![Auckland Council logo — Te Kaunihera o Tāmaki Makaurau]

Mahurangi Estuary Ecological Monitoring Programme: Report on data collected from July 1994 to January 2013

November 2013   Technical Report 2013/038

This report has been peer reviewed by the Peer Review Panel using the Panel's terms of reference
Submitted for review on 22 July 2013 Review completed on 8 November 2013 Reviewed by two reviewers
Approved for Auckland Council publication by: Name: Greg Holland Position: Manager, Research, Investigations and Monitoring Unit
Date: 8 November 2013

Mahurangi Estuary Ecological Monitoring Programme:

Report on data collected from July 1994 to January 2013

Jane Halliday

Scott Edhouse

Drew Lohrer

Simon Thrush

Vonda Cummings

Reviewed by	Approved for publication by
Name: Dr Judi Hewitt Position: Programme Leader Coasts and Oceans Organisation: NIWA Date: 11 June 2013	Name: Dr Drew Lohrer Position: Group Manager Benthic Ecology Organisation: NIWA Date: 7 August 2013

Executive Summary

Populations and communities of monitored macrofaunal taxa in Mahurangi Harbour, and sediment characteristics at all long-term monitoring sites, have not changed markedly over the past two years. The monitored macrofaunal communities at Hamilton Landing and Te Kapa Inlet 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. A total of 26 intertidal populations have exhibited ecologically meaningful trends in abundance (increases or decreases); 14 of these are increasing trends and 12 are decreasing trends. All sites have populations that are exhibiting trends; most of these populations occur at Hamilton Landing, with the fewest at Jamieson Bay.

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 five sites and one site, 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. Also of concern is the recent increase in mud-preferring oligochaetes at Hamilton Landing.

Five ecologically meaningful trends have been identified at Dyers Creek over the last 7.5 years. Four are consistent with predictions associated with increased fine sediment. However, *Austrovenus* abundances have increased at Dyers Creek, a trend that initially appears inconsistent with predictions associated with increased fine sediment. However, this bivalve is found in high numbers at a range of sediment types and increased condition of adult *Austrovenus* in response to low level increases in suspended sediment concentrations have also been noted.

Twenty two populations exhibit cyclic abundance patterns. Very few exhibit peaks in abundance in the same monitoring month every year. 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).

Eight monitored populations are still exhibiting trends in abundance which 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 six different taxa at two sites (Hamilton Landing and Te Kapa Inlet) 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.

An assessment of functional 'health' of the monitored community Trait Based Indicator (TBI) 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. 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).

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.

In 2013, a new video-based method for monitoring *Atrina* beds within Mahurangi Harbour was trialled. Past monitoring of *Atrina* density by diver-held video cameras at the three subtidal sites of this monitoring programme has suggested declines in *Atrina* densities. This monitoring is constrained to a 40 m transect at each of the three sites due to cost and thus does not inform us as to whether the whole *Atrina* bed at each site is also declining, or whether other beds in the harbour are suffering the same fate. This survey of a number of sites in Mahurangi Harbour which had previously held large beds of *Atrina* confirmed that the decline in densities noted along short transects at the three subtidal monitoring sites was occurring elsewhere in the harbour, with no beds found at any of the sites. A number of beds that had previously been observed in Kawau Bay had also disappeared. *Atrina* do not generally recruit into an existing *Atrina* bed, thus new beds evolve from larvae produced in beds elsewhere, with their dispersal driven by hydrodynamics. Decreasing numbers of existing *Atrina* beds (and densities within them) elsewhere in Mahurangi and Kawau Bay and potentially in the Hauraki Gulf would decrease the likelihood of recruitment in Mahurangi.

One medium-to-low density *Atrina* bed was found in Big Bay, just north of the mouth of Mahurangi Harbour, and the new video surveying method was trialled. While in-field processing did not give the desired precision or repeatability, laboratory post-processing gave a resolution of 10 m with repeated surveys on different days giving results within this resolution. Once a bed has been located and its outline initially surveyed, crossing transects that maximise information could be set up for future monitoring, with up to 10 sites able to be sampled in a single day.

As a survey tool this method generates high quality, georeferenced data on many basic habitat characteristics such as sediment type (sand, mud, shell, cobble, rock), sediment features (ripples, burrows), and presence of large plants and animals (various marine macroalgae, sea stars, sponges, solitary ascidians, *Atrina*, large holothurians, etc.). However, the slow boat speed (0.5 kts) that is required to provide useable footage, combined with the narrow field of view, means that only a tiny proportion of area at a site is able to be observed. Thus, as a search tool, the use of acoustic swath mapping technology, such as side scan sonar, to locate and outline possible habitats would be preferable, with video used to then identify the habitat-forming organisms and monitor density and size.

Contents

1.0 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 – now Auckland Council) (Cummings et al. 1994).

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.

Since June 2011, Auckland Council has continued to support work to reduce sediment loads to the Mahurangi catchment and to the Dyers Creek subcatchment in particular. This includes:

- funding for 2,703 m of fencing on private land to protect streams, restoration planting and coastal edge habitats; including 2,353 m in the Dyers Creek subcatchment, and 350 m in Mahurangi River Catchment;
- protection of 5.4 hectares of land through this fencing; 4 ha in the Dyers Creek subcatchment and 1.4 ha in the Mahurangi River catchment;
- planting of 22,000 native plants in the Dyers Creek subcatchment;
- undertaking soil mapping at three Dyers Creek farm sites, to be included in updated 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 2013).

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).

This monitoring programme has now been running for 19 years. For 17 of these years we assessed benthic macrofaunal communities both at intertidal and subtidal sites, and abundances of the large horse mussel, *Atrina zelandica*, at the subtidal sites. Initially, there were five intertidal sites, monitored quarterly, and three subtidal sites, monitored six monthly. In 2001, a review of the monitoring programme noted that the ability to detect changes over time (both trends and cyclic patterns) for the subtidal sites was lower than that of the intertidal sites, due to the six monthly cf quarterly sampling. The number of subtidal sites was reduced from three to two and quarterly sampling commenced in October, 2001. In 2005, in response to management plans in the harbour, monitoring at a new intertidal site in Dyers Creek commenced. In 2011, another review of the monitoring programme took place (Halliday and Cummings 2011): the most temporally consistent intertidal site and both subtidal sites were dropped.

For cost effectiveness, the intertidal monitoring is based on 19 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). However, since 2010, Auckland Council State of the Environment yearly reporting has also included information on Benthic Health Model (BHM) and Traits Based Index (TBI) values. This reporting requires all taxa to be identified in October of each year. 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 and community indices, we describe the current ecological status of the estuary and make recommendations for the future of this monitoring programme.

Previous subtidal monitoring of *Atrina* in Mahurangi involved diver video transects at two locations. Results showed a decline in densities but could not determine whether the larger *Atrina* bed around the transects was shrinking, or whether the decline was general at other sites within the harbour. Auckland Council therefore sought a cost-effective method of monitoring both the density of *Atrina* within beds and the size of beds at a number of sites throughout the harbour to replace the more spatially restrictive diver video transects. Within the shallow waters of Mahurangi Harbour, towed video was an obvious choice, as most areas are too shallow for effective side-scan or multibeam, and visual observations would still be required to distinguish live from dead *Atrina*.

In this report, we comment on the temporal variation in abundance of the monitored macrofaunal populations at the intertidal sites. For the pilot project to map the size and location of subtidal horse mussel, *Atrina zelandica*, patches within the harbour we investigated and report on:

1. Whether towed video was an option to monitor the spatial extent of *Atrina* beds in Mahurangi Harbour.

   a. What is the cost and accuracy of the method?

   b. Can the monitoring be completed on board or is laboratory analysis of the video required?

2. Would the method be suitable elsewhere for locating presently unknown habitats in shallow waters where side-scan or multibeam sonar are not applicable?

2.0 Methods

2.1 Intertidal sites

In July 1994, five 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).

Sampling of the Cowan's Bay site was temporarily suspended in April 2011, following recommendation of the 2011 Mahurangi Estuary Ecological Monitoring report (Halliday and Cummings 2011). The sediment grain size, monitored populations and community structure at this site had remained stable for a number of years.

All five intertidal sites are sampled at three-monthly intervals. In addition, in May 2013 a visual inspection of each intertidal site was made by NIWA staff.

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 Auckland Council, this methodology and the size classes used have been modified to enable direct comparison with the Manukau and Waitemata ecological monitoring programmes. Individual bivalves are now allotted a size class under a dissecting microscope and large individuals are measured using electronic callipers. Size class groupings used are: <5 mm, 5-10 mm, 10-15 mm, 15-20 mm, 20-30 mm, 30-40 mm, 40-50 mm and >50 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 and Cummings 2009).

Figure 1 Map of Mahurangi Harbour, showing locations of the intertidal 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. Note sampling at CB was suspended in 2011, following recommendations of Halliday and Cummings (2011).
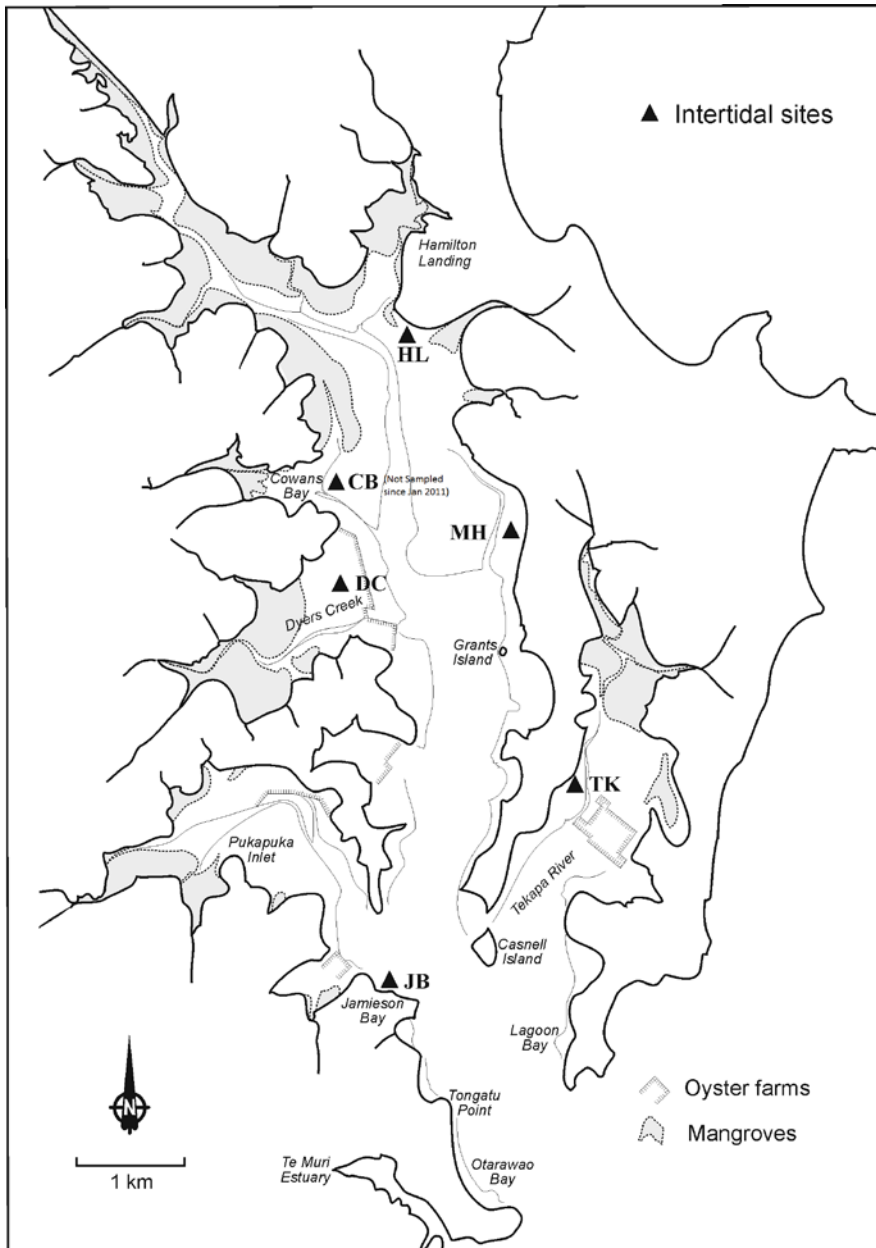
2.1.2 Sediment characteristics

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 (>2 mm), coarse sand (500 – 2000 μm), medium sand (250 – 500 μm), fine sand (62.5 – 500 μm), silt (3.9 – 62.5 μm) and clay (<3.9 μm).

_____

Also beginning in July 2000, the organic 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, composite 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   Analyses of macrofaunal abundance

2.2.1 Biological interpretation of patterns

Plots of total abundance for each monitored population 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.

2.2.2 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.

2.2.3 Community analysis

To make an overall assessment of stability of sites over time, we constructed multivariate ordination plots using monitored taxa only, 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 and 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 2012 were analysed using the TBI index (Lohrer and Rodil 2011). The TBI (originally called 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.) that were shown to be the 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 TBI 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 (Rodil et al. 2013 in press).

The TBI index was calculated using the October 2011 and 2012 data. This is the best taxonomically resolved data set each year and allows 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 2012) 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 SUMmax value used was 226.39, which is the maximum SUM score for 12 replicates calculated in Lohrer and Rodil (2011).

The Benthic Health Models (BHMmud and BHMmetal) were then used to assess the influence of mud content and contamination by copper, lead and zinc, respectively on all taxa from October 2011 and 2012 benthic communities (Anderson et. al 2006, Hewitt and 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 multivariate analysis of community composition responses to storm-water contamination (now called BHMmetal). Stormwater contamination was represented by a single composite variable produced by PCA (Principle Components Analysis) of copper, lead and zinc concentrations in the sediment. Later, the BHMmud was added, a multivariate analysis of community composition responses to percent sediment mud content.

2.3   *Atrina zelandica* survey trial

2.3.1   Equipment

The boat used for this work was a 7.0 m Senator with a dry cabin (necessary for the electronic equipment) and a davit capable of retrieving up to 75kgs (due to the need for a heavy camera frame, see below). Most of the electronic gear used for this project ran from either boat power (12V) or from an invertor connected to an onboard battery bank.

All of the drop camera equipment (cameras, lasers, lights) were attached to a galvanised steel frame, fitted with a tail fin to provide directional stability. The frame used was relatively large and heavy and could be modified in the field to adjust the height and angle of the cameras within it. Two lasers were mounted 20cm apart to provide scaling and a small fishing weight on a 1 m piece of string was hung into the field of view to

provide an indication of the elevation of the frame above the seabed. Two diffuse white video lights (Big Blue, VL1800's) were used to increase and texture definition in the video footage.

Figure 1 Setup of the Drop camera (centre of picture) in its frame, with scaling lasers and adjustable underwater video lights mounted above on each side. The GoPro high definition camera is top centre; mounted on the bar between the scaling lasers.
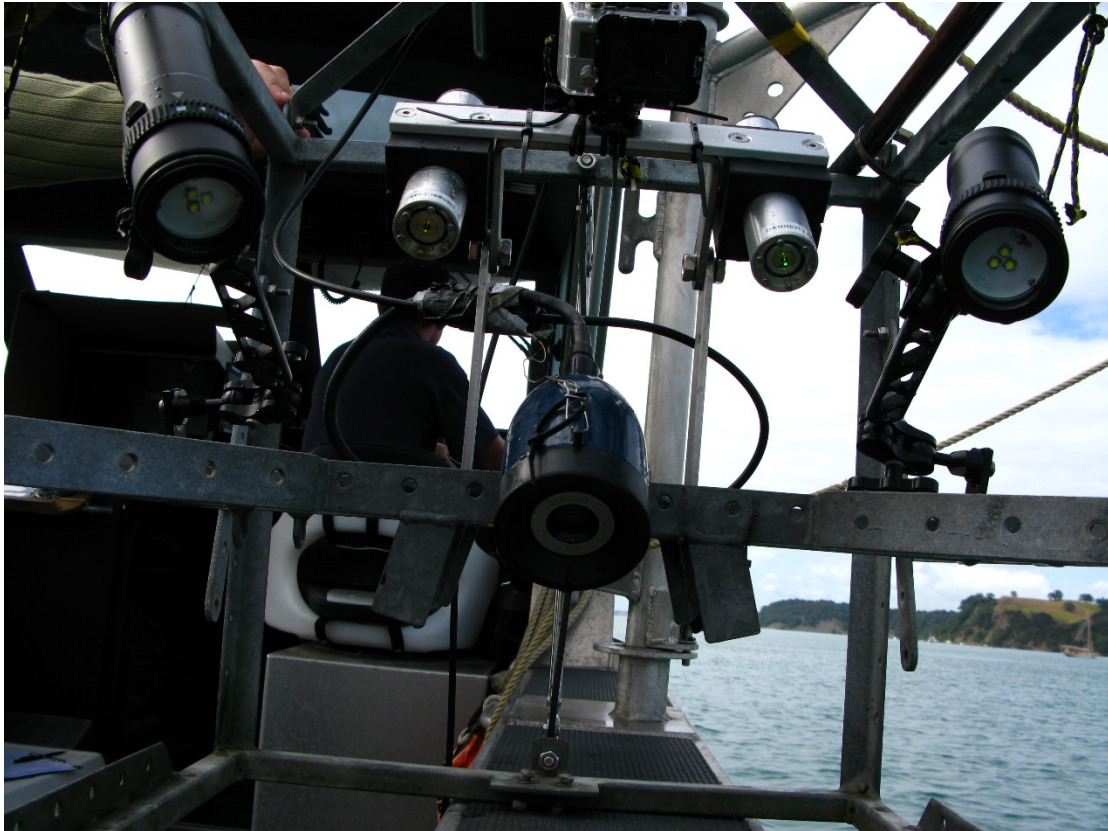
Two cameras were used to gather video footage. The main camera was a Splashcam® Deep Blue Pro (Ocean Systems Inc., 570 lines of resolution, i.e., low definition) that was connected via cable to the boat. This camera has been used for similar work for several years and is reliable, simple and robust. The Splashcam video was routed through a Horita titler that in turn was linked to the boat's GPS unit (Furuno Navnet VX2, ± 3 m accuracy). This allowed us to view position and time information on video display screens in real time and in the recorded footage.

