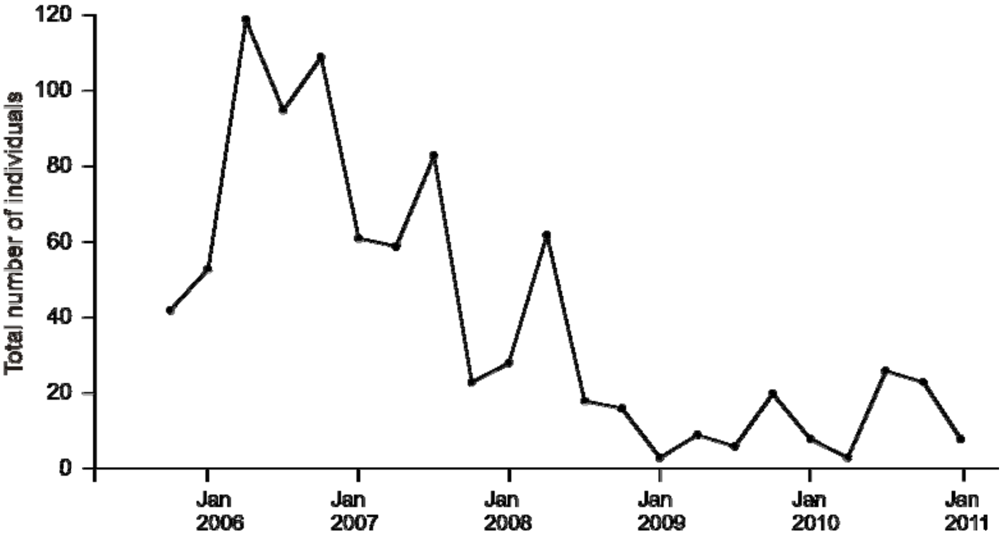
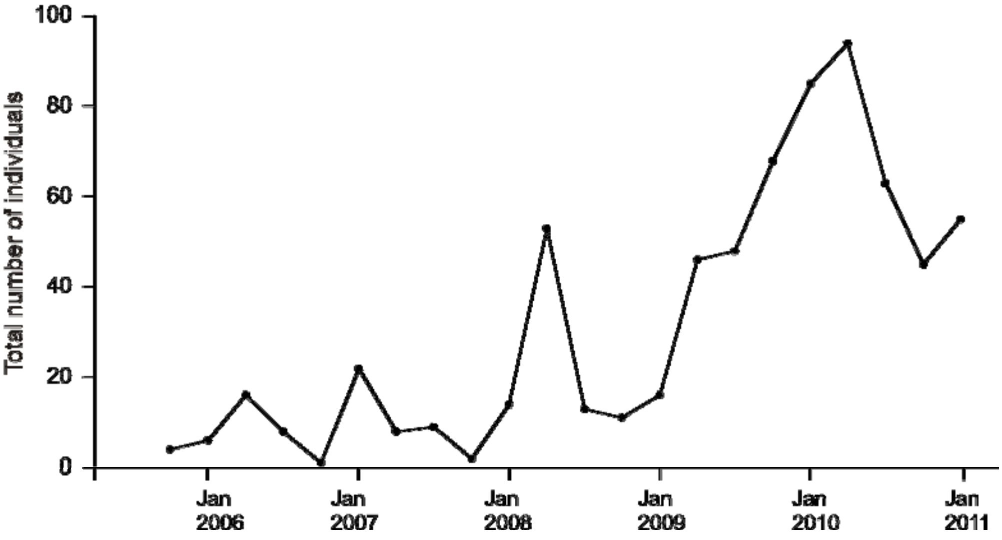


Figure 10

Total abundance of *Prionospio aucklandica* collected on each sampling occasion at Dyers Creek, showing an apparent increasing trend in abundance.



3.1.2.3 Hamilton Landing

Cossura consimilis continues to be the most abundant taxon at Hamilton Landing (Appendix 7) following a step increase in abundance in early 2000 (see Cummings et al. 2001). In the past two years, *Heteromastus filiformis* and *Aricidea* sp. have generally been the second and third most common taxa, respectively. Polydorid polychaetes and oligochaetes have also featured amongst the common taxa recently, on one occasion each.

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 peaked in abundance in January of most years, except for 1995 and 2002 when peaks occurred in October and April, respectively. Numbers of polydorids have been considerably lower at this site since October 1999, but abundances remain steady (Figure 7C).

The crab *Hemiplax hirtipes* and the polychaete *Heteromastus filiformis* exhibit peaks in abundance every year, most often in October (Figure 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, most often in January or October months.

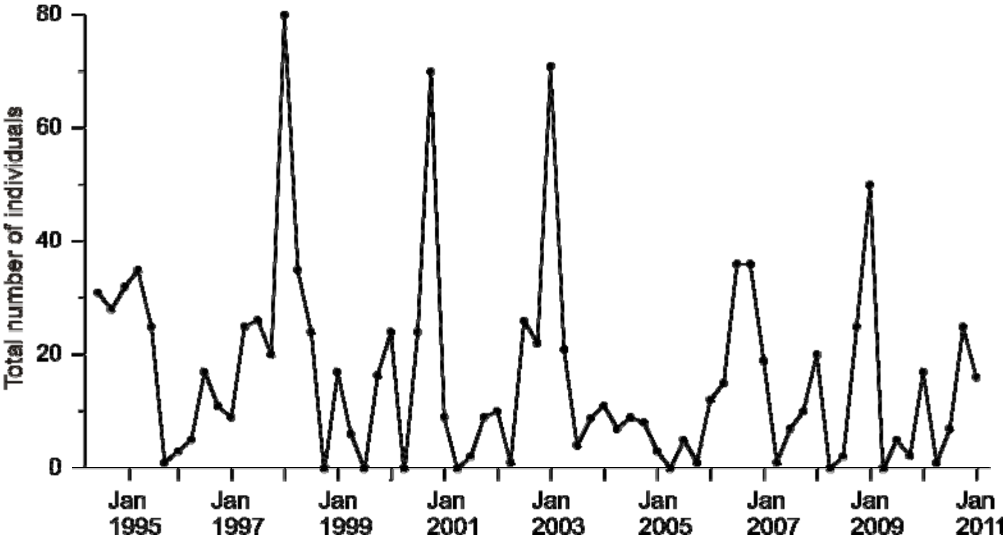


Figure 12

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

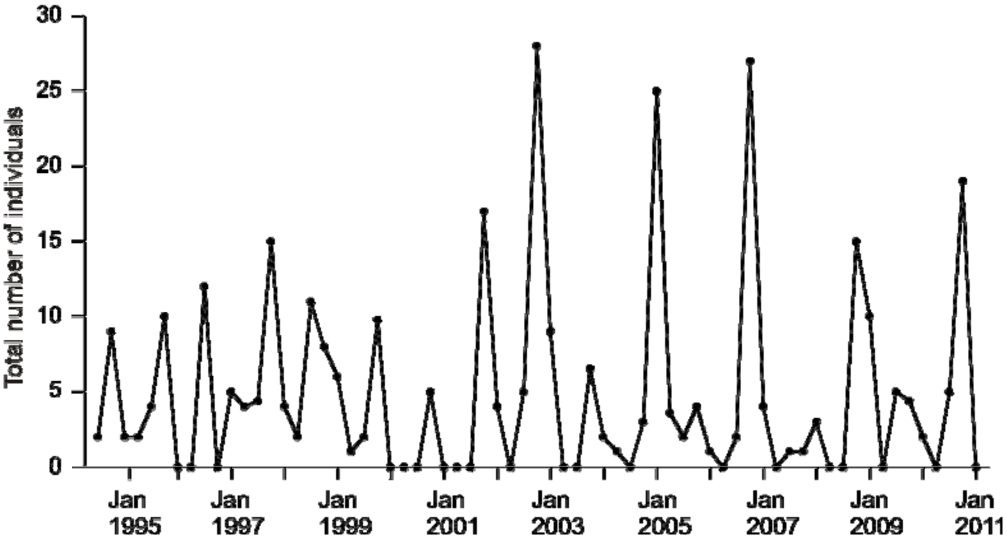
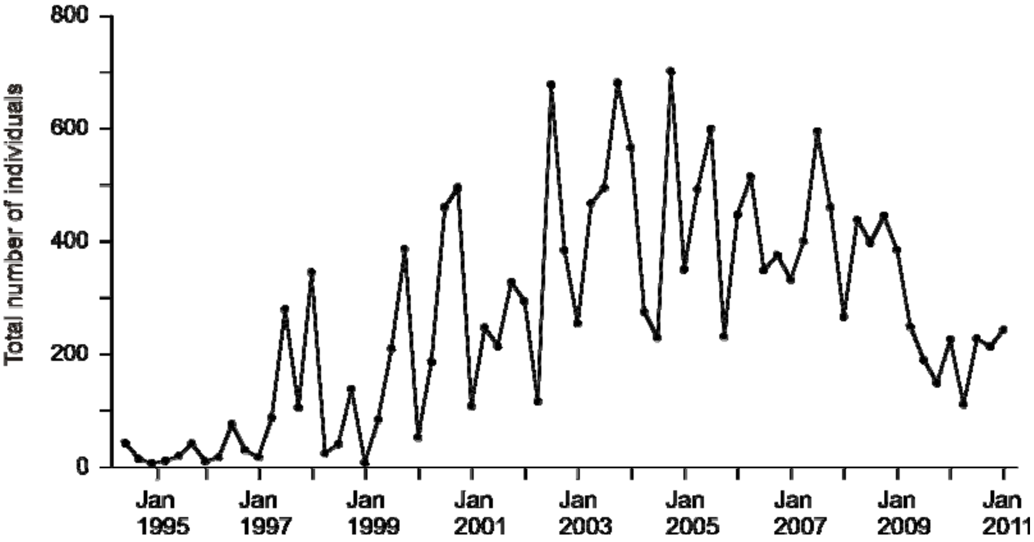


Figure 13

Total number of *Heteromastus filiformis* collected on each sampling occasion at Hamilton Landing. Peaks in abundance of this polychaete occur annually, most often October.



Populations showing trends in abundance

Trends in abundance over the monitoring period were detected for 11 of the monitored populations at Hamilton Landing; all were noted in our 2007 report, but three were statistically insignificant in 2009 (Table 1). Five populations exhibit increases in abundance (i.e., *Cossura consimilis*, *Heteromastus filiformis*, *Aricidea* sp., Nemerteans, *Prionospio aucklandica*), and six exhibit decreases (i.e., polydorids, *Austrovenus* *stutchburyi, Macomona liliana, Nucula hartvigiana, Scoloplos cylindrifer, Perineris vallata*).

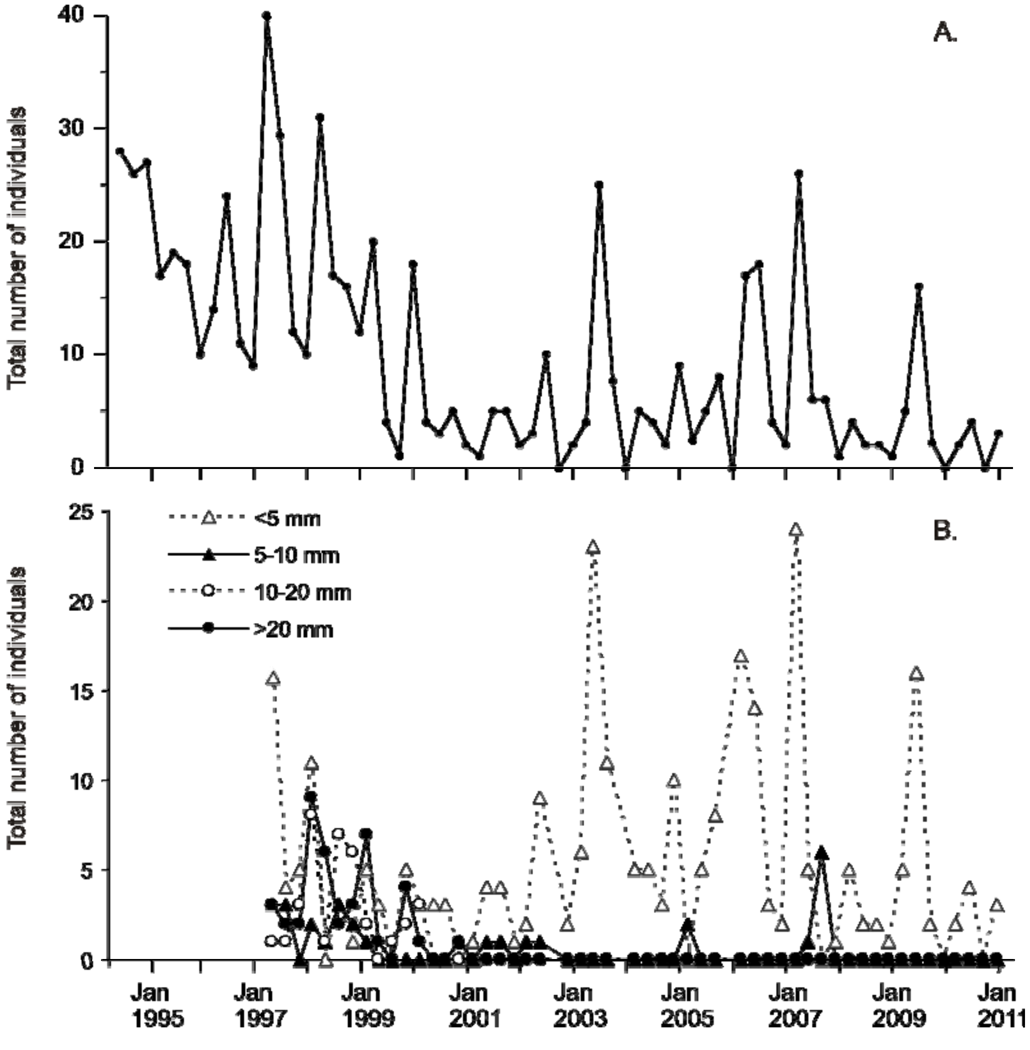
Seven of these trends appear to be due to sudden 'step' changes in abundance, rather than to gradual changes over time. Abrupt changes in density were noted for several taxa around the estuary in early 2000 (Cummings et. al 2003). However, the environmental event which led to this change particularly affected Hamilton Landing; and, for several taxa (discussed below), the resulting abundance changes have persisted. We suspect that the fauna at the already muddy Hamilton Landing may have been closer to their ecological 'thresholds' for survival than those at the other sites, resulting in a stronger response to the change in sediment composition.

- *Cossura consimilis* exhibited a step increase followed by a very strong linear increasing trend. Since January 2003 the abundance of this polychaete has stabilised around a new mean.
- Overall baseline abundances of polydorids declined in a step manner in early 2000, and have not since returned to pre 2000 levels (Figure 7C, Table 1).
- The bivalves *Austrovenus stutchburyi* and *Macomona liliana* continue to exhibit statistically significant lower abundances at Hamilton Landing following step changes in early 2000 (Table 1). *Austrovenus* was regularly amongst the dominant taxon at this site for the first six years of monitoring, but numbers declined significantly after this. Since January 2001, less than 26 individual *Austrovenus* have been found at this site per sampling occasion. While *Macomona* were never amongst the dominant taxa, it's numbers too have declined. Although abundances have been up around pre-2000 high values (approx 20 individuals) on several occasions, basal abundances have not returned to previous 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 mostly comprised of very small (<5 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 estuary, but 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. Note however, that the magnitude of this trend for *Perinereis* is very small (-0.04; Table 1).
- A decreasing step trend was also detected for the bivalve *Nucula hartvigiana* (Table 1). However, a large recruitment event in January 2010 indicates this trend may disappear in future years.
- A strongly positive linear trend was detected for *Heteromastus filiformis* from 1997 to 2003/4 (Figure 13, Table 1). Although abundances of this species are still higher than they were initially, the magnitude of the trend detected is smaller than previous years (Table 1), and these changes may be part of a multi-year cycle in abundance.
- A positive linear trend was also detected for the polychaete *Aricidea* sp (Table 1). The baseline and peak abundances for this taxon have been increasing since mid-2003.

Two other populations (nemerteans and *Prionospio aucklandica*) exhibit increasing trends in abundance at Hamilton Landing (Table 1). In the 2009 report we suggested the abundance patterns of both taxa were best described by greater than annual cycles rather than a sustained increase over the monitoring period. Despite a positive trend being detected for nemertean abundance over the whole monitoring period, a fluctuating multiyear cycle is still the best descriptor for this abundance pattern. *Prionospio aucklandica*, on the other hand, does appear to have increased in abundance over the whole monitoring period, especially in the last two years. However, more data will be required to confirm this trend.

Figure 14

A. The total number of *Macomona liliana* collected on each sampling occasion at Hamilton Landing. A decreasing step 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 (<5 mm shell length) individuals have been commonly found since April 2000.



3.1.2.4 Jamieson Bay

Nucula hartvigiana and polydorid polychaetes were either the first or second most abundant taxa at Jamieson Bay in the last two years of monitoring (Appendix 8), when 229-384 *Nucula* and 17-760 polydorids were found. Six different taxa have been the third most common taxon at Jamieson Bay over the last eight sampling occasions: oligochaetes, the polychaetes *Cossura consimillis*; *Heteromastus filiformis* and *Aonides trifida,* and the amphipods *Torridoharpinia hurleyi* and *Paracalliope novizealandiae.*

Populations showing cyclic abundance patterns

Four populations exhibit annual cyclic abundance patterns at Jamieson Bay: polydorids, *Aricidea* sp. oligochaetes and *Nucula hartvigiana* (Figure 16). Polydorids generally have highest numbers in July or April each year. Although peaks were lower from early 2000 to 2009, they have recently returned to their previously high levels (Figure 7D). Peak abundances of oligochaetes and *Aricidea* sp. occur in either July or October (figures not shown), while *Nucula* consistently exhibits its highest numbers in January or April.

Populations showing trends in abundance

Statistically significant trends in abundance were detected in three taxa at Jamieson Bay in this year's analysis, compared with one in the 2009 report and five in the 2005 and 2007 reports (Table 1). Polydorids had exhibited a step reduction in overall abundances in 2000, but high numbers over the past year have removed the negative trend and indicate the taxon has returned to pre 2000 levels (Figure 7D).

A small but significant positive trend was detected in *Aricidea* sp. abundance at Jamieson Bay. This trend was noted in 2003, 2005 and 2007, but not in 2009 (Table 1). A small negative trend was detected for *Macomona liliana* abundance in all previous years except 2009 (Table 1). *Macomona* was abundant at this site for the first three years of monitoring, after which it declined to around 10 individuals on average (Figure 15A). Numbers have remained relatively low, with occasional large peaks comprised almost entirely of <5 mm individuals (Figure 15B). We consider this to be a step change in abundance.

A new, positive trend in the abundance of *Nucula hartvigiana* was detected (Table 1, Figure 16), however the abundance of this taxon fluctuates considerably at Jamieson Bay and we are unsure if this trend will prove to be ecologically meaningful upon collection of more data.

Figure 15

Total number of *Macomona liliana* collected on each sampling occasion at Jamieson Bay. A small decreasing step trend in overall abundance of this bivalve was detected. B. The total number of individuals in each size class, from July 1997 onwards.

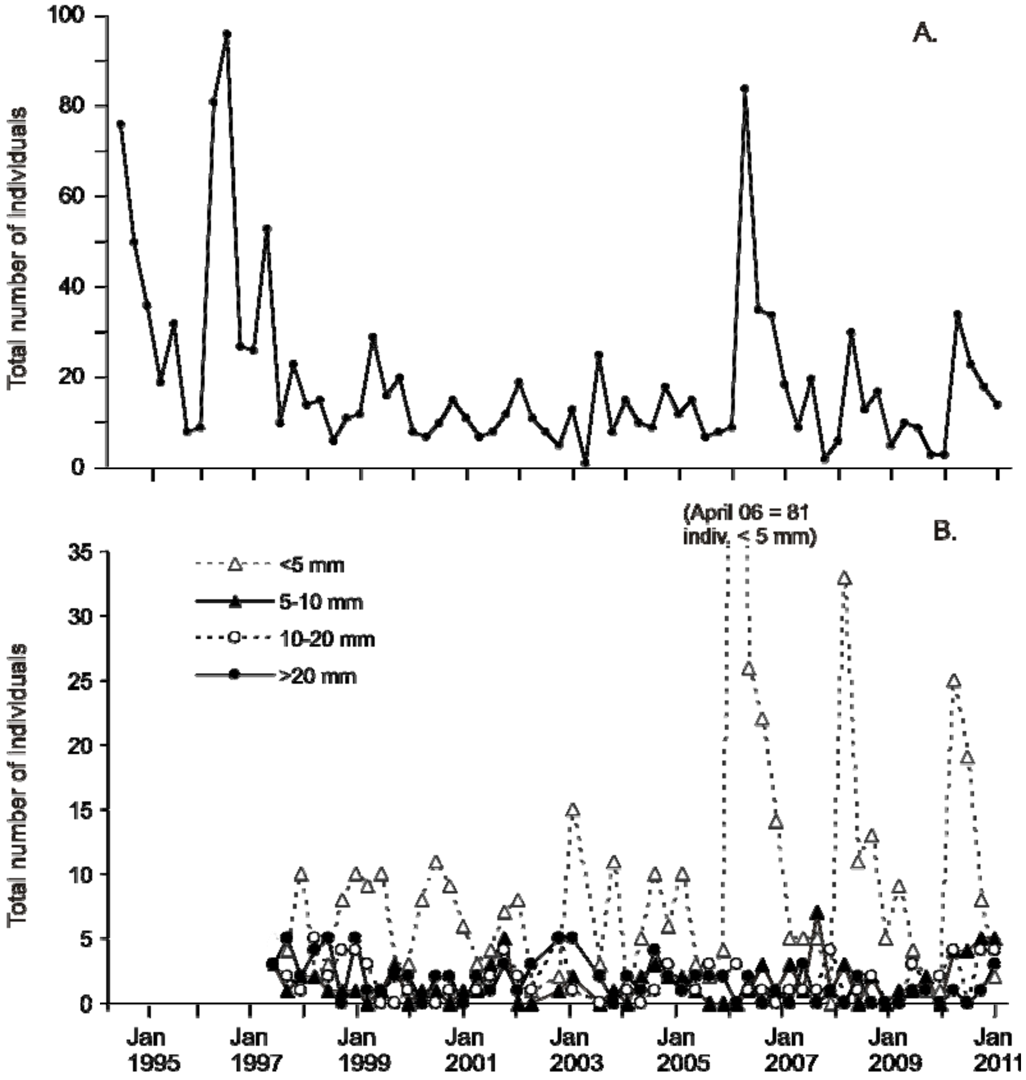
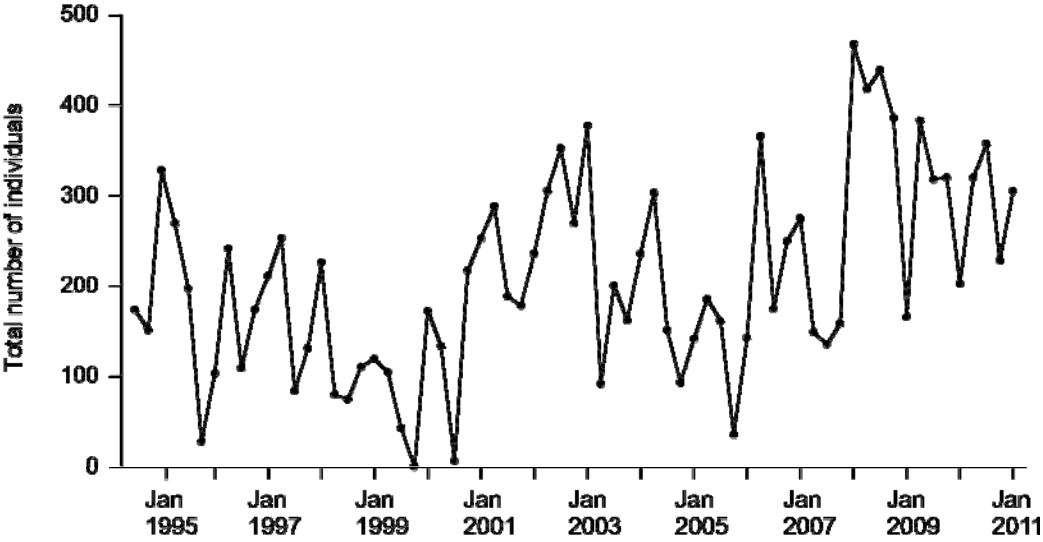


Figure 16

Total number of *Nucula hartvigiana* collected on each sampling occasion at Jamieson Bay showing large fluctuations in abundance and a statistically significant increasing trend.



3.1.2.5 Mid Harbour

Nucula hartvigiana continues to dominate Mid Harbour (Appendix 9, Figure 17), with between 347 and 771 individuals collected on the last eight monitoring dates. *Arthritica bifurca* was either the second or third most common taxon, with between 33 and 223 individuals found. *Cossura consimilis* (40-71 individuals) and *Heteromastus filiformis* (10-65 individuals) were either the second or third most common taxa in the past two years.

Populations showing cyclic abundance patterns

Heteromastus filiformis (figure not shown) and *Hemiplax hirtipes* (Figure 18) 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 occurred in April) (figure not shown). The polychaete *Aricidea* sp. exhibits large fluctuations in abundance, with peaks occurring in July or April since April 2001 (figure not shown).

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.

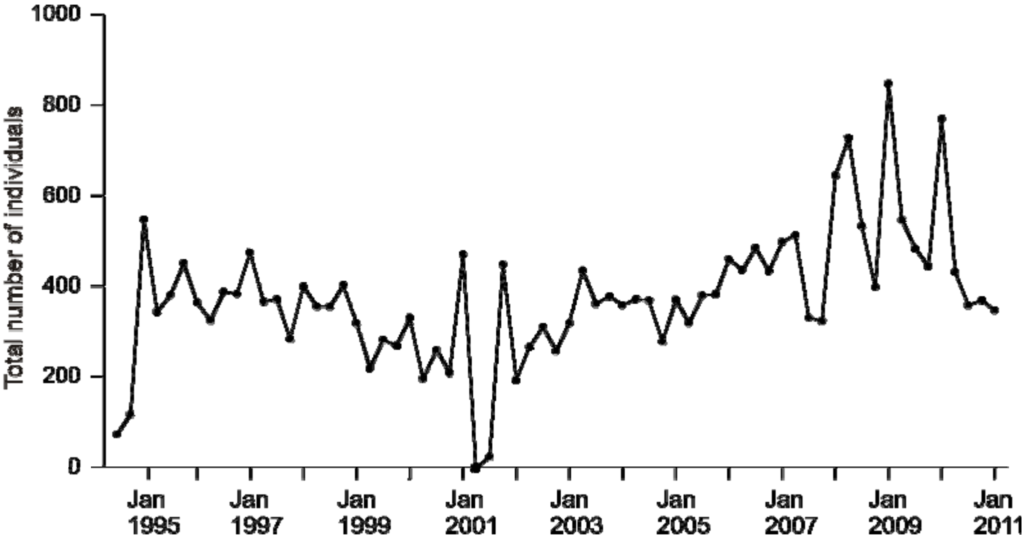
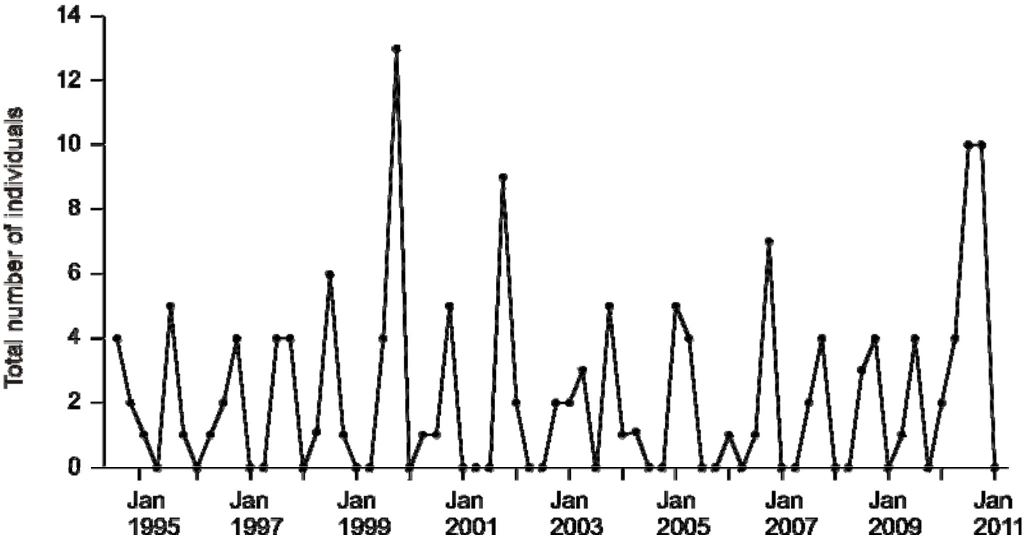


Figure 18

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



Populations showing trends in abundance

Four populations exhibit trends in abundance at Mid Harbour: *Arthritica bifurca, Aricidea* sp. and *Nucula hartvigiana* (increases) and *Macomona liliana* (a decrease) (Table 1).

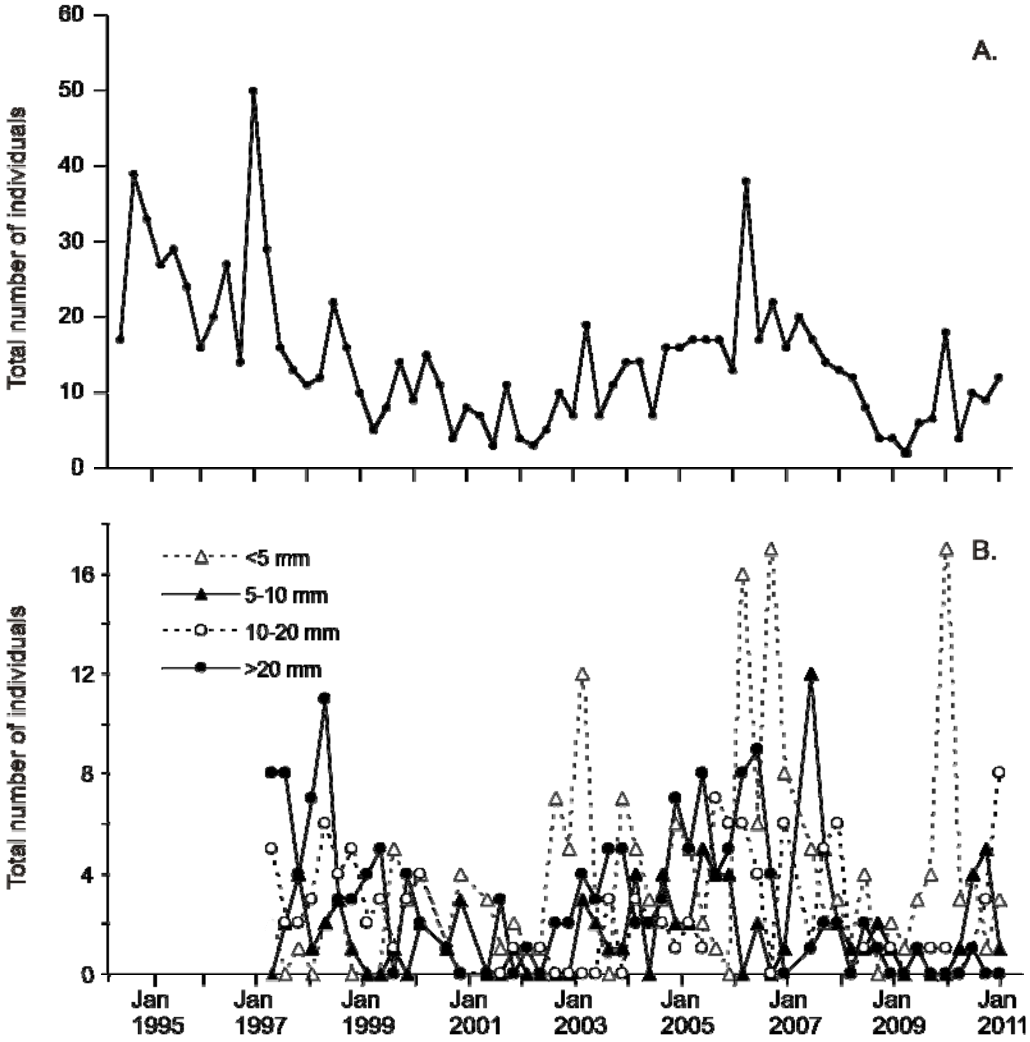
Arthritica bifurca abundances fluctuate considerably, however their numbers have been generally higher in the last half of the monitoring period. A large recruitment event (223 individuals) occurred on the most recent sampling occasion, January 2011, which followed a similar sized peak, exactly 2 years previous (January 2009, 210 individuals).

As noted in 2009, an increasing trend was detected in the abundance of the small bivalve *Nucula hartvigiana.* This mainly reflects large recruitment events in January 2008, 2009 and 2010 (Figure 17).

Although a decreasing trend was detected for *Macomona liliana* over the entire monitoring period, this taxon actually exhibits large fluctuations in abundance, with no apparent seasonal/annual pattern (Figure 19A). *Macomona* numbers declined in the early years of the monitoring programme. Peak abundances since 2003 are similar to those noted prior to this decline, and baseline abundances suggest a multiyear cyclic pattern may become apparent once more data have been collected (Figure 19A). Since 2003 the population has been comprised of individuals of a range of sizes, but numbers of adult (spawning-sized) individuals remain very low (Figure 19B).

Figure 19

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.



A small increasing trend was detected for *Aricidea* sp. and *Scoloplos cylindrifer* (Table 1). The increasing trend detected for *Scoloplos* was particularly small; as this taxon occurs only rarely at this site, the trend is unlikely to be ecologically significant.

3.1.2.6 Te Kapa Inlet

The Te Kapa Inlet community continues to be dominated by high numbers of *Cossura consimilis* (137-428 individuals since the last report) (Appendix 10). *Heteromastus filiformis* (47-116 individuals) and *Aricidea* sp. (29-155 individuals) were also common. *Austrovenus stutchburyi* (6-130 individuals) was the second most common monitored taxon in January 2010 and the third most common in January 2011. *Nucula hartvigiana* (2-54 individuals) and *Prionospio aucklandica* (14-106 individuals) were the third most common monitored taxa on one occasion each. All six of these taxa have featured amongst the most dominant at this site over the course of the monitoring programme.

Populations showing cyclic abundance patterns

All three of the populations exhibiting cyclic patterns in abundance in the 2009 report (i.e., *Aricidea* sp., *Heteromastus filiformis* and polydorids) continue to do so.

Aricidea sp. and *Heteromastus filiformis* exhibit peaks in abundance each year, but the timing of these peaks is not predictable. Polydorids show an annual cycle in abundance; peaks have usually occurred in July or October months, although a large peak occurred in April of 2006 (Figure 7E).

Populations showing trends in abundance

Statistically significant trends in abundance were detected for eight populations at Te Kapa Inlet: three increasing (i.e., *Cossura consimilis*, nemerteans, oligochaetes) and five decreasing (i.e., *Austrovenus stutchburyi*, *Macomona liliana*, *Notoacmea scapha*, *Nucula hartvigiana*, polydorids; Table 1).

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. *Cossura* now appear to be fluctuating around a new mean of approximately 400 individuals. Numbers of polydorids decreased in a step manner in early 2000 (Table 1). There has been some sign of recovery of this population, with a large abundance peak in April 2006, but polydorids are still less frequently found at this site now than in the early years of monitoring (Figure 7F).

A decline in abundance of *Austrovenus stutchburyi* was again detected at this site (Table 1), and lowest ever numbers of this bivalve (i.e., 6 individuals) were recorded twice over the past two years of monitoring (Figure 20A). In general, the proportion and abundance of medium and large-sized cockles has been lower over the last five years than previously, although we do note the relatively high numbers of >20 mm individuals on the most recent sampling date (Figure 20B). The relatively high number of large individuals and juveniles recorded in the last sampling occasion indicates that recovery of this population is possible.

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

The negative trend in *Prionospio aucklandica* abundance reported in previous reports is no longer apparent. Although the abundance of this polychaete decreased after 2000, numbers are again similar to those found at the start of the monitoring programme.

A new, low magnitude trend in abundance has been detected for oligochaetes. This increasing trend is due to relatively high numbers being found over the past three years; however, as total abundances are relatively small, more data is required to determine if this is an ecologically meaningful change.

The *Macomona liliana* population at Te Kapa Inlet has steadily declined over the monitoring period, but a large recruitment event in April 2006 masked this trend in recent reports (Table 1, Figure 21A and B).

Numbers of the limpet, *Notoacmea scapha,* have also significantly declined to a point where they have been found on only two dates in the last four years of monitoring.

An increasing trend has again been detected in the abundance of nemerteans. This increase has mostly been driven by high abundances over the last four sampling occasions. More data are required to determine if this trend will continue.

Figure 20

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 the relatively high numbers of large sized cockles found on the most recent sampling date.

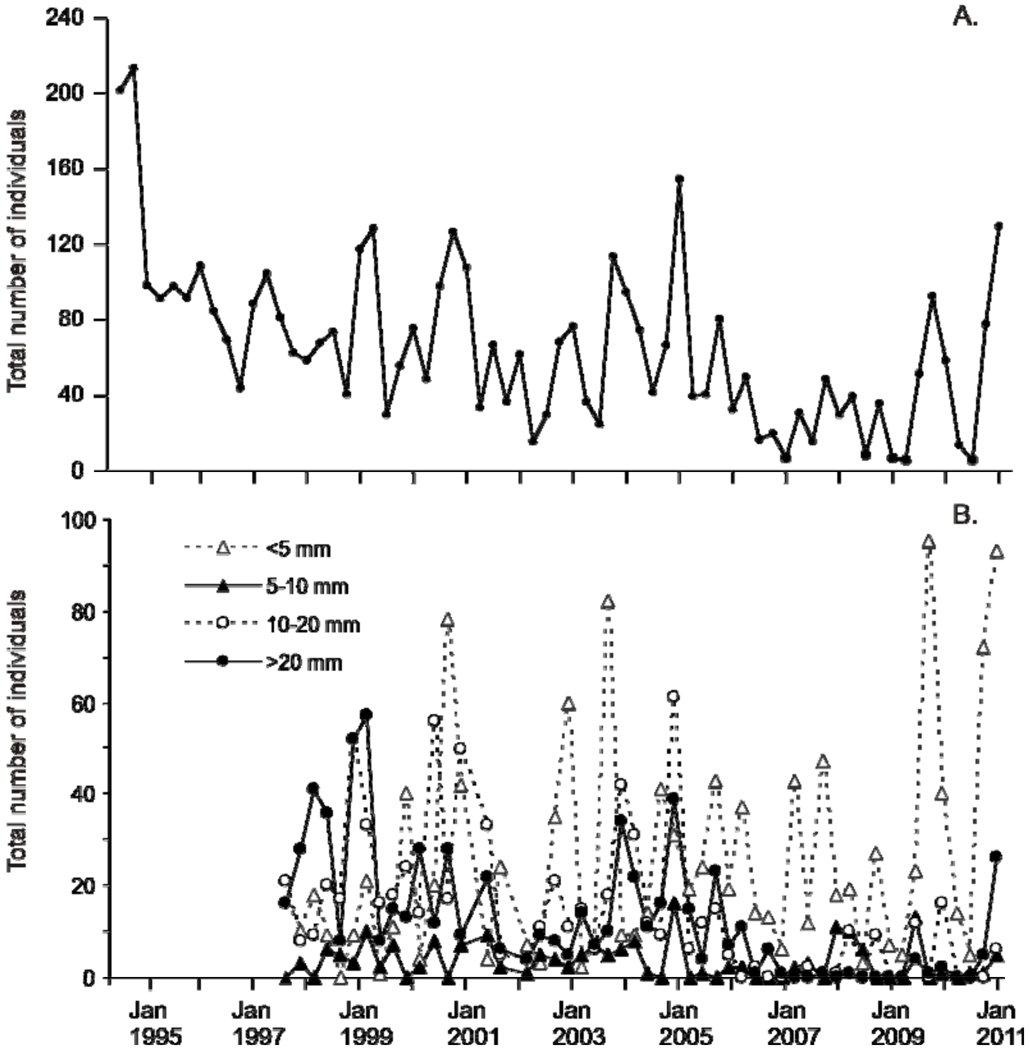


Figure 21

Total number of *Macomona liliana* collected on each sampling occasion at Te Kapa Inlet. A decreasing trend has been detected despite a large recruitment of juveniles in April 2006, and smaller peaks in July 2007 and October 2009. B. The total number of individuals in each size class, from July 1997 onwards.

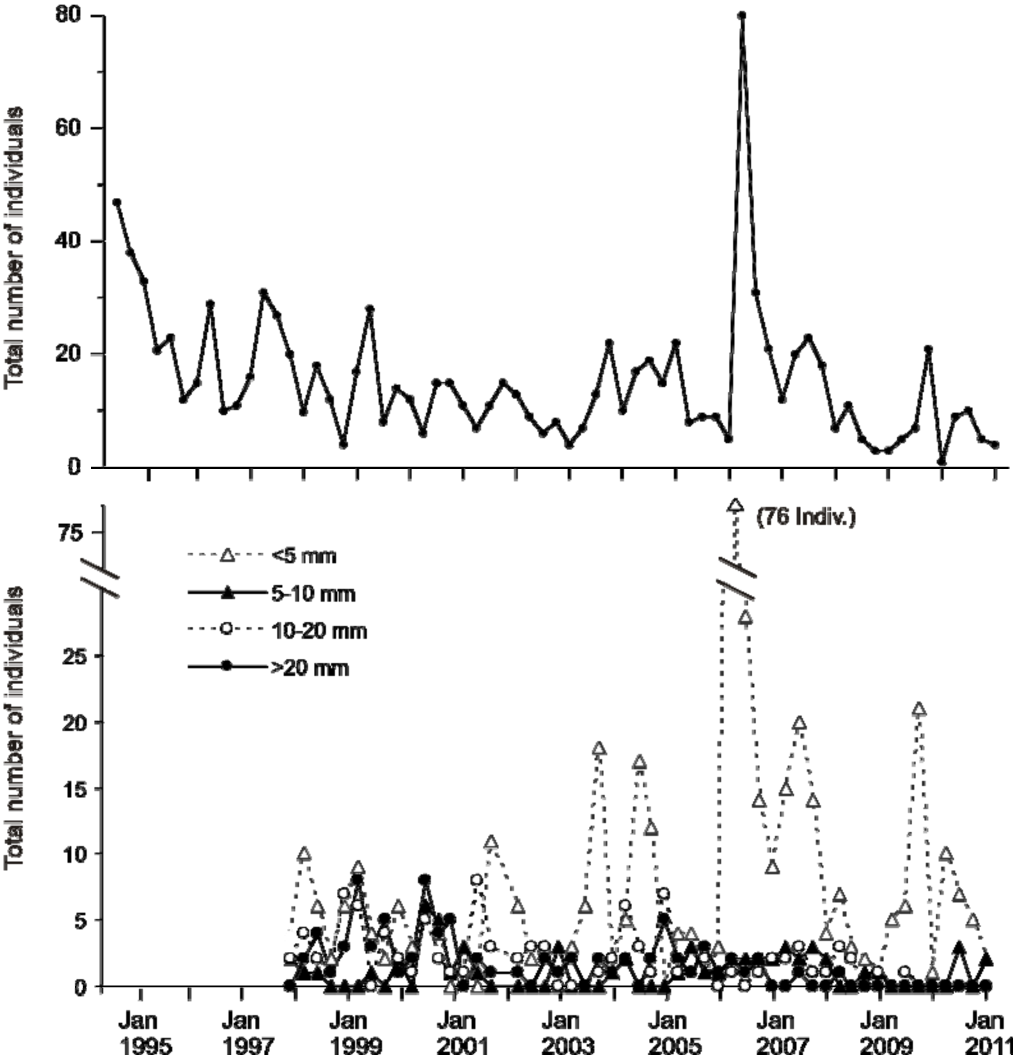


Table 1

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 taxon 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'. * trends that are unlikely to be ecologically significant.

Monitored Taxa	2011	2009	2007	2005	2003
Cowans Bay					
Cossura consimilis	-5.06	-4.47	-4.07	No trend	No trend
Nemerteans	No trend	-0.09	-0.08	No trend	No trend
Dyers Creek					
Heteromastus filiformis	-4.00				
Hemiplax hirtipes*	0.26				
Oligochaete*	0.46				
Prionospio aucklandica	3.47				
Hamilton Landing					
Aricidea sp.	0.96	0.86	0.66	0.86	No trend
Austrovenus stutchburyi	-1.50 step	-1.76 step	-2.33	-2.82	-3.67 (-3.46)
Cossura consimilis	13.44 step	19.58 step	19.73	22.09	17.60
Heteromastus filiformis	5.02	8.70	10.36 (10.16)	12.37	11.20 (6.67)
Macomona liliana	-0.30 step	-0.31 step	-0.39	-0.51	-0.71
Nemerteans*	0.10	No trend	0.18	0.30	0.288
Nucula hartvigiana	-0.14 step	No trend	No trend	-0.35	-0.44
Perinereis vallata*	-0.04 step	-0.04 step	-0.06	No trend	-0.10
Polydorids	-2.92 step	-3.41 step	-4.16 (-2.68)	-5.05	No trend
Prionospio aucklandica	0.61	No trend	0.28	0.52	0.35
Scoloplos cylindrifer	-0.18 step	-0.23 step	-0.25	-0.30	No trend
Jamieson Bay					
Aricidea sp.	0.22	No trend	0.28 (0.32)	(0.36)	0.41 (0.54)
Polydorids	No trend	-5.05 step	-6.37 (-2.16)	-9.11 (-3.62)	-11.89 (-4.48)
Macomona liliana	-0.34 step	No trend	-0.48	-0.89	-1.24
Nucula hartvigiana*	2.46	No trend	No trend	No trend	No trend
Mid Harbour					
Aricidea sp.	0.20	No trend	No trend	0.27	0.52
Arthritica bifurca	1.20	0.98	0.83	No trend	1.01
Macomona liliana	-0.20	-0.20	No trend	-0.48	-0.79
Nucula hartvigiana	3.32	3.42	No trend	No trend	No trend
Scoloplos cylindrifer*	0.01	No trend	No trend	No trend	No trend

Te Kapa Inlet					
Austrovenus stutchburyi	-1.11	-1.51	-1.57	No trend	-2.21
Cossura consimilis	6.30 step	8.39 step	9.76	14.90	13.64
Macomona liliana	-0.20	No Trend	No trend	-0.36	-0.9 (-1.0)
Notoacmea scapha	-0.13	No trend	-0.14	No trend	No trend
Nucula hartvigiana	-0.95	-0.85	-0.84	No trend	No trend
Nemerteans*	0.15	No trend	0.12	0.263	0.29
Oligochaetes*	0.11	No trend	No trend	No trend	No trend
Polydorids	-0.48 step	-0.54 step	-0.57	-0.9 (-1.1)	-1.1 (-1.1)
Prionospio aucklandica	No trend	-1.18	-1.18	-1.17	No trend

3.1.3 Intertidal sites - general patterns

3.1.3.1 Harbour-wide patterns in intertidal macrofaunal populations

Populations showing cyclic abundance patterns

Ten populations exhibit cyclic abundance patterns, including three provisionally identified from Dyers Creek (Table 2). Very few of these taxa exhibit highly predictable patterns, where peaks in abundance occur in the same monitoring month every year, or where the timing of peaks for a single taxon are the same across sites. This is not surprising as two-monthly monitoring in Manukau Harbour suggests that recruitment peaks may vary in timing from year to year by 2 – 3 months. The lower frequency of sampling in 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 5.5 years of data and that more data are required to confirm these apparent cyclical patterns in abundance.

Table 2

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 more data are required to confirm the trends identified from the Dyers Creek site.

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

Populations showing step abundance patterns

In our 2009 report we highlighted that the abundance of a number of monitored populations at more than one site either increased or decreased in a step manner in early 2000 (Halliday & Cummings 2009). In our pre- 2009 reports, many of these changes had been identified as long-term trends in abundance. However, by 2009 we had sufficient data to test if the abundances prior to and following the change were significantly different, and this analysis showed that nine of the seventeen previously identified long-term intertidal trends were in fact step changes. Although the type of trend identified changed, the probable cause of the change has not.

A total of eight populations exhibit ecologically significant step changes in abundance occurring in early 2000 from which the population has not recovered (Table 3 and 4). 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 that 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 22). Another Hamilton Landing population (*Heteromastus filiformis*) increased in abundance to a new higher level between 1997 and 2003/4 (Figure 13). Abundances of both of these taxa have reduced a little over the last four years, indicating their numbers have stabilised and that, perhaps, the environment is no longer changing at the same rate or, in the case of *Heteromastus filiformis*, abundances may be following a multiyear cycle.

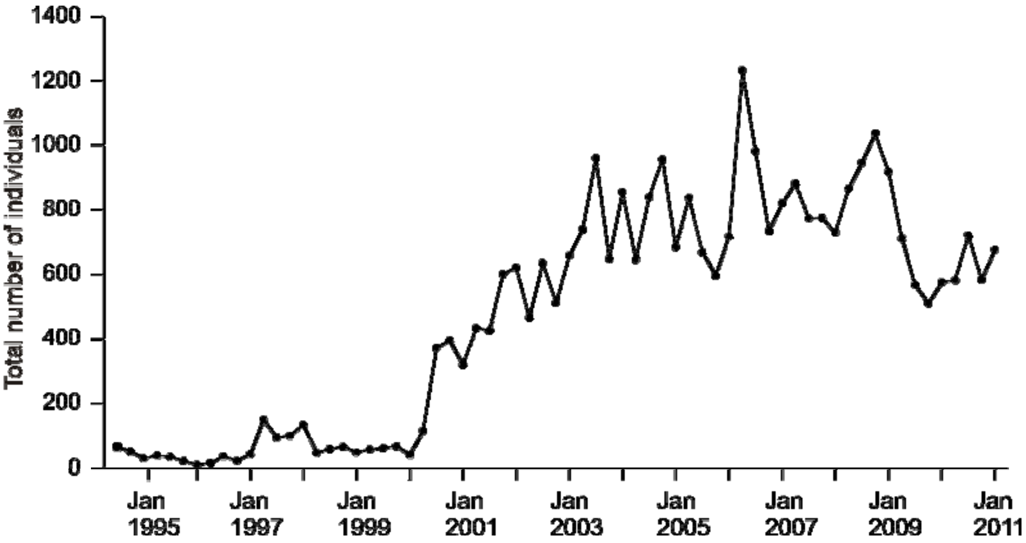
Table 3

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	-ve	
Nucula hartvigiana	-ve		
Perinereis vallata	-ve		
Polydorids	-ve		-ve
Scoloplos cylindrifer	-ve		

Figure 22

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, then gradually increased for the next 4 years. The abundance has stabilised over the last 7 years around a new mean value.



Populations showing trends in abundance

A total of 25 populations are currently showing ecologically significant trends in abundance (including two at Dyers Creek); 10 of these are increasing trends and 15 are decreasing trends (Table 4). All sites have taxa that are exhibiting trends; most occur at Hamilton Landing (9 taxa) and Te Kapa Inlet (6 taxa), and the least at Cowans Bay (1 taxa).