Figure 2 View of the Drop-camera frame, ready to deploy with scaling lasers, lights and GoPro attached. Also visible is the tail fin that provides directional stability. The wooden pole attached to the top had a small weight on a bright coloured line attached to the end. This was set to give us a visual reference in the image that we could use to judge the distance of the frame off the seafloor.
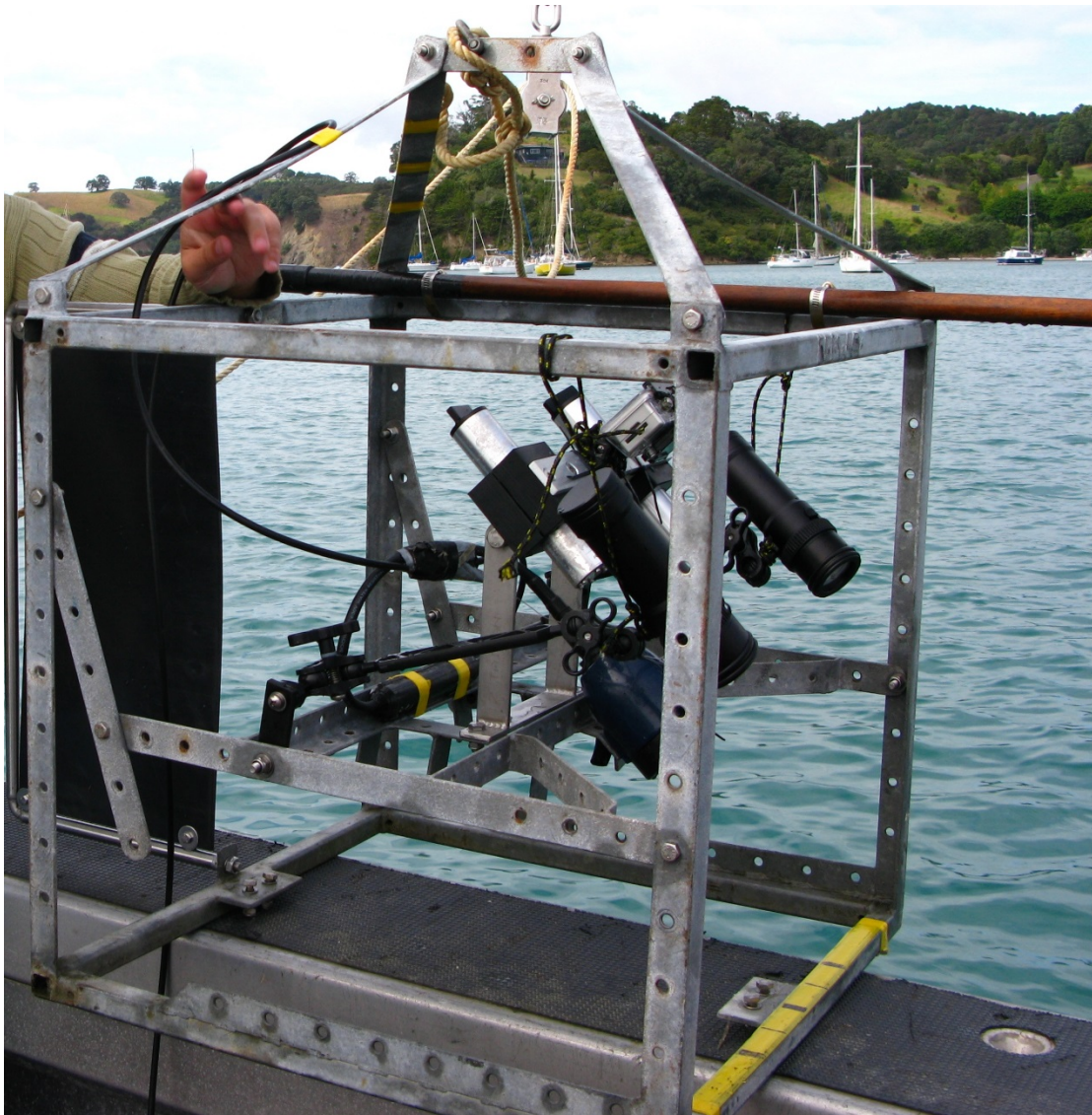
Although there was a short lay back between the GPS antenna on the boat and the position of the camera collecting the footage, this was minimised by travelling slowly and using a heavy frame to keep the camera vertical. In the shallow water that we surveyed (8-12 m depth), the boat's GPS and the camera were <3 m apart.

The video feed being viewed on the boat along with data from the titler was captured and written to the hard drive in .mp4 format, with duplicate copies saved during recordings.

2.3.2 Defining a patch

Defining what is meant by the term "patch" is one of the most difficult decisions in mapping habitats. It is generally comprised of two components: density and resolution. We chose our density definition based on previously published studies in Mahurangi Harbour / Kawau Bay area (Green et al. 1998; Norkko et al. 2002, 2006; Ellis et al. 2002; Hewitt et al. 2002, 2006; Gibbs et al. 2005; Coco et al. 2006; Chiaroni et al. 2007; Lohrer et al. 2010, 2013) and AC's long-term monitoring (Halliday and Cummings 2011) as >1 *Atrina*/m^2. Because of the inherent patchiness of *Atrina* beds, we chose our resolution to be 10 m. That is, patches were defined as anything exceeding the 1 *Atrina*/m^2 in a 10 m transect, and if 10 m passed without at least 1 *Atrina*/m^2 being observed then no patch was apparent.

This translated into a workable definition in the field of 10 *Atrina* shells in a 40 second period when travelling at the videoable boat speed of 0.5 kts (0.25 m/s), with a camera field of view of approximately 1 m.

Before field work, several search patterns ("star", "zig zag", "asterisk" and "expanding square") were tested by computer on a set of theoretical patch shapes (squares, rectangles, pentagons, random) of different sizes. We ran tests with the sampling design centred directly over the patch as well as offset. Points where transect lines crossed over patch edges were plotted to show how the patch would appear based on the different sampling strategies and this was then compared to the actual patch shape.

After analysing several options, a set of turning rules that provided more flexibility and resulted in less time being spent outside of patches was developed. Analysis of several different theoretical patch shapes using these rules yielded similarly good results. This method was also deemed practical in terms of maneuvering the boat. The first position where the density of *Atrina* exceeded a certain threshold (signaling entry into the patch) would be marked using the GPS.

The number of *Atrina* sighted in each consecutive 40 second interval after entry into a patch was noted until abundance dropped below the threshold density (i.e., < 10 *Atrina* per 40 s), signaling exit. After exiting the patch, the boat was turned 135 degrees (either port or starboard) in order to head back towards the patch. The process of crossing the patch boundary to mark entry and exit points was repeated at least 4 times. After 6-8 waypoints were recorded and the shape of the patch began to emerge on the boat's GPS, additional lines were run to achieve adequate coverage of the patch (or until a total time of 40 minutes had elapsed). If *Atrina* were not observed to reach the threshold density at a site after a search period of at least 20 minutes, the area was deemed not to have a patch and we would then move to the next site.

Divers assessed the characteristics of one patch (sizes, densities and ratios of live to dead *Atrina*, etc.,) to ground truth previously collected the drop cam footage characterising the patch boundary and *Atrina* density. The divers videoed along a 33 m runline that had been assessed previously from the boat, so that the quality and information content of the two approaches could be compared. The video collected by the divers was obtained using a housed Sony HD video camera held ~50 cm above the bed. A marked transect tape was laid out on the bed to provide scale and field of view information for the diving video (field of view was ~70 cm width).

All video footage was analysed in the laboratory by a single technician. The video was slowed down, paused and rewound to enable identification of the location of patch edges at a finer resolution. Live *Atrina* were distinguished from standing dead shells and their sizes measured.

3.0 Results and discussion

3.1 Intertidal sites

3.1.1 Site observations

A visual inspection of the sites carried out in May 2013 by NIWA staff and examination of photographs taken by Auckland Council staff on each sampling date revealed several changes to the sites over the last two years.

The vegetation at the Dyers Creek site seems to be changing. When the site was first established in October 2005, patches of seagrass (*Zostera capricorni*) were occasionally seen at the site. Seagrass patches were absent in May 2013, and have not been seen at the site for at least four years. In the May 2013 inspection, small mangrove seedlings (*Avicennia resinifera*, 10-15 mm high) were common (S. Edhouse, pers obs.). Seedlings of this size were not visible on site photos taken prior to May 2013. As such seedlings are easily moved around by storms, this is not a strong indication that mangroves will establish at the site (although it is likely that some will).

Two changes were noted at the Jamieson Bay site. During the April 2012, July 2012 and October 2012 sampling occasions, a green algal mat was noted in the photographs taken of the sediment surface in the lower third of the site. This mat was not noticed during the May 2013 visual inspection, and was unfortunately not able to be identified from the photographs. The visual inspection of the site in May 2013 revealed that the raised shell bank at the eastern end of the site (first noted in Oct 2010) had reduced in height and size (S. Edhouse, pers. obs.); subsequent examination of the site photos suggests that the shell bank has been reduced in size since July 2012. The photos also reveal that the proportion of shell hash, cobbles and sand on the sediment surface (small scale habitat heterogeneity) changes more at this site than any other. This observation is backed by the sediment grain size analysis (Figure 4).

No visible changes were noted at the Hamilton Landing or Mid Harbour sites.

3.1.2 Sediment characteristics

The sediment grain size composition of the four 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 (represented by April 1995; Figure 4, 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 2011 to January 2013 are provided in Appendix 3. The organic content is lowest at Dyers Creek (range 0.75-1.94% 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 Dyers Creek, Jamieson Bay and Te Kapa Inlet (Figure 5).

Chlorophyll *a* content of the sediments continues to be highest at Hamilton Landing (5.93 -18.11 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 4 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.
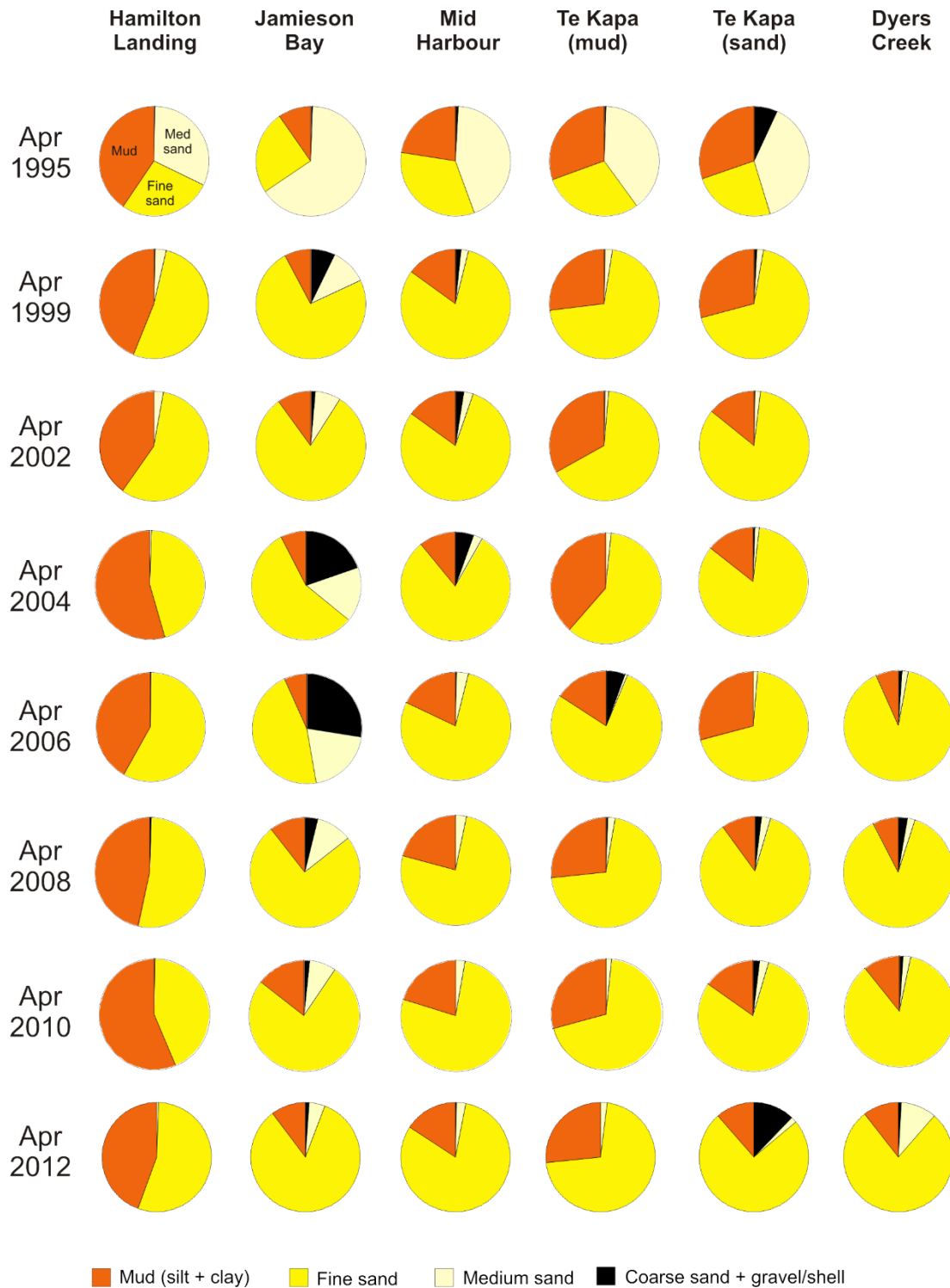
Figure 5 Sediment organic content at the intertidal sites on each sampling occasion since July 2000.
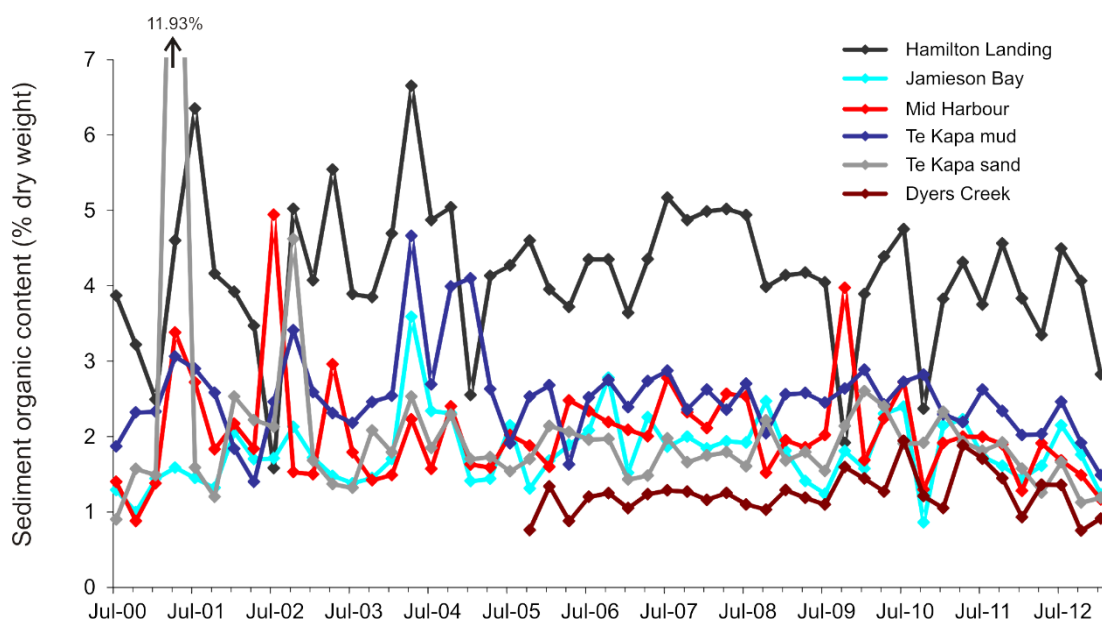
3.1.3 Macrofauna - comments on the abundance of common taxa

Throughout this report 'total' abundances (i.e., total numbers of individuals collected in 12 samples) of the monitored taxa are discussed. The total, mean, median and range of all the intertidal monitored taxa collected at each site on each sampling date since the last report (i.e., from April 2011 to January 2013) are given in Appendix 41.

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).

3.1.3.1 Dyers Creek

The Dyers Creek site was added as a long-term monitoring site in October 2005. Cummings et al. (2007) provided a detailed description of the site and compared 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* (8-263 individuals) and *Austrovenus stutchburyi* (179-415 individuals) (Appendix 5). The polychaete *Prionospio aucklandica* (64-121 individuals) was the second or third most dominant taxon on seven of the eight sampling occasions over the past two

---

[1] Since the beginning of the monitoring programme, four species have had taxonomic name changes: *Macropthalmus hirtipes* is now *Hemiplax hirtipes; Aquilaspio aucklandica* is now *Prionospio aucklandica; Owenia fusiformis* is now *Owenia petersenae* and *Aonides oxycephala* is now *Aonides trifida*.

years. This taxon had not been recorded amongst the three most dominant taxa prior to April 2009. *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 four years. In contrast, the bivalve *Arthritica bifurca*, the polychaete *Aricidea* sp. and the amphipod *Paracalliope novizealandiae* have recently appeared amongst the three dominant taxa. *Arthritica bifurca* is generally found consistently in low numbers at this site (6-93 individuals). However, peak abundances have been higher over the last two years. *Aricidea* sp has steadily increased in abundance over the last two years (33-77 individuals). The amphipod *Paracalliope novizealandiae* is found at low numbers at this site (< 20 individuals), except for a peak in abundance in October 2012 (110 individuals).

Populations showing cyclic abundance patterns

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

Four annual cyclic trends are suggested. Polydorid polychaetes peak in abundance in July or April (Figure 6B), the bivalve *Arthritica bifurca* either in January or April (Figure 7), the polychaete *Prionospio aucklandica* peaks in April (Figure not shown) and the limpet *Notoacmea scapha* in July or October each year (Figure not shown).

Figure 6 Total number of polydorid polychaetes collected on each sampling occasion. Peaks in abundance of these polychaetes 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 to some extent at Te Kapa Inlet, and in the last few years, have increased at Jamieson Bay and Mid Harbour. This species exhibits 5 – 7 year abundance cycles in Manukau Harbour.
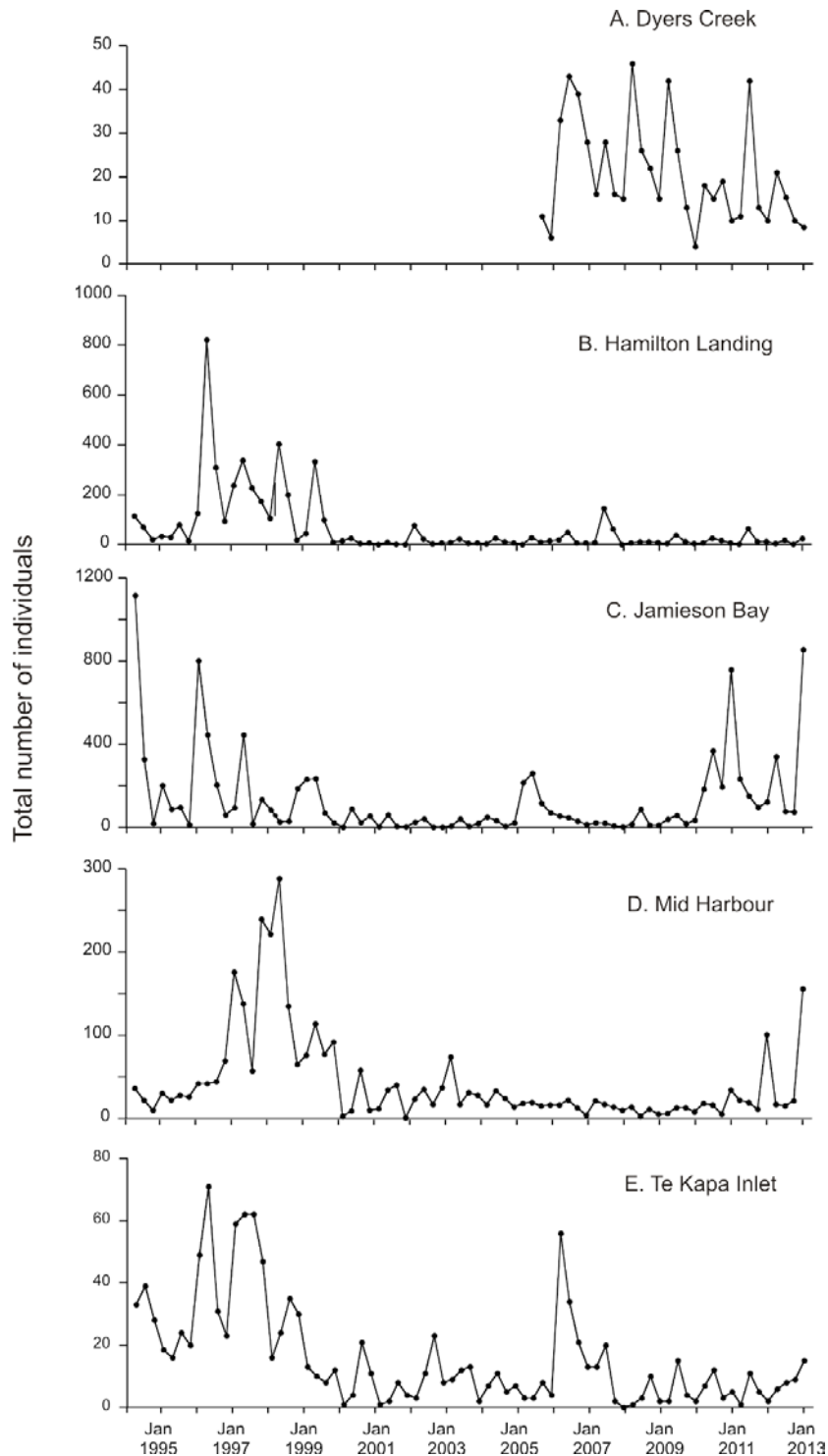
Figure 7 Total abundance of Arthritica bifurca collected on each sampling occasion at Dyers Creek. Peaks in abundance of this species occur annually, usually in January.
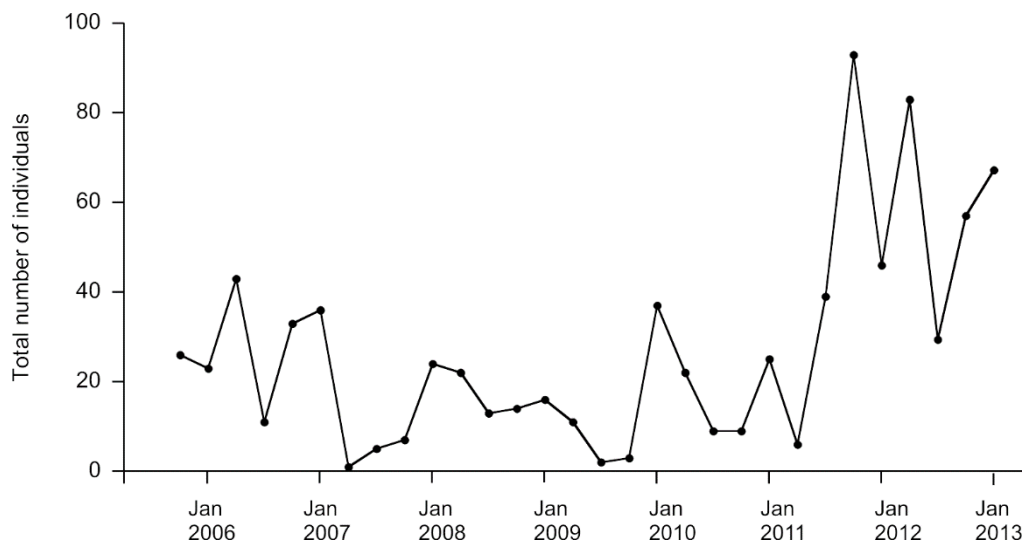
Populations showing trends in abundance

As with identification of annual cycles in abundance, any abundance trends detected from only 7.5 years of data should also be treated as provisional.