Five taxa considered sensitive to increased suspended sediment concentrations, sedimentation rates, or sediment mud content have declined in abundance in Mahurangi Estuary (Table 4). Two important bivalves, *Austrovenus stutchburyi* and *Macomona liliana* have declined at two and four sites, respectively. 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, and low abundances for a number of years. Abundances have since increased at most sites. However, much of this apparent recovery is due to a couple of large recruitment events (<5 mm individuals) the largest of which were in April 2006 (Figures 15, 19 & 21). High *Macomona* numbers have not persisted at Cowans Bay, Mid Harbour, Jamieson Bay or Te Kapa Inlet over the last four years, due to poor retention of recruits at these sites. Very few adult sized individuals are found at these sites.

Austrovenus stutchburyi exhibited a step decrease in abundance at Hamilton Landing in early 2000 (Table 4). Over the last 4 – 6 years, *Austrovenus* has also declined in abundance at Te Kapa Inlet (Table 4). *Notoacmea scapha*, which uses *Austrovenus* as an attachment substrate, has also declined at Te Kapa Inlet (Table 4). In our earlier 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 *Austrovenu*s at this site. In our last report we noted that a considerable number of riparian 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 also exhibited a step decrease in abundance at Hamilton Landing over early 2000 (Tables 1 & 4). This polychaete is considered sensitive to increased sedimentation rates (Gibbs & Hewitt 2004). Prior to October 1999 between 0 and 54 individual *Scoloplos* were collected on any one sampling date. It has since been found at this site only in very low numbers (1-2 individuals) and on few occasions. Interestingly, the bivalve *Nucula hartvigiana* is increasing slightly 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 <5% mud (Gibbs & Hewitt 2004).

A number of trends were detected for taxa that show intermediate responses to increased sediment mud content (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, have clearly increased in abundance at Hamilton Landing (both taxa), Jamieson Bay and Mid Harbour (*Aricidea* only) and Te Kapa Inlet (*Cossura* only). The increases in *Cossura* numbers at Hamilton Landing and Te Kapa Inlet are considerable (trends of 13.44 and 6.30, respectively), while the other trends mentioned above are of much smaller magnitude (<1, Table 1; Table 4). Interestingly, *Cossura* is exhibiting a decline in peak abundances at Cowans Bay (-5.06, Table 1; Table 4). Polydorid polychaete numbers decreased at Te Kapa Inlet and Hamilton Landing (Table 4), and now show occasional recruitment events (Figure 7). The polychaete *Prionospio aucklandica* is increasing at Dyers Creek and Hamilton Landing (Table 4).

Table 4

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). SS = strong preference for sand, 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)	DC	MH	TK	CB	HL (most muddy)
SS	Notoacmea scapha				dec		
S	Austrovenus stutchburyi	.	.	.	dec	.	dec (S)
S	Macomona liliana	dec (S)	.	dec	dec	.	dec (S)
S	Nucula hartvigiana	.	.	inc	dec	.	dec (S)
S	Scoloplos cylindrifer	.	.	.	.	.	dec (S)
I	Aricidea sp.	inc	.	inc	.	.	inc
I	Arthritica bifurca	.	.	inc	.	.	.
I	Cossura consimilis	.	.	.	inc (S)	dec	inc (S+)
I	Heteromastus filiformis	.	dec	.	.	.	inc
I	Nemerteans	.	.	.	.	.	.
I	Polydorids	.	.	.	dec (S)	.	dec (S)
I	Prionospio aucklandica	.	inc	.	.	.	inc

Contaminant levels

The levels of copper, zinc and lead in the intertidal monitoring site sediments were low (Table 5), and did not exceed any management thresholds levels. Concentrations of these metals at all sites meet the Auckland Council Environmental Response Criteria (AC ERC) green standard for estuarine environments, indicating they are of low concern and additional investigation is not required unless significant changes in catchment land use occur (ARC 2004b). The levels of other contaminants were also low and, with one exception, did not exceed management threshold levels (ERC) (Table 5). Levels of arsenic at Te Kapa Inlet were slightly higher than that of the Threshold Effect Level (TEL) of MacDonald et al. (1996) and close to the Effects Range Low level of Long & Morgan (1990) (Table 5). Arsenic levels at all sites except DC were very close to the TEL (Table 5). Note however, that below the ERL value, adverse effects are rarely reported (Long et al. 1995).

The levels of arsenic at all sites were considerably lower than the interim sediment quality guidelines for low & medium thresholds defined in the ANZECC (2000) guidelines (20 mg kg^{-1} and 70 mg/kg, respectively, on a dry weight basis) (ANZECC 2000). These guidelines have been developed for New Zealand and Australia and are considered more appropriate for the elevated background sediment levels in New Zealand and Western Australia, than the TEL management thresholds which were developed in Canada (ANZECC 2000). It is important to note that all these guidelines are all derived for single contaminants and do not take into consideration the combined effects of several different contaminants present in the site-specific sediments on community ecology. HMW-PAH and Total PAH (< 500 µm fraction, normalised to 1% total organic carbon), which were quantified for Hamilton Landing and Jamieson Bay only (Table 5) did not exceed any management thresholds, but were considerably higher at Jamieson Bay. In fact, Jamieson Bay had the highest values for all metals and contaminants of any site.

Table 5

Summary of sediment contaminant results, values given are mg kg^{-1} dry wt. Management thresholds under the Auckland Council Environmental Response Criteria (ERC) for copper, lead, zinc and total PAH are given. All sites meet the green criteria. The most conservative management threshold threshold effect level (TEL, MacDonald et al. 1996) for arsenic, cadmium, chromium, mercury, HMW- and total PAH is given. The TEL value was exceeded for arsenic at Te Kapa Inlet (bold text). Sediment contaminant results are given for total recoverable metals (mg/kg) in the >500 µm fraction of sediment, with concentrations in the <63 µm fraction given in parentheses (where available). HMW-PAH = high molecular weight polyaromatic hydrocarbons, PAH = polyaromatic hydrocarbon, CB = Cowans Bay, DC = Dyers Creek, JB = Jamieson Bay, HL = Hamilton Landing, MH = Mid Harbour, TK = Te Kapa Inlet. [1]ARC 2004b guidelines; [2]MacDonald et al. 1996; [3]Long & Morgan 1990. Additional threshold guidelines are provided (for some of these contaminants) in Lundquist et al. (2010).

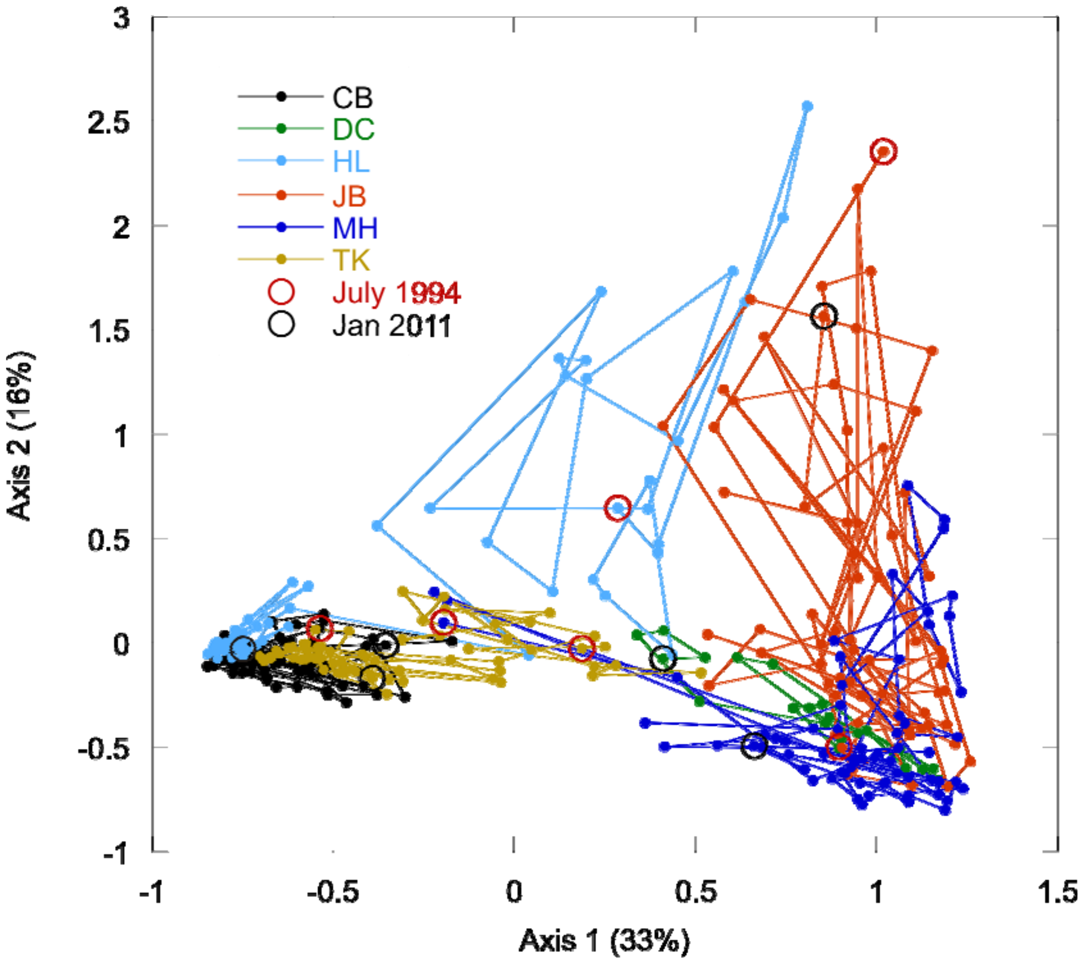
Contaminant	ERC Green[1]	ERC Amber[1]	ERC Red[1]	TEL[2]	ERL[3]	CB	DC	JB	HL	MH	TK
Copper	<19	19-34	>34	18.7	34	3.0 (6.7)	<2 (8.0)	6.0 (15.9)	5.3 (8.3)	3.3 (7.8)	5.7 (6.6)
Lead	<30	30-50	>50	30.2	47	3.5 (6.2)	1.8 (6.2)	6.0 (11.1)	5.3 (7.5)	3.5 (7.3)	4.5 (5.5)
Zinc	<124	124-150	>150	124	150	30.0 (37.0)	15.3 (39.3)	39.0 (51.7)	30.3 (42.3)	31.3 (40.0)	35.3 (37.3)
Arsenic				7.24	8.2	7	3	7	7	7	**8**
Cadmium				0.68	1.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Chromium				52.3	81	12	7	15	14	12	20
Mercury				0.13		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel				15.9	20.9	4	3	10	5	6	9
Iron						13800	6900	23000	15300	15000	21000
Manganese						78	43	240	97	115	124
HMW-PAH	<0.66	0.66-1.68	>1.68	0.66	1.7			0.53	0.08		
Total PAH				1.7	4			0.96	0.16		

3.1.3.2 Intertidal macrofaunal community composition

Figure 23 shows the relative positions of the monitored-taxa communities at each site in ordination space, 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 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 (see January 2011 symbols). A similar pattern had been apparent for the monitored communities at Jamieson Bay, Mid Harbour and Dyers Creek. However, on the most recent sampling date the monitored community at Jamieson Bay was less like those of Dyers Creek and Mid Harbour, and more similar to its own community in July 1994. As Jamieson Bay shows considerable temporal variation in community composition, we consider this fluctuation to be a normal part of this pattern. The Dyers Creek community has remained relatively stable since monitoring began 5.5 years ago.

Figure 23

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 2011) sampling occasions are represented by open circles. 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 6). Changes in within-year similarity mainly involved small (less than 5%) increases in similarity (i.e., variability decreased). A 7.8% increase in within-year similarity was noted at Jamieson Bay (Table 6). Between year variability 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 6

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

	Year	CB	HL	JB	MH	TK
within year	first 5 years	75.55	79.45	70.59	79.85	82.82
	last 2 years	80.41	84.10	78.36	83.71	85.21
	difference	4.86	4.65	7.79	3.86	2.36
between year	first 5 years	74.62	76.10	68.49	78.17	82.09
	last 2 years	80.33	78.63	72.51	81.44	85.47
	difference	5.71	2.53	4.02	3.27	3.38

The newly developed index to assess the functional redundancy of benthic communities as an indicator of resilience (NIWACOOBII) was also applied to the October 2010 Mahurangi data (van Houte-Howes & Lohrer 2010; Lohrer & Rodil 2011). Values closer to 0 indicate low ecosystem functionality (and possibly an indication of site degradation) and values near 1 indicate high ecosystem functionality. Habitats with a high functionality (i.e., many species present in each functional trait group) tend to have a higher inherent resistance and resilience in the face of environmental change (Lohrer & Rodil 2011). The values generated for the intertidal sites range from 0.38 at the muddy Hamilton Landing site, to 0.93 at the sandier, heterogeneous Jamieson Bay site. The other four sites had very similar scores (0.40 Dyers Creek; 0.44 Mid Harbour; 0.47 Te Kapa Inlet; 0.49 Cowans Bay), and values were similar to those recorded for the sandy Auckland Airport and Cape Horn Manukau Harbour sites in October 2009 (Hailes & Hewitt 2011). The extremely high value for Jamieson Bay indicates that the community at this site has a higher ecological functionality compared to the communities at the other sites. Jamieson Bay has particularly high taxonomic diversity (71 taxa recorded in October 2010 c.f. 28 – 38 at the other five intertidal sites). This may be due to the heterogeneous nature of the sediment at this site, as it extends to lower on the shore than the other intertidal sites.

Using the Benthic Health Model (BHM; Anderson et al. 2006; Hewitt & Ellis 2010), the health of the Mahurangi sites (in October 2010) was assessed relative to sediment copper, zinc and/or lead concentrations (intertidal sites only) and sediment muddiness (intertidal and subtidal sites). The Mahurangi intertidal sites are situated towards the bottom left of the principle components analysis contaminant plot (Figure 24), indicating that these communities remain relatively healthy and unaffected by copper, zinc and/or lead concentrations. Jamieson Bay is the most contaminated site (highest PC1 values in Figure 24; also see Table 5 for actual values) and Dyers Creek the least. Despite its higher contaminant levels, Jamieson Bay appears the healthiest (lowest CAPcont scores in Figure 24) and Hamilton Landing is the least healthy. The positioning of Dyers Creek well outside the original model data cloud, and of Cowans Bay, Hamilton Landing and Jamieson Bay right on the edge of the data cloud, indicate that these sites do not fit the original model well.

Subtidal Site C is the muddiest of the monitoring sites, and Mid Harbour, Dyers Creek and Jamieson Bay are the least muddy (Figure 25). All of the Mahurangi sites fit within the original data cloud, suggesting that the BHM model for mud describes them well. This, together with the relatively poor fit for the BHM contaminant model, suggests that these community assemblages are more driven by mud content than contamination by copper, zinc and/or lead.

Figure 24

Plot of the relationship between the principle component axis related to copper, lead and zinc concentrations in the sediment and community composition related to them (CAPcont). Sites used to derive the initial BHM are blue and the Mahurangi sites are in red.

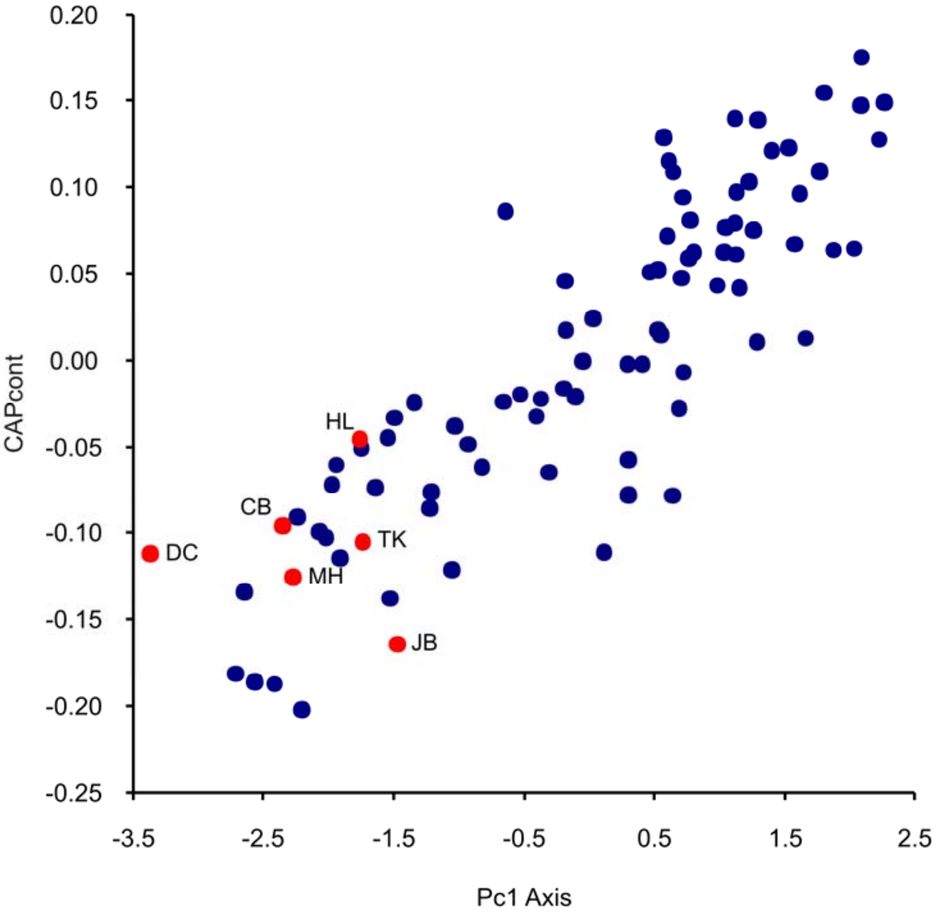
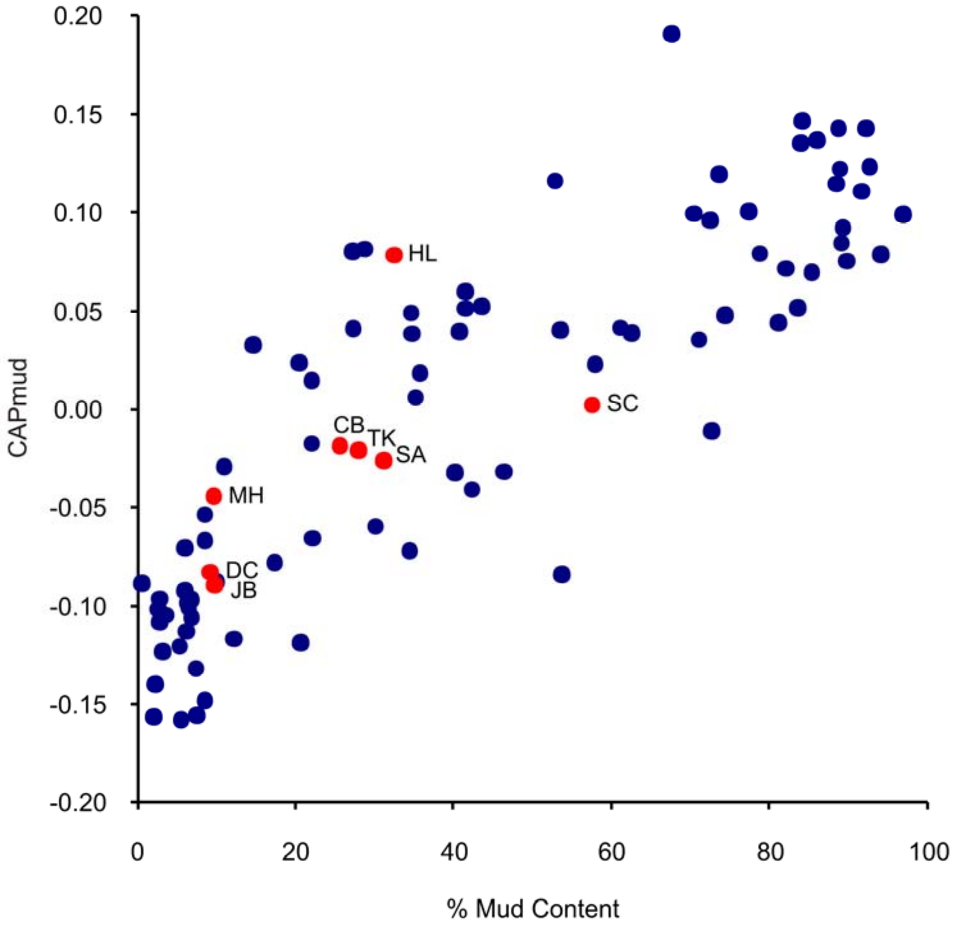


Figure 25

Plot of the relationship between the principle component axis related to the percent mud content of the sediment and community composition related to mud (CAPmud). Sites used to derive the initial BHM are blue and the Mahurangi sites are in red.

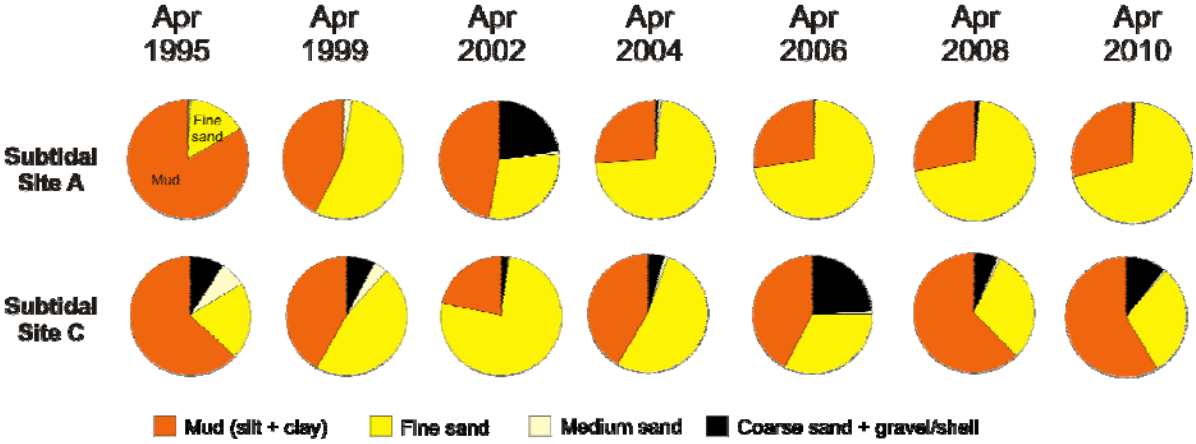


3.2 Subtidal sites

3.2.1 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 11). 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. 30 - 39% 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 26, Appendix 11).

Figure 26
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 on representative dates over the monitored period. Detailed sediment grain size data, on which these graphs are based, is presented in Appendix 11.

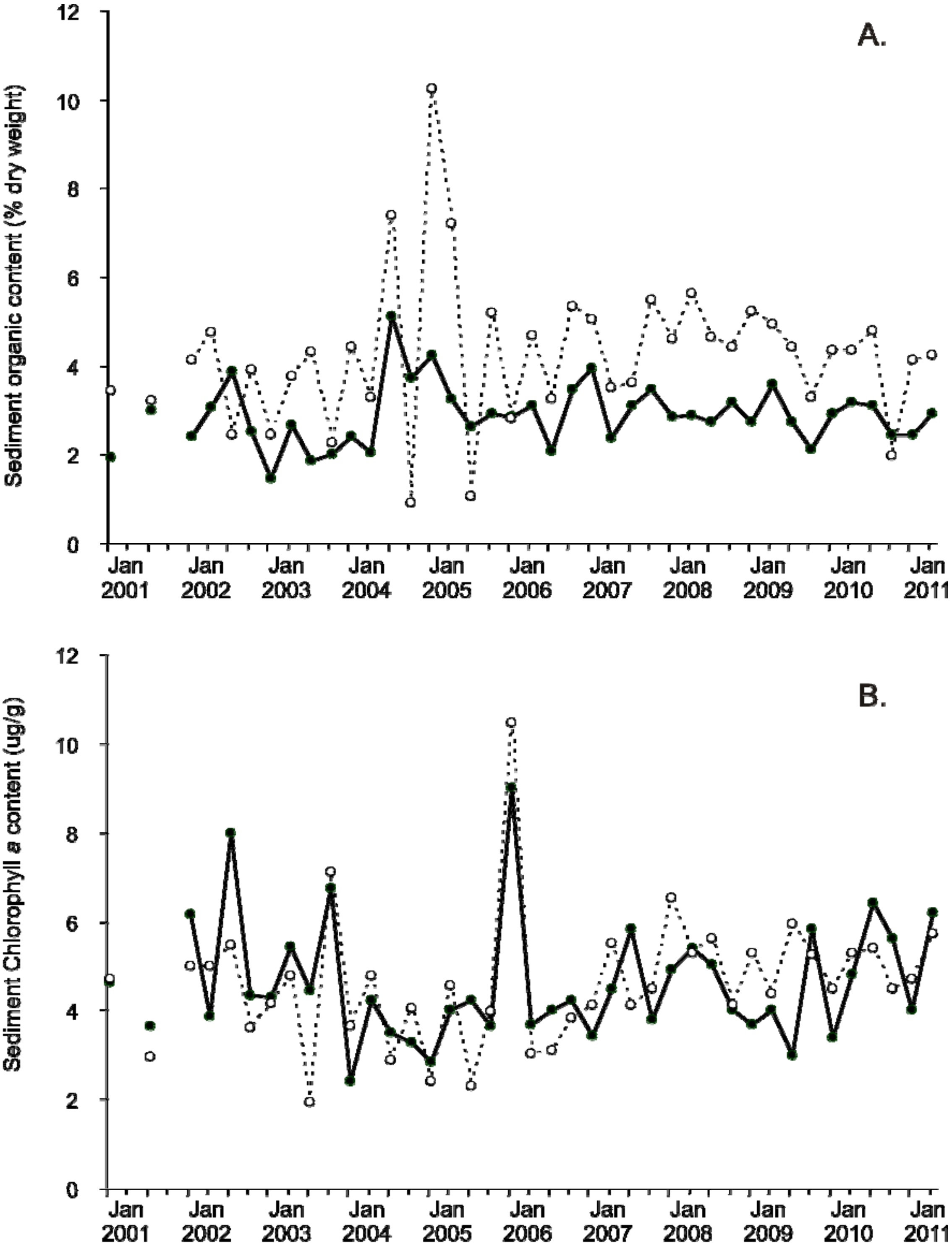


Organic content of the sediments is generally <5% at both subtidal sites, although levels tend to be slightly higher at Site C on most occasions (Figure 27A; Appendix 12). As noted in previous reports, the sediment organic content was higher at both sites between January 2004 and January 2005 than on previous sampling dates; levels since have remained slightly elevated relative to those found pre-January 2004 (Figure 27A).

Sediment chlorophyll *a* levels are very similar at each site and follow similar temporal fluctuations (Figure 27B; Appendix 12). Despite this, there is no predictable relationship between high and low chlorophyll *a* levels and sampling month (season).

Figure 27

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

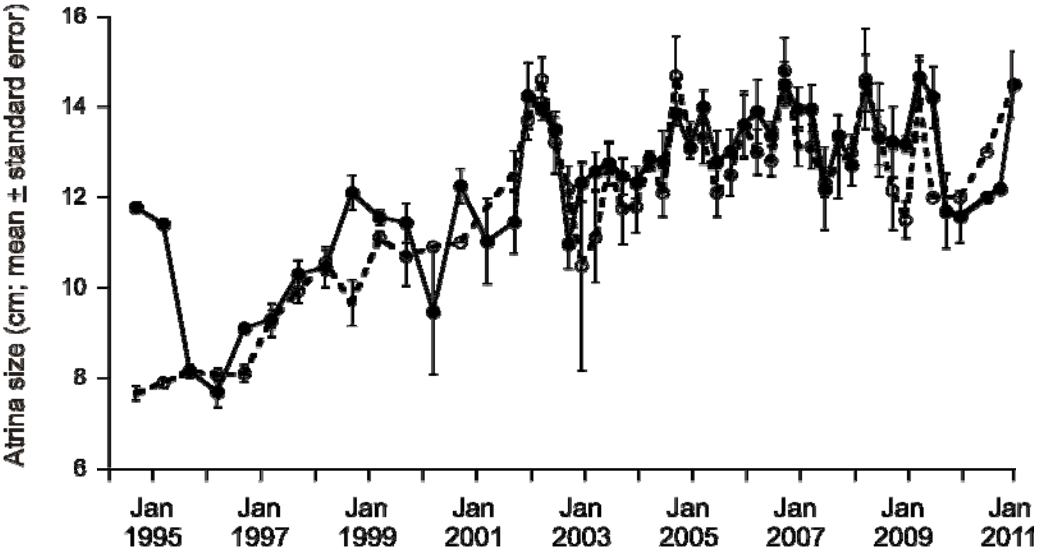


3.2.2 Atrina zelandica

Numbers and sizes of *Atrina zelandica* are similar at both of the subtidal sites, although slightly more live *Atrina* are found at Site A than Site C (2.5 c.f 1.5 individuals on average in each 0.25 m^2 quadrat). Numbers of live *Atrina* have been particularly low at both sites during the past year (0-0.3 and 0-0.1 individuals 0.25 m^{-2} at sites A and C respectively). *Atrina* sizes over the past two years have generally been similar at the two sites, and are similar to those noted in our last report. As stated previously, this probably reflects the fact that the growth of these populations has slowed or stopped as the individuals have aged and reached their maximum size (Figure 28). Beds of smaller individuals have not been observed in the vicinity of the areas targeted for monitoring, indicating there has been no recent recruitment to these sites.

Figure 28

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.



3.2.3 Macrofauna - comments on the abundance of common taxa

The abundances of subtidal monitored taxa collected at each site on each sampling date since the last report (i.e., from April 2009 to January 2011) are given in Appendix 13.

The following are site descriptions of the monitored macrofauna. We discuss the three most abundant populations, those exhibiting visually identifiable cycles in abundance, and populations for which statistically identifiable trends in abundance have been detected by trend analysis (see Table 7).

3.2.3.1 Site A

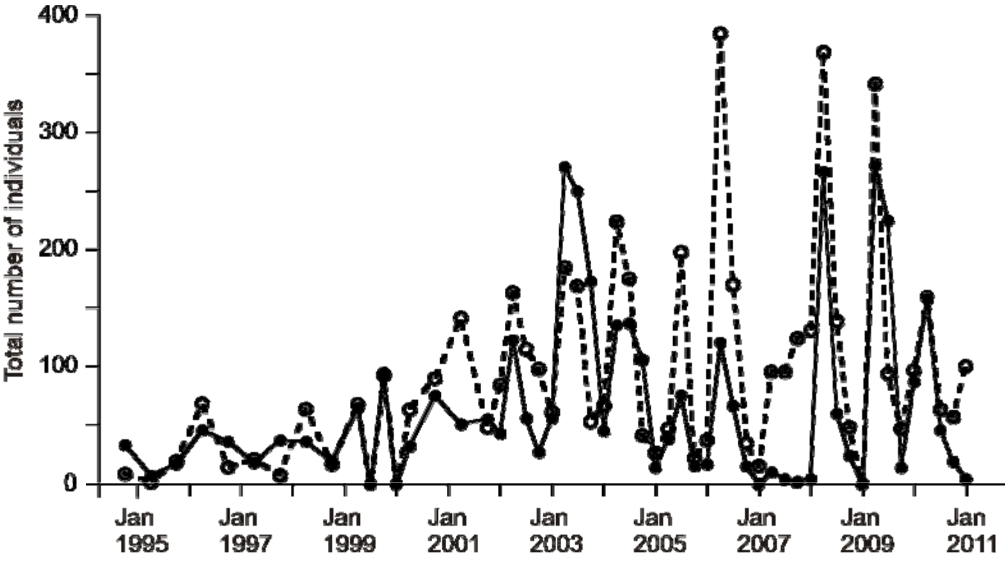
Eight taxa have comprised the dominant three at Site A over the past two years of monitoring: the bivalves *Theora lubrica* (4-272 individuals), *Nucula hartvigiana* (0-71 individuals) and *Arthritica bifurca* (6-76 individuals), the polychaetes *Aricidea* sp. (2-17 individuals), cirratulids (8-20 individuals), and *Prionospio* spp. (2-22 individuals), and the amphipods *Torridoharpinia hurleyi* (0-18 individuals) and corophidae-complex (0-16 individuals). All exhibit considerable fluctuations in abundance and all have previously featured amongst the dominant taxa at this site over the monitored period (Appendix 14).

Populations showing cyclic abundance patterns

Two populations exhibit annual abundance cycles at Site A. The polychaete *Armandia maculata* has large peaks in April, and smaller ones in October months. *Theora lubrica* generally exhibits peak abundances in April (Figure 29). Oligochaetes show a greater than annual cyclic abundance pattern; numbers have peaked in October of 1996, 2000 and 2010, in April of 2002, 2004, 2006 and 2008 and in July of 2009. All of these patterns were also noted in the 2009 report.

Figure 29

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



Populations showing trends in abundance

Two populations, *Aricidea* sp. and *Arthritica bifurca*, have increased in abundance at subtidal Site A over the duration of the monitoring programme (Table 7). The increase in *Aricidea* sp. still appears to be due to a step change early in 2000 (Table 7, Figure 30). While the increasing trend in *Arthritica bifurca* abundance is mostly due to a large recruitment event in April 2010 (76 individuals, more than twice any previous peak), abundances of this bivalve have generally been higher in the second half of the monitoring period (Table 7). The increasing abundance trend that had been noted for cirratulids in previous reports appears to be due to a step change in early 2000; since this time multiyear cycles have dominated the temporal dynamics to an extent that no significant increase can now be detected over the whole monitoring period (Figure 31). This pattern is also apparent for cirratulids at Site C where a significant increase is detected over the whole monitoring period (Figure 31)(see below).

Figure 30

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

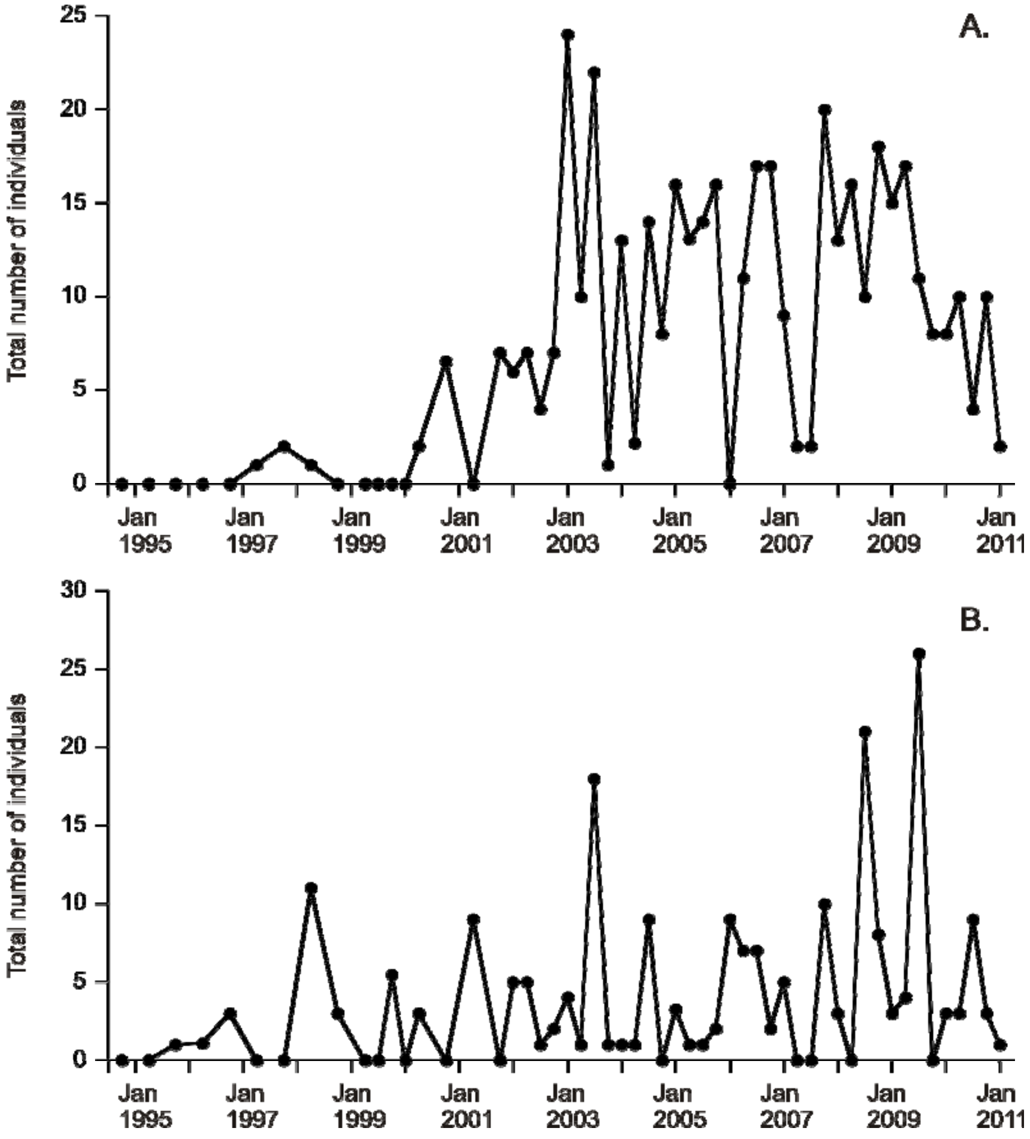


Figure 31

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

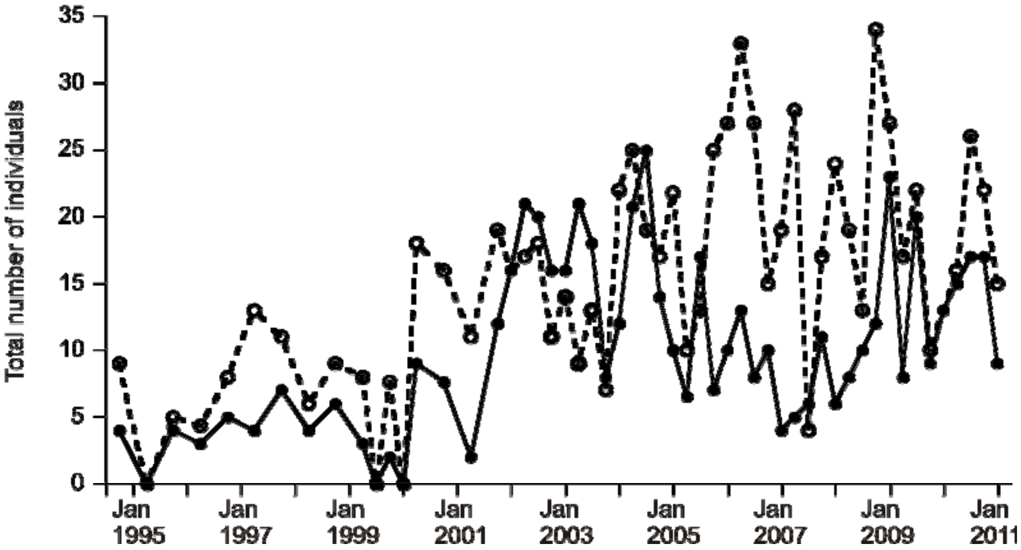
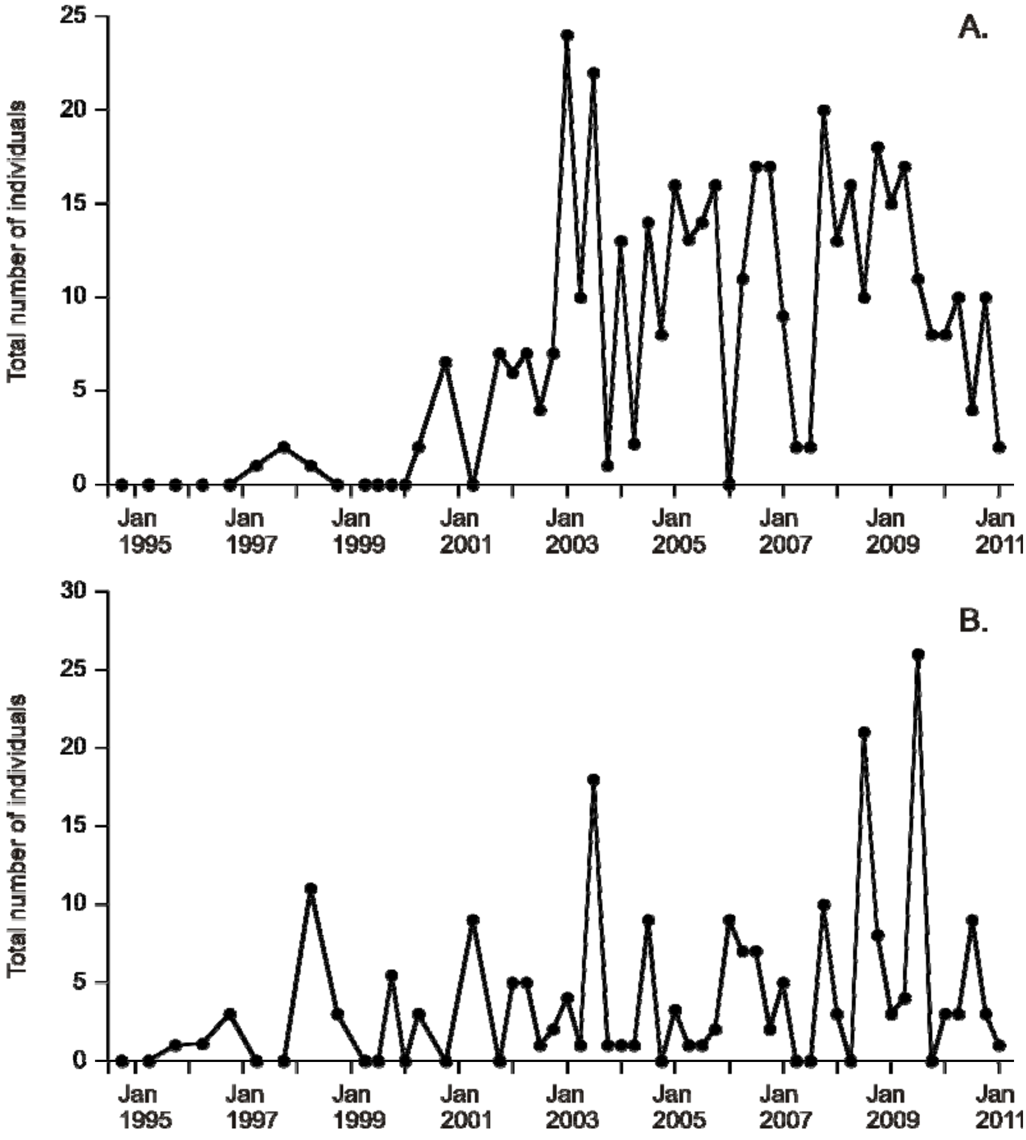


Figure 31

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



3.2.3.2 Site C

Seven taxa have comprised the dominant three at Site C over the past two years of monitoring: the bivalves *Theora lubrica* (47-342 individuals) and *Arthritica bifurca* (3-61 individuals), cirratulids (10-26 individuals) and polydorid (2-548 individuals) polychaetes, oligochaetes (31-149 individuals) and the amphipod *Torridoharpinia hurleyi* (1-31 individuals). These taxa have all previously featured amongst the dominant taxa at this site (Appendix 15).

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 29). Cirratulids (Figure 31) and corophidae-complex (figure not shown) exhibit complex cyclic patterns. Corophidae-complex numbers are generally low, but their peak abundances most often occur in January or April. Cirratulids peak in abundance every year, but the timing of these peaks is not predictable (Figure 31).

Populations showing trends in abundance

Three taxa are exhibiting trends in abundance at Site C (Table 7). A step trend was detected for cirratulid polychaetes, with numbers significantly higher post 1999. It's abundances have continued to increase, although less steeply in recent years (Figure 30). Peak abundances of *Theora lubrica* started to increase at a similar time to the step change in cirratulid abundance; however we consider this trend is being driven by large peaks in abundance only, as basal abundances of this bivalve have remained steady for a number of years now (Figure 29, Table 7). *Aricidea* sp. is generally rare at this site (mean of 4 individuals) but peak numbers have been increasing slightly. Due to the low density of this taxon at Site C and the small absolute change in mean abundance, we do not consider this trend to be ecologically meaningful. The increasing trend noted for *Arthritica bifurca* in previous reports is no longer apparent.

Table 7

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.* trends that are unlikely to be ecologically significant due to low numbers and/or sporadic occurrences of these taxa.

Monitored taxa	2011	2009	2007	2005	2003	2001
Site A						
Arthritica bifurca	0.31	No trend	0.29	0.40	No trend	No trend
Aricidea sp.	0.21 (step)	0.30 (step)	0.34	0.36 (0.18)	0.34	0.14
Cirratulids	No trend	0.28 (step)	0.21	0.44	0.46	No trend
Site C						
Aricidea sp.*	0.08	No trend				
Arthritica bifurca	No trend	-0.60	-0.75	-0.97	No trend	No trend
Cirratulids	0.27 (step)	0.35 (step)	0.38	0.36	0.36	No trend
Theora lubrica*	1.76	2.17	2.67	2.96 (1.32)	3.18	3.13

3.2.4 Subtidal sites - general patterns

Populations showing cyclic abundance patterns

Six of the monitored populations exhibit cyclic patterns in abundance at the subtidal sites (Table16). *Theora lubrica* [illegible]

Table 8

Summary of monitored taxa currently exhibiting cyclic abundance patterns at the Mahurangi subtidal monitoring sites. > indicates a greater than annual abundance cycle. * peaks occur annually but month of occurrence varies.

Taxa currently showing a cyclic abundance pattern	Site A	Site C
Armandia maculata	Apr/Oct	
Cirratulids		*
Corophidae complex		Jan/Apr
Oligochaetes	Apr/Oct (>)	
Theora lubrica	Apr	Apr

Populations showing trends in abundance

A total of three subtidal populations are exhibiting increasing trends in abundance at the Mahurangi Estuary subtidal sites (Table 9). *Aricidea* sp. and *Arthritica bifurca* are increasing in abundance at Site A. For *Aricidea*, this increase has persisted following a step change in early 2000. Cirratulid polychaetes are increasing in abundance at Site C following a step change in 1999. All of these taxa are known to prefer some mud content in the sediment but not high proportions (Gibbs & Hewitt 2004).

Table 9

Summary of monitored taxa showing statistically significant and ecologically meaningful 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. .* trends that are unlikely to be ecologically significant due to low numbers and/or sporadic occurrences of these taxa.

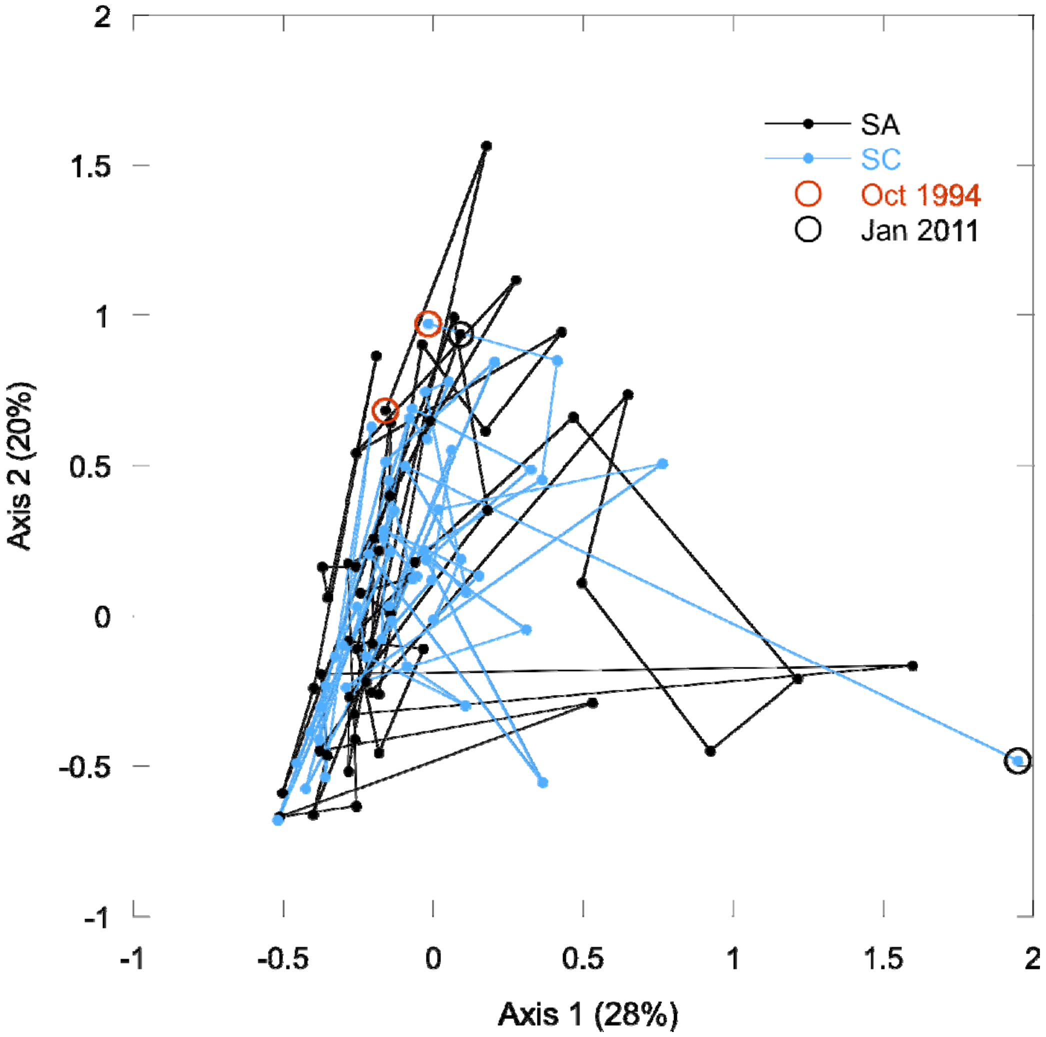
Taxa currently showing trends	Site A	Site C
Aricidea sp.	inc (step)	.
Arthritica bifurca	inc	.
Cirratulids	.	inc (step)

Community composition

In our previous reports, we noted that Sites A and C monitored communities have exhibited considerable fluctuations in abundance over the monitored period. The monitoring community at Site A is currently very similar to that at the start of the monitoring programme (Figure 32). In October 2010, the Site C community was also similar to that observed at the start of the monitoring programme, and to Site A. However, in January 2011 the Site C community deviated considerably from the communities previously noted at this site (Figure 32). This is mostly a reflection of the large increase in polydorid numbers (seven times higher than previously recorded), and a more modest increase in *Arthritica bifurca* numbers (Appendix 4).

Figure 32

Correspondence analysis ordination plot, showing the temporal variation in the monitored community composition at the subtidal sites over the monitored period. For each site, the positions of the community on the first (October 1994) and the most recent (January 2011) sampling occasions are highlighted. The percentage values associated with each axis indicate the % variance explained.