Eight abundance trends have been identified in the monitored taxa at Dyers Creek, six of which are new and the majority of which are increasing trends (Table 1).

The abundance of *Macomona liliana* has decreased significantly over the monitoring period and has remained low for the past four years (Figure 6A). This is primarily due to a decline in the number of large individuals (>20 mm SL; Figure 6B).

In contrast clear increasing trends in abundance were detected for the polychaetes *Prionospio aucklandica* (Figure 9) and *Aricidea* sp. (Figure 10) and an emerging positive trend in the abundance of the bivalve *Austrovenus stutchburyi*. *Aricidea* sp. have clearly increased in abundance since January 2011 (Figure 10). Similar increases in the abundance of *Aricidea* were noted at the other four monitoring sites over this same period, suggesting a harbour-wide pattern (Figures not shown). Encouragingly, a new, positive, trend in the abundance of *Austrovenus stutchburyi* was detected (Figure 11). The abundance of *Austrovenus* at Dyers Creek decreased over the first one and half years of monitoring (from 267 individuals in October 2005 to 123 individuals in January 2007). Since then, the numbers in all size classes have increased, and on the last sampling date more were found than on any previous sampling date (510 individuals in January 2013). More data will confirm if this is an ecologically meaningful change or part of greater than annual cycles in abundance.

The abundance of *Torridoharpinia hurleyi* has decreased significantly since monitoring began in October 2005. This decline is driven by relatively high numbers on two occasions early in the time series, and for this reason and the low densities of this species (0-13 individuals), we consider this trend is unlikely to be ecologically meaningful.

The three remaining trends detected were for taxa which had previously been found in low abundances (<6 individuals) and have increased over the past two to three years: the polychaete *Cossura consimilis*, nemerteans and oligochaetes. The increases in numbers of oligochaetes and *Cossura* were small (to 10 and 7 individuals, respectively), and we consider these trends are unlikely to be ecologically meaningful, due to

the low densities of these taxa. However, baseline abundances of nemerteans are now twice as high as those noted previously (around 15 individuals).

The decline in *Heteromastus* abundance noted in the 2011 report has proven, with the addition of 2 more years of data, to be part of a multiyear cycle in abundance.

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

Figure 8 A. Total abundance of *Macomona liliana* collected on each sampling occasion at Dyers Creek, showing an apparent decreasing trend in abundance. B. Total number of individuals in each size class. Note the decline in the abundance of large (>20 mm diameter) *Macomona*.


.
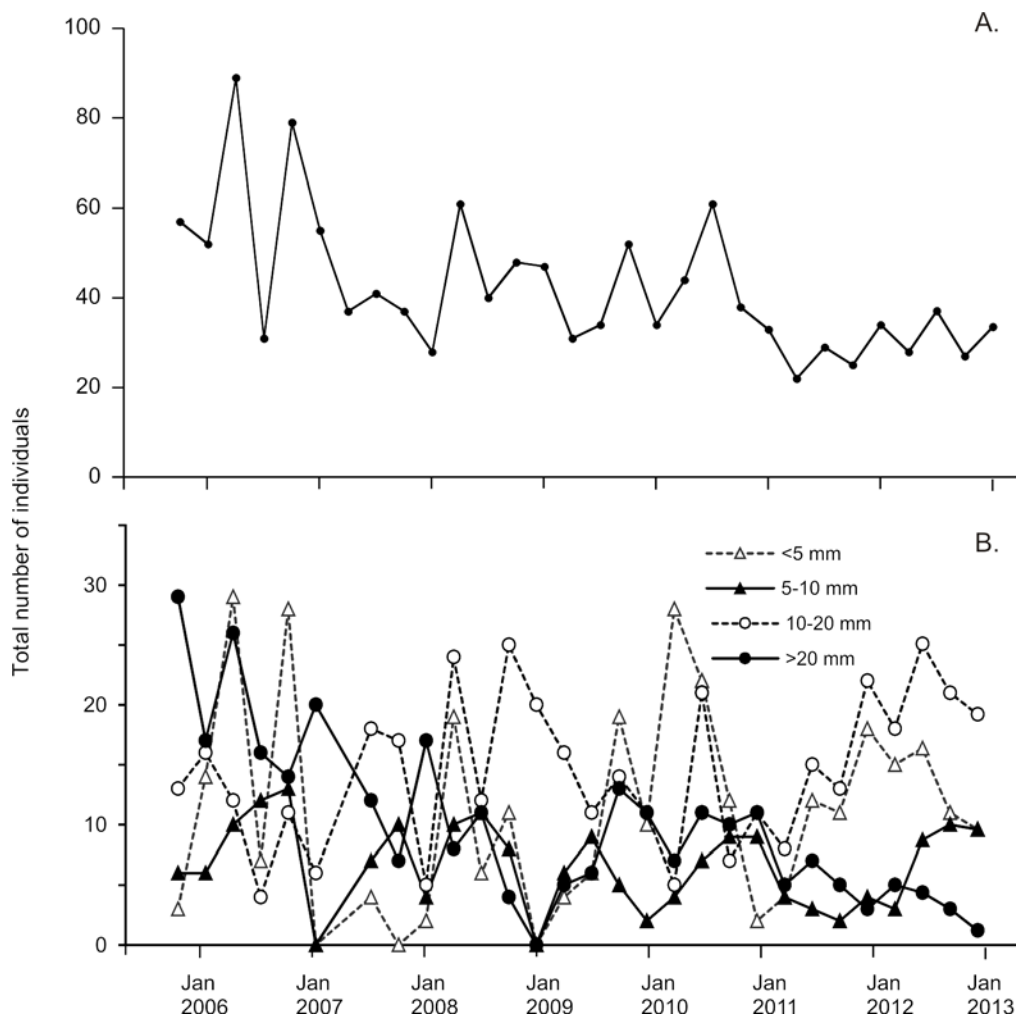
Figure 9 Total abundance of *Prionospio aucklandica* collected on each sampling occasion at Dyers Creek, showing an apparent increasing trend in abundance
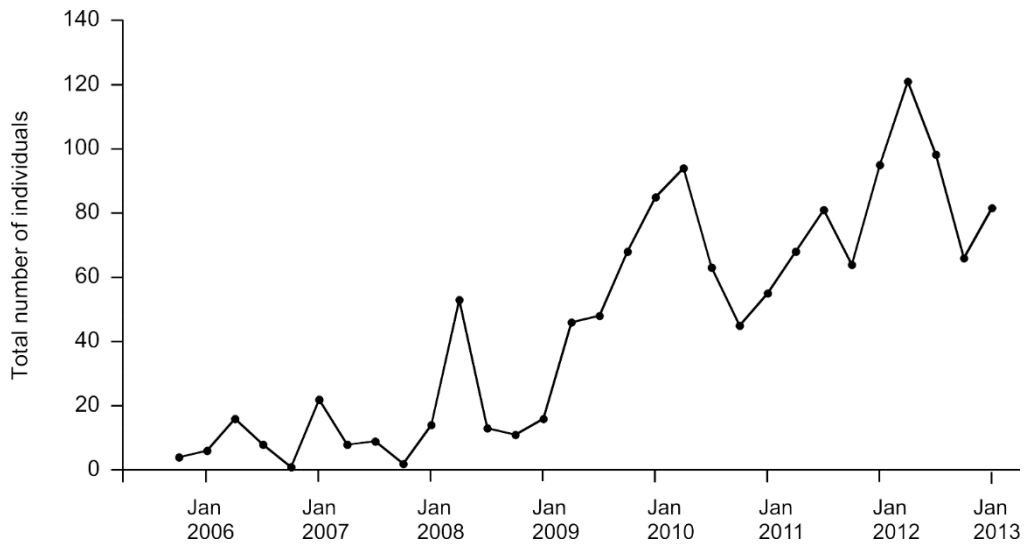

Figure 10 Total abundance of *Aricidea* sp. collected on each sampling occasion at Dyers Creek, showing an apparent increasing trend in abundance.
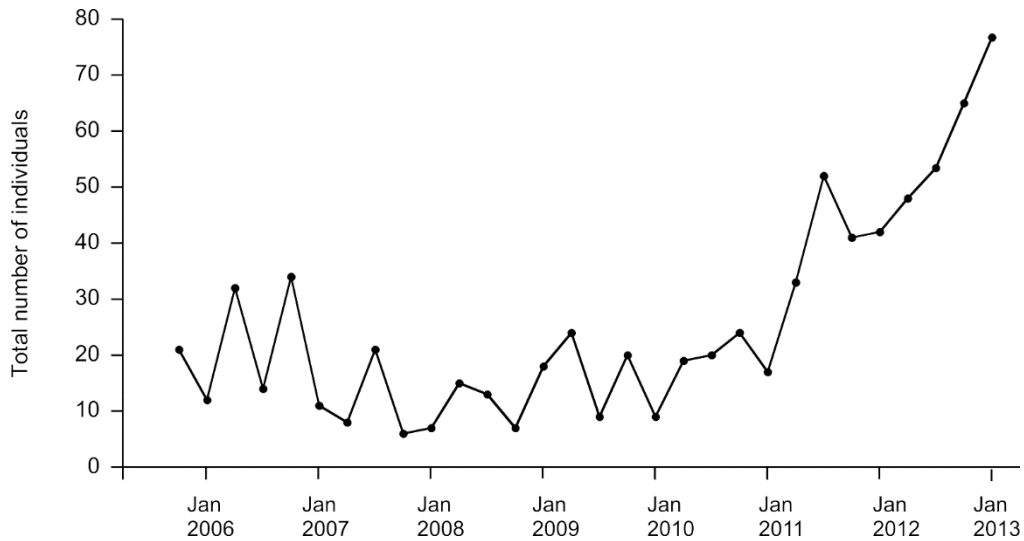
Figure 11 A. Total abundance of *Austrovenus stutchburyi* collected on each sampling occasion at Dyers Creek, showing an apparent increasing trend in abundance. B. Total number of individuals in each size class.
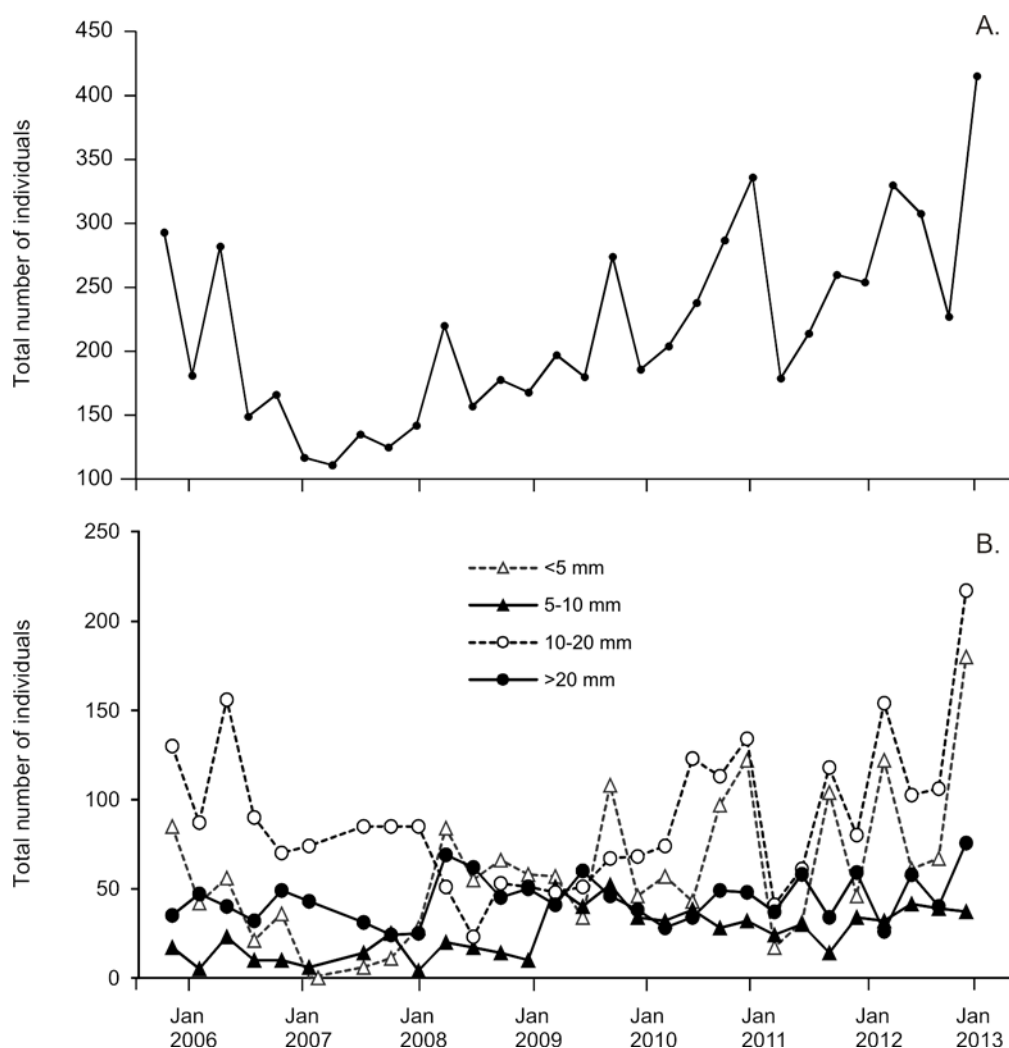
3.1.3.2 Hamilton Landing

Cossura consimilis continues to be the most abundant taxon at Hamilton Landing (Appendix 6) 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 been the second and third most common taxa.

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 12, Table 2).

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 6C).

The crab *Hemiplax hirtipes* and the polychaete *Heteromastus filiformis* exhibit peaks in abundance every year, most often in October (Figures 13 and 15, respectively), with both exhibiting greater than annual cycles in recruitment peaks.

Figure 12 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.
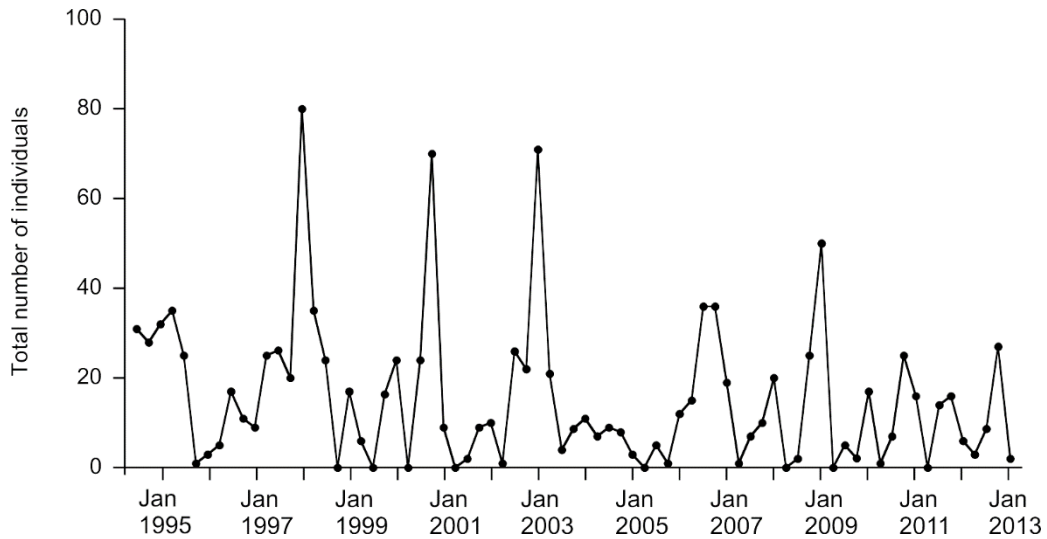

Figure 13 **Total number of *Hemiplax hirtipes* collected on each sampling occasion at Hamilton Landing. Peaks in abundance of this crab occur annually, most often in October months.**
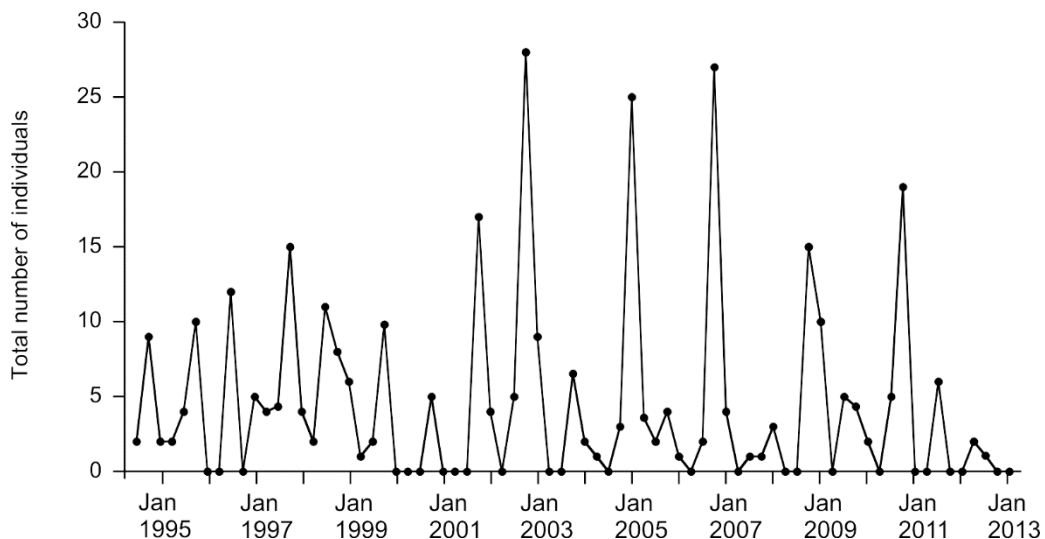
Figure 14 Total number of *Heteromastus filiformis* collected on each sampling occasion at Hamilton Landing. Peaks in abundance of this polychaete occur annually, most often October.
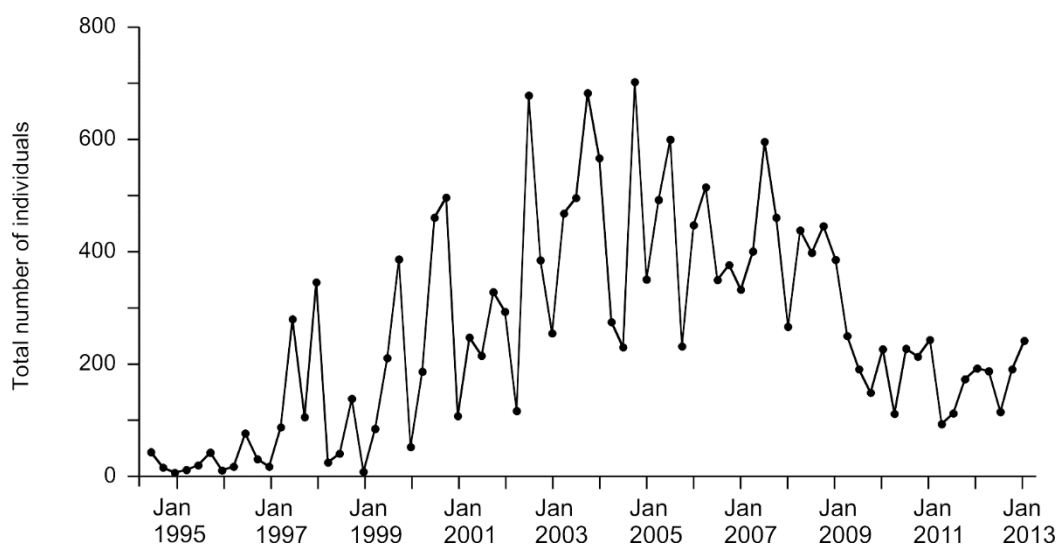
Populations showing trends in abundance

Trends in abundance over the sampling period were detected for 10 of the monitored populations at Hamilton Landing; nine of which were noted as statistically significant trends in the 2011 report (Table 1). The new trend detected was an increase in the abundance of oligochaetes (Figure 14). Although numbers of *Heteromastus filiformis* remain considerably higher than they were for the first four years of sampling, the increasing trend noted for this polychaete in the past four reports is no longer statistically significant (Figure 14, Table 1). The magnitude of this trend was greatest in the 2007 report and this poychaete is most likely exhibiting multi-year cycles in abundance, with very high densities found in the middle-years of this monitoring programme. The minor decreasing trend in numbers of *Perinereis vallata* apparent in the past four reports has also disappeared. Note that *Perinereis* is a rare taxa at Hamilton Landing and we have not considered these prior trends in abundance to be ecologically meaningful (Appendix 4).