We considered whether there was any increase in temporal variability of subtidal community dynamics between the start of the monitored period and the last two years (Table 10). As for the intertidal sites, changes in within-year similarity were all increases (decreased variability) although the magnitude of these increases were slightly higher (10-14% cf. less than 8% for the intertidal sites). Between year variability also decreased *c.f.* the first five years of monitoring at both sites (i.e., % similarity between years was higher in the last two years)

Table 10

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

	Period	Site A	Site C
within year	first 5 years	63.76	70.95
	last 2 years	77.87	80.72
	difference	14.11	9.77
between year	first 5 years	63.14	67.86
	last 2 years	71.59	77.64
	difference	8.45	9.76

The NIWACOOBII has been calculated for the two Mahurangi subtidal sites using the October 2010 data; however these results should be treated as indicative-only of functional redundance as the index was developed using intertidal data only and has never been applied to or tested using subtidal data. The two subtidal sites scored moderate/high, and were very similar to each other: Site A (0.70) and Site C (0.66).

4 Summary and recommendations

4.1 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 six years of monitoring (Cummings et al. 2001). The sediment composition changes occurred sometime between April 1996 and April 1997 and have persisted (Figure 2 & 23; Appendices 2 & 5). Some of the patterns in the abundance of the monitored taxa are consistent with those that may be associated with elevated levels of sedimentation and/or organic enrichment. A major joint project between Auckland Regional Council and the Rodney District Council was initiated (i.e., the Mahurangi Action Plan, MAP), the aims of which were 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/environment/coastal-and-marine/sustainable-catchment-programme/mahurangi-action-plan/mahurangi-action-plan_home.cfm for details). Over about six years, the MAP has contributed to fencing and planting in selected subcatchment areas, to limit access of stock and input of sediments to waterways. Target catchment areas in the vicinity of our monitoring sites were Dyers Creek and Te Kapa Inlet. In response, a new 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 changes in catchment management. While trends and cycles in abundance have been detected at this site, more than 5.5 years of data is required to identify these with any certainty, so we will re-evaluate these trends in our next report. We will continue to assess any changes in the monitored communities at the Dyers Creek and Te Kapa Inlet sites in light of these catchment activities.

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 (Figure 23). The intertidal macrofaunal community at Dyers Creek exhibits strong similarities with those of Mid Harbour. The Jamieson Bay monitored community is the most variable over time. The subtidal monitored communities of Sites A and C had been very similar to each other on all but the most recent sampling date, when a seven-fold increase in numbers of polydorid polychaetes drove a change in community composition at Site C (Figure 32). Examination of more recently collected macrofaunal samples (April 2011, data not included in this report) shows these high numbers have not persisted at the site, and suggest this community change was only temporary.

A total of 24 intertidal populations have shown ecologically significant trends in abundance; 10 increases and 14 decreases (Table 4). All sites have populations that have exhibited, or still are exhibiting, ecologically significant trends; most occur at Hamilton Landing and Te Kapa Inlet (9 and 6 populations, respectively), and the least at Cowans Bay (1 population) (Table 4). Three subtidal populations have exhibited ecologically significant trends in abundance, and all of these are increases (Table 9). These subtidal taxa are known to prefer some mud but not high percentages (Gibbs & Hewitt 2004).

Twelve 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., 1999 - early 2000). As this pattern was observed in nine different taxa at five sites (Hamilton Landing, Jamieson Bay, Te Kapa Inlet, subtidal Sites A and C; Tables 3 and 9) it could not have been a localised event. We have hypothesised in our previous reports that these changes could have been due to a lagged response to an increase in the proportion of fine sand within the sediments that occurred in 1996/7, or as a result of larger than annual cyclic abundance patterns in some taxa. Halliday & Cummings (2009) described these one-off abundance changes that persisted over time as 'step' changes in abundance, where the mean abundances before and after the event are significantly different. Prior to our 2009 report, we had considered these abundance changes to be 'long-term trends'. However, by 2009 sufficient data were available before and after the 1999/2000 'change' to statistically test for step change patterns. Although the type of trend has changed as a result of this later analysis, the reasons for the changes (shifts in sediment grain size composition) have not. For all but one of the nine taxa (i.e., polydorids), the direction of change (an increase or decrease in abundance) was as would be predicted in response to an increase in sediment mud content, given our knowledge of their sensitivities to sediments.

Of most concern is that five taxa considered sensitive to increased sediment loadings are exhibiting declines in abundance in Mahurangi Estuary (*Macomona liliana, Austrovenus stutchburyi, Notoacmea scapha, Nucula hartvigiana, Scoloplos cylindrifer*; Table 4). Four of these continue to decline in abundance at the muddiest site, Hamilton Landing, and no sign of increase in these populations has been observed. Decreasing trends for *Austrovenus*, *Nucula and Notoacmea scapha* at Te Kapa Inlet are correlated with the continued expansion of the muddy portion of this site noted over the monitored period. The apparent recovery of *Macomona* noted at some sites in our previous report was due to large recruitment events in 2006–2009; unfortunately these high abundances have not persisted.

Nineteen intertidal and four subtidal populations exhibit cyclic abundance patterns (Tables 2 and 8). Very few exhibit peaks in abundance in the same monitoring month every year. This is not surprising given that these populations are only sampled at three monthly intervals. Long-term data from the Manukau Harbour ecological monitoring programme, where sites are sampled every two months, frequently shows offsets in recruitment by 2-3 months (Hewitt & Thrush 2007).

Numbers of *Atrina zelandica* continue to be very low at both subtidal sites, with 0-0.3 live individuals on average found in a 0.25 m^2 quadrat on any one sampling date. Over the past six years, *Atrina* sizes have also not changed, probably reflecting the fact that the growth of these populations has slowed or stopped as the individuals have aged and reached their maximum size (Figure 28). Consequently, we see no value in continuing to monitor the *Atrina* at these sites, and suggest that mapping the populations of these important bivalves in the wider estuary, at less frequent intervals, would be more informative.

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 at Mahurangi intertidal locations. For example, the stronger response of the Hamilton Landing populations to the estuary wide change in sediment characteristics may have been due to the already muddy nature of the sediments at this site, and the fact that the sediment-sensitive fauna residing there were closer to their ecological ‘tipping points’ than those at other sites. Interpretations of trends and patterns in abundance of Mahurangi populations is also done with knowledge of information on populations of the same taxa from Manukau (in particular) and Central 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 have not yet detected increases (to previous levels) in abundances of taxa known to be sensitive to increased sediment loading. Recruitment of juvenile bivalves to some of the intertidal populations has continued and is encouraging, as it highlights the potential for the recovery of some areas of the harbour should these control measures be effective. Unfortunately, however, this has not yet translated to increases in the numbers of spawning-sized individuals at these sites. The change in the bivalve measuring protocol (noted in the Methods) has not impacted on our ability to interpret abundance changes in monitored bivalve taxa.

The NIWACOOBII index was developed for the Auckland Council by NIWA to provide an understandable and scientifically defensible indicator of the ecological integrity of its estuarine and coastal areas. The index ranges from 0 to 1, with values near 0 indicating highly degraded sites and values near 1 indicating the opposite. The values generated for the Mahurangi Estuary intertidal sites using the October 2010 data ranged from 0.38 at the muddy Hamilton Landing site (indicative of low ecological functioning and, potentially, a moderately degraded site), to 0.93 at the sandier, more heterogeneous Jamieson Bay site (an extremely high value indicating high ecological functioning). The remaining sites scored from 0.40 – 0.49, which were similar values to the sandy Auckland Airport and Cape Horn monitoring sites in Manukau Harbour. The two subtidal sites scored relatively high values (0.66 – 0.70), but further investigation is needed to better determine the relevance of this index to subtidal sites.

Using the Benthic Health Model (BHM; Anderson et al. 2006; Hewitt & Ellis 2010), the health of the Mahurangi sites were assessed relative to sediment metal concentrations (copper, zinc and lead), and sediment muddiness. The contaminant BHM shows the Mahurangi sites are relatively healthy and unaffected by copper, zinc and/or lead concentrations. The mud BHM indicates that Subtidal Site C is the muddiest site and Mid Harbour, Dyers Creek and Jamieson Bay the least muddy (Figure 24). All the

Mahurangi sites fit well within the original data cloud for the mud BHM, suggesting that it describes them well. This, together with the relatively poor fit for the contaminant BHM, suggests that the observed community assemblages are more influenced by mud content than by concentrations of copper, zinc and/or lead.

Sediment contamination by several different metals and Polycyclic Aromatic Hydrocarbons (PAHs) at the intertidal sites were assessed against three management threshold standards. Levels of all metals and PAHs were, with one exception, below threshold levels. Concentrations of arsenic at Te Kapa Inlet exceeded one guideline threshold (TEL, MacDonald et al. 1996; Table 5), and arsenic levels at all other intertidal sites except Dyers Creek were close to this threshold. We recommend that monitoring levels of this contaminant in particular continues on a regular basis in the future.

The additional analyses presented in this year's report have been useful in providing further understanding of the functional health of the Mahurangi Estuary communities and the potential influences of site environmental conditions on the monitored taxa.

4.2 Recommendations for the monitoring programme

We recommend that the sampling conducted at the monitored sites should continue in its current form, but that regular evaluations are made of additional potentially useful variables to be monitored and analyses to be conducted. Given that the Mahurangi Action Plan has been in place for six years now, we consider that provision of a comprehensive summary of catchment management actions implemented over this time (and any future plans) by the Auckland Council would be extremely valuable to future interpretation of the monitoring results.

After careful examination of the monitoring results to date, we recommend that three sites (Cowans Bay, Subtidal Site A and Subtidal Site C) could be 'rested' from the programme for five years without significant loss of information. Cowans Bay and Subtidal Site A in particular have both shown very consistent patterns in community composition over the 16.5 years of monitoring to date (Figures 23 and 32). In stark contrast to the remaining intertidal monitoring sites, where numerous trends and cycles are apparent, the Cowans Bay monitored populations exhibit no repeatable cyclic patterns in abundance, and only one population currently exhibits a trend. Both Subtidal Site A and Subtidal Site C have shown a trends and cycles in abundance of a few populations only. The subtidal monitoring sites were established primarily to monitor the 'health' of *Atrina zelandica* (horse mussel), a key species in Mahurangi Estuary. However, the *Atrina* populations at both subtidal sites are at the end of their lives, and there has been no recruitment of *Atrina* to either site since monitoring began. To ensure that information on the state of *Atrina* beds in the estuary is assessed, we recommend that mapping the location and size of *Atrina* beds in selected part(s) of the estuary on a less frequent basis (e.g., two-yearly surveys using remote camera techniques) would be more informative. As is done for the Manukau and Central Waitemata monitoring programmes, we will continue to evaluate these decisions in light of future catchment development, or any other concerns which Auckland Council might have for this estuary. Recent discussions with Auckland Council around this recommendation have confirmed that there are no plans for Mahurangi estuary which may specifically affect these three sites in the near future.

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6 Appendices

6.1 Appendix 1

The taxa monitored at the intertidal and subtidal sites. Sediment preferences are derived from Tables 5 and 6 in Gibbs & Hewitt (2004) and from Norkko et al. (2001). Optimum range = the percent mud where taxa exhibit their highest abundances. Disturb. range = total range of occurrence over different mud concentrations. SS = strong preference for sand, S = prefers sand, I = prefers some mud but not in high percentages, MM = strong mud preference.

Taxonomic name	Common name/ description	Optimum range (%)	Distribution range (%)	Sediment preference
Intertidal				
Aonides trifida	worm	0-5	0-5	SS
Aricidea sp.	worm	35-40	0-70	I
Arthritica bifurca	small shellfish	55-60	5-70	I
Austrovenus stutchburyi	cockle	5-10	0-60	S
Cossura consimilis	worm	20-25	5-65	I
Hemiplax hirtipes	stalk-eyed mud crab	45-50	0-65	I
Heteromastus filiformis	worm	0-15	0-95	I
Macomona liliana	wedge shell	0-5	0-40	S
Nemerteans	nemertean worm			I
Notoacmea scapha	limpet	0-5	0-10	SS
Nucula hartvigiana	nut shell	0-5	0-60	S
Oligochaetes	worm	95-100	0-100	MM
Owenia fusiformis	tube dwelling worm	-	-	S
Paracalliope novizealandiae	sand hopper	35-40	0-50	MM
Perinereis vallata	worm	55-60	0-100	M[2]
Prionospio aucklandica	worm	65-70	0-95	I
Polydorids	tube dwelling worm	10-15	0-50	I[3]
Scoloplos cylindrifer	worm	0-5	0-60	S
Torridoharpinia hurleyi	sand hopper	-	-	S[4]

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[2] *Perinereis vallata* sensitivity to fine sediment based on sensitivity of all Nereidae.
[3] Polydorid sensitivity to fine sediment is derived from a specific polydorid, *Boccardia syrtis*.
[4] *Torridoharpinia hurleyi* sensitivity to fine sediment is derived from all phoxocephalids, not specifically *Torridoharpinia hurleyi*

Taxonomic name	Common name/ description	Optimum range (%)	Distribution range (%)	Sediment preference
Subtidal				
Aricidea sp.	worm	35-40	0-70	I
Armandia maculata	worm	-	-	-
Arthritica bifurca	small shellfish	55-60	5-70	I
Cirratulids	worm	10-15	5-70	I
Corophidae-complex	sand hopper	95-100	40-100	MM[5]
Nucula hartvigiana	nut shell	0-5	0-60	S
Oligochaetes	worm	95-100	0-100	MM
Polydorids	worm	10-15	0-50	I[6]
Prionospio spp.	worm	65-70	0-95	I
Tawera spissa	morning star shellfish	-	-	-
Theora lubrica	Asian semele shellfish	45-50	5-65	I
Torridoharpinia hurleyi	sand hopper	-	-	S[7]

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[5] Corophid-complex sediment sensitivity to fine sediment is derived from a specific Corophidae species, *Paracorophium excavatum*.

[6] Polydorid sensitivity to fine sediment from a specific polydorid, *Boccardia syrtis*.

[7] *Torridoharpinia hurleyi* sensitivity to fine sediment is derived from all Phoxocephalids, not specifically *Torridoharpinia hurleyi*

6.2 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/	1995	Apr	0.07	0.04	0.37	0.64	3.50	0.24	
Shell hash	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
		Oct	0.00	0.00	18.04	0.27	14.38	0.02	0.19
	2009	Jan	0.01	0.00	3.32	0.62	0.49	0.01	0.99
		Apr	0.02	0.03	10.69	0.49	3.76	0.08	0.90
		Jul	0.00	0.00	0.70	0.04	0.37	0.00	1.65
		Oct	0.00	0.14	3.01	0.00	11.28	0.00	0.63
	2010	Jan	0.00	0.00	0.00	1.32	2.54	0.05	1.02
		Apr	0.00	0.00	0.55	0.00	1.67	0.00	0.84

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
		Jul	0.00	0.00	0.01	0.06	0.07	0.37	1.70
		Oct	0.08	0.08	1.24	0.09	0.33	0.12	1.32
	2011	Jan	0.00	0.00	0.92	0.00	0.10	0.03	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
		Apr	0.05	0.10	6.97	0.10	0.17	0.15	0.16
		Jul	0.00	0.11	5.44	0.14	0.40	0.09	0.31
		Oct	0.00	0.27	5.82	0.05	0.20	0.12	0.38
	2010	Jan	0.06	0.00	0.59	0.03	0.65	0.30	0.25
		Apr	0.12	0.08	1.18	0.12	0.37	0.12	0.16
		Jul	0.25	0.28	0.40	0.24	0.20	0.44	0.29
		Oct	0.18	0.17	0.72	0.25	0.59	0.25	0.19
	2011	Jan	0.02	0.18	0.74	0.07	0.26	0.13	0.10
Medium sand	1995	Apr	38.94	30.74	64.93	43.64	38.15	39.60	
	1996	Apr	18.37	15.71	32.19	39.50	26.03	13.42	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
	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
		Apr	0.52	0.39	19.45	4.09	1.67	1.35	1.88
		Jul	0.39	0.25	15.39	2.87	1.21	1.69	2.47
		Oct	0.76	4.33	23.85	0.38	1.78	2.52	3.61
	2010	Jan	0.84	0.33	4.05	3.52	1.94	3.27	2.76
		Apr	0.61	0.20	7.69	2.56	1.66	2.67	2.33
		Jul	0.48	0.30	2.94	3.10	1.64	1.52	1.81
		Oct	0.78	0.34	5.10	4.47	1.53	2.91	1.65
	2011	Jan	0.45	0.15	3.91	3.36	1.46	1.75	2.82
Fine sand	1995	Apr	38.04	26.50	24.65	33.05	24.41	29.34	
	1996	Apr	28.40	19.08	19.11	26.16	16.90	19.79	
	1997	Apr	75.34	33.23	52.17	72.05	73.46	67.23	
	1998	Apr	79.76	52.91	47.18	80.72	75.12	58.41	
	1999	Apr	77.54	52.55	74.14	81.09	68.21	70.32	
	2000	Apr	66.19	60.20	29.26	79.84	79.29	63.18	
		Jul	70.18	42.73	56.13	74.69	87.48	54.48	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
		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
		Apr	73.79	51.95	59.24	78.05	77.56	72.12	89.25
		Jul	71.46	54.27	72.55	77.25	83.73	65.74	89.01
		Oct	72.92	83.46	60.16	62.89	70.02	65.00	85.31
	2010	Jan	76.04	55.13	87.57	85.18	71.63	60.70	84.89
		Apr	74.08	43.46	76.20	77.06	79.91	69.19	85.91
		Jul	70.93	55.41	77.32	73.13	81.40	74.45	83.45
		Oct	73.39	67.02	83.22	85.61	76.24	62.34	87.74
	2011	Jan	75.40	57.22	78.19	81.59	81.66	65.40	89.47
Silt	1995	Apr	17.42	34.03	6.44	18.37	27.38	23.63	
	1996	Apr	38.08	46.32	19.30	19.69	33.01	48.03	
	1997	Apr	11.12	39.04	4.09	7.78	7.27	21.66	
	1998	Apr	12.74	29.06	2.38	6.71	12.75	29.93	
	1999	Apr	8.24	27.77	7.56	8.73	17.98	19.41	
	2000	Apr	24.61	20.37	0.30	9.94	12.50	27.58	
		Jul	29.01	54.62	3.79	17.36	4.27	34.20	
		Oct	22.02	41.08	3.06	3.88	16.76	19.14	
	2001	Jan	22.22	28.10	8.00	7.10	7.93	29.95	
		Apr	18.98	40.19	0.04	31.70	36.64	29.83	
		Jul	26.93	47.46	7.36	30.22	17.02	35.93	
		Oct	7.84	48.63	11.09	3.31	11.83	32.13	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
	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
		Apr	18.19	29.71	1.82	16.41	9.24	18.89	4.30
		Jul	20.95	31.84	4.51	14.29	6.63	25.80	3.28
		Oct	22.78	8.21	4.38	26.32	8.95	28.87	7.55
	2010	Jan	14.96	31.26	4.28	3.87	11.25	29.75	6.16
		Apr	20.66	46.39	9.42	15.76	7.95	20.96	6.28
		Jul	22.11	33.65	14.00	15.65	15.78	14.63	8.06
		Oct	25.57	28.79	9.71	5.48	11.63	35.76	8.40
	2011	Jan	21.65	42.45	14.21	12.60	10.32	30.97	5.50
Clay	1995	Apr	5.45	4.96	3.34	4.10	2.98	6.98	
	1996	Apr	14.61	17.42	8.29	8.48	18.07	17.03	
	1997	Apr	4.75	26.33	0.51	6.54	6.76	7.52	
	1998	Apr	6.64	10.77	0.32	4.18	7.09	11.00	
	1999	Apr	12.31	16.05	0.14	6.25	11.09	7.65	
	2000	Apr	8.60	14.12	0.90	5.03	6.43	7.37	
		Jul	0.08	1.34	0.11	3.01	2.00	10.89	
		Oct	5.74	6.54	0.53	0.37	3.22	18.19	
	2001	Jan	4.19	5.02	0.45	1.47	2.55	5.82	
		Apr	2.45	3.04	1.67	3.23	8.83	5.65	
		Jul	0.13	1.55	0.05	0.62	1.06	1.49	
		Oct	11.05	6.83	0.58	7.40	2.35	5.38	
	2002	Jan	0.44	6.41	0.37	2.64	2.61	4.11	
		Apr	6.68	3.95	3.53	5.53	1.88	4.31	
		Jul	2.13	11.87	2.52	7.09	23.95	8.59	
		Oct	4.92	11.50	3.49	2.76	2.63	6.43	
	2003	Jan	4.43	9.01	2.64	3.38	10.79	8.55	

% sediment composition	Year	Month	CB	HL	JB	MH	TK (sand)	TK (mud)	DC
		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
		Apr	7.44	17.83	1.82	0.86	7.92	7.09	3.52
		Jul	7.20	13.53	1.41	5.42	7.18	7.17	3.28
		Oct	3.53	3.59	2.79	10.37	7.03	4.23	2.52
	2010	Jan	8.10	13.28	3.50	6.08	10.66	7.26	4.93
		Apr	4.52	9.87	4.96	4.50	7.42	8.06	4.48
		Jul	6.22	10.35	5.33	7.83	1.03	8.47	4.70
		Oct	0.00	3.60	0.00	4.11	8.30	0.00	0.70
	2011	Jan	2.47	0.00	2.03	2.36	5.90	2.02	2.12

6.3 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
Apr-09	1.57	4.17	1.41	1.86	2.58	1.79	1.19
Jul-09	2.25	4.05	1.24	2.02	2.45	1.54	1.10
Oct-10	2.33	1.92	1.81	3.97	2.64	2.14	1.60

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Jan-10	1.96	3.89	1.58	1.69	2.89	2.60	1.44
Apr-10	2.42	4.39	2.30	2.24	2.42	2.40	1.27
Jul-10	4.46*	4.75	2.40	2.72	2.73	1.91	1.94*
Oct-10	1.23	2.37	0.86	1.30	2.82	1.92	1.21
Jan-11	1.91	3.83	2.15	1.91	2.30	2.33	1.05

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
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
Apr-09	15.82	11.46	5.62	12.15*	12.38	8.02	9.40
Jul-09	16.05	14.22	4.59	8.60	13.07	6.65	9.86*

	Cowans Bay	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Oct-10	15.82	7.11	4.53	11.92	9.28	6.19	9.40
Jan-10	14.22	9.97	6.30	7.79	9.17	7.68	6.65
Apr-10	15.82	13.52	8.94*	9.40	14.67	6.65	7.22
Jul-10	13.99	11.12	4.93	7.11	10.78	5.50	7.57
Oct-10	17.31	11.12	4.47	8.25	12.95	6.19	6.76
Jan-11	17.88	8.71	5.85	7.79	11.35	7.68	7.34

6.4 Appendix 4

Summary of temporal results at the intertidal sites from April 2009 (Time = 60) to January 2011 (Time = 67). CB = Cowans Bay, DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Aonides trifida	CB	60	0	0	0	0.00
Aonides trifida	CB	61	0	0	0	0.00
Aonides trifida	CB	62	0	0	0	0.00
Aonides trifida	CB	63	0	0	0	0.00
Aonides trifida	CB	64	0	0	0	0.00
Aonides trifida	CB	65	0	0	0	0.00
Aonides trifida	CB	66	0	0	0	0.00
Aonides trifida	CB	67	0	0	0	0.00
Aonides trifida	DC	60	0	0	0	0.00
Aonides trifida	DC	61	0	0	0	0.00
Aonides trifida	DC	62	0	0	0	0.00
Aonides trifida	DC	63	0	0	0	0.00
Aonides trifida	DC	64	4	0	3	0.33
Aonides trifida	DC	65	0	0	0	0.00
Aonides trifida	DC	66	0	0	0	0.00
Aonides trifida	DC	67	0	0	0	0.00
Aonides trifida	HL	60	0	0	0	0.00
Aonides trifida	HL	61	0	0	0	0.00
Aonides trifida	HL	62	0	0	0	0.00
Aonides trifida	HL	63	0	0	0	0.00
Aonides trifida	HL	64	18	0	6	1.50
Aonides trifida	HL	65	0	0	0	0.00
Aonides trifida	HL	66	0	0	0	0.00
Aonides trifida	HL	67	0	0	0	0.00
Aonides trifida	JB	60	12	0	10	1.00
Aonides trifida	JB	61	4	0	3	0.33
Aonides trifida	JB	62	35	0	23	2.92
Aonides trifida	JB	63	4	0	4	0.33
Aonides trifida	JB	64	52	0	37	4.33
Aonides trifida	JB	65	0	0	0	0.00
Aonides trifida	JB	66	0	0	0	0.00
Aonides trifida	JB	67	1	0	1	0.08
Aonides trifida	MH	60	0	0	0	0.00
Aonides trifida	MH	61	1	0	1	0.08
Aonides trifida	MH	62	0	0	0	0.00
Aonides trifida	MH	63	0	0	0	0.00
Aonides trifida	MH	64	0	0	0	0.00
Aonides trifida	MH	65	0	0	0	0.00