Five additional populations exhibit increases in abundance (i.e., *Aricidea* sp., *Cossura consimilis*, Nemerteans, Oligochaetes, *Prionospio aucklandica*), and five exhibit decreases (i.e., *Austrovenus stutchburyi*, *Macomona liliana*, *Nucula hartvigiana*, polydorids, *Scoloplos cylindrifer*).

Six 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 in early 2000.

- *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 6C, Table 1).

- The bivalves *Austrovenus stutchburyi* and *Macomona liliana* continue to exhibit significantly 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, and they are all juveniles (< 5 mm SL). While *Macomona* were never amongst the dominant taxa, its 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 16A). 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 16B). This indicates that juvenile *Macomona* are being supplied to this site from elsewhere in the estuary, but that few are surviving to adulthood.

- A decreasing step trend was detected for *Scoloplos cylindrifer* polychaetes; they have been scarce or absent at Hamilton Landing since early 2000 (Table 1).

- A decreasing step trend was detected for the bivalve *Nucula hartvigiana* (Table 1). However, large recruitment events in January 2010 and January 2013 indicate this trend may disappear in future years.

- A positive linear trend was also detected for the polychaete *Aricidea* sp (Table 1). The basal and peak abundances for this taxon have been increasing since mid-2003, and numbers have been particularly high since July 2012.

Three other populations (nemerteans, oligochaetes and *Prionospio aucklandica*) exhibit increasing trends in abundance at Hamilton Landing (Table 1). 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* and oligochaetes (Figure 15), on the other hand, appear to have increased in abundance over the whole monitoring period, especially in the last four to six years. However, more data will be required to confirm these trends. Note, both nemerteans and *Prionospio aucklandica* have slightly lower basal abundances prior to 2000 than after, suggesting that these populations were also affected by the change that occurred in early 2000. Oligochaetes were extremely rare at Hamilton Landing prior to April 2007, and significant peaks in abundance have occurred almost every year since (Figure 15).

Figure 15 **The total number of oligochates collected on each sampling occasion at Hamilton Landing. Note an apparent increasing trend in abundance.**
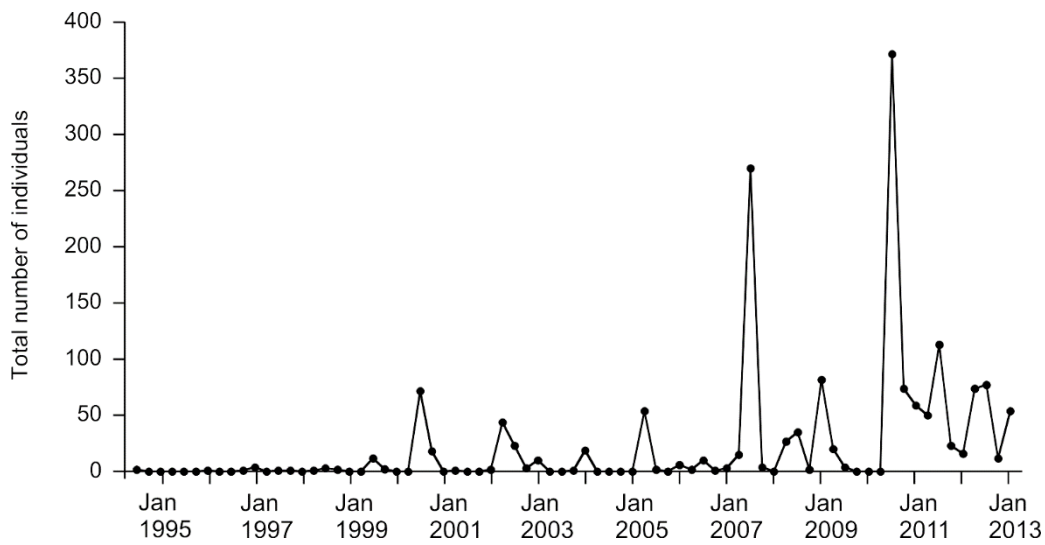
**Figure 16 A. The total number of *Macomona liliana* collected on each sampling occasion at Hamilton Landing. A decreasing step trend in overall abundance was detected for this bivalve. Numbers have stabilised since April 2000. B. The total number of individuals in each size class, from July 1997 onwards. Note only small (<5 mm shell length) individuals have been commonly found since April 2000.**
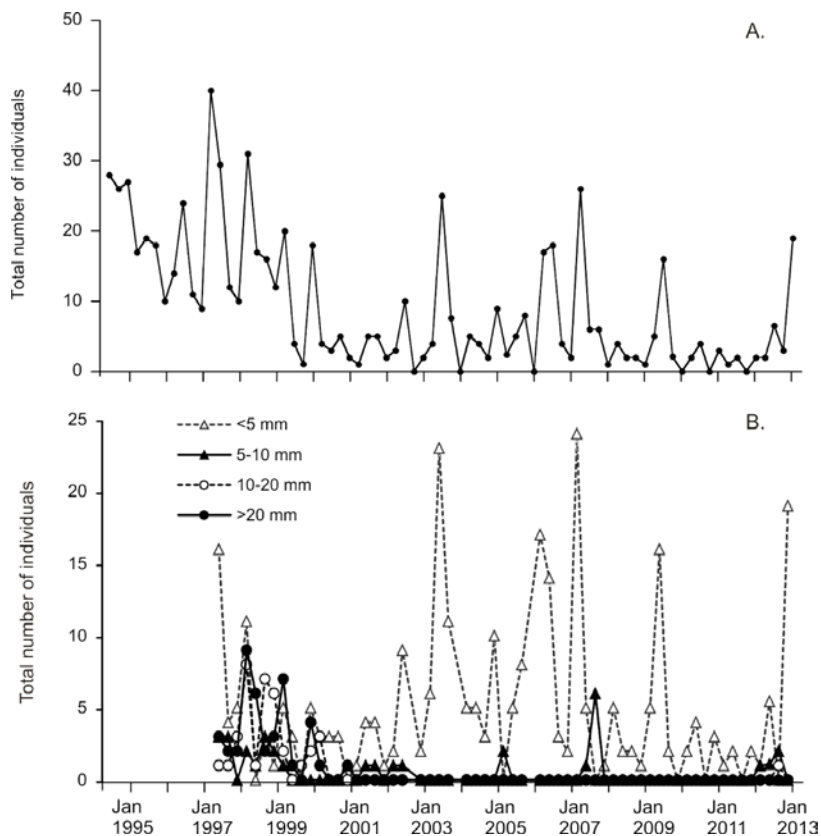
3.1.3.3 Jamieson Bay

Polydorid polychaetes were either the first or second most abundant taxa at Jamieson Bay in the last two years of monitoring (Appendix 7), when 74-857 individuals were found. *Heteromastus filiformis* were the most common taxa on two occasions and the third most common on four other occasions in the last two years (30-155 individuals). *Nucula hartvigiana* were the second or third most abundant taxa on six occasions in the last two years (37-105 individuals). Four additional taxa have been the third most common taxon at Jamieson Bay over the last eight sampling occasions: the bivalve *Arthritica bifurca*, the polychaetes *Prionospio aucklandica* and *Aricidea* sp., and the amphipod *Paracalliope novizealandiae*.

Populations showing cyclic abundance patterns

Four populations exhibit annual cyclic abundance patterns at Jamieson Bay: polydorids (Figure 6C), *Aricidea* sp., *Nucula hartvigiana* and oligochaetes (Table 2). Polydorids generally have highest numbers in July or April each year and also exhibit a multi-year cycle. Although peaks were lower from early 2000 to 2009, they have recently returned to their previously high levels (Figure 6C). Peak abundances of oligochaetes and *Aricidea* sp. occur in either July or October, while *Nucula* consistently exhibits its highest numbers in January or April (figures not shown).

Populations showing trends in abundance

Statistically significant trends in abundance were detected in two taxa at Jamieson Bay in this year's analysis, compared with three in the 2011 report, one in the 2009 report and five in the 2005 and 2007 reports (Table 1). While a small overall increase in the abundance of *Nucula hartvigiana* was detected in the 2011 report, numbers have been low over the past two years and this trend is no longer significant, confirming our suspicion that the 2011 trend was not ecologically meaningful (Table 1; Halliday and Cummings 2011).

A significant positive trend was detected in *Aricidea* sp. abundance. Numbers on the last two sampling occasions (October 2012 and January 2013) were the highest ever for this species at Jamieson Bay (Figure 17), but at least one more years sampling will be needed to confirm whether this is an actual population trend or merely a higher than normal recruitment. A negative trend was detected for *Macomona liliana* abundance; this bivalve was abundant at this site over the first three years of monitoring, after which numbers declined to around 10 individuals on average (Figure 18A). Numbers have remained relatively low, with occasional large peaks comprised almost entirely of <5 mm individuals (Figure 18B). While this decline was identified as a step trend in our 2011 report, with more data this is no longer apparent (Figure 18A). The variability over time in whether a decreasing trend is detected suggests that this population undergoes multi-year cycles in abundance.

A positive trend was detected in *Arthritica bifurca* abundance, primarily due to high abundances on the last two sampling occasions (62 individuals in October 2012 and 35 individuals in January 2013). Prior to October 2012 numbers of *Arthritica* were generally low (average 6 individuals). More data are required to confirm this trend continue, however at this stage we do not consider it to be ecologically significant.

Four new trends were detected: decreasing trends in abundance of two polychaetes, *Aonides* sp. and *Cossura consimilis*, and increasing trends for oligochaetes and *Paracalliope novizealandiae*. The abundance of *Aonides* fluctuates considerably, and its peak and baseline abundances have been lower over the last three years. However, as baseline abundances have been low for periods in the past we do not consider this an ecologically significant trend. The abundance of *Cossura* also fluctuates considerably and a small decline

in abundance has been detected; this slight decline does not appear to be ecologically significant. A slight increasing trend was detected in oligochaete abundance, driven by fewer occasions when no individuals were present and by an increase in the frequency of large peaks in abundance (>20 individuals) since mid-2003. Considering the highly fluctuating abundance of this taxa we do not believe this trend to be ecologically significant at this stage. A slight increasing trend was also detected in *Paracalliope* abundance, driven by an unusually high number of individuals in April 2012 (148 individuals). As numbers of *Paracalliope* have returned to their normal range since this peak, we do not consider this trend to be ecologically significant.

Figure 17 **Total number of *Aricidea* sp. collected on each sampling occasion at Jamieson Bay. Note a small, but statistically significant increase in the abundance of *Aricidea* over the entire monitoring period and higher abundances over the last two sampling occasions**.
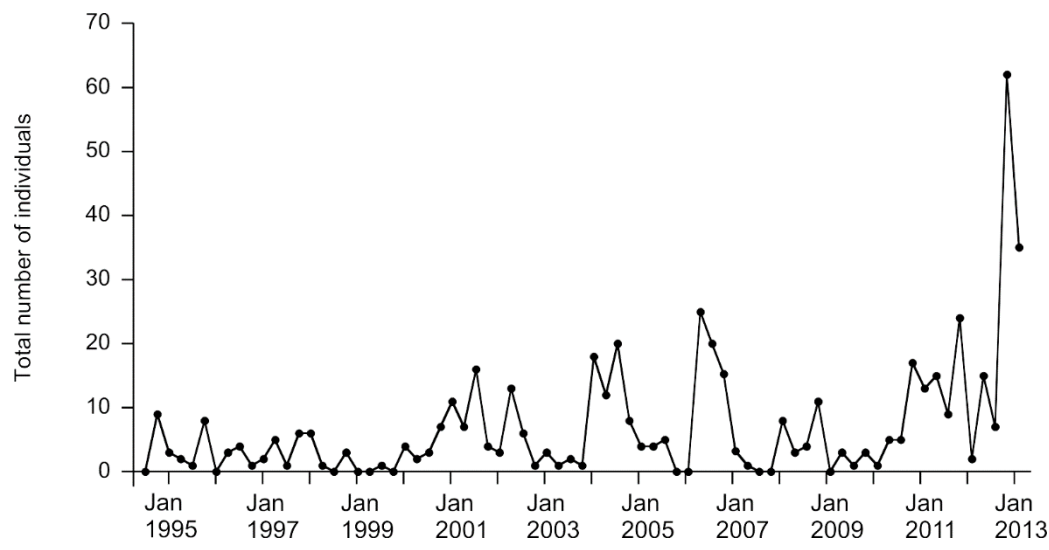
Figure 18 A. Total number of *Macomona liliana* collected on each sampling occasion at Jamieson Bay. A small decreasing trend in overall abundance of this bivalve was detected. B. The total number of individuals in each size class, from July 1997 onwards.
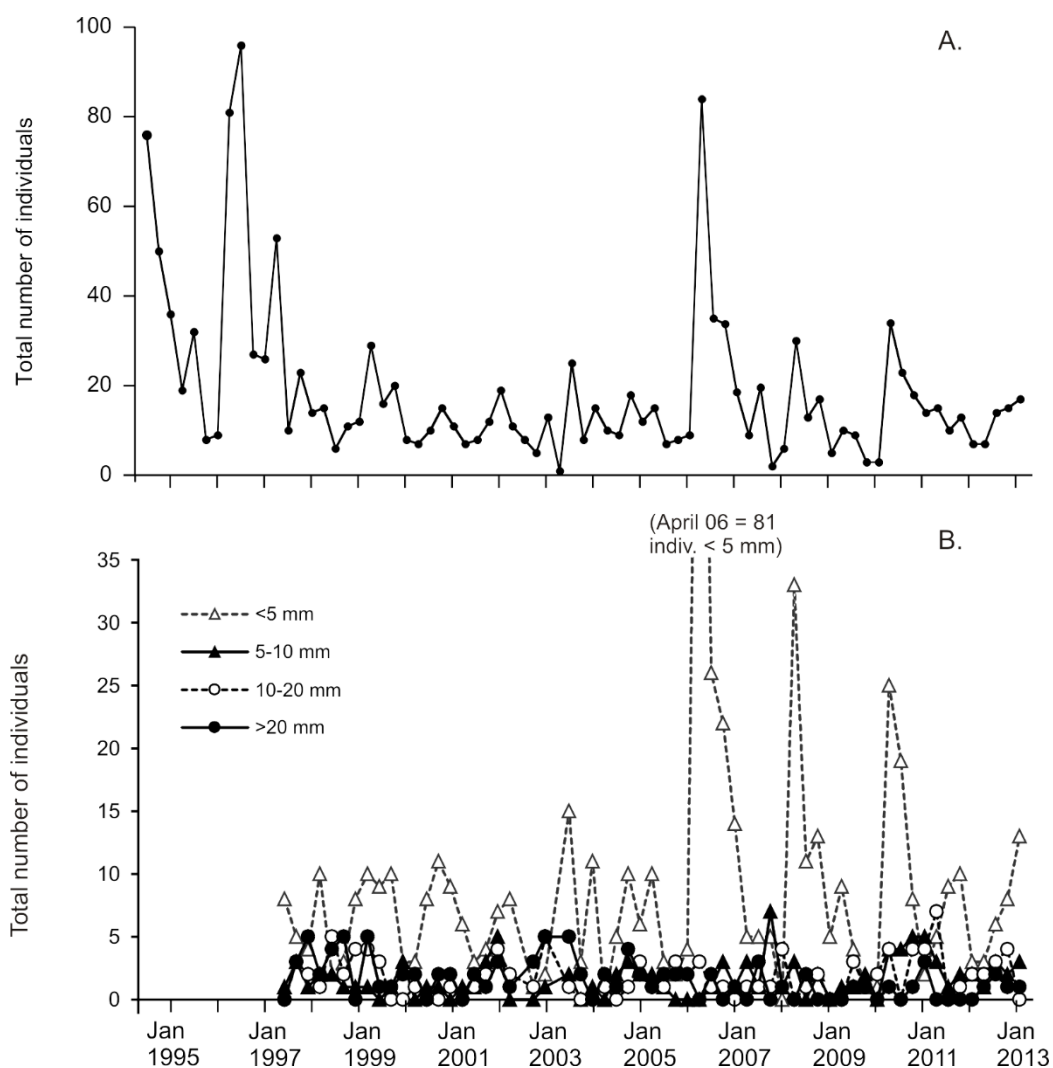
3.1.3.4 Mid Harbour

Prior to Oct 2011, *Nucula hartvigiana* had been the most abundant taxa at Mid Harbour on all but three occasions. This dominance ended in late 2011 (Appendix 8), with between 24 and 187 individuals collected on the last eight monitoring dates (c.f. 347 - 771 individuals collected in the previous eight monitoring dates). *Arthritica bifurca* were the most abundant taxon on six of these occasions, and the second or third most common on one occasion each over the last two years, with between 54 and 267 individuals found. Polydorid polychaetes were the second most abundant taxon on two occasions (11-156 individuals); *Cossura consimilis (*40-112 individuals) were either the second or third most common on six occasions; and *Heteromastus filiformis* were the third most common on three occasions in the past two years (19-88 individuals).

Populations showing cyclic abundance patterns

Heteromastus filiformis (figure not shown) and *Hemiplax hirtipes* (Figure 19) exhibit peaks in abundance every year at Mid Harbour, in July or October months (Table 2). *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, April or Oct (figure not shown).