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

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

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Aonides trifida	MH	66	0	0	0	0.00
Aonides trifida	MH	67	0	0	0	0.00
Aonides trifida	TK	60	0	0	0	0.00
Aonides trifida	TK	61	0	0	0	0.00
Aonides trifida	TK	62	0	0	0	0.00
Aonides trifida	TK	63	0	0	0	0.00
Aonides trifida	TK	64	0	0	0	0.00
Aonides trifida	TK	65	0	0	0	0.00
Aonides trifida	TK	66	0	0	0	0.00
Aonides trifida	TK	67	0	0	0	0.00
Aonides trifida	CB	60	6	0.5	1	0.50
Aonides trifida	CB	61	14	1	4	1.17
Aonides trifida	CB	62	7	0	3	0.58
Aonides trifida	CB	63	1	0	1	0.08
Aonides trifida	CB	64	8	0	3	0.67
Aonides trifida	CB	65	8	0	2	0.67
Aonides trifida	CB	66	6	0	2	0.50
Aonides trifida	CB	67	5	0	3	0.42
Aonides trifida	DC	60	24	1.5	6	2.00
Aonides trifida	DC	61	9	0.5	2	0.75
Aonides trifida	DC	62	20	1	5	1.67
Aonides trifida	DC	63	9	0.5	3	0.75
Aonides trifida	DC	64	19	1	7	1.58
Aonides trifida	DC	65	20	2	3	1.67
Aonides trifida	DC	66	24	2	5	2.00
Aonides trifida	DC	67	17	1	6	1.42
Aonides trifida	HL	60	71	5	10	5.92
Aonides trifida	HL	61	36	2	10	3.00
Aonides trifida	HL	62	55.6	4.3	11	4.64
Aonides trifida	HL	63	44	3	8	3.67
Aonides trifida	HL	64	49	3.5	8	4.08
Aonides trifida	HL	65	93	8	13	7.75
Aonides trifida	HL	66	86	6.5	20	7.17
Aonides trifida	HL	67	90	7	15	7.50
Aonides trifida	JB	60	19	1.5	4	1.58
Aonides trifida	JB	61	18	1	4	1.50
Aonides trifida	JB	62	19	1	7	1.58
Aonides trifida	JB	63	5	0	2	0.42
Aonides trifida	JB	64	16	0.5	5	1.33
Aonides trifida	JB	65	37	2	7	3.08
Aonides trifida	JB	66	30	2	8	2.50
Aonides trifida	JB	67	32	2.5	9	2.67
Aonides trifida	MH	60	16	1	4	1.33
Aonides trifida	MH	61	41	3	9	3.42
Aonides trifida	MH	62	33.8	1	16	2.82
Aonides trifida	MH	63	30	2	6	2.50
Aonides trifida	MH	64	12	1	4	1.00

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Aonides trifida	MH	65	37	3	4	3.08
Aonides trifida	MH	66	11	1	4	0.92
Aonides trifida	MH	67	11	0	3	0.92
Aonides trifida	TK	60	86	5.5	22	7.17
Aonides trifida	TK	61	91	4	34	7.58
Aonides trifida	TK	62	109	7.5	26	9.08
Aonides trifida	TK	63	29	2	6	2.42
Aonides trifida	TK	64	108	6.5	35	9.00
Aonides trifida	TK	65	112	8.5	18	9.33
Aonides trifida	TK	66	155	11.5	25	12.92
Aonides trifida	TK	67	88	4.5	18	7.33
Arthritica bifurca	CB	60	25	1	7	2.08
Arthritica bifurca	CB	61	25	2	5	2.08
Arthritica bifurca	CB	62	10	0.5	3	0.83
Arthritica bifurca	CB	63	83	4	20	6.92
Arthritica bifurca	CB	64	102	4.5	31	8.50
Arthritica bifurca	CB	65	106	5	34	8.83
Arthritica bifurca	CB	66	74	5	17	6.17
Arthritica bifurca	CB	67	152	9.5	39	12.67
Arthritica bifurca	DC	60	11	0	7	0.92
Arthritica bifurca	DC	61	2	0	1	0.17
Arthritica bifurca	DC	62	3	0	1	0.25
Arthritica bifurca	DC	63	37	1.5	10	3.08
Arthritica bifurca	DC	64	22	1	10	1.83
Arthritica bifurca	DC	65	9	0	4	0.75
Arthritica bifurca	DC	66	9	0	4	0.75
Arthritica bifurca	DC	67	25	1.5	7	2.08
Arthritica bifurca	HL	60	0	0	0	0.00
Arthritica bifurca	HL	61	5	0	3	0.42
Arthritica bifurca	HL	62	2.2	0	1	0.18
Arthritica bifurca	HL	63	17	0	11	1.42
Arthritica bifurca	HL	64	1	0	1	0.08
Arthritica bifurca	HL	65	7	0	5	0.58
Arthritica bifurca	HL	66	25	1.5	8	2.08
Arthritica bifurca	HL	67	16	0	8	1.33
Arthritica bifurca	JB	60	3	0	3	0.25
Arthritica bifurca	JB	61	1	0	1	0.08
Arthritica bifurca	JB	62	3	0	2	0.25
Arthritica bifurca	JB	63	1	0	1	0.08
Arthritica bifurca	JB	64	5	0	2	0.42
Arthritica bifurca	JB	65	5	0	3	0.42
Arthritica bifurca	JB	66	17	0.5	6	1.42
Arthritica bifurca	JB	67	13	0	5	1.08
Arthritica bifurca	MH	60	123	9	19	10.25
Arthritica bifurca	MH	61	82	4.5	20	6.83
Arthritica bifurca	MH	62	32.7	2.4	10	2.73
Arthritica bifurca	MH	63	70	5.5	12	5.83

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Arthritica bifurca	MH	64	108	7.5	22	9.00
Arthritica bifurca	MH	65	58	3	14	4.83
Arthritica bifurca	MH	66	48	4	9	4.00
Arthritica bifurca	MH	67	223	14.5	39	18.58
Arthritica bifurca	TK	60	12	0.5	4	1.00
Arthritica bifurca	TK	61	12	0	4	1.00
Arthritica bifurca	TK	62	7	0	2	0.58
Arthritica bifurca	TK	63	12	0.5	3	1.00
Arthritica bifurca	TK	64	24	1	6	2.00
Arthritica bifurca	TK	65	36	2.5	10	3.00
Arthritica bifurca	TK	66	50	2.5	11	4.17
Arthritica bifurca	TK	67	137	5	35	11.42
Austrovenus stutchburyi	CB	60	1	0	1	0.08
Austrovenus stutchburyi	CB	61	0	0	0	0.00
Austrovenus stutchburyi	CB	62	7	1	1	0.58
Austrovenus stutchburyi	CB	63	6	0	2	0.50
Austrovenus stutchburyi	CB	64	0	0	0	0.00
Austrovenus stutchburyi	CB	65	0	0	0	0.00
Austrovenus stutchburyi	CB	66	5	0	1	0.42
Austrovenus stutchburyi	CB	67	1	0	1	0.08
Austrovenus stutchburyi	DC	60	197	17.5	27	16.42
Austrovenus stutchburyi	DC	61	180	11.5	21	15.00
Austrovenus stutchburyi	DC	62	274	20	36	22.83
Austrovenus stutchburyi	DC	63	186	14.5	23	15.50
Austrovenus stutchburyi	DC	64	204	15	22	17.00
Austrovenus stutchburyi	DC	65	238	17.5	42	19.83
Austrovenus stutchburyi	DC	66	287	21.5	41	23.92
Austrovenus stutchburyi	DC	67	336	27.5	30	28.00
Austrovenus stutchburyi	HL	60	4	0	2	0.33
Austrovenus stutchburyi	HL	61	26	2	5	2.17
Austrovenus stutchburyi	HL	62	3.27	0	1	0.27
Austrovenus stutchburyi	HL	63	2	0	1	0.17
Austrovenus stutchburyi	HL	64	6	0	2	0.50
Austrovenus stutchburyi	HL	65	11	0.5	2	0.92
Austrovenus stutchburyi	HL	66	9	0	4	0.75
Austrovenus stutchburyi	HL	67	2	0	1	0.17
Austrovenus stutchburyi	JB	60	2	0	1	0.17
Austrovenus stutchburyi	JB	61	8	0	3	0.67
Austrovenus stutchburyi	JB	62	38	0	28	3.17
Austrovenus stutchburyi	JB	63	0	0	0	0.00
Austrovenus stutchburyi	JB	64	9	0.5	2	0.75
Austrovenus stutchburyi	JB	65	1	0	1	0.08
Austrovenus stutchburyi	JB	66	7	0	2	0.58
Austrovenus stutchburyi	JB	67	31	0	13	2.58
Austrovenus stutchburyi	MH	60	0	0	0	0.00
Austrovenus stutchburyi	MH	61	0	0	0	0.00
Austrovenus stutchburyi	MH	62	0	0	0	0.00

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Austrovenus stutchburyi	MH	63	1	0	1	0.08
Austrovenus stutchburyi	MH	64	0	0	0	0.00
Austrovenus stutchburyi	MH	65	0	0	0	0.00
Austrovenus stutchburyi	MH	66	1	0	1	0.08
Austrovenus stutchburyi	MH	67	0	0	0	0.00
Austrovenus stutchburyi	TK	60	6	0	4	0.50
Austrovenus stutchburyi	TK	61	52	0.5	45	4.33
Austrovenus stutchburyi	TK	62	93	8	15	7.75
Austrovenus stutchburyi	TK	63	59	1	36	4.92
Austrovenus stutchburyi	TK	64	14	0.5	5	1.17
Austrovenus stutchburyi	TK	65	6	0	4	0.50
Austrovenus stutchburyi	TK	66	78	4.5	14	6.50
Austrovenus stutchburyi	TK	67	130	1	61	10.83
Cossura consimilis	CB	60	200	15.5	22	16.67
Cossura consimilis	CB	61	194	17.5	21	16.17
Cossura consimilis	CB	62	150	12	9	12.50
Cossura consimilis	CB	63	167	15	16	13.92
Cossura consimilis	CB	64	145	12.5	17	12.08
Cossura consimilis	CB	65	150	13	21	12.50
Cossura consimilis	CB	66	139	10.5	17	11.58
Cossura consimilis	CB	67	132	9.5	17	11.00
Cossura consimilis	DC	60	0	0	0	0.00
Cossura consimilis	DC	61	4	0	3	0.33
Cossura consimilis	DC	62	0	0	0	0.00
Cossura consimilis	DC	63	0	0	0	0.00
Cossura consimilis	DC	64	0	0	0	0.00
Cossura consimilis	DC	65	2	0	1	0.17
Cossura consimilis	DC	66	1	0	1	0.08
Cossura consimilis	DC	67	3	0	2	0.25
Cossura consimilis	HL	60	712	52.5	121	59.33
Cossura consimilis	HL	61	568	45	86	47.33
Cossura consimilis	HL	62	510.6	44.5	42	42.55
Cossura consimilis	HL	63	578	43	68	48.17
Cossura consimilis	HL	64	583	48	93	48.58
Cossura consimilis	HL	65	723	64.5	87	60.25
Cossura consimilis	HL	66	585	50	77	48.75
Cossura consimilis	HL	67	678	51.5	67	56.50
Cossura consimilis	JB	60	3	0	1	0.25
Cossura consimilis	JB	61	47	2	30	3.92
Cossura consimilis	JB	62	3	0	2	0.25
Cossura consimilis	JB	63	6	0	2	0.50
Cossura consimilis	JB	64	8	0	5	0.67
Cossura consimilis	JB	65	17	1.5	4	1.42
Cossura consimilis	JB	66	19	1	8	1.58
Cossura consimilis	JB	67	9	0	3	0.75
Cossura consimilis	MH	60	46	2.5	10	3.83
Cossura consimilis	MH	61	54	4.5	9	4.50

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Cossura consimilis	MH	62	41.5	3	10	3.45
Cossura consimilis	MH	63	52	3.5	8	4.33
Cossura consimilis	MH	64	40	3	9	3.33
Cossura consimilis	MH	65	71	6	9	5.92
Cossura consimilis	MH	66	45	3.5	7	3.75
Cossura consimilis	MH	67	40	2.5	8	3.33
Cossura consimilis	TK	60	314	23.5	58	26.17
Cossura consimilis	TK	61	346	26.5	75	28.83
Cossura consimilis	TK	62	384	30.5	64	32.00
Cossura consimilis	TK	63	230	24	38	19.17
Cossura consimilis	TK	64	324	27.5	57	27.00
Cossura consimilis	TK	65	428	35	64	35.67
Cossura consimilis	TK	66	411	25.5	87	34.25
Cossura consimilis	TK	67	471	35.5	109	39.25
Hemiplax hirtipes	CB	60	1	0	1	0.08
Hemiplax hirtipes	CB	61	4	0	2	0.33
Hemiplax hirtipes	CB	62	7	0	2	0.58
Hemiplax hirtipes	CB	63	6	0	3	0.50
Hemiplax hirtipes	CB	64	1	0	1	0.08
Hemiplax hirtipes	CB	65	17	1.5	3	1.42
Hemiplax hirtipes	CB	66	10	0.5	2	0.83
Hemiplax hirtipes	CB	67	0	0	0	0.00
Hemiplax hirtipes	DC	60	2	0	1	0.17
Hemiplax hirtipes	DC	61	7	0	2	0.58
Hemiplax hirtipes	DC	62	2	0	1	0.17
Hemiplax hirtipes	DC	63	6	0	3	0.50
Hemiplax hirtipes	DC	64	2	0	1	0.17
Hemiplax hirtipes	DC	65	7	0.5	2	0.58
Hemiplax hirtipes	DC	66	14	1	3	1.17
Hemiplax hirtipes	DC	67	6	0	2	0.50
Hemiplax hirtipes	HL	60	0	0	0	0.00
Hemiplax hirtipes	HL	61	5	0	4	0.42
Hemiplax hirtipes	HL	62	4.4	0	1	0.36
Hemiplax hirtipes	HL	63	2	0	1	0.17
Hemiplax hirtipes	HL	64	0	0	0	0.00
Hemiplax hirtipes	HL	65	5	0	2	0.42
Hemiplax hirtipes	HL	66	19	2	3	1.58
Hemiplax hirtipes	HL	67	0	0	0	0.00
Hemiplax hirtipes	JB	60	0	0	0	0.00
Hemiplax hirtipes	JB	61	1	0	1	0.08
Hemiplax hirtipes	JB	62	0	0	0	0.00
Hemiplax hirtipes	JB	63	0	0	0	0.00
Hemiplax hirtipes	JB	64	1	0	1	0.08
Hemiplax hirtipes	JB	65	4	0	3	0.33
Hemiplax hirtipes	JB	66	3	0	1	0.25
Hemiplax hirtipes	JB	67	2	0	1	0.17
Hemiplax hirtipes	MH	60	1	0	1	0.08

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Hemiplax hirtipes	MH	61	4	0	2	0.33
Hemiplax hirtipes	MH	62	0	0	0	0.00
Hemiplax hirtipes	MH	63	2	0	2	0.17
Hemiplax hirtipes	MH	64	4	0	2	0.33
Hemiplax hirtipes	MH	65	10	1	3	0.83
Hemiplax hirtipes	MH	66	10	0	3	0.83
Hemiplax hirtipes	MH	67	0	0	0	0.00
Hemiplax hirtipes	TK	60	0	0	0	0.00
Hemiplax hirtipes	TK	61	2	0	1	0.17
Hemiplax hirtipes	TK	62	1	0	1	0.08
Hemiplax hirtipes	TK	63	1	0	1	0.08
Hemiplax hirtipes	TK	64	2	0	1	0.17
Hemiplax hirtipes	TK	65	2	0	1	0.17
Hemiplax hirtipes	TK	66	7	0.5	2	0.58
Hemiplax hirtipes	TK	67	2	0	1	0.17
Heteromastus filiformis	CB	60	55	3.5	11	4.58
Heteromastus filiformis	CB	61	108	7	23	9.00
Heteromastus filiformis	CB	62	180	14.5	25	15.00
Heteromastus filiformis	CB	63	144	13	11	12.00
Heteromastus filiformis	CB	64	157	12	25	13.08
Heteromastus filiformis	CB	65	151	9	41	12.58
Heteromastus filiformis	CB	66	158	12	24	13.17
Heteromastus filiformis	CB	67	96	7	16	8.00
Heteromastus filiformis	DC	60	9	0	3	0.75
Heteromastus filiformis	DC	61	6	0	3	0.50
Heteromastus filiformis	DC	62	20	1	4	1.67
Heteromastus filiformis	DC	63	8	0.5	2	0.67
Heteromastus filiformis	DC	64	3	0	1	0.25
Heteromastus filiformis	DC	65	26	1	6	2.17
Heteromastus filiformis	DC	66	23	1.5	5	1.92
Heteromastus filiformis	DC	67	8	0.5	2	0.67
Heteromastus filiformis	HL	60	250	22	28	20.83
Heteromastus filiformis	HL	61	191	13	29	15.92
Heteromastus filiformis	HL	62	149.5	12.3	29	12.45
Heteromastus filiformis	HL	63	227	20	17	18.92
Heteromastus filiformis	HL	64	112	9.5	12	9.33
Heteromastus filiformis	HL	65	228	18	22	19.00
Heteromastus filiformis	HL	66	214	17	26	17.83
Heteromastus filiformis	HL	67	244	20	37	20.33
Heteromastus filiformis	JB	60	5	0	2	0.42
Heteromastus filiformis	JB	61	15	0	6	1.25
Heteromastus filiformis	JB	62	9	0.5	3	0.75
Heteromastus filiformis	JB	63	10	0	8	0.83
Heteromastus filiformis	JB	64	21	1	6	1.75
Heteromastus filiformis	JB	65	29	2	8	2.42
Heteromastus filiformis	JB	66	47	2.5	18	3.92
Heteromastus filiformis	JB	67	115	1.5	42	9.58

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Heteromastus filiformis	MH	60	25	1.5	8	2.08
Heteromastus filiformis	MH	61	33	3	6	2.75
Heteromastus filiformis	MH	62	17.5	0.5	6	1.45
Heteromastus filiformis	MH	63	18	1	4	1.50
Heteromastus filiformis	MH	64	10	0.5	4	0.83
Heteromastus filiformis	MH	65	47	4	9	3.92
Heteromastus filiformis	MH	66	65	4.5	13	5.42
Heteromastus filiformis	MH	67	41	4	8	3.42
Heteromastus filiformis	TK	60	47	3.5	9	3.92
Heteromastus filiformis	TK	61	106	7	25	8.83
Heteromastus filiformis	TK	62	110	7	20	9.17
Heteromastus filiformis	TK	63	52	5	8	4.33
Heteromastus filiformis	TK	64	82	3.5	17	6.83
Heteromastus filiformis	TK	65	116	9.5	20	9.67
Heteromastus filiformis	TK	66	82	6.5	12	6.83
Heteromastus filiformis	TK	67	88	6.5	20	7.33
Macomona liliana	CB	60	2	0	1	0.17
Macomona liliana	CB	61	4	0	1	0.33
Macomona liliana	CB	62	19	1.5	5	1.58
Macomona liliana	CB	63	4	0	1	0.33
Macomona liliana	CB	64	17	1.5	4	1.42
Macomona liliana	CB	65	6	0	2	0.50
Macomona liliana	CB	66	6	0	2	0.50
Macomona liliana	CB	67	2	0	2	0.17
Macomona liliana	DC	60	31	2.5	7	2.58
Macomona liliana	DC	61	34	2.5	5	2.83
Macomona liliana	DC	62	52	5	8	4.33
Macomona liliana	DC	63	34	3	5	2.83
Macomona liliana	DC	64	44	4	7	3.67
Macomona liliana	DC	65	61	5	11	5.08
Macomona liliana	DC	66	38	2.5	6	3.17
Macomona liliana	DC	67	33	2.5	5	2.75
Macomona liliana	HL	60	5	0	1	0.42
Macomona liliana	HL	61	16	1	5	1.33
Macomona liliana	HL	62	2.2	0	1	0.18
Macomona liliana	HL	63	0	0	0	0.00
Macomona liliana	HL	64	2	0	1	0.17
Macomona liliana	HL	65	4	0	2	0.33
Macomona liliana	HL	66	0	0	0	0.00
Macomona liliana	HL	67	3	0	1	0.25
Macomona liliana	JB	60	10	0.5	3	0.83
Macomona liliana	JB	61	9	0	4	0.75
Macomona liliana	JB	62	3	0	2	0.25
Macomona liliana	JB	63	3	0	1	0.25
Macomona liliana	JB	64	34	1	9	2.83
Macomona liliana	JB	65	23	1.5	4	1.92
Macomona liliana	JB	66	18	1.5	4	1.50

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Macomona liliana	JB	67	14	1	5	1.17
Macomona liliana	MH	60	2	0	1	0.17
Macomona liliana	MH	61	6	0	2	0.50
Macomona liliana	MH	62	6.6	0.3	2	0.55
Macomona liliana	MH	63	18	1	6	1.50
Macomona liliana	MH	64	4	0	1	0.33
Macomona liliana	MH	65	10	1	2	0.83
Macomona liliana	MH	66	9	0.5	2	0.75
Macomona liliana	MH	67	12	1	2	1.00
Macomona liliana	TK	60	5	0	3	0.42
Macomona liliana	TK	61	7	0	4	0.58
Macomona liliana	TK	62	21	1.5	5	1.75
Macomona liliana	TK	63	1	0	1	0.08
Macomona liliana	TK	64	9	1	2	0.75
Macomona liliana	TK	65	10	1	2	0.83
Macomona liliana	TK	66	5	0	2	0.42
Macomona liliana	TK	67	4	0	2	0.33
Nemerteans	CB	60	2	0	1	0.17
Nemerteans	CB	61	7	0	2	0.58
Nemerteans	CB	62	4	0	2	0.33
Nemerteans	CB	63	8	0.5	2	0.67
Nemerteans	CB	64	8	0	2	0.67
Nemerteans	CB	65	9	0	3	0.75
Nemerteans	CB	66	3	0	1	0.25
Nemerteans	CB	67	10	0.5	3	0.83
Nemerteans	DC	60	6	0	3	0.50
Nemerteans	DC	61	1	0	1	0.08
Nemerteans	DC	62	6	0	2	0.50
Nemerteans	DC	63	3	0	1	0.25
Nemerteans	DC	64	22	1.5	6	1.83
Nemerteans	DC	65	12	1	3	1.00
Nemerteans	DC	66	15	1	4	1.25
Nemerteans	DC	67	10	0	3	0.83
Nemerteans	HL	60	12	1	3	1.00
Nemerteans	HL	61	2	0	1	0.17
Nemerteans	HL	62	2.2	0	1	0.18
Nemerteans	HL	63	8	0	2	0.67
Nemerteans	HL	64	15	1	6	1.25
Nemerteans	HL	65	13	1	4	1.08
Nemerteans	HL	66	17	1.5	2	1.42
Nemerteans	HL	67	9	0	3	0.75
Nemerteans	JB	60	12	0	7	1.00
Nemerteans	JB	61	18	0	13	1.50
Nemerteans	JB	62	3	0	2	0.25
Nemerteans	JB	63	3	0	2	0.25
Nemerteans	JB	64	7	0	2	0.58
Nemerteans	JB	65	12	0.5	5	1.00

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Nemerteans	JB	66	8	0	2	0.67
Nemerteans	JB	67	22	2	4	1.83
Nemerteans	MH	60	3	0	1	0.25
Nemerteans	MH	61	4	0	1	0.33
Nemerteans	MH	62	0	0	0	0.00
Nemerteans	MH	63	0	0	0	0.00
Nemerteans	MH	64	4	0	2	0.33
Nemerteans	MH	65	10	1	3	0.83
Nemerteans	MH	66	3	0	3	0.25
Nemerteans	MH	67	11	0.5	3	0.92
Nemerteans	TK	60	14	0.5	5	1.17
Nemerteans	TK	61	12	1	4	1.00
Nemerteans	TK	62	13	1	3	1.08
Nemerteans	TK	63	4	0	2	0.33
Nemerteans	TK	64	29	1	9	2.42
Nemerteans	TK	65	24	1	10	2.00
Nemerteans	TK	66	26	2	4	2.17
Nemerteans	TK	67	26	2	6	2.17
Notoacmea hemlsi	CB	60	0	0	0	0.00
Notoacmea hemlsi	CB	61	0	0	0	0.00
Notoacmea hemlsi	CB	62	0	0	0	0.00
Notoacmea hemlsi	CB	63	0	0	0	0.00
Notoacmea hemlsi	CB	64	0	0	0	0.00
Notoacmea hemlsi	CB	65	1	0	1	0.08
Notoacmea hemlsi	CB	66	0	0	0	0.00
Notoacmea hemlsi	CB	67	0	0	0	0.00
Notoacmea hemlsi	DC	60	14	1	3	1.17
Notoacmea hemlsi	DC	61	26	2	6	2.17
Notoacmea hemlsi	DC	62	93	4.5	29	7.75
Notoacmea hemlsi	DC	63	9	0	4	0.75
Notoacmea hemlsi	DC	64	0	0	0	0.00
Notoacmea hemlsi	DC	65	9	0	5	0.75
Notoacmea hemlsi	DC	66	15	1	4	1.25
Notoacmea hemlsi	DC	67	3	0	2	0.25
Notoacmea hemlsi	HL	60	0	0	0	0.00
Notoacmea hemlsi	HL	61	0	0	0	0.00
Notoacmea hemlsi	HL	62	0	0	0	0.00
Notoacmea hemlsi	HL	63	0	0	0	0.00
Notoacmea hemlsi	HL	64	0	0	0	0.00
Notoacmea hemlsi	HL	65	0	0	0	0.00
Notoacmea hemlsi	HL	66	0	0	0	0.00
Notoacmea hemlsi	HL	67	0	0	0	0.00
Notoacmea hemlsi	JB	60	2	0	1	0.17
Notoacmea hemlsi	JB	61	21	0	12	1.75
Notoacmea hemlsi	JB	62	13	0	5	1.08
Notoacmea hemlsi	JB	63	0	0	0	0.00
Notoacmea hemlsi	JB	64	0	0	0	0.00

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Notoacmea hemlsi	JB	65	0	0	0	0.00
Notoacmea hemlsi	JB	66	3	0	2	0.25
Notoacmea hemlsi	JB	67	0	0	0	0.00
Notoacmea hemlsi	MH	60	0	0	0	0.00
Notoacmea hemlsi	MH	61	0	0	0	0.00
Notoacmea hemlsi	MH	62	0	0	0	0.00
Notoacmea hemlsi	MH	63	0	0	0	0.00
Notoacmea hemlsi	MH	64	0	0	0	0.00
Notoacmea hemlsi	MH	65	1	0	1	0.08
Notoacmea hemlsi	MH	66	0	0	0	0.00
Notoacmea hemlsi	MH	67	0	0	0	0.00
Notoacmea hemlsi	TK	60	0	0	0	0.00
Notoacmea hemlsi	TK	61	1	0	1	0.08
Notoacmea hemlsi	TK	62	0	0	0	0.00
Notoacmea hemlsi	TK	63	0	0	0	0.00
Notoacmea hemlsi	TK	64	0	0	0	0.00
Notoacmea hemlsi	TK	65	0	0	0	0.00
Notoacmea hemlsi	TK	66	0	0	0	0.00
Notoacmea hemlsi	TK	67	0	0	0	0.00
Nucula hartvigiana	CB	60	4	0	1	0.33
Nucula hartvigiana	CB	61	4	0	2	0.33
Nucula hartvigiana	CB	62	14	1	5	1.17
Nucula hartvigiana	CB	63	22	1	6	1.83
Nucula hartvigiana	CB	64	4	0	2	0.33
Nucula hartvigiana	CB	65	6	0	3	0.50
Nucula hartvigiana	CB	66	17	1	3	1.42
Nucula hartvigiana	CB	67	3	0	1	0.25
Nucula hartvigiana	DC	60	153	9	31	12.75
Nucula hartvigiana	DC	61	71	3.5	25	5.92
Nucula hartvigiana	DC	62	346	31.5	48	28.83
Nucula hartvigiana	DC	63	97	4.5	21	8.08
Nucula hartvigiana	DC	64	22	1.5	5	1.83
Nucula hartvigiana	DC	65	18	0.5	7	1.50
Nucula hartvigiana	DC	66	83	5.5	15	6.92
Nucula hartvigiana	DC	67	26	0.5	12	2.17
Nucula hartvigiana	HL	60	0	0	0	0.00
Nucula hartvigiana	HL	61	0	0	0	0.00
Nucula hartvigiana	HL	62	4.36	0	1	0.36
Nucula hartvigiana	HL	63	25	1	7	2.08
Nucula hartvigiana	HL	64	2	0	1	0.17
Nucula hartvigiana	HL	65	1	0	1	0.08
Nucula hartvigiana	HL	66	1	0	1	0.08
Nucula hartvigiana	HL	67	2	0	1	0.17
Nucula hartvigiana	JB	60	384	31.5	67	32.00
Nucula hartvigiana	JB	61	319	31.5	41	26.58
Nucula hartvigiana	JB	62	321	24.5	66	26.75
Nucula hartvigiana	JB	63	203	19	40	16.92

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Nucula hartvigiana	JB	64	321	27	71	26.75
Nucula hartvigiana	JB	65	358	28	77	29.83
Nucula hartvigiana	JB	66	229	15	50	19.08
Nucula hartvigiana	JB	67	306	24	80	25.50
Nucula hartvigiana	MH	60	547	42.5	110	45.58
Nucula hartvigiana	MH	61	484	37.5	52	40.33
Nucula hartvigiana	MH	62	445.1	31	46	37.09
Nucula hartvigiana	MH	63	771	67.5	33	64.25
Nucula hartvigiana	MH	64	433	35	42	36.08
Nucula hartvigiana	MH	65	359	26	33	29.92
Nucula hartvigiana	MH	66	370	33.5	46	30.83
Nucula hartvigiana	MH	67	347	27.5	38	28.92
Nucula hartvigiana	TK	60	2	0	1	0.17
Nucula hartvigiana	TK	61	17	1	6	1.42
Nucula hartvigiana	TK	62	10	0.5	3	0.83
Nucula hartvigiana	TK	63	54	2.5	22	4.50
Nucula hartvigiana	TK	64	7	0.5	2	0.58
Nucula hartvigiana	TK	65	6	0	2	0.50
Nucula hartvigiana	TK	66	24	2	7	2.00
Nucula hartvigiana	TK	67	51	3.5	15	4.25
Oligochaetes	CB	60	0	0	0	0.00
Oligochaetes	CB	61	8	0	4	0.67
Oligochaetes	CB	62	0	0	0	0.00
Oligochaetes	CB	63	2	0	2	0.17
Oligochaetes	CB	64	4	0	2	0.33
Oligochaetes	CB	65	2	0	1	0.17
Oligochaetes	CB	66	2	0	1	0.17
Oligochaetes	CB	67	2	0	1	0.17
Oligochaetes	DC	60	1	0	1	0.08
Oligochaetes	DC	61	1	0	1	0.08
Oligochaetes	DC	62	5	0	3	0.42
Oligochaetes	DC	63	1	0	1	0.08
Oligochaetes	DC	64	16	1	4	1.33
Oligochaetes	DC	65	15	0.5	4	1.25
Oligochaetes	DC	66	11	0	5	0.92
Oligochaetes	DC	67	9	1	2	0.75
Oligochaetes	HL	60	20	1	7	1.67
Oligochaetes	HL	61	4	0	1	0.33
Oligochaetes	HL	62	0	0	0	0.00
Oligochaetes	HL	63	0	0	0	0.00
Oligochaetes	HL	64	0	0	0	0.00
Oligochaetes	HL	65	372	29	50	31.00
Oligochaetes	HL	66	74	6	15	6.17
Oligochaetes	HL	67	59	3.5	16	4.92
Oligochaetes	JB	60	21	0	11	1.75
Oligochaetes	JB	61	47	0	38	3.92
Oligochaetes	JB	62	3	0	3	0.25

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Oligochaetes	JB	63	0	0	0	0.00
Oligochaetes	JB	64	39	2	17	3.25
Oligochaetes	JB	65	2	0	2	0.17
Oligochaetes	JB	66	13	0	11	1.08
Oligochaetes	JB	67	10	0	4	0.83
Oligochaetes	MH	60	3	0	1	0.25
Oligochaetes	MH	61	1	0	1	0.08
Oligochaetes	MH	62	0	0	0	0.00
Oligochaetes	MH	63	0	0	0	0.00
Oligochaetes	MH	64	0	0	0	0.00
Oligochaetes	MH	65	17	1	5	1.42
Oligochaetes	MH	66	2	0	2	0.17
Oligochaetes	MH	67	0	0	0	0.00
Oligochaetes	TK	60	8	0	3	0.67
Oligochaetes	TK	61	3	0	1	0.25
Oligochaetes	TK	62	25	0	19	2.08
Oligochaetes	TK	63	0	0	0	0.00
Oligochaetes	TK	64	13	0	4	1.08
Oligochaetes	TK	65	9	0	4	0.75
Oligochaetes	TK	66	15	0.5	7	1.25
Oligochaetes	TK	67	3	0	1	0.25
Owenia fusiformis	CB	60	0	0	0	0.00
Owenia fusiformis	CB	61	0	0	0	0.00
Owenia fusiformis	CB	62	0	0	0	0.00
Owenia fusiformis	CB	63	0	0	0	0.00
Owenia fusiformis	CB	64	0	0	0	0.00
Owenia fusiformis	CB	65	0	0	0	0.00
Owenia fusiformis	CB	66	0	0	0	0.00
Owenia fusiformis	CB	67	0	0	0	0.00
Owenia fusiformis	DC	60	0	0	0	0.00
Owenia fusiformis	DC	61	0	0	0	0.00
Owenia fusiformis	DC	62	0	0	0	0.00
Owenia fusiformis	DC	63	0	0	0	0.00
Owenia fusiformis	DC	64	0	0	0	0.00
Owenia fusiformis	DC	65	0	0	0	0.00
Owenia fusiformis	DC	66	0	0	0	0.00
Owenia fusiformis	DC	67	0	0	0	0.00
Owenia fusiformis	HL	60	0	0	0	0.00
Owenia fusiformis	HL	61	0	0	0	0.00
Owenia fusiformis	HL	62	0	0	0	0.00
Owenia fusiformis	HL	63	0	0	0	0.00
Owenia fusiformis	HL	64	0	0	0	0.00
Owenia fusiformis	HL	65	0	0	0	0.00
Owenia fusiformis	HL	66	0	0	0	0.00
Owenia fusiformis	HL	67	0	0	0	0.00
Owenia fusiformis	JB	60	4	0	3	0.33
Owenia fusiformis	JB	61	3	0	2	0.25

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Owenia fusiformis	JB	62	1	0	1	0.08
Owenia fusiformis	JB	63	2	0	1	0.17
Owenia fusiformis	JB	64	8	0	5	0.67
Owenia fusiformis	JB	65	2	0	1	0.17
Owenia fusiformis	JB	66	3	0	1	0.25
Owenia fusiformis	JB	67	2	0	1	0.17
Owenia fusiformis	MH	60	0	0	0	0.00
Owenia fusiformis	MH	61	0	0	0	0.00
Owenia fusiformis	MH	62	0	0	0	0.00
Owenia fusiformis	MH	63	0	0	0	0.00
Owenia fusiformis	MH	64	0	0	0	0.00
Owenia fusiformis	MH	65	0	0	0	0.00
Owenia fusiformis	MH	66	0	0	0	0.00
Owenia fusiformis	MH	67	0	0	0	0.00
Owenia fusiformis	TK	60	0	0	0	0.00
Owenia fusiformis	TK	61	0	0	0	0.00
Owenia fusiformis	TK	62	0	0	0	0.00
Owenia fusiformis	TK	63	0	0	0	0.00
Owenia fusiformis	TK	64	0	0	0	0.00
Owenia fusiformis	TK	65	0	0	0	0.00
Owenia fusiformis	TK	66	0	0	0	0.00
Owenia fusiformis	TK	67	0	0	0	0.00
Paracalliope novizelandiae	CB	60	0	0	0	0.00
Paracalliope novizelandiae	CB	61	0	0	0	0.00
Paracalliope novizelandiae	CB	62	0	0	0	0.00
Paracalliope novizelandiae	CB	63	0	0	0	0.00
Paracalliope novizelandiae	CB	64	0	0	0	0.00
Paracalliope novizelandiae	CB	65	0	0	0	0.00
Paracalliope novizelandiae	CB	66	0	0	0	0.00
Paracalliope novizelandiae	CB	67	0	0	0	0.00
Paracalliope novizelandiae	DC	60	0	0	0	0.00
Paracalliope novizelandiae	DC	61	0	0	0	0.00
Paracalliope novizelandiae	DC	62	0	0	0	0.00
Paracalliope novizelandiae	DC	63	4	0	2	0.33
Paracalliope novizelandiae	DC	64	2	0	1	0.17
Paracalliope novizelandiae	DC	65	26	1	10	2.17
Paracalliope novizelandiae	DC	66	11	0	7	0.92
Paracalliope novizelandiae	DC	67	2	0	2	0.17
Paracalliope novizelandiae	HL	60	0	0	0	0.00
Paracalliope novizelandiae	HL	61	0	0	0	0.00
Paracalliope novizelandiae	HL	62	1.09	0	1	0.09
Paracalliope novizelandiae	HL	63	0	0	0	0.00
Paracalliope novizelandiae	HL	64	1	0	1	0.08
Paracalliope novizelandiae	HL	65	0	0	0	0.00
Paracalliope novizelandiae	HL	66	0	0	0	0.00
Paracalliope novizelandiae	HL	67	0	0	0	0.00
Paracalliope novizelandiae	JB	60	4	0	3	0.33

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Paracalliope novizelandiae	JB	61	0	0	0	0.00
Paracalliope novizelandiae	JB	62	9	0	9	0.75
Paracalliope novizelandiae	JB	63	7	0	3	0.58
Paracalliope novizelandiae	JB	64	11	0	5	0.92
Paracalliope novizelandiae	JB	65	48	0	18	4.00
Paracalliope novizelandiae	JB	66	20	0.5	9	1.67
Paracalliope novizelandiae	JB	67	1	0	1	0.08
Paracalliope novizelandiae	MH	60	0	0	0	0.00
Paracalliope novizelandiae	MH	61	0	0	0	0.00
Paracalliope novizelandiae	MH	62	0	0	0	0.00
Paracalliope novizelandiae	MH	63	2	0	1	0.17
Paracalliope novizelandiae	MH	64	1	0	1	0.08
Paracalliope novizelandiae	MH	65	2	0	1	0.17
Paracalliope novizelandiae	MH	66	2	0	2	0.17
Paracalliope novizelandiae	MH	67	5	0	2	0.42
Paracalliope novizelandiae	TK	60	0	0	0	0.00
Paracalliope novizelandiae	TK	61	0	0	0	0.00
Paracalliope novizelandiae	TK	62	0	0	0	0.00
Paracalliope novizelandiae	TK	63	0	0	0	0.00
Paracalliope novizelandiae	TK	64	0	0	0	0.00
Paracalliope novizelandiae	TK	65	5	0	1	0.42
Paracalliope novizelandiae	TK	66	0	0	0	0.00
Paracalliope novizelandiae	TK	67	0	0	0	0.00
Perinereis nuntia	CB	60	0	0	0	0.00
Perinereis nuntia	CB	61	0	0	0	0.00
Perinereis nuntia	CB	62	0	0	0	0.00
Perinereis nuntia	CB	63	0	0	0	0.00
Perinereis nuntia	CB	64	0	0	0	0.00
Perinereis nuntia	CB	65	0	0	0	0.00
Perinereis nuntia	CB	66	0	0	0	0.00
Perinereis nuntia	CB	67	0	0	0	0.00
Perinereis nuntia	DC	60	2	0	2	0.17
Perinereis nuntia	DC	61	1	0	1	0.08
Perinereis nuntia	DC	62	3	0	2	0.25
Perinereis nuntia	DC	63	0	0	0	0.00
Perinereis nuntia	DC	64	1	0	1	0.08
Perinereis nuntia	DC	65	5	0	2	0.42
Perinereis nuntia	DC	66	0	0	0	0.00
Perinereis nuntia	DC	67	0	0	0	0.00
Perinereis nuntia	HL	60	1	0	1	0.08
Perinereis nuntia	HL	61	0	0	0	0.00
Perinereis nuntia	HL	62	0	0	0	0.00
Perinereis nuntia	HL	63	0	0	0	0.00
Perinereis nuntia	HL	64	0	0	0	0.00
Perinereis nuntia	HL	65	1	0	1	0.08
Perinereis nuntia	HL	66	2	0	2	0.17
Perinereis nuntia	HL	67	0	0	0	0.00

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Perinereis nuntia	JB	60	2	0	2	0.17
Perinereis nuntia	JB	61	0	0	0	0.00
Perinereis nuntia	JB	62	0	0	0	0.00
Perinereis nuntia	JB	63	0	0	0	0.00
Perinereis nuntia	JB	64	0	0	0	0.00
Perinereis nuntia	JB	65	0	0	0	0.00
Perinereis nuntia	JB	66	0	0	0	0.00
Perinereis nuntia	JB	67	0	0	0	0.00
Perinereis nuntia	MH	60	0	0	0	0.00
Perinereis nuntia	MH	61	0	0	0	0.00
Perinereis nuntia	MH	62	0	0	0	0.00
Perinereis nuntia	MH	63	0	0	0	0.00
Perinereis nuntia	MH	64	0	0	0	0.00
Perinereis nuntia	MH	65	1	0	1	0.08
Perinereis nuntia	MH	66	0	0	0	0.00
Perinereis nuntia	MH	67	0	0	0	0.00
Perinereis nuntia	TK	60	0	0	0	0.00
Perinereis nuntia	TK	61	0	0	0	0.00
Perinereis nuntia	TK	62	0	0	0	0.00
Perinereis nuntia	TK	63	0	0	0	0.00
Perinereis nuntia	TK	64	2	0	1	0.17
Perinereis nuntia	TK	65	3	0	1	0.25
Perinereis nuntia	TK	66	1	0	1	0.08
Perinereis nuntia	TK	67	0	0	0	0.00
Polydorids	CB	60	3	0	2	0.25
Polydorids	CB	61	2	0	1	0.17
Polydorids	CB	62	1	0	1	0.08
Polydorids	CB	63	2	0	1	0.17
Polydorids	CB	64	0	0	0	0.00
Polydorids	CB	65	5	0	2	0.42
Polydorids	CB	66	7	0	2	0.58
Polydorids	CB	67	27	2	7	2.25
Polydorids	DC	60	42	2.5	11	3.50
Polydorids	DC	61	26	1.5	6	2.17
Polydorids	DC	62	13	1	4	1.08
Polydorids	DC	63	4	0	2	0.33
Polydorids	DC	64	18	1	6	1.50
Polydorids	DC	65	15	1	4	1.25
Polydorids	DC	66	19	1	4	1.58
Polydorids	DC	67	10	0.5	5	0.83
Polydorids	HL	60	5	0	2	0.42
Polydorids	HL	61	38	1.5	13	3.17
Polydorids	HL	62	12	1	4	1.00
Polydorids	HL	63	5	0	2	0.42
Polydorids	HL	64	6	0	2	0.50
Polydorids	HL	65	25	2	4	2.08
Polydorids	HL	66	16	1	3	1.33

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Polydorids	HL	67	6	0	2	0.50
Polydorids	JB	60	40	0	27	3.33
Polydorids	JB	61	58	0.5	29	4.83
Polydorids	JB	62	17	1	4	1.42
Polydorids	JB	63	34	2	12	2.83
Polydorids	JB	64	185	3	83	15.42
Polydorids	JB	65	369	22.5	84	30.75
Polydorids	JB	66	195	8	70	16.25
Polydorids	JB	67	760	52.5	206	63.33
Polydorids	MH	60	6	0	2	0.50
Polydorids	MH	61	13	0.5	4	1.08
Polydorids	MH	62	13.1	1	6	1.09
Polydorids	MH	63	8	0	3	0.67
Polydorids	MH	64	18	1.5	4	1.50
Polydorids	MH	65	16	1	3	1.33
Polydorids	MH	66	5	0	1	0.42
Polydorids	MH	67	34	2	10	2.83
Polydorids	TK	60	2	0	1	0.17
Polydorids	TK	61	15	0	5	1.25
Polydorids	TK	62	4	0	2	0.33
Polydorids	TK	63	2	0	1	0.17
Polydorids	TK	64	7	0	3	0.58
Polydorids	TK	65	12	1	4	1.00
Polydorids	TK	66	3	0	1	0.25
Polydorids	TK	67	5	0	2	0.42
Prionospio aucklandica	CB	60	4	0	2	0.33
Prionospio aucklandica	CB	61	4	0	1	0.33
Prionospio aucklandica	CB	62	3	0	1	0.25
Prionospio aucklandica	CB	63	5	0	2	0.42
Prionospio aucklandica	CB	64	0	0	0	0.00
Prionospio aucklandica	CB	65	7	0	2	0.58
Prionospio aucklandica	CB	66	2	0	1	0.17
Prionospio aucklandica	CB	67	1	0	1	0.08
Prionospio aucklandica	DC	60	46	3.5	9	3.83
Prionospio aucklandica	DC	61	48	3	17	4.00
Prionospio aucklandica	DC	62	68	5	10	5.67
Prionospio aucklandica	DC	63	85	6	27	7.08
Prionospio aucklandica	DC	64	94	6.5	17	7.83
Prionospio aucklandica	DC	65	63	4	15	5.25
Prionospio aucklandica	DC	66	45	3.5	10	3.75
Prionospio aucklandica	DC	67	55	4	11	4.58
Prionospio aucklandica	HL	60	46	3.5	10	3.83
Prionospio aucklandica	HL	61	14	1	6	1.17
Prionospio aucklandica	HL	62	34.9	2	8	2.91
Prionospio aucklandica	HL	63	32	1.5	16	2.67
Prionospio aucklandica	HL	64	35	2	6	2.92
Prionospio aucklandica	HL	65	39	3	9	3.25

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Prionospio aucklandica	HL	66	40	3.5	5	3.33
Prionospio aucklandica	HL	67	81	7	12	6.75
Prionospio aucklandica	JB	60	6	0	3	0.50
Prionospio aucklandica	JB	61	6	0	5	0.50
Prionospio aucklandica	JB	62	0	0	0	0.00
Prionospio aucklandica	JB	63	0	0	0	0.00
Prionospio aucklandica	JB	64	10	0.5	3	0.83
Prionospio aucklandica	JB	65	4	0	3	0.33
Prionospio aucklandica	JB	66	0	0	0	0.00
Prionospio aucklandica	JB	67	10	0	4	0.83
Prionospio aucklandica	MH	60	6	0.5	1	0.50
Prionospio aucklandica	MH	61	3	0	1	0.25
Prionospio aucklandica	MH	62	1.1	0	1	0.09
Prionospio aucklandica	MH	63	1	0	1	0.08
Prionospio aucklandica	MH	64	1	0	1	0.08
Prionospio aucklandica	MH	65	1	0	1	0.08
Prionospio aucklandica	MH	66	3	0	3	0.25
Prionospio aucklandica	MH	67	0	0	0	0.00
Prionospio aucklandica	TK	60	29	2	11	2.42
Prionospio aucklandica	TK	61	46	2	14	3.83
Prionospio aucklandica	TK	62	46	3	14	3.83
Prionospio aucklandica	TK	63	14	1	3	1.17
Prionospio aucklandica	TK	64	99	7.5	18	8.25
Prionospio aucklandica	TK	65	59	5	9	4.92
Prionospio aucklandica	TK	66	30	2	7	2.50
Prionospio aucklandica	TK	67	106	6.5	23	8.83
Scoloplos cylindrifer	CB	60	0	0	0	0.00
Scoloplos cylindrifer	CB	61	0	0	0	0.00
Scoloplos cylindrifer	CB	62	4	0	1	0.33
Scoloplos cylindrifer	CB	63	1	0	1	0.08
Scoloplos cylindrifer	CB	64	1	0	1	0.08
Scoloplos cylindrifer	CB	65	0	0	0	0.00
Scoloplos cylindrifer	CB	66	14	0.5	4	1.17
Scoloplos cylindrifer	CB	67	0	0	0	0.00
Scoloplos cylindrifer	DC	60	1	0	1	0.08
Scoloplos cylindrifer	DC	61	4	0	2	0.33
Scoloplos cylindrifer	DC	62	41	1.5	13	3.42
Scoloplos cylindrifer	DC	63	3	0	3	0.25
Scoloplos cylindrifer	DC	64	9	0	5	0.75
Scoloplos cylindrifer	DC	65	23	1	7	1.92
Scoloplos cylindrifer	DC	66	23	1	7	1.92
Scoloplos cylindrifer	DC	67	15	1	5	1.25
Scoloplos cylindrifer	HL	60	0	0	0	0.00
Scoloplos cylindrifer	HL	61	0	0	0	0.00
Scoloplos cylindrifer	HL	62	0	0	0	0.00
Scoloplos cylindrifer	HL	63	0	0	0	0.00
Scoloplos cylindrifer	HL	64	0	0	0	0.00

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Scoloplos cylindrifer	HL	65	0	0	0	0.00
Scoloplos cylindrifer	HL	66	0	0	0	0.00
Scoloplos cylindrifer	HL	67	0	0	0	0.00
Scoloplos cylindrifer	JB	60	0	0	0	0.00
Scoloplos cylindrifer	JB	61	0	0	0	0.00
Scoloplos cylindrifer	JB	62	0	0	0	0.00
Scoloplos cylindrifer	JB	63	1	0	1	0.08
Scoloplos cylindrifer	JB	64	5	0	3	0.42
Scoloplos cylindrifer	JB	65	0	0	0	0.00
Scoloplos cylindrifer	JB	66	1	0	1	0.08
Scoloplos cylindrifer	JB	67	0	0	0	0.00
Scoloplos cylindrifer	MH	60	0	0	0	0.00
Scoloplos cylindrifer	MH	61	0	0	0	0.00
Scoloplos cylindrifer	MH	62	0	0	0	0.00
Scoloplos cylindrifer	MH	63	0	0	0	0.00
Scoloplos cylindrifer	MH	64	0	0	0	0.00
Scoloplos cylindrifer	MH	65	1	0	1	0.08
Scoloplos cylindrifer	MH	66	5	0	1	0.42
Scoloplos cylindrifer	MH	67	0	0	0	0.00
Scoloplos cylindrifer	TK	60	0	0	0	0.00
Scoloplos cylindrifer	TK	61	0	0	0	0.00
Scoloplos cylindrifer	TK	62	0	0	0	0.00
Scoloplos cylindrifer	TK	63	2	0	2	0.17
Scoloplos cylindrifer	TK	64	0	0	0	0.00
Scoloplos cylindrifer	TK	65	0	0	0	0.00
Scoloplos cylindrifer	TK	66	1	0	1	0.08
Scoloplos cylindrifer	TK	67	2	0	2	0.17
Torridoharpinia hurleyi	CB	60	0	0	0	0.00
Torridoharpinia hurleyi	CB	61	0	0	0	0.00
Torridoharpinia hurleyi	CB	62	17	1.5	4	1.42
Torridoharpinia hurleyi	CB	63	101	7.5	12	8.42
Torridoharpinia hurleyi	CB	64	4	0	3	0.33
Torridoharpinia hurleyi	CB	65	5	0	1	0.42
Torridoharpinia hurleyi	CB	66	51	4	7	4.25
Torridoharpinia hurleyi	CB	67	43	3.5	9	3.58
Torridoharpinia hurleyi	DC	60	0	0	0	0.00
Torridoharpinia hurleyi	DC	61	1	0	1	0.08
Torridoharpinia hurleyi	DC	62	1	0	1	0.08
Torridoharpinia hurleyi	DC	63	0	0	0	0.00
Torridoharpinia hurleyi	DC	64	2	0	1	0.17
Torridoharpinia hurleyi	DC	65	1	0	1	0.08
Torridoharpinia hurleyi	DC	66	1	0	1	0.08
Torridoharpinia hurleyi	DC	67	1	0	1	0.08
Torridoharpinia hurleyi	HL	60	0	0	0	0.00
Torridoharpinia hurleyi	HL	61	0	0	0	0.00
Torridoharpinia hurleyi	HL	62	5.5	0	3	0.45
Torridoharpinia hurleyi	HL	63	4	0	2	0.33