Figure 19 **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.**
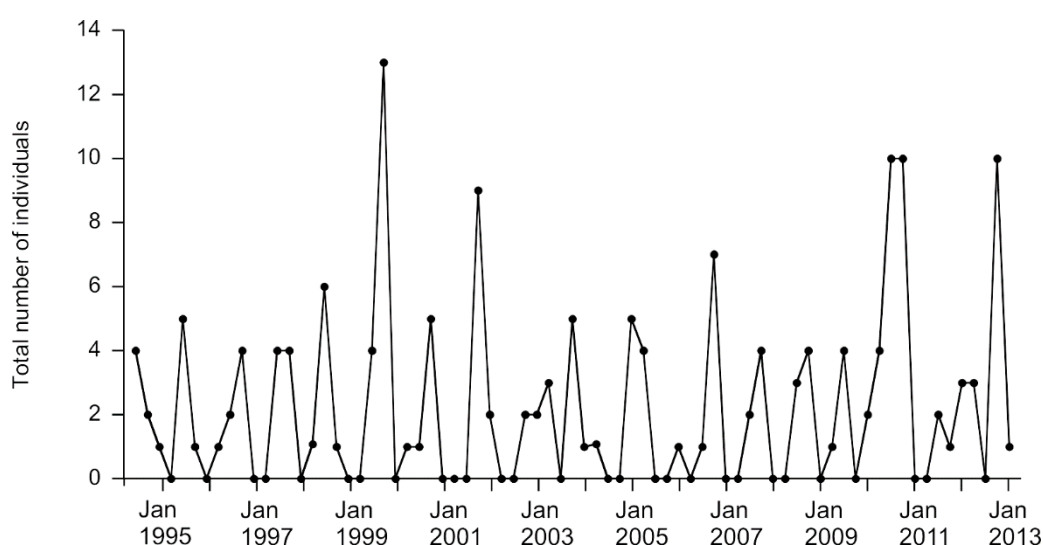
Populations showing trends in abundance

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

A small increasing trend was detected for Aricidea sp., with 25 - 61 individuals found at this site since April 2011 (around three times as many as commonly occurred previously). *Arthritica bifurca* abundances fluctuate considerably, however, their numbers have been increasing since January 2007. A large recruitment event occurred in January 2012 (267 individuals), which followed a large peak in January 2011 (223 individuals) and a similar sized peak exactly 2 years previous (January 2009, 210 individuals).

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 20A). *Macomona* numbers declined in the early years of the monitoring programme. Baseline abundances suggest a multiyear cyclic pattern, possibly superimposed over the longer-term decline (Figure 20A). 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 20B).

The increasing trend in the abundance of the small bivalve *Nucula hartvigiana* detected in our 2009 and 2011 analyses is no longer apparent (Table 1). Numbers have fluctuated considerably over the entire monitoring period, and the previous increasing trends were driven by large recruitment events in January

2008, 2009 and 2010, as noted at the time. A large decline in the abundance of *Nucula* over the last two years indicates that these increasing trends were part of larger fluctuations in abundance (Figure not shown). The extremely small increasing trend detected for *Scoloplos* in our 2011 analysis was disproven with the addition of two more years of data.

Figure 20 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.
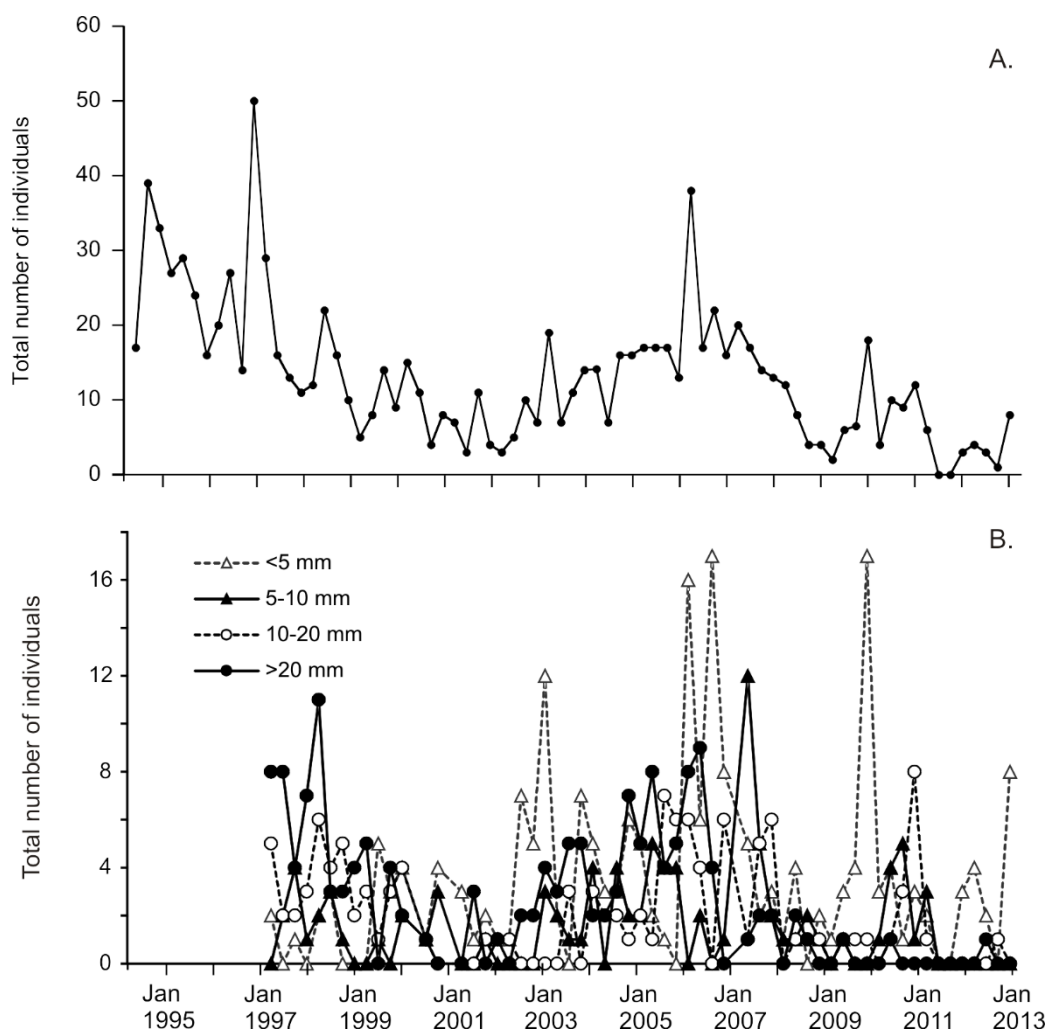
3.1.3.5 Te Kapa Inlet

The Te Kapa Inlet community continues to be dominated by high numbers of *Cossura consimilis* (158-407 individuals since the last report; Appendix 9). *Aricidea* sp. (69-312 individuals) and *Heteromastus filiformis* (0-207 individuals) were also common. *Austrovenus stutchburyi* (36-247 individuals) was the second or third most common taxa on four occasions in the last two years. All four 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, within a multi-year cycle (Figure 6E). In addition, a yearly cyclic pattern in *Nucula hartivigiana* abundance has been noted, with peaks generally occurring in October and January each year.

Populations showing trends in abundance

Eleven statistically significant trends in abundance were detected for monitored populations at Te Kapa Inlet, although we consider that five of these are unlikely to be ecologically significant due to low or sporadic occurrences. Six populations are exhibiting ecologically significant trends: two increasing (i.e., *Arthritica bifurca* and nemerteans) and four decreasing (i.e., *Macomona liliana*, *Notoacmea scapha*, *Nucula hartvigiana*, polydorids; Table 1).

The abundance of *Arthritica bifurca* fluctuates with time, however high abundances over the last three years have resulted in an ecologically meaningful increase in abundance being detected. An increasing trend has again been detected in the abundance of nemerteans. This increase has mostly been driven by high abundances over the last three years of sampling.

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 the 2007 and 2009 reports (Table 1, Figure 21A and B). Numbers of the limpet, *Notoacmea scapha*, have significantly declined over the entire monitoring period to a point where none were found between January 2007 and April 2011, however higher abundances on three occasions over the last two years indicates that a recovery 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. 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 6E).

An increasing trend in abundance of oligochaetes was detected, with relatively high numbers being found over the past five years. Low magnitude increases were also detected in populations of *Aricidea* sp., *Paracalliope novizealandiae*, *Perinereis vallata* and *Scoloplos cylindrifer*. At this stage we consider that none of these trends are likely to be ecologically significant, and more data are required to determine if they will continue.

Two of the abundance trends detected in the 2011 report are, with the addition of two years more data, no longer significant. A decline in abundance of *Austrovenus stuchburyi* had been previously noted, primarily driven by high abundances in the first two sampling occasions (July and October 1994). A large recruitment event in January 2013 (247 individuals, the most ever recorded at this site) has removed this trend. However, given that abundances of this bivalve fluctuate considerably (Figure 22A), we will confirm in our next report whether these extremely high numbers noted on this one sampling occasion have meant this trend removal persists. Encouragingly though, large numbers of >20 mm individuals were noted on several occasions over the past two years (Figure 22B). An increase in the abundance of *Cossura consimilis* noted in the 2011 report is no longer statistically significant, however a step change in its abundance since early 2000 is still evident (Figure 23).

Figure 21 A. **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.**
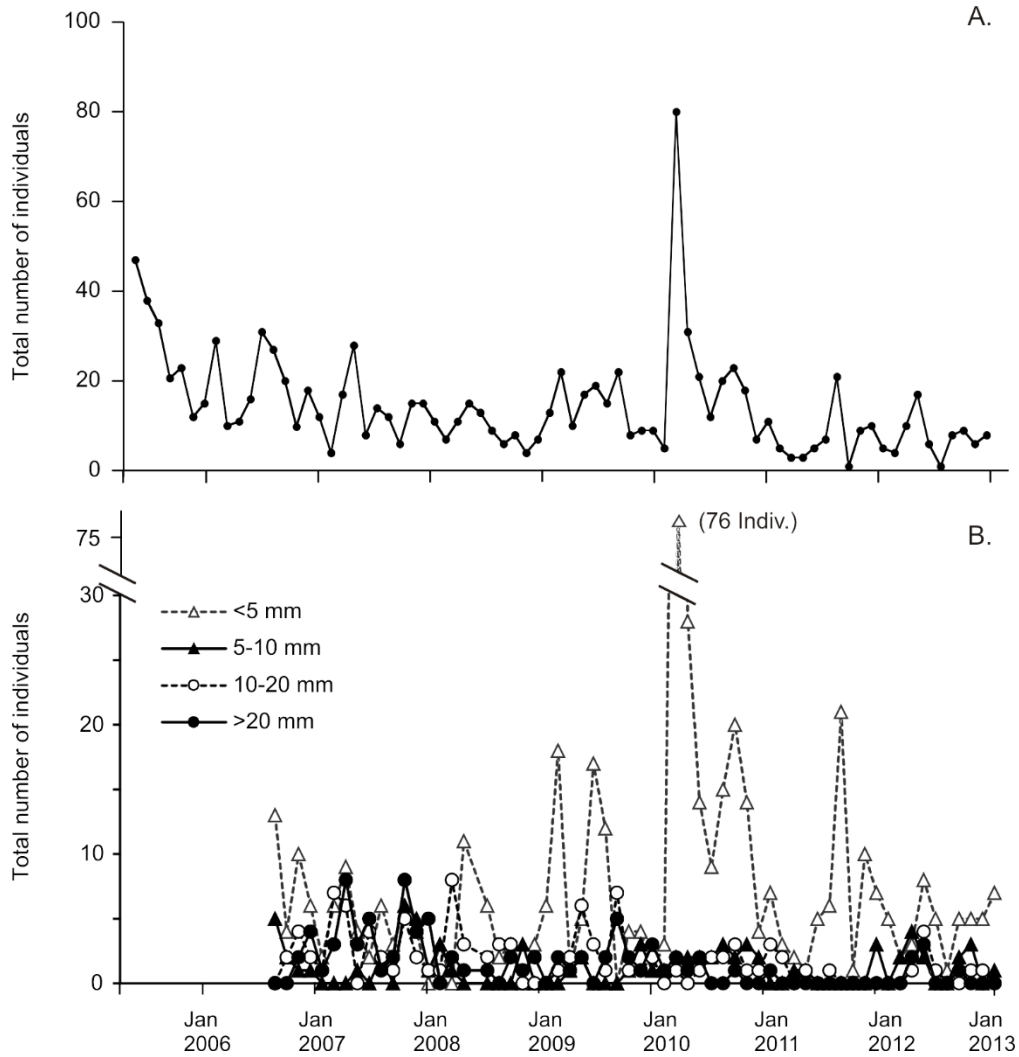
Figure 22 A. **Total number of *Austrovenus stutchburyi* collected on each sampling occasion at Te Kapa Inlet. A decreasing trend in overall abundance of this bivalve was detected until early 2010, since then the numbers of *Austrovenus* have increased again. B. The total number of individuals in each size class, from July 1997 onwards. Note the large number of Juvenile (<5 mm diameter) *Austrovenus* in January 2013**.
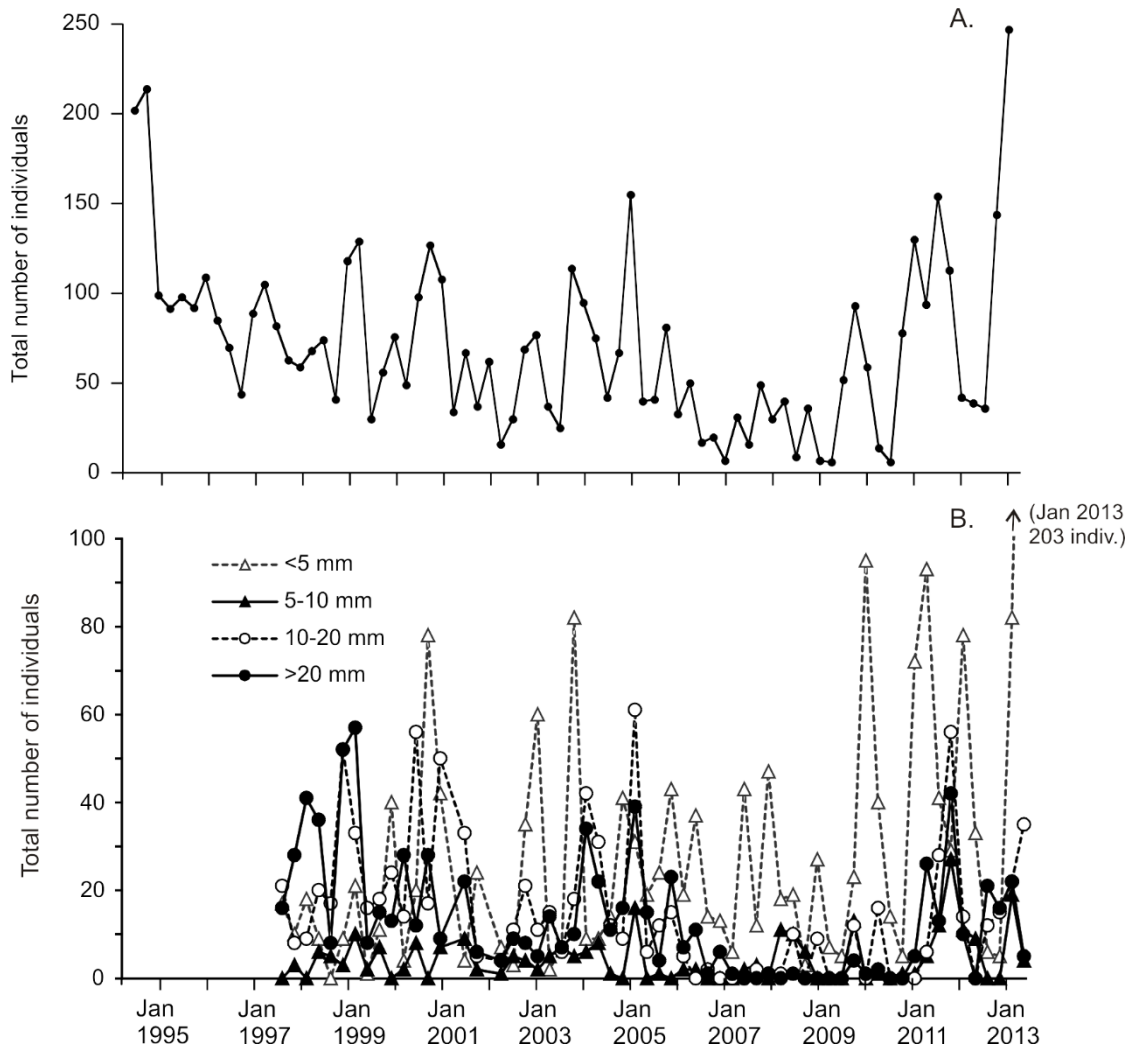
**Figure 23 Total number of *Cossura consimilis* collected on each sampling occasion at Te Kapa Inlet. Increasing trend in abundance no longer statistically significant, however a step change in its abundance since early 2000 is still evident.**
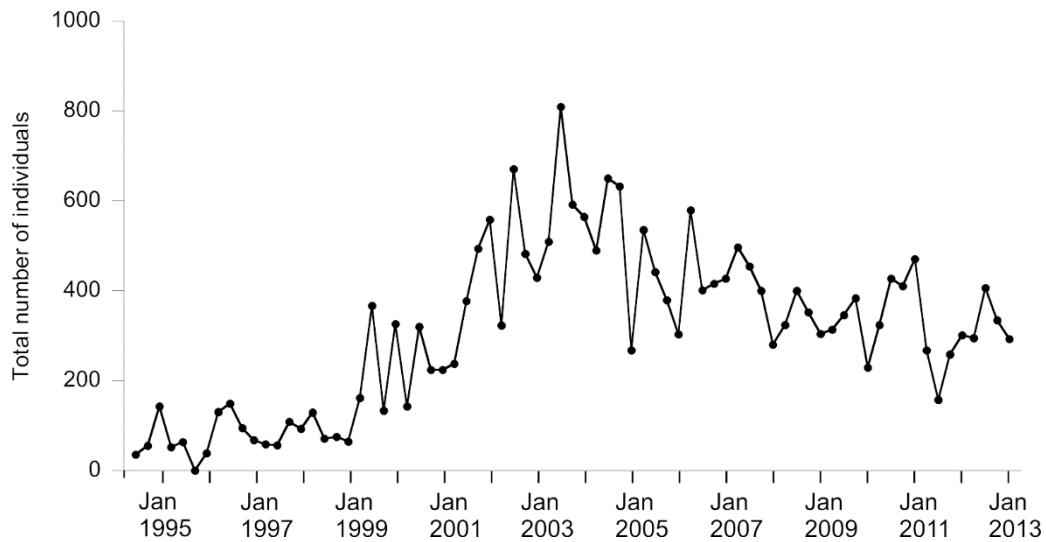
Table 1 Statistically significant trends in abundance of intertidal taxa at each site, shown for all years that this analysis has been conducted. Negative numbers indicate a decrease in abundance, while positive numbers indicate an increase. Analysis of each taxon was conducted firstly on all data, and 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. § = A step change in abundance is apparent, despite the lack of a significant trend.