Taxa	Site	Time	Total[8]	Median	Range[9]	Mean
Torridoharpinia hurleyi	HL	64	1	0	1	0.08
Torridoharpinia hurleyi	HL	65	2	0	2	0.17
Torridoharpinia hurleyi	HL	66	2	0	1	0.17
Torridoharpinia hurleyi	HL	67	2	0	1	0.17
Torridoharpinia hurleyi	JB	60	3	0	1	0.25
Torridoharpinia hurleyi	JB	61	10	0.5	4	0.83
Torridoharpinia hurleyi	JB	62	0	0	0	0.00
Torridoharpinia hurleyi	JB	63	14	0	9	1.17
Torridoharpinia hurleyi	JB	64	14	0	5	1.17
Torridoharpinia hurleyi	JB	65	28	2	6	2.33
Torridoharpinia hurleyi	JB	66	55	2.5	17	4.58
Torridoharpinia hurleyi	JB	67	80	5	17	6.67
Torridoharpinia hurleyi	MH	60	1	0	1	0.08
Torridoharpinia hurleyi	MH	61	2	0	1	0.17
Torridoharpinia hurleyi	MH	62	7.6	0.8	2	0.64
Torridoharpinia hurleyi	MH	63	30	1	12	2.50
Torridoharpinia hurleyi	MH	64	2	0	2	0.17
Torridoharpinia hurleyi	MH	65	0	0	0	0.00
Torridoharpinia hurleyi	MH	66	5	0	3	0.42
Torridoharpinia hurleyi	MH	67	6	0	2	0.50
Torridoharpinia hurleyi	TK	60	1	0	1	0.08
Torridoharpinia hurleyi	TK	61	2	0	1	0.17
Torridoharpinia hurleyi	TK	62	16	0	6	1.33
Torridoharpinia hurleyi	TK	63	8	0	3	0.67
Torridoharpinia hurleyi	TK	64	4	0	2	0.33
Torridoharpinia hurleyi	TK	65	6	0	2	0.50
Torridoharpinia hurleyi	TK	66	2	0	1	0.17
Torridoharpinia hurleyi	TK	67	7	0	2	0.58

6.5 Appendix 5

The three dominant taxa collected at Cowans Bay between July 1994 and January 2011. The most abundant taxon are on the left hand side of the table. When more than one taxon 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 94	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
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
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

Jul 94	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jan 09	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Apr 09	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Jul 09	Cossura consimilis	Heteromastus filiformis	Arthritica bifurca
Oct 09	Heteromastus filiformis	Cossura consimilis	Macomona liliana
Jan 10	Cossura consimilis	Heteromastus filiformis	Torridoharpinia hurleyi
Apr 10	Heteromastus filiformis	Cossura consimilis	Arthritica bifurca
Jul 10	Heteromastus filiformis	Cossura consimilis	Arthritica bifurca
Oct 10	Heteromastus filiformis	Cossura consimilis	Arthritica bifurca
Jan 11	Arthritica bifurca	Cossura consimilis	Heteromastus filiformis

6.6 Appendix 6

The three dominant taxa collected at Dyers Creek from October 2005 to January 2011. The most abundant taxaon 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 scapha
Apr 08	Nucula hartvigiana	Austrovenus stutchburyi	Heteromastus filiformis
Jul 08	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea scapha
Oct 08	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea scapha
Jan 09	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea scapha
Apr 09	Austrovenus stutchburyi	Nucula hartvigiana	Prionospio aucklandica
Jul 09	Austrovenus stutchburyi	Nucula hartvigiana	Prionospio aucklandica
Oct 09	Nucula hartvigiana	Austrovenus stutchburyi	Notoacmea scapha
Jan 10	Austrovenus stutchburyi	Nucula hartvigiana	Prionospio aucklandica
Apr 10	Austrovenus stutchburyi	Prionospio aucklandica	Macomona liliana
July 10	Austrovenus stutchburyi	Prionospio aucklandica	Macomona liliana
Oct 10	Austrovenus stutchburyi	Nucula hartvigiana	Prionospio aucklandica
Jan 10	Austrovenus stutchburyi	Prionospio aucklandica	Macomona liliana

6.7 Appendix 7

The three dominant taxa collected at Hamilton Landing between July 1994 and January 2011. The most abundant taxon are on the left hand side of the table. When more than one taxon 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
Apr 09	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 09	Cossura consimilis	Heteromastus filiformis	Polydorids
Oct 09	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 10	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Apr 10	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jul 10	Cossura consimilis	Oligochaetes	Heteromastus filiformis
Oct 10	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 11	Cossura consimilis	Heteromastus filiformis	Aricidea sp.

6.8 Appendix 8

The three dominant taxa collected at Jamieson Bay between July 1994 and January 2011. The most abundant taxon is on the left hand side of the table. When more than one taxaon has the same rank they are represented as (for example) '*Cossura consimilis*/*Heteromastus filiformis*'

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 trifida	Heteromastus filiformis
Apr 96	Polydorids	Nucula hartvigiana	Aonides trifida
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 trifida
Jul 97	Polydorids	Nucula hartvigiana	Torridoharpinia hurleyi
Oct 97	Aonides trifida	Nucula hartvigiana	Heteromastus filiformis
Jan 98	Nucula hartvigiana	Polydorids	Heteromastus filiformis
Apr 98	Polydorids	Nucula hartvigiana	Heteromastus filiformis
Jul 98	Aonides trifida	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 trifida
Jan 00	Nucula hartvigiana	Nemerteans	Polydorids
Apr 00	Nucula hartvigiana	Aonides trifida	Scoloplos cylindrifer
Jul 00	Polydorids	Aonides trifida	Heteromastus filiformis
Oct 00	Nucula hartvigiana	Aonides trifida	Polydorids
Jan 01	Nucula hartvigiana	Polydorids	Aonides trifida
Apr 01	Nucula hartvigiana	Aonides trifida	Paracalliope novizealandiae
Jul 01	Nucula hartvigiana	Polydorids	Aonides trifida
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 trifida	Aricidea sp.
Jul 03	Nucula hartvigiana	Heteromastus filiformis	Oligochaete
Oct 03	Nucula hartvigiana	Aonides trifida	Heteromastus filiformis
Jan 04	Nucula hartvigiana	Heteromastus filiformis	Aonides trifida

Apr 04	Nucula hartvigiana	Polydorids	Aonides trifida
Jul 04	Nucula hartvigiana	Oligochaete	Aonides trifida
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 trifida	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 trifida / Oligochaete	Polydorids
Oct 07	Nucula hartvigiana	Aonides trifida	Heteromastus filiformis
Jan 08	Nucula hartvigiana	Heteromastus filiformis	Torridoharpinia hurleyi
Apr08	Nucula hartvigiana	Macomona liliana	Austrovenus stutchburyi
Jul 08	Nucula hartvigiana	Polydorids	Aonides trifida
Oct 08	Nucula hartvigiana	Oligochaete	Heteromastus filiformis
Jan 09	Nucula hartvigiana	Oligochaete	Aricidea sp.
Apr 09	Nucula hartvigiana	Polydorids	Oligochaete
Jul 09	Nucula hartvigiana	Polydorids	Cossura consimilis / Oligochaete
Oct 09	Nucula hartvigiana	Polydorids	Aonides trifida
Jan 10	Nucula hartvigiana	Polydorids	Torridoharpinia hurleyi
Apr 10	Nucula hartvigiana	Polydorids	Aonides trifida
Jul 10	Polydorids	Nucula hartvigiana	Paracalliope novizealandiae
Oct 10	Nucula hartvigiana	Polydorids	Torridoharpinia hurleyi
Jan 11	Polydorids	Nucula hartvigiana	Heteromastus filiformis

6.9 Appendix 9

The three dominant taxa collected at Mid Harbour between July 1994 to January 2011. The most abundant taxon are 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
Apr 09	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Jul 09	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Oct 09	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Jan 10	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Apr 10	Nucula hartvigiana	Arthritica bifurca	Cossura consimilis
Jul 10	Nucula hartvigiana	Cossura consimilis	Arthritica bifurca
Oct 10	Nucula hartvigiana	Heteromastus filiformis	Arthritica bifurca
Jan 11	Nucula hartvigiana	Arthritica bifurca	Heteromastus filiformis

6.10 Appendix 10

The three dominant taxa collected at Te Kapa Inlet between July 1994 to January 2011. The most abundant taxon are on the left hand side of the table. When more than one taxon 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.
Apr 09	Cossura consimilis	Aricidea sp.	Heteromastus filiformis
Jul 09	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 09	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Jan 10	Cossura consimilis	Austrovenus stutchburyi	Nucula hartvigiana
Apr 10	Cossura consimilis	Aricidea sp.	Prionospio aucklandica
Jul 10	Cossura consimilis	Heteromastus filiformis	Aricidea sp.
Oct 10	Cossura consimilis	Aricidea sp.	Heteromastus filiformis
Jan 11	Cossura consimilis	Aricidea sp.	Austrovenus stutchburyi

6.11 Appendix 11

Results of the 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
		Apr	2.37	22.91
		Jul	0.76	14.85
		Oct	0.68	8.52
	2010	Jan	1.53	5.78
		Apr	0.39	8.22
		Jul	0.66	12.29
		Oct	0.90	8.096
	2011	Jan	0.16	1.649

% 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
		Apr	1.08	1.73
		Jul	0.31	2.96
		Oct	0.44	1.29
	2010	Jan	0.41	2.70
		Apr	0.23	2.54
		Jul	0.33	4.89
		Oct	0.35	1.72
	2011	Jan	0.10	1.10
Medium sand	1995	Apr	0.51	6.98
	1996	Apr	13.07	12.01
	1997	Apr	0.79	1.20
	1998	Apr	23.31	1.47
	1999	Apr	2.35	3.84
	2000	Apr	1.29	1.53
		Oct	1.04	1.22

% Sediment composition	Year	Month	Site A	Site C
	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
		Apr	0.63	0.48
		Jul	0.29	1.05
		Oct	0.34	1.00
	2010	Jan	0.33	1.00
		Apr	0.33	0.62
		Jul	0.27	1.40
		Oct	0.32	0.56
	2011	Jan	0.33	0.42
Fine sand	1995	Apr	15.83	20.87
	1996	Apr	25.58	25.67
	1997	Apr	74.86	49.10
	1998	Apr	54.79	35.58
	1999	Apr	54.89	46.46
	2000	Apr	73.83	31.02
		Oct	71.15	28.51
	2001	Apr	71.34	46.34
		Oct	44.40	39.82
	2002	Jan	78.85	53.98
		Apr	29.04	76.10
		Jul	75.38	56.23
		Oct	77.04	44.27
	2003	Jan	76.85	41.51
		Apr	30.62	91.30

% Sediment composition	Year	Month	Site A	Site C
		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
		Apr	73.62	29.87
		Jul	69.39	33.11
		Oct	71.74	30.85
	2010	Jan	67.62	36.07
		Apr	70.24	29.88
		Jul	69.92	39.48
		Oct	67.33	32.07
	2011	Jan	71.33	32.81
Silt	1995	Apr	73.72	55.41
	1996	Apr	41.96	40.91
	1997	Apr	18.13	42.85
	1998	Apr	16.13	46.06
	1999	Apr	29.39	39.47
	2000	Apr	15.37	30.09
		Oct	23.11	37.01
	2001	Apr	20.18	36.55
		Oct	21.31	45.77
	2002	Jan	17.85	35.53
		Apr	14.95	16.15
		Jul	15.76	32.51
		Oct	10.60	34.23
	2003	Jan	12.65	16.32
		Apr	9.47	22.50
		Jul	17.46	18.46
		Oct	12.34	41.61
	2004	Jan	17.69	35.58
		Apr	13.08	23.89
		Jul	27.24	52.63
		Oct	19.71	43.74
	2005	Jan	19.72	49.71
		Apr	17.73	34.27

% Sediment composition	Year	Month	Site A	Site C
		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
		Apr	12.87	30.33
		Jul	19.92	32.24
		Oct	17.54	46.50
	2010	Jan	19.16	36.65
		Apr	19.40	42.62
		Jul	10.02	29.17
		Oct	30.10	47.34
	2011	Jan	21.28	48.57

6.12 Appendix 12

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
Apr-09	2.74	4.41
Jul-09	2.13	3.29
Oct-09	2.93	4.35
Jan-10	3.17	4.35
Apr-10	3.11	4.78
Jul-10	2.45	1.99
Oct-10	2.46	4.15
Jan-11	2.94	4.24
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
Apr-09	2.98	5.96
Jul-09	5.85	5.27
Oct-09	3.38	4.47
Jan-10	4.81	5.27
Apr-10	6.42	5.39
Jul-10	5.62	4.47
Oct-10	4.01	4.70
Jan-11	6.19	5.73
range	2.41 - 9.01	1.94 - 10.48

6.13 Appendix 13

Summary of temporal results at the subtidal sites from April 2009 (Time = 60) to January 2011 (Time = 67). SA = Site A, SC = Site C.

Taxa	Site	Time	Total[10]	Median	Range[11]	Mean
Aricidea sp.	SA	60	17	1.5	3	1.42
Aricidea sp.	SA	61	11	1	3	0.92
Aricidea sp.	SA	62	8	1	2	0.67
Aricidea sp.	SA	63	8	1	2	0.67
Aricidea sp.	SA	64	10	0	5	0.83
Aricidea sp.	SA	65	4	0	1	0.33
Aricidea sp.	SA	66	10	1	2	0.83
Aricidea sp.	SA	67	2	0	1	0.17
Aricidea sp.	SC	60	4	0	1	0.33
Aricidea sp.	SC	61	26	0	12	2.17
Aricidea sp.	SC	62	0	0	0	0.00
Aricidea sp.	SC	63	3	0	2	0.25
Aricidea sp.	SC	64	3	0	1	0.25
Aricidea sp.	SC	65	9	0.5	2	0.75
Aricidea sp.	SC	66	3	0	2	0.25
Aricidea sp.	SC	67	1	0	1	0.08
Armandia maculata	SA	60	0	0	0	0.00
Armandia maculata	SA	61	0	0	0	0.00
Armandia maculata	SA	62	0	0	0	0.00
Armandia maculata	SA	63	0	0	0	0.00
Armandia maculata	SA	64	0	0	0	0.00
Armandia maculata	SA	65	0	0	0	0.00
Armandia maculata	SA	66	0	0	0	0.00
Armandia maculata	SA	67	0	0	0	0.00
Armandia maculata	SC	60	1	0	1	0.08
Armandia maculata	SC	61	13	0.5	7	1.08
Armandia maculata	SC	62	0	0	0	0.00
Armandia maculata	SC	63	0	0	0	0.00
Armandia maculata	SC	64	0	0	0	0.00
Armandia maculata	SC	65	0	0	0	0.00
Armandia maculata	SC	66	0	0	0	0.00
Armandia maculata	SC	67	0	0	0	0.00
Arthritica bifurca	SA	60	7	0	2	0.58
Arthritica bifurca	SA	61	16	1	4	1.33
Arthritica bifurca	SA	62	6	0	3	0.50
Arthritica bifurca	SA	63	9	0.5	3	0.75
Arthritica bifurca	SA	64	76	6.5	14	6.33
Arthritica bifurca	SA	65	27	2.5	7	2.25
Arthritica bifurca	SA	66	36	3	8	3.00

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

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

Taxa	Site	Time	Total[10]	Median	Range[11]	Mean
Arthritica bifurca	SA	67	19	0.5	5	1.58
Arthritica bifurca	SC	60	20	1.5	6	1.67
Arthritica bifurca	SC	61	6	0	3	0.50
Arthritica bifurca	SC	62	3	0	2	0.25
Arthritica bifurca	SC	63	21	1.5	9	1.75
Arthritica bifurca	SC	64	33	1	19	2.75
Arthritica bifurca	SC	65	23	0	7	1.92
Arthritica bifurca	SC	66	15	0	5	1.25
Arthritica bifurca	SC	67	61	4.5	18	5.08
Cirratulids	SA	60	8	0	3	0.67
Cirratulids	SA	61	20	1	5	1.67
Cirratulids	SA	62	9	0	3	0.75
Cirratulids	SA	63	13	1	4	1.08
Cirratulids	SA	64	15	1	3	1.25
Cirratulids	SA	65	17	1	4	1.42
Cirratulids	SA	66	17	1	4	1.42
Cirratulids	SA	67	9	0	3	0.75
Cirratulids	SC	60	17	1	6	1.42
Cirratulids	SC	61	22	1.5	7	1.83
Cirratulids	SC	62	10	0	5	0.83
Cirratulids	SC	63	13	1	4	1.08
Cirratulids	SC	64	16	0	5	1.33
Cirratulids	SC	65	26	2	5	2.17
Cirratulids	SC	66	22	1.5	6	1.83
Cirratulids	SC	67	15	1	4	1.25
Corophidae-complex	SA	60	0	0	0	0.00
Corophidae-complex	SA	61	0	0	0	0.00
Corophidae-complex	SA	62	16	0	9	1.33
Corophidae-complex	SA	63	0	0	0	0.00
Corophidae-complex	SA	64	0	0	0	0.00
Corophidae-complex	SA	65	0	0	0	0.00
Corophidae-complex	SA	66	0	0	0	0.00
Corophidae-complex	SA	67	1	0	1	0.08
Corophidae-complex	SC	60	3	0	2	0.25
Corophidae-complex	SC	61	3	0	2	0.25
Corophidae-complex	SC	62	1	0	1	0.08
Corophidae-complex	SC	63	0	0	0	0.00
Corophidae-complex	SC	64	3	0	2	0.25
Corophidae-complex	SC	65	3	0	1	0.25
Corophidae-complex	SC	66	0	0	0	0.00
Corophidae-complex	SC	67	5	0	2	0.42
Nucula hartvigiana	SA	60	15	0	9	1.25
Nucula hartvigiana	SA	61	20	0	7	1.67
Nucula hartvigiana	SA	62	22	2	6	1.83
Nucula hartvigiana	SA	63	40	3	9	3.33
Nucula hartvigiana	SA	64	71	6	11	5.92
Nucula hartvigiana	SA	65	1	0	1	0.08

Taxa	Site	Time	Total[10]	Median	Range[11]	Mean
Nucula hartvigiana	SA	66	0	0	0	0.00
Nucula hartvigiana	SA	67	0	0	0	0.00
Nucula hartvigiana	SC	60	9	0.5	4	0.75
Nucula hartvigiana	SC	61	6	0	3	0.50
Nucula hartvigiana	SC	62	8	0	3	0.67
Nucula hartvigiana	SC	63	17	1	4	1.42
Nucula hartvigiana	SC	64	13	1	2	1.08
Nucula hartvigiana	SC	65	0	0	0	0.00
Nucula hartvigiana	SC	66	0	0	0	0.00
Nucula hartvigiana	SC	67	0	0	0	0.00
Oligochaetes	SA	60	3	0	2	0.25
Oligochaetes	SA	61	10	0	3	0.83
Oligochaetes	SA	62	0	0	0	0.00
Oligochaetes	SA	63	3	0	1	0.25
Oligochaetes	SA	64	6	0	2	0.50
Oligochaetes	SA	65	3	0	1	0.25
Oligochaetes	SA	66	12	1	5	1.00
Oligochaetes	SA	67	9	1	2	0.75
Oligochaetes	SC	60	149	9	39	12.42
Oligochaetes	SC	61	42	2	13	3.50
Oligochaetes	SC	62	31	1.5	12	2.58
Oligochaetes	SC	63	45	0.5	16	3.75
Oligochaetes	SC	64	92	5.5	46	7.67
Oligochaetes	SC	65	80	5.5	14	6.67
Oligochaetes	SC	66	141	11	36	11.75
Oligochaetes	SC	67	118	5	40	9.83
Polydorids	SA	60	1	0	1	0.08
Polydorids	SA	61	2	0	2	0.17
Polydorids	SA	62	0	0	0	0.00
Polydorids	SA	63	3	0	2	0.25
Polydorids	SA	64	0	0	0	0.00
Polydorids	SA	65	0	0	0	0.00
Polydorids	SA	66	3	0	1	0.25
Polydorids	SA	67	1	0	1	0.08
Polydorids	SC	60	13	0	6	1.08
Polydorids	SC	61	45	2.5	15	3.75
Polydorids	SC	62	2	0	1	0.17
Polydorids	SC	63	30	2	9	2.50
Polydorids	SC	64	31	2	11	2.58
Polydorids	SC	65	20	1	7	1.67
Polydorids	SC	66	2	0	2	0.17
Polydorids	SC	67	548	44.5	95	45.67
Prionospio spp.	SA	60	7	0	4	0.58
Prionospio spp.	SA	61	22	1	6	1.83
Prionospio spp.	SA	62	6	0	2	0.50
Prionospio spp.	SA	63	3	0	1	0.25
Prionospio spp.	SA	64	5	0	2	0.42

Taxa	Site	Time	Total[10]	Median	Range[11]	Mean
Prionospio spp.	SA	65	8	0.5	2	0.67
Prionospio spp.	SA	66	18	1	3	1.50
Prionospio spp.	SA	67	2	0	1	0.17
Prionospio spp.	SC	60	12	0.5	4	1.00
Prionospio spp.	SC	61	6	0.5	1	0.50
Prionospio spp.	SC	62	1	0	1	0.08
Prionospio spp.	SC	63	6	0	6	0.50
Prionospio spp.	SC	64	10	0	3	0.83
Prionospio spp.	SC	65	10	1	2	0.83
Prionospio spp.	SC	66	17	1	4	1.42
Prionospio spp.	SC	67	3	0	1	0.25
Tawera spissa	SA	60	0	0	0	0.00
Tawera spissa	SA	61	0	0	0	0.00
Tawera spissa	SA	62	0	0	0	0.00
Tawera spissa	SA	63	0	0	0	0.00
Tawera spissa	SA	64	1	0	1	0.08
Tawera spissa	SA	65	0	0	0	0.00
Tawera spissa	SA	66	0	0	0	0.00
Tawera spissa	SA	67	0	0	0	0.00
Tawera spissa	SC	60	2	0	1	0.17
Tawera spissa	SC	61	0	0	0	0.00
Tawera spissa	SC	62	0	0	0	0.00
Tawera spissa	SC	63	0	0	0	0.00
Tawera spissa	SC	64	0	0	0	0.00
Tawera spissa	SC	65	0	0	0	0.00
Tawera spissa	SC	66	0	0	0	0.00
Tawera spissa	SC	67	0	0	0	0.00
Theora lubrica	SA	60	272	23	37	22.67
Theora lubrica	SA	61	225	19.5	40	18.75
Theora lubrica	SA	62	14	1	4	1.17
Theora lubrica	SA	63	87	6.5	21	7.25
Theora lubrica	SA	64	158	14	25	13.17
Theora lubrica	SA	65	46	3	6	3.83
Theora lubrica	SA	66	19	1	6	1.58
Theora lubrica	SA	67	4	0	3	0.33
Theora lubrica	SC	60	342	27.5	46	28.50
Theora lubrica	SC	61	94	7.5	11	7.83
Theora lubrica	SC	62	47	3.5	9	3.92
Theora lubrica	SC	63	97	6.5	14	8.08
Theora lubrica	SC	64	160	12.5	15	13.33
Theora lubrica	SC	65	63	4.5	9	5.25
Theora lubrica	SC	66	57	4	10	4.75
Theora lubrica	SC	67	100	8.5	16	8.33
Torridoharpinia hurleyi	SA	60	2	0	1	0.17
Torridoharpinia hurleyi	SA	61	18	1	6	1.50
Torridoharpinia hurleyi	SA	62	13	1	3	1.08
Torridoharpinia hurleyi	SA	63	8	1	2	0.67

Taxa	Site	Time	Total[10]	Median	Range[11]	Mean
Torridoharpinia hurleyi	SA	64	0	0	0	0.00
Torridoharpinia hurleyi	SA	65	5	0	2	0.42
Torridoharpinia hurleyi	SA	66	13	1	5	1.08
Torridoharpinia hurleyi	SA	67	14	1	3	1.17
Torridoharpinia hurleyi	SC	60	1	0	1	0.08
Torridoharpinia hurleyi	SC	61	20	1	5	1.67
Torridoharpinia hurleyi	SC	62	18	2	3	1.50
Torridoharpinia hurleyi	SC	63	31	2	5	2.58
Torridoharpinia hurleyi	SC	64	11	0.5	2	0.92
Torridoharpinia hurleyi	SC	65	1	0	1	0.08
Torridoharpinia hurleyi	SC	66	16	1	8	1.33
Torridoharpinia hurleyi	SC	67	17	1	8	1.42

6.14 Appendix 14

The three dominant taxa collected at subtidal Site A between October 1994 and January 2011. The most abundant taxaon are on the left hand side of the table. When more than one taxaon 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 spp.
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.
Apr 09	Theora lubrica	Aricidea sp	Nucula hartvigiana
Jul 09	Theora lubrica	Prionospio spp.	Nucula hartvigiana / Cirratulids
Oct 09	Nucula hartvigiana	Corophidae-complex	Theora lubrica
Jan 10	Theora lubrica	Nucula hartvigiana	Cirratulids
Apr 10	Theora lubrica	Arthritica bifurca	Nucula hartvigiana
Jul 10	Theora lubrica	Arthritica bifurca	Cirratulids
Oct 10	Arthritica bifurca	Theora lubrica	Prionospio spp.
Jan 11	Arthritica bifurca	Torridoharpinia hurleyi	Oligochaetes

6.15 Appendix 15

The three dominant taxa collected at subtidal Site C between October 1994 and January 20011. The most abundant taxaon 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
Apr 09	Theora lubrica	Oligochaetes	Arthritica bifurca
Jul 09	Theora lubrica	Polydorids	Oligochaetes
Oct 09	Theora lubrica	Oligochaetes	Torridoharpinia hurleyi
Jan 10	Theora lubrica	Oligochaetes	Torridoharpinia hurleyi
Apr 10	Theora lubrica	Oligochaetes	Arthritica bifurca
Jul 10	Oligochaetes	Theora lubrica	Cirratulids
Oct 10	Oligochaetes	Theora lubrica	Cirratulids
Jan 11	Polydorids	Oligochaetes	Theora lubrica