Monitored Taxa	2013	2011	2009	2007	2005	2003
Dyers Creek						
Aricidea sp.	1.44	No trend				
Austrovenus stutchburyi	4.84	No trend				
Cossura consimilis*	0.33	No trend				
Hemiplax hirtipes*	No trend	0.26				
Heteromastus filiformis	No trend	-4.00				
Macomona liliana	-1.03	No trend				
Nemerteans	0.52	No trend				
Oligochaete*	0.57	0.46				
Prionospio aucklandica	3.48	3.47				
Torridoharpinia hurleyi*	-0.15	No trend				

Monitored Taxa Hamilton Landing	2013	2011	2009	2007	2005	2003
Aricidea sp.	1.91	0.96	0.86	0.66	0.86	No trend
Austrovenus stutchburyi	-1.13 step	-1.50 step	-1.76 step	-2.33	-2.82	-3.67 (-3.46)
Cossura consimilis	13.30 step	13.44 step	19.58 step	19.73	22.09	17.60
Heteromastus filiformis	No trend	5.02	8.70	10.36 (10.16)	12.37	11.20 (6.67)
Macomona liliana	-0.23 step	-0.30 step	-0.31 step	-0.39	-0.51	-0.71
Nemerteans	0.16	0.10	No trend	0.18	0.30	0.29
Nucula hartvigiana	-0.12 step	-0.14 step	No trend	No trend	-0.35	-0.44
Oligochaete	0.96	No trend	No trend	No trend	No trend	0.50
Perinereis vallata	No trend	-0.04 step	-0.04 step	-0.06	No trend	-0.10
Polydorids	-2.48 step	-2.92 step	-3.41 step	-4.16 (-2.68)	-5.05	No trend
Prionospio aucklandica	0.51	0.61	No trend	0.28	0.52	0.35
Scoloplos cylindrifer	-0.17 step	-0.18 step	-0.23 step	-0.25	-0.30	No trend

Monitored Taxa Jamieson Bay	2013	2011	2009	2007	2005	2003
Aonides sp.*	-0.39	No trend	No trend	No trend	No trend	No trend
Aricidea sp.	0.35	0.22	No trend	0.28 (0.32)	(0.36)	0.41 (0.54)
*Arthritica bifurca**	0.18	No trend	No trend	0.17	0.16	No trend
*Cossura consimilis**	-0.14	No trend	No trend	No trend	No trend	No trend
Macomona liliana	-0.29	-0.34 step	No trend	-0.48	-0.89	-1.24
Notoacmea scapha	No trend	No trend	No trend	No trend	No trend	0.18
Nucula hartvigiana	No trend	2.46	No trend	No trend	No trend	No trend
Oligochaete*	0.23	No trend	No trend	No trend	No trend	No trend
Owenia fusiformis	No trend	No trend	No trend	No trend	-0.05	-0.11
*Paracalliope novizealandiae**	0.26	No trend	No trend	No trend	0.34	0.59
Polydorids	No trend	No trend	-5.05 (step)	-6.37 (-2.16)	-9.11 (-3.62)	-11.89 (-4.45)
Torridoharpinia hurleyi	No trend	No trend	No trend	-0.41 (-0.42)	-0.58	-0.97
Mid Harbour						
Aonides sp.	No trend	No trend	No trend	No trend	-0.01	-0.01
Aricidea sp.	0.34	0.20	No trend	No trend	0.27	0.52
Arthritica bifurca	1.70	1.20	0.98	0.83	No trend	1.01
Cossura consimilis	No trend	No trend	No trend	No trend	No trend	-1.6
Macomona liliana	-0.23	-0.20	-0.20	No trend	-0.48	-0.79
*Notoacmea scapha**	No trend	No trend	No trend	-0.01	No trend	No trend
Nucula hartvigiana	No trend	3.32	3.42	No trend	No trend	(-6.83)
*Paracalliope novizelandiae**	No trend	No trend	No trend	0.08	No trend	No trend
Scoloplos cylindrifer	No trend	0.01	No trend	No trend	No trend	No trend

Monitored Taxa Te Kapa Inlet	2013	2011	2009	2007	2005	2003
Aonides sp.	No trend	No trend	No trend	No trend	No trend	0.02
Aricidea sp.*	0.01	No trend	No trend	No trend	No trend	No trend
Arthritica bifurca	0.52	No trend	No trend	0.40	No trend	No trend
Austrovenus stutchburyi	No trend	-1.11	-1.51	-1.57	No trend	-2.21
Cossura consimilis	No trend§	6.30 step	8.39 step	9.76	14.90	13.64
Heteromastus filiformis	No trend	No trend	No trend	2.00	(4.58)	No trend
Macomona liliana	-0.19	-0.20	No trend	No trend	-0.36	-0.9 (-1.0)
Nemerteans	0.25	0.15	No trend	0.12	0.26	0.29
Notoacmea scapha	-0.08	-0.13	No trend	-0.14	No trend	No trend
Nucula hartvigiana	-0.89	-0.95	-0.85	-0.84	No trend	No trend
Oligochaetes*	0.10	0.11	No trend	No trend	No trend	No trend
Paracalliope novizealandiae *	0.04	No trend	No trend	No trend	No trend	No trend
Perinereis vallata *	0.03	No trend	No trend	No trend	No trend	No trend
Polydorids	-0.42 step	-0.48 step	-0.54 step	-0.57	-0.91 (-1.09)	-1.1 (-1.1)
Prionospio aucklandica	No trend	No trend	-1.18	-1.18	-1.17	No trend
*Scoloplos cylindrifer**	0.04	No trend	No trend	0.05	No trend	No trend
Torridoharpinia hurleyi	No trend	No trend	No trend	No trend	0.27	No trend

3.1.4 Intertidal sites - general patterns

3.1.4.1 Harbour-wide patterns in intertidal macrofaunal populations

Populations showing cyclic abundance patterns

Twenty two 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 7.5 years of data (cf. 19 years of data for the remaining monitoring sites) 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. 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	DC	HL	JB	MH	TK
Aricidea sp.	.	.	Jul/Oct	*	*
Arthritica bifurca	Jan/Apr	Jan/Oct (>)	.	.	.
Hemiplax hirtipes	.	Oct	.	Jul/Oct	.
Heteromastus filiformis	.	Oct	.	Jul/Oct	*
Nemerteans	.	>	.	.	>
Notoacmea scapha	Jul/Oct	.	.	.	.
Nucula hartvigiana	.	.	Jan/Apr	Oct/Jan	Oct/Jan
Oligochaetes	.	.	Jul/Oct	.	.
Polydorids	Jul/Apr	Jan	Jul/Apr	.	Jul/Oct (>)
Prionospio aucklandica	Apr	.	.	.	.

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 and 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 (Tables 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 24).

With the addition of two years more of data the previously detected step decline in *Macomona liliana* at Jamieson Bay is no longer apparent and we now believe the peaks in abundance during the first three years of sampling were part of greater than annual fluctuations in abundance.

Table 3 Summary of intertidal monitored taxa exhibiting persistent, ecologically significant step abundance changes in early 2000. HL = Hamilton Landing, TK = Te Kapa Inlet. –ve= reduction in abundance, +ve = increase in abundance. No step abundance changes were detected for populations at Jamieson Bay or Mid Harbour. [§] A step change in abundance is apparent, despite the lack of a significant trend.

Taxa showing step abundance pattern	HL	TK
Austrovenus stutchburyi	-ve	
Cossura consimilis	+ve	+ve[§]
Macomona liliana	-ve	
Nucula hartvigiana	-ve	
Polydorids	-ve	-ve
Scoloplos cylindrifer	-ve	

Figure 24 **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.**
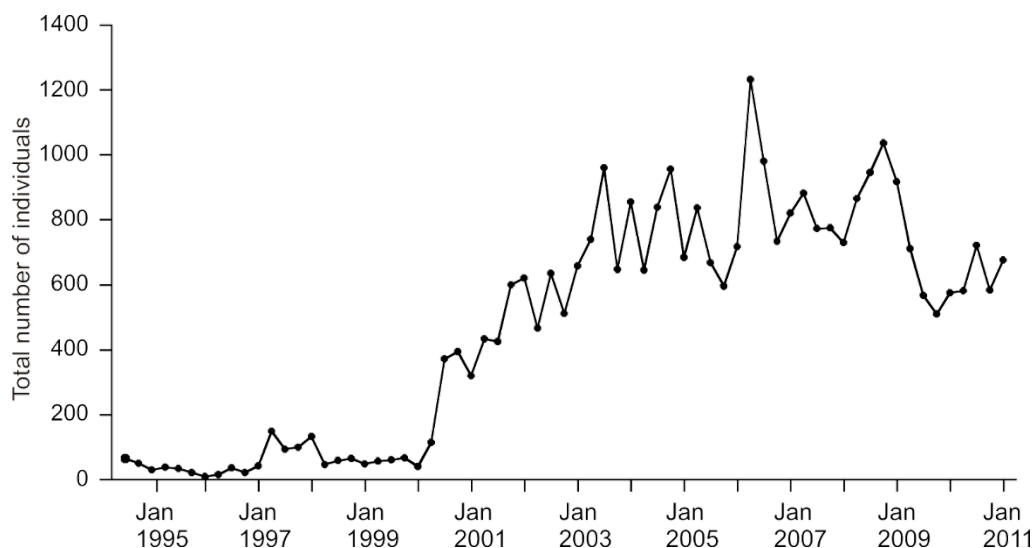
Populations showing trends in abundance

A total of 26 populations are currently showing ecologically significant trends in abundance; fourteen of these are increasing trends and twelve are decreasing trends (Table 4). All sites have populations that are exhibiting trends; most occur at Hamilton Landing (10 taxa) and the least occur at Jamieson Bay (2 taxa); Dyers Creek, Mid Harbour, and Te Kapa Inlet have five, three and six populations, respectively, exhibiting trends (Table 4).

Five taxa considered sensitive to increased suspended sediment concentrations, sedimentation rates, or sediment mud content have changed in abundance in Mahurangi Estuary (Table 4).

Macomona liliana is now exhibiting a decreases at all five sites, following the detection of a new trend at Dyers Creek. The pattern of change in *Macomona* abundance is similar at all four of the long term sites, with an initial period of high abundance, and low abundances for a number of years. At one site (Hamilton Landing) this change in abundance followed a step decline in early 2000. Abundances have since increased at most sites, but abundances are still lower than at the start of monitoring. Much of this apparent recovery is due to a couple of large recruitment events (<5 mm individuals) the largest of which was in April 2006 (Figures 14, 16, 18 and 19). High *Macomona* numbers have not persisted at Dyers Creek, Hamilton Landing, Mid Harbour, Jamieson Bay or Te Kapa Inlet over the last four years, due to poor retention of recruits at these sites. With the exception of Dyers Creek, very few adult sized individuals are found at the five sites (Figure 8 cf. Figures 16, 18, 20 and 21).

Austrovenus stuchburyi is continuing to show a declining trend in abundance at Hamilton Landing. In the 2011 report we noted that *Austrovenus* and *Notoacmea scapha*, which uses *Austrovenus* as an attachment substrate, had also declined at Te Kapa Inlet (Table 4). Encouragingly for this site, recovery in all size classes over the last two years and strong recruitment of juveniles in January 2013 has reversed this decline and there was no trend detected in this years' analysis. *Notoacmea* abundance at Te Kapa Inlet also showed signs of recovery in the last two years, although a negative trend was still detected. There was also a significant increase in the abundance of *Austrovenus* at Dyers Creek, which is counter to what we would expect at a site with increased muddiness. However, although Austrov*enus* prefers sandy sediments (i.e., optimal densities are found in sand; Gibbs and Hewitt,), it occurs in reasonable numbers across a wide range of sediment types (Norkko).

Scoloplos cylindrifer exhibited a step decrease in abundance at Hamilton Landing over early 2000 (Tables 1 and 4). This polychaete is considered sensitive to increased sedimentation rates (Gibbs and 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.

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; Table 4). The polychaetes *Cossura consimilis* and *Aricidea* sp. have clearly increased in abundance at Hamilton Landing and Dyers Creek, and *Aricidea* sp. has increased at Jamieson Bay and Mid Harbour. The increases in *Cossura* at Hamilton Landing are considerable (trends of 13.30), while the other trends mentioned above are of much smaller magnitude (<2, Table 1; Table 4). There was also a step increase in abundance of *Cossura* at Te Kapa Inlet around 2000 (Figure 23). The polychaete *Prionospio aucklandica* is increasing at Dyers Creek and Hamilton Landing (Table 4). Abundances of nemerteans have increased at these two sites and at Te Kapa Inlet; at Dyers Creek and Te Kapa Inlet, baseline numbers have been considerably higher since April 2010 than previously. Polydorid numbers decreased at Te Kapa Inlet and Hamilton Landing (Table 4); these polychaetes prefer some mud, although not high percentages, and more data are required to determine if the declines at these sites may be sediment-related.

In our 2009 and 2011 reports 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 had positive implications in reducing future sediment inputs to this monitoring site.

Table 4 Summary of monitored taxa showing statistically and ecologically meaningful trends in abundance at the Mahurangi monitoring sites in 2013, 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 and 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, M = prefers mud, dec = decreasing trend, inc = increasing trend. (S) = step abundance trend, (S+) steady increase after a certain date, [§]A step increase in abundance is apparent, despite the lack of a significant increasing trend. JB = Jamieson Bay, DC = Dyers Creek, MH = Mid Harbour, TK = Te Kapa Inlet, HL = Hamilton Landing.

Sed pref	Taxa currently showing trends	JB (least muddy)	DC	MH	TK	HL (most muddy)
SS	*Notoacmea scapha*	.	.	.	dec	.
S	*Macomona liliana*	dec	dec	dec	dec	dec (S)
S	*Nucula hartvigiana*	.	.	.	dec	dec (S)
S	*Scoloplos cylindrifer*	.	.	.	.	dec (S)
S	*Austrovenus stutchburyi*	.	inc	.	.	dec (S)
I	*Aricidea* sp.	inc	inc	inc		inc
I	*Arthritica bifurca*	.	.	inc	inc	.
I	*Cossura consimilis*	.	.	.	[§]	Inc (S+)
I	Nemerteans	.	inc	.	inc	inc
I	Polydorids	.	.	.	dec (S)	dec (S)
I	*Prionospio aucklandica*	.	inc	.	.	inc
M	Oligochaetes	.	.	.	.	inc

Finally, it is worth noting that that very obvious changes in the abundance of several species were noted over the past 2-3 years at some sites: around April 2010 oligochaetes declined and *Notoacmea* and nemerteans increased at Dyers Creek, *Nucula* declined at Mid Harbour and Te Kapa Inlet, and nemerteans increased at Te Kapa Inlet; around April 2011 *Aricidea* sp., and *Arthritica bifurca* increased at Dyers Creek; and around April 2012 *Cossura* sp. increased at Dyers Creek. Some of these have resulted in statistically significant trends, but others have not. At the time of writing we are not aware of any changes at these sites which would have caused responses in these diverse species at these different sites.

While there has been significant planting and fencing work in the Dyers Creek catchment over the past two years (as mentioned previously), which could potentially have resulted in the short-term release of sediment into Dyers Creek itself, and the Dyers Creek arm of the harbour. Without more detailed information on these activities (e.g., timing, location and weather conditions) it is not possible to determine if this is a factor in the observed abundance changes.

3.1.4.2 Intertidal macrofaunal community composition

Figure 25 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 Hamilton Landing and Te Kapa Inlet sites have become more similar to each other in recent years, and are now situated more closely together in ordination space (see Oct 2012 symbols). A similar pattern had been apparent for the monitored communities at Mid Harbour and Dyers Creek. The monitored community at Jamieson Bay shows

considerable temporal variation and is now most similar to the Hamilton Landing community in Oct 1994 and its own community in Oct 1994. The Dyers Creek community had been relatively stable for the first years of monitoring, however the community composition has shown a considerable shift in the last three to four years.

Figure 25 **Correspondence analysis ordination plot, showing the yearly temporal variation in the monitored community composition at each site over the monitored period (October dates only). For each site, the positions of the community on the first October (October 1994) and the most recent October (October 2012) sampling occasions are represented by open circles. The percentage values associated with each axis indicate the % variance explained. DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.**
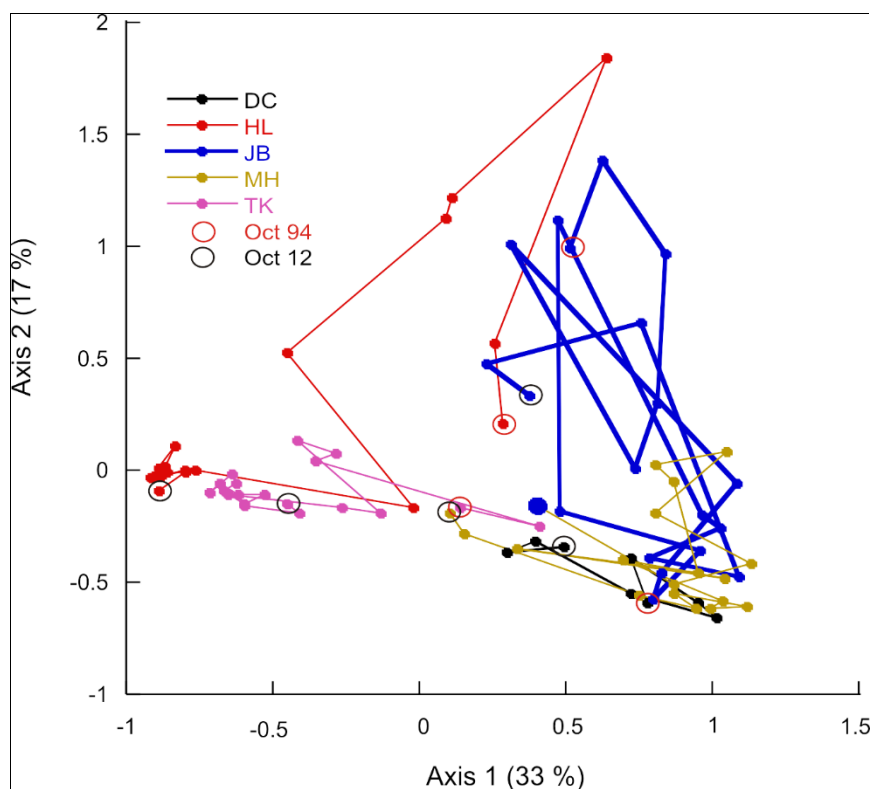
Ecological theory suggests that an early warning for abrupt degradative change may be increased temporal variability in community dynamics. Within and between year variability at the start of the monitoring programme was compared with that of the last 2 years (Table 6). Changes in within-year similarity mainly involved small (less than 5%) increases in similarity (i.e., variability decreased). A 10.3% increase in within-year similarity was noted at Jamieson Bay (Table 6). Between year variability also decreased, especially at Jamieson Bay (% 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	HL	JB	MH	TK
within year	first 5 years	79.45	70.59	79.85	82.82
	last 2 years	84.28	80.86	81.54	87.24
	difference	4.83	10.26	1.69	4.42
between year	first 5 years	76.10	68.49	78.17	82.09
	last 2 years	81.90	78.67	81.36	87.64
	difference	5.80	10.18	3.19	5.55

The Trait Based Indicator index (TBI index; previously called NIWACOOBII index) was also applied to the October 2011 and October 2012 Mahurangi data. This index was developed to assess the functional redundancy of benthic communities as an indicator of resilience (van Houte-Howes and Lohrer 2010; Lohrer and 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 and Rodil 2011). The values generated for the intertidal sites range from 0.40 at the muddy Dyers Creek site in October 2011, to 1.11 at the sandier, heterogeneous Jamieson Bay site in October 2012. The other four sites had very similar scores (Table 7), and values were similar to those recorded for the sandy Auckland Airport site in Manukau Harbour in October 2012 (Greenfield et al. 2013). The extremely high values for Jamieson Bay indicate 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 (82 taxa recorded in October 2012 c.f. 34 – 39 at the other four sites), with the TBI showing a positive trend over the monitoring period (Table 7; Hewitt et al. 2012 Draft). This may be due to the heterogeneous nature of the sediment at this site and the tidal height it encompasses, as it extends to lower on the shore than the other intertidal sites. There is some indication that TBI values are increasing over time at Hamilton Landing (Table 7; Hewitt et al. 2012).

Table 7 Trait Based Indicator (TBI) values at the five Mahurangi monitoring sites in October 2010, 2011 and 2012.

Site	October 2010	October 2011	October 2012
Dyers Creek	0.40	0.40	0.46
Hamilton Landing	0.38	0.42	0.45
Jamieson Bay	0.93	0.83	1.11
Mid Harbour	0.44	0.43	0.50
Te Kapa Inlet	0.47	0.48	0.51

Using the Benthic Health Model (BHM; Anderson et al. 2006; Hewitt and Ellis 2010), the health of the Mahurangi sites in October 2011 and 2012 was assessed relative to sediment copper, zinc and/or lead concentrations (November 2010 data) and sediment muddiness (October 2011 and 2012 data respectively). The results were also compared with the BHM values observed over time (Figure 27). The BHM CAPmetal values were relatively low, below the cutoff between group 3 and group 4 and for all sites are within the previous temporal variation noted at the site. Hamilton Landing shows a clear trend in CAPmud scores over the initial part of the monitoring period, before leveling off within group 4 "poor health". Jamieson Bay is the

healthiest, varying from group 2 "good" to group 3 "moderate" in relationship to mud content, and within group 2 for stormwater contaminants. A decreasing trend in health may be occurring at Dyers Creek, more related to mud than contaminants. However, given the short time frame of monitoring at Dyers Creek relative to the multiyear cycles apparent at the other sites, more data would be needed to confirm this. No other trends are apparent.

Figure 27 **CAP scores from the BHM for stormwater contaminants (CAPmet) and mud content (CAPmud) for all Octobers since beginning of monitoring. Health groups are given for each BHM: 5 = "unhealthy", 4 = '"poor", 3 = "moderate", 2 = "good" and 1 = "very good".**
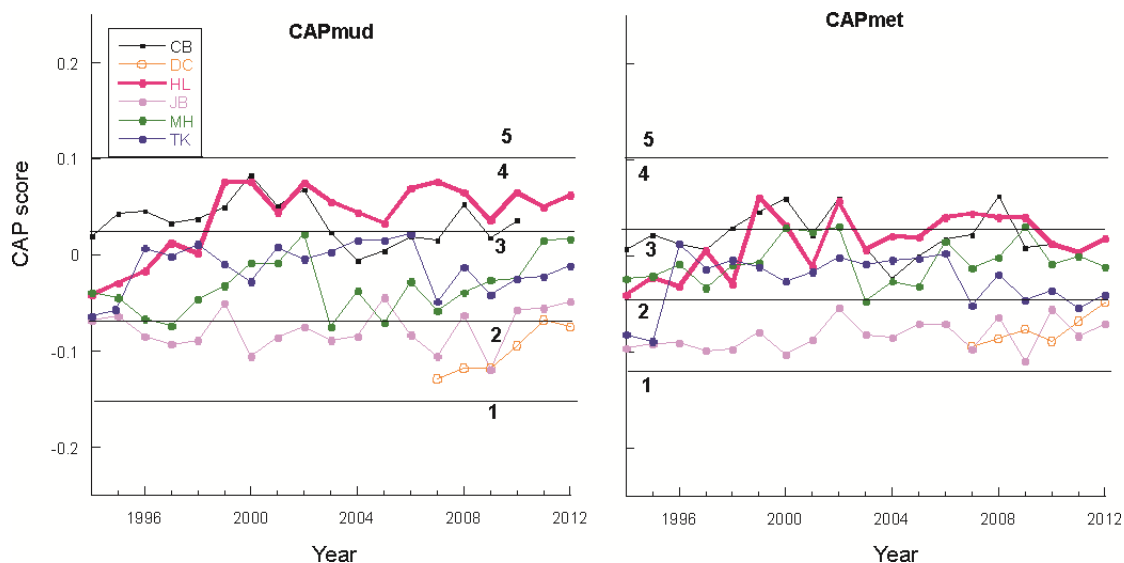
Hamilton Landing is the muddiest of the monitored sites, and Mid Harbour, Dyers Creek and Jamieson Bay are the least muddy (Figure 26). All of the Mahurangi sites fit within the original data cloud, suggesting that the BHM model for mud describes them well (Halliday and Cummings 2011). This, together with the relatively poor fit for the BHM contaminant model in October 2010, suggests that these community assemblages are more driven by mud content than contamination by copper, zinc and/or lead.

3.2 *Atrina zelandica* survey trial

3.2.1 Field work

Nineteen sites were selected for surveying based on previously observed *Atrina* zelandica beds: seven sites within Mahurangi Harbour itself, including the two subtidal sites from the long term monitoring program (Halliday and Cummings 2011); and another twelve possible sites in the surrounding area and Kawau Bay. These sites encompassed a range of depths, likely sea conditions, sediment types and past *Atrina* densities. The survey consisted of two intensive days of drop cam video collection to get through the 19 sites plus a third day for divers to assess identified patches.

Of the 19 sites, previously recorded GPS coordinates were available for some sites, but not all. Those for which GPS coordinates were not available had previously been located using line of sight directions and these were used to orientate the boat for the initial search position. We searched for a minimum of 20 minutes in each locality. Patches of *Atrina* were detected at only two sites, neither of which was in Mahurangi

_____

Harbour. Only one of the two sites was large enough to trial the proposed survey methodology. The patch located in Big Bay (on the open coast, just north of Mahurangi Harbour) was surveyed a total of three times with the drop camera, allowing us to test the repeatability of the method.

Figure 28 shows the area in Big Bay that was covered during the three days of surveying. The figure shows a large cloud of red points where the densities of *Atrina* were below the patch density threshold of 1 individual/m^2. Within this cloud of red points is a localised area of yellow points where *Atrina* densities were sufficiently high (>1 individual/m^2) to be considered part of a patch.

Figure 28 All points and track lines sampled over a three day period in the proximity of an *Atrina* patch in Big Bay. Red dots = density of *Atrina* < 1 m^2; yellow dots = density of *Atrina* was > 1 m^2 as calculated from laboratory analysis of video data.
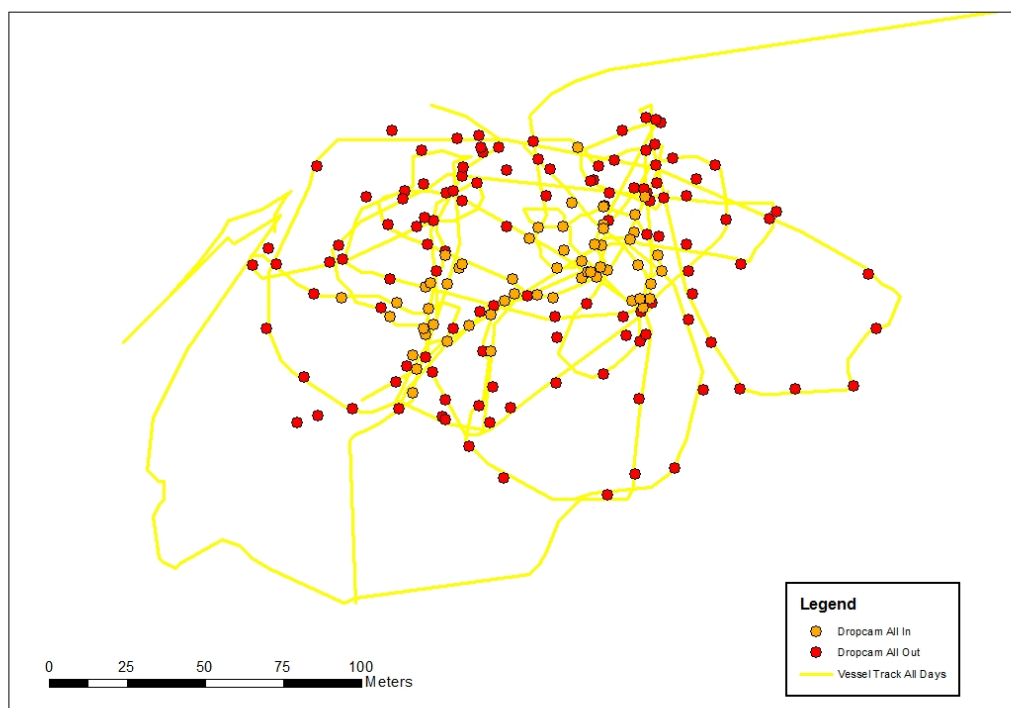
Assessing patch shape in the field

An examination of Figures 29 and 30 suggests that the accuracy and repeatability of the live on-board methodology was not satisfactory, given that the patch shapes were different and not completely overlapping. The patch size determined by the on-board method was estimated to be 1880 m^2 on February 13th; on February 15th the patch was estimated to be 2925 m^2 (more than 50% larger). The on-board video analysis methodology seemed to capture the core central portion of the patch on each date, but deviated to the north and east on the 13th, and to the north and south on the 15th. The western portion of the patch was not well defined using the onboard video analysis methodology on either date (Figure 32).

Figure 29 February 13th boat track (blue line and arrows), edge of patch (waypoints blue triangles) and *Atrina* patch (tan polygon). Red dots = density of *Atrina* < 1 m^2; from the three days of surveying at Big Bay.
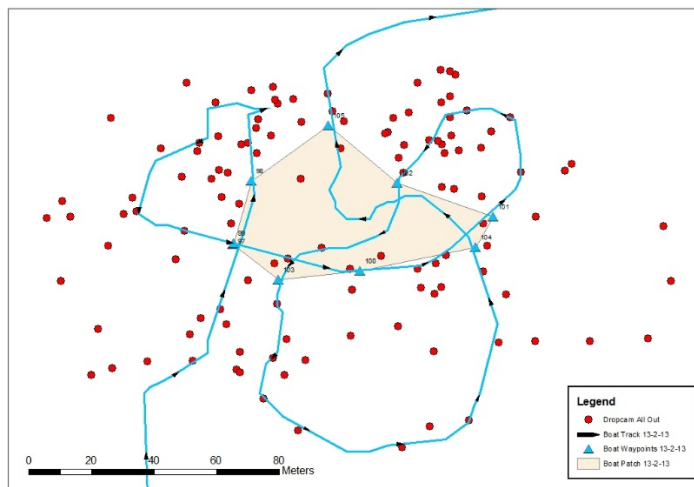
Figure 30 **February 15th boat track (green line and arrows), edge of patch (waypoints green triangles) and *Atrina* patch (pink polygon). Red dots = density of *Atrina* < 1 m^2; from the three days of surveying at Big Bay.**
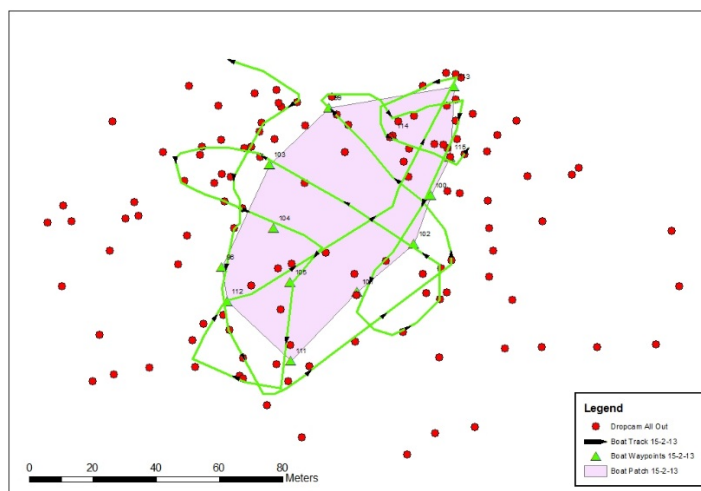
The discrepancies between the patch areas that were defined onboard were due to three factors:

- The delay in deciding whether we were in or out of a patch using the time-based rule and the logging of GPS waypoints. Depending on boat speed, this can result in errors of up to 20 m or more in the vicinity of an edge. This error can be compounded if the density threshold was reached early or late in the 40 second viewing interval; the importance of this error varied depending on whether we were going into or out of a patch.

- The minimum scale that could be shown on the boat GPS system was 0.125 NM (231 m). With the overall patch being less than 100 m across this caused the waypoints to appear clustered closely

_____

together on screen. However later analysis showed that we actually needed to be able to zoom in closer in order to get more accurate coverage of the patch. The smaller number of boat waypoints caused us to oversimplify the shapes of the patches using the on-board analysis methodology, relative to the more convoluted shape seen in the overall patch (e.g., Figures 29 and 30).

- Currents and wind made it difficult to maintain a slow and constant boat speed (0.5 kts) and post processing revealed the boat speed averaged 0.7 ± 0.29 kts (mean ± 1 S.D.), varying between 0.13 and 1.51kts (Figure 31) . Moreover, in order to see the seafloor well, we had to fly the camera at a height of ~0.3 m above the bed (as opposed to the 0.5 m originally planned), decreasing our field of view to 74 cm ± 16 (mean ± 1 S.D). The amount of time required to cover 10 m increased (thereby decreasing the number of *Atrina* that needed to be counted in a 40 second period to reach the threshold density of >1 *Atrina*/m^2).

Waypoint information was not available for the first day due to problems with the computer system.

Figure 31 **"Box and whisker" plot showing the comparison between the distance travelled in a 40 second period and how it varied on each of the three days that we surveyed the patch at Big Bay. The boxes contain the middle 50% of the observations made per date (inter-quartile range, i.e., 25th to 75th percentile). Median values are indicated by the lines in each box. The "whiskers" represent the 10th to 90th percentile range. Individual outliers are shown as open circles.**
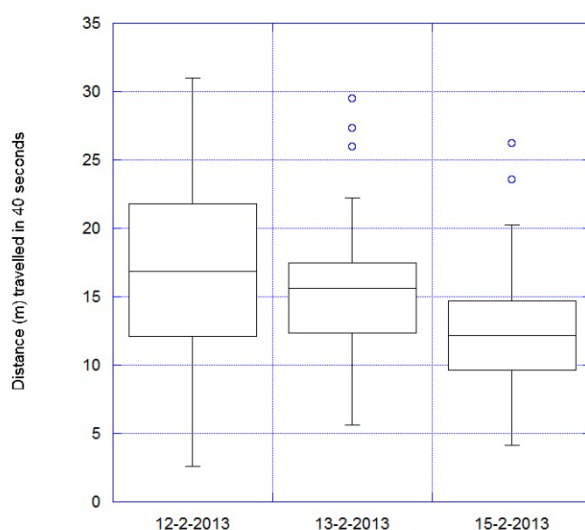
3.2.2 Laboratory video assessment of patch

In the laboratory, live counts were adjusted by speed and field of view to give densities per m^2. Patch edges could also be better defined where there were obviously abrupt changes. The densities observed on each day were overlain on the boat runlines to produce lines that were within the patch versus not in the patch (see Figure 32a). A patch outline that encompassed all these lines was then constructed (Figure 32b). In many cases there had not been an abrupt change signalling the transition from within to outside the patch. In this case an approximate edge of patch was drawn as 5 m outside the last high density count, or hallway between the in and out estimate whichever was the lesser (Figure 32c). Finally, the patch edge line was converted to a dashed line when no video transect crossed it within 15 m (Figure 32c).

_____

Figure 32 **Example: Process used to define patch boundaries from laboratory analysis. (a) Runlines in patch, (b) patch shape from those runlines, (c) estimated patch boundary. Data from the 13**[th]**.**
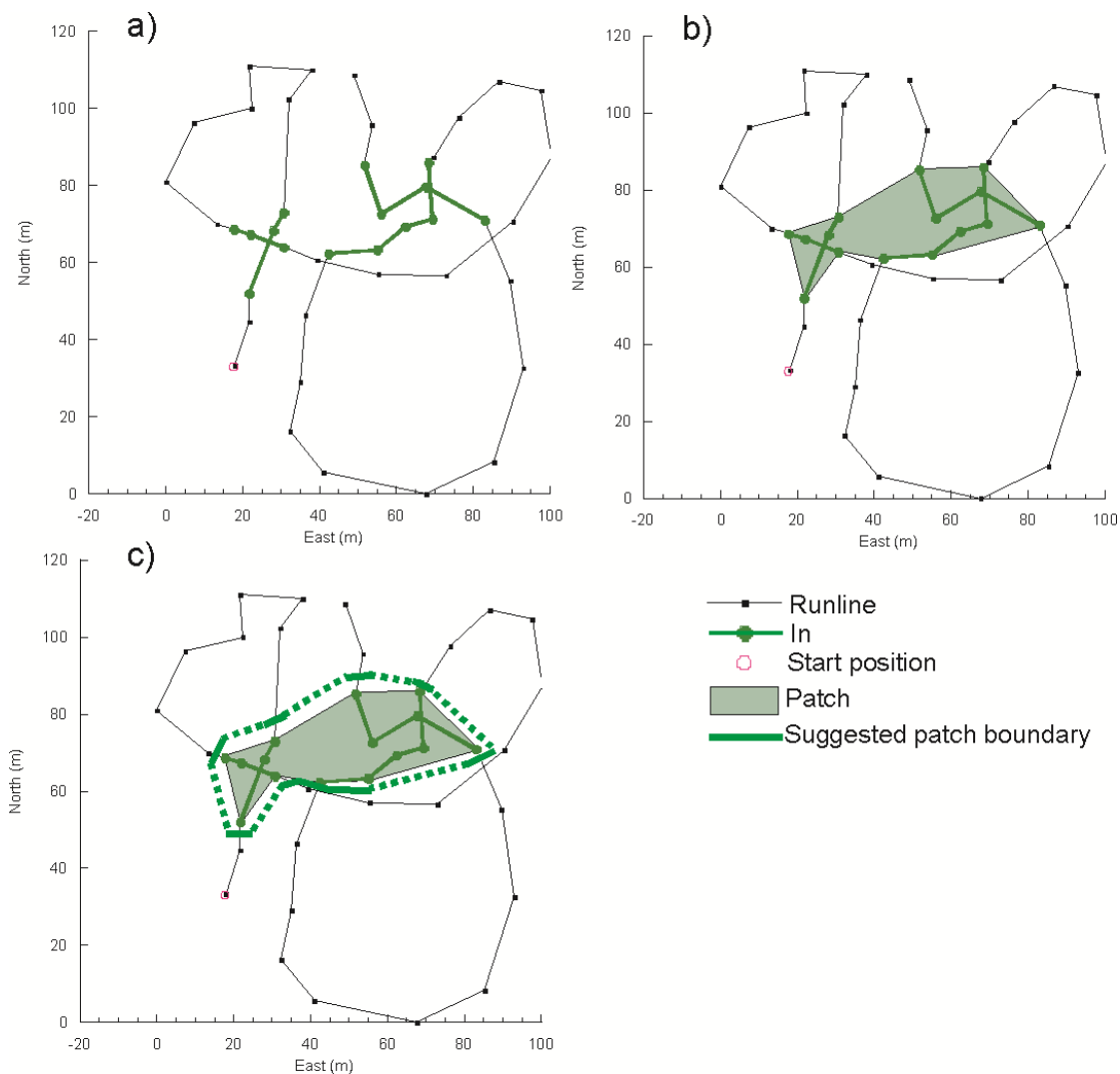

3.2.3 Comparison between field and laboratory video assessments

For the 13th and the 15th when both field way points and laboratory counts were available, we could compare the difference between the laboratory estimated patch edges and the field way points. The absolute difference between the patch edge and the waypoints both entering and exiting the patches was calculated. On February 13th, the average difference was 4.5 ± 3.5 m (± 1 S.D.) entering the patch and 17.33 ± 4.50 m exiting the patch. For February 15th, the average difference was 7.5 ± 1.80 m (± 1 S.D.) entering the patch and 14.0 ± 3.74 m exiting the patch. While the differences when entering the patch are within the expected error margins of the GPS unit and difference between the boat and camera position, those exiting the patch are not. This is likely due to using timed counts in the field. If the threshold number is reached near the start of a 40 second interval, quite a large distance will have been travelled by the end of the next 40 second interval when it is determined that we are outside the patch.

3.2.4 Comparison between days in laboratory video assessments

Overlaying the patch estimates from the video analysis for the three days show general concordance within the 10 m resolution expected, along all except south boundary (Figure 33).

Figure 33 **Estimated patch boundaries from the laboratory video analysis. Dashed lines are used when a transect line has not crossed within 15 m of the estimated edge. The west boundary was not estimated for the 13th and 15th as no video transect ran within 50 m. Grid cells squares are 5 x 5 m.**
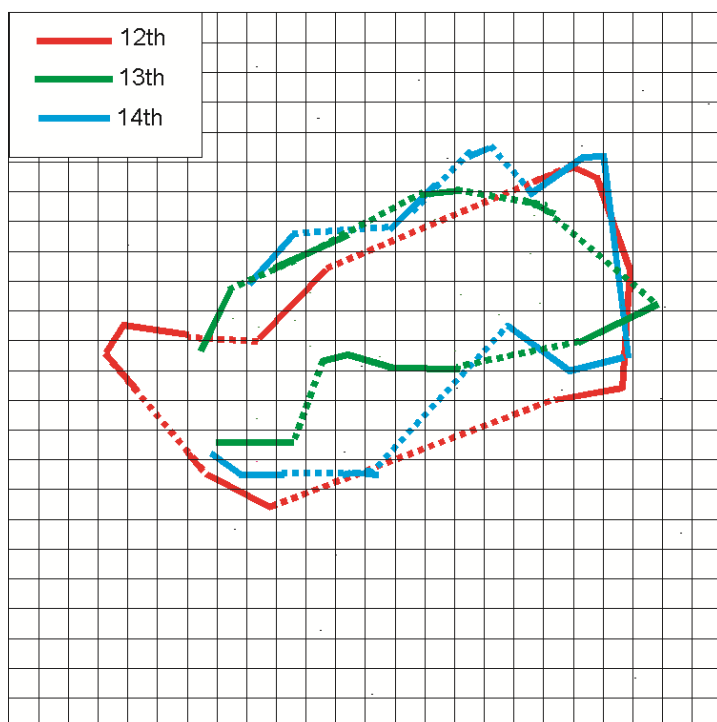
However along the southern edge we ran into issues due to the "patchiness" of the *Atrina* density. Here density is variable, making it difficult to define an edge in this area. Investigation of the counts showed that densities varied between 0.4 to 1.4 m^2 in this area, thus differences were observed between days dependent on whether an area of slightly higher densities (>1 m^2) was encountered. This blurring of patch edges into transition zones is discussed in Lohrer et al. (2013).

This may cause problems with future monitoring as this type of transition zone is more likely to occur in older established patches. However, laboratory counts of actual densities can be used to offset this problem.

3.2.5 Comparison between diver and towed video estimates of Atrina

Across the trackline for which both drop camera and diver video footage was available, the counts were almost the same (26 on the laboratory based analysis of dropcam video to 22 on the diver video). The diver video also confirmed the differentiation between live and dead *Atrina*. The divers also noted marks in the sediment from the drop weight hanging below the drop camera's frame, demonstrating that both the divers and the drop cam path overlapped. This provides confidence that the GPS positions that we record on the boat (and which appear on-screen in the video footage) correctly identify the location of camera ± 3 m.

4.0   Summary and recommendations

4.1   Summary of monitoring results

The populations of a selected range of invertebrate taxa have been monitored at intertidal sites in Mahurangi Estuary since 1994. Estuary-wide changes in the abundance of some macrofaunal taxa, 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 that occurred sometime between April 1996 and April 1997 and have persisted (Figure 2; Appendices 2). 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 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.mahurangi.org.nz/Action-Plan/PDF/Mahurangi-Action-Plan.pdf 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. The majority of the work carried out under the MAP since June 2011, has been in the Dyers Creek catchment, with 2.4 km of riparian fencing, 22,000 native plants planted and the protection of 4 hectares of riparian land through fencing. In response to the MAP, 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 7.5 years of data is required to identify these with any certainty.

The four of the five ecologically meaningful trends detected at Dyers Creek are consistent with those that may be associated with elevated levels of sedimentation and/or organic enrichment, i.e., the mud sensitive *Macomona* is decreasing, nemerteans and two mud insensitive polychaete taxa are increasing in abundance. However, *Austrovenus* abundances have increased at Dyers Creek, a trend that initially appears inconsistent with predictions associated with increased fine sediment. However, this bivalve is found in high numbers at a range of sediment types and increased condition of adult *Austrovenus* in response to low level increases in suspended sediment concentrations have also been noted (Hewitt and Norkko 2007). The number of ecologically meaningful trends consistent with elevated levels of sedimentation and/or organic enrichment has not changed at Te Kapa Inlet since the 2011 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 at all sites, have not changed markedly at the remaining sites over the past two years of monitoring. The monitored macrofaunal communities at Hamilton Landing and Te Kapa Inlet have continued to become more similar to each other (Figure 25). The macrofaunal community at Dyers Creek exhibits strong similarities with those of Mid Harbour. The Jamieson Bay monitored community is the most variable over time, and likely reflects the substrate variability noted from visual observations and sediment grainsize analysis.

A total of 26 intertidal populations have shown ecologically significant trends in abundance; fourteen increases and twelve decreases (Table 4). All sites have populations that have exhibited, or still are exhibiting, ecologically significant trends; most occur at Hamilton Landing (10 populations), and the least at Jamieson Bay and Mid Harbour (two and three populations, respectively) (Table 4).

Eight monitored populations are still exhibiting trends in abundance which 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 six different taxa at two sites (Hamilton Landing and Te Kapa Inlet) 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 and 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 six 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. With the addition of two years more of data, the previously detected step decline in *Macomona liliana* at Jamieson Bay is no longer apparent; higher baseline abundances have been noted since 2009/2010.

Of most concern is that five taxa considered sensitive to increased sediment loadings are exhibiting declines in abundance in Mahurangi Estuary (*Notoacmea scapha*, *Macomona liliana*, *Austrovenus stutchburyi*, *Nucula hartvigiana*, *Scoloplos cylindrifer*; Table 4). Four of these continue to decline in abundance at the muddiest site, Hamilton Landing. Also of concern at Hamilton Landing is the increase in mud-preferring oligochaetes. Decreasing trends for *Notoacmea scapha*, *Macomona* and *Nucula* at Te Kapa Inlet are correlated with the continued expansion of the muddy portion of this site noted over the monitored period.

The abundance of *Macomona liliana* which is considered sensitive to increased sediment loadings is decreasing at all five monitoring sites, primarily due to a reduction in the number of medium and large sized individuals. 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. *Austrovenus stutchburyi* which also has a preference for sandy sediment is only reducing in abundance at Hamilton Landing. At this site, small juvenille recruitment events have occurred over the last four years, however this has not translated into an increase in the numbers of spawning-sized individuals. On the other hand, *Austrovenus* numbers have increased at Dyers Creek over the last seven years, including spawning-sized individuals. This trend, unlike the other four trends at Dyers Creek, initially appears inconsistent with predictions associated with increased fine sediment. However, as mentioned above, this bivalve is found in high numbers at a range of sediment types. Furthermore, increased condition of adult *Austrovenus* in response to low level increases in suspended sediment concentrations have also been noted (Hewitt and Norkko 2007).

A harbour wide increasing trend in nemertean abundance was observed over the last 2-3 years, with statistically significant increases at Dyers Creek, Hamilton Landing and Te Kapa Inlet, and peaks in abundance noted in the last two years at Jamieson Bay and Mid Harbour. Nemerteans prefer sediment with some mud, but not in high percentages. A harbour wide increase was also noted in the polychaete *Aricidea* sp. since January 2011. *Aricidea* is increasing in abundance at all five monitoring sites. *Aricidea*, like nemerteans, prefer sediment with some mud, but not in high percentages.

Twenty two 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 and Thrush 2007).

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 and 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.

The TBI index (previously called 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 2011 and October 2012 data was lowest at the muddy Dyers Creek site. The 0.40 TBI score this site receives is indicative of moderate-to-good ecological functioning. The other sites all score above 0.4 indicating good functionality. The TBI value at Hamilton Landing has increased in the past two years (0.45 in Oct 2012; 0.38 in Oct 2010) which suggests the ecological functioning at this site is increasing, however it will be important to see whether this improvement continues.

Using the Benthic Health Model (BHM; Anderson et al. 2006; Hewitt and Ellis 2010), the health of the Mahurangi sites were assessed relative to sediment metal concentrations (copper, zinc and lead), and sediment muddiness. The BHM contaminant values were relatively low (i.e., healthy) and for all sites are within the previous temporal variation noted at the site (see Hewitt et al. 2012). A decreasing trend in health may be occurring at site Dyers Creek but given the short time frame of monitoring, relative to the multiyear cycles apparent at the other sites, more data would be needed to confirm this. The mud BHM indicates that Hamilton Landing is the muddiest site and Dyers Creek and Jamieson Bay the least muddy (Figure 26). 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.

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.

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 eight 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.

In the 2011 report we recommended that the 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. We also recommended that new methods for mapping and monitoring the 'health' of *Atrina zelandica* (horse mussel), a key subtidal species in Mahurangi Estuary. Both these recommendations have been taken up.

Also in the 2011 report, we reported on the November 2010 sediment contaminant concentrations from the intertidal sites. Levels of all metals and Polycyclic Aromatic Hydrocarbons (PAHs) were, with one exception, below threshold levels. Concentrations of arsenic at Te Kapa Inlet exceeded one guideline threshold and arsenic levels at all other intertidal sites except Dyers Creek were close to this threshold. We recommended that monitoring levels of this contaminant in particular continues on a regular basis in the future (at least once every two years in October).

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.

4.3 Summary of field trial of *Atrina* monitoring and recommendations

The objective of this work was to trial a cost-effective method for monitoring *Atrina* beds within Mahurangi Harbour, and to determine whether the same method could be used to both survey and monitor this and other subtidal benthic habitats. The value of broad-scale survey and the description of habitat change is readily apparent in terrestrial ecosystems; obtaining the same of high resolution aerial or satellite imagery of the seafloor is not so easy. The method trialled used remote video assessment.

Atrina is a large suspension-feeding bivalve species that is both functionally important (Norkko et al. 2002, 2006) and susceptible to sedimentation and suspended sediment loads. Past monitoring of *Atrina* density by diver-held video cameras at the three subtidal sites of the Mahurangi State of the Environment monitoring programme has suggested declines in *Atrina* populations inside Mahurangi Harbour. This monitoring was constrained to a transect at each of the three sites due to cost and thus does not inform us as to whether the whole *Atrina* bed at each site is also declining, or whether other beds in the harbour are suffering the same fate. This is important information, particularly as *Atrina* can occur in dense patches that affect hydrodynamics and ecological processes in a manner that is different to the effects of isolated individual *Atrina* shells (Nikora et al. 2002; Coco et al. 2006).

Our survey of a number of sites in Mahurangi Harbour which had previously held large beds of *Atrina* confirmed that the decline in densities noted along short transects at the three subtidal monitoring sites was occurring elsewhere in the harbour, with no beds found at any of the sites. A number of beds that had previously been observed in Kawau Bay had also disappeared. The extensive studies conducted in Mahurangi over the last 15 years have not revealed any substantive recruitment of *Atrina*. *Atrina* do not generally recruit into an existing *Atrina* bed or patch, thus new beds evolve from larvae produced in beds elsewhere, with their dispersal driven by hydrodynamics. Beds of juvenile *Atrina* are usually densely packed, but densities decline as they age and gaps develop within the patches. Thus, the observed declines in density of existing patches in Mahurangi could be a result of natural aging, accelerated in some places by increased suspended sediment concentrations. Decreasing numbers of existing *Atrina* beds (and densities within them) elsewhere in Mahurangi and Kawau Bay and, potentially in the Hauraki Gulf (potentially driven by a variety of factors) would decrease the likelihood of recruitment in Mahurangi. Wash ups of *Atrina* onto the shore after storms have been noted in the past (e.g., at Pakuri, Whangapoua and, most recently, Waiheke).

One new moderate-to-low density *Atrina* bed was found in Big Bay, just north of the mouth of Mahurangi Harbour, and the new video surveying method was trialed. Using only in-field processing did not give

sufficient precision or repeatability due to the field of view of the camera used, the on-board resolution of the GPS screen and varying boat speed. However, laboratory assessment of the video and GPS data gave a resolution of 10 m with repeated surveys on different days giving results within this resolution. Once a bed has been located and its outline initially surveyed, crossing transects that maximise information can be set up for future monitoring. The video gear used was easily deployable for 20-30 minutes at 10 sites in a day, with post-processing time being roughly twice that. Using the average speed travelled during the mapping, we estimate that to monitor a 500 m x 100 m patch would take approximately 1 hour. This would allow us to monitor 6 patches of this size during a day in the field, and more if the patches were smaller in size.

As a survey tool, this method generates high quality, georeferenced data on many basic habitat characteristics such as sediment type (sand, mud, shell, cobble, rock), sediment features (ripples, burrows), and presence of large plants and animals (various marine macroalgae, sea stars, sponges, solitary ascidians, *Atrina*, large holothurians, etc.). Precise identification and quantification is not always possible; fine details and small, cryptic animals will definitely be missed by this technology. However, the slow boat speed (~0.5 kts, maximally 1 kt) that is required to provide useable footage, combined with the narrow field of view, means that only a tiny proportion of area at a site is able to be observed with the camera in a 20-30 minute period. Thus, as a search tool, the drop camera methodology is not ideal. The use of acoustic swath mapping technology, such as side scan sonar, to locate and outline possible habitats would be preferable, with video used to then identify the habitat-forming organisms and monitor density and size.

Improvements could be made to the system that we used in the field. We trialed a high definition camera (GoPro) which gave us clearer images and was able to be mounted further off the bottom. It also has a 120° angle of vision; both this and the higher mounting increases the field of view making it easier to estimate *Atrina* densities and cover a larger area. Unfortunately only very high resolution cameras that can work effectively in low light would allow for use of a faster boat speed. The ability to observe specific habitat features will be related to their size, but other factors may also be important, e.g., differentiating between live and dead *Atrina*. NIWAs DTIS is generally towed at similar speeds to this (0.25 to 0.5 m/s).

Compared to other more costly methods of subtidal surveying such as divers, remotely operated vehicles (ROV's) or side scan sonar, this method has several advantages. Although divers can capture better video and also take samples (for example, macrofauna and grain size), they are limited by depth, bottom time, and the number of dives each diver can carry out in a day. ROV's are costly pieces of equipment that require a trained operator to use effectively. While maneuverable and having the ability to pause and pan around, they are limited by umbilical length and require larger vessels from which to deploy and operate. Side scan data has improved over recent years, however no information on living versus dead animals is able to be gathered, and a camera is still required to confirm the specific habitat type that has been identified by side scan. Another issue with side scan is the decrease in beam width in shallow water. Hewitt and Funnell (2005) discuss the use of side scan in shallow water and recommend that it only be used in waters greater than 6 m. NIWA's current side scan is optimized for use in depths of 5-20 m, and in 3 - 6 m would only have a beam width of 40 m. This effectively rules out most of the Mahurangi Harbour for this type of technology.

As we improve our camera technology (high definition and wide angle lenses) our ability to discern more details from the footage will improve, this will increase our ability to gather information (e.g., live/dead, identify other species, count clumps/higher density accurately) from the footage. Using different chart plotter software will improve how we cover the search area, giving us better definition of the spatial extent, especially for smaller patches (<100 m across). By combining with swath based technology (e.g., side scan sonar) we will reduce the time spent looking for patches, and have a better idea of what shape we are looking at to start with. The limitations of the swath based systems in shallow water can be worked around by using the drop camera system to search these areas, provided that they are not overly extensive.

5.0 Acknowledgements

We would like to thank the field staff from Auckland Council for conducting the field sampling over the past two years. We also acknowledge the help of Samantha Parkes and Julia Simpson with macrofaunal sorting, and Barry Greenfield, Sarah Hailes, Samantha Parkes, Katie Cartner and Geoff Read with macroinvertebrate identification.

For the *Atrina* survey we acknowledge Samantha Parkes and Fraser Aidney for their assistance in the field, and Fraser for his efforts with the video analysis. We also thank Prof. Roman Zajac for providing the GoPro camera for comparison and offering advice and assistance.

6.0 References

Anderson, M. J., Hewitt, J. E., Ford, R. B., Thrush, S. F. 2006. Regional models of benthic ecosystem health: predicting pollution gradients from biological data. Prepared by Auckland UniServices Ltd for Auckland Regional Council. *Auckland Regional Council Technical Publication, 317.*

Anderson, C.N.K., Hsieh, C., Sandin, S. A., Hewitt, R., Hollowed, A., Beddington, J., May, R. M., Sugihara, G. 2008. Why fishing magnifies fluctuations in fish abundance. *Nature,* 452: 835-839.

ANZECC 2000. Australian and New Zealand guidelines for fresh and marine water quality. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council. Agriculture and Resource Management Councils of Australia and New Zealand. Canberra, Australia.

Auckland Regional Council 2002. Environmental targets for the urban coastal marine area. *TP169*:26.

Auckland Regional Council 2004a. Review and Response: Mahurangi Estuary Ecological Monitoring Results 1994-2003. *Working Report*, 114: 24.

Auckland Regional Council 2004b. Blueprint for monitoring and assessing coastal marine receiving environments. *Auckland Regional Council TP168 revised edition – August 2004.*

Carpenter, S. R., Brock, W. A. 2006. Rising variance: a leading indicator of ecological transition. *Ecology Letters,* 9: 308-315.

Chiaroni, L., Hewitt, J. E., Hancock, N. 2007. Kawau Bay: benthic marine habitats, ecological values and threats. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report 2008/006.*

Coco, G., Thrush, S. F., Green, M. O., Hewitt, J. E. 2006. The role of feedbacks between bivalve (*Atrina zelandica*) density, flow and suspended sediment concentration on patch stable states. *Ecology*, 87: 2862-2870.

Cummings, V. J. 2007. Mahurangi Estuary ecological monitoring programme: report on data collected from July 1994 to January 2007. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 335*: 100.

Cummings, V. J., Funnell, G. A., Schultz, D. L., Thrush, S. F., Berkenbusch, K., Nicholls, P. E. 2001. Mahurangi Estuary ecological monitoring programme: report on data collected from July 1994 to January 2001. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 175.*

Cummings, V. J., Hewitt, J. E., Wilkinson, M. R., Thrush, S. F., Turner, S. J. 1995. Mahurangi Harbour biological monitoring programme – report on data collected during the first year of the monitoring. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report Number 2009/039.*

Cummings, V. J., Funnell, G. A., Thrush, S. F. 1999. Mahurangi Estuary ecological monitoring programme: report on data collected up to January 1999. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 111.*

Cummings, V. J., Halliday, N. J., Thrush, S. F., Hancock, N., Funnell, G. A. 2005. Mahurangi Estuary ecological monitoring programme- report on data collected from July 1994 to January 2005. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 277.*

Cummings, V. J., Nicholls, P., Thrush, S. F. 2003. Mahurangi Estuary ecological monitoring programme - report on data collected from July 1994 to January 2003. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 209.*

Cummings, V. J., Pridmore, R. D., Thrush, S. F., Hewitt, J. E. 1994. Mahurangi Estuary soft-sediment communities: predicting and assessing the effects of estuary and catchment development. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report Number 2009/040.*

Cummings, V. J., Turner, S. J., Funnell, G. A., Milburn, C. J., Thrush, S. F. 1997. Mahurangi Estuary ecological monitoring programme: report on data collected up to January 1997. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 86.*

Ellis, J., Cummings, V., Hewitt, J., Thrush, S., Norkko, A. 2002. Determining effects of suspended sediment on condition of a suspension feeding bivalve (*Atrina zelandica*): Results of a survey, a laboratory experiment and a field transplant experiment. *Journal of Experimental Marine Biology and Ecology*, 267(2): 147-174.

Gatehouse, J.S.I. 1971. Sedimentary analysis. In: Carver, R.E. (ed.). *Procedures in Sedimentology and Petrology.* Wiley Interscience, New York.

Gibbs, M., Hewitt, J. 2004. Effects of sedimentation on macrofaunal communities: a synthesis of research studies for ARC. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 264.*

Gibbs, M., Funnell, G., Pickmere, S., Norkko, A., Hewitt, J. 2005. Benthic nutrient fluxes along an estuarine gradient: influence of the pinnid bivalve, *Atrina zelandica,* in summer. *MEPS,* 288: 151-164.

Green, M. O., Hewitt, J. E., Thrush, S. F. 1998. Seabed drag coefficients over natural beds of horse mussels (*Atrina zelandica*). *Journal of Marine Research, 56: 613-637.*

Greenfield, B., Hewitt, J., Hailes, S. 2013 Manukau Harbour Ecological Monitoring Programme: Report of data collected up until February 2013. Prepared by NIWA for Auckland Council. In Press.

Halliday, J., Cummings, V. 2009. Mahurangi Estuary Ecological Monitoring Programme-report on data collected from July 1994 to January 2009. Report prepared by NIWA for Auckland Regional Council*. Auckland Regional Council Technical Publication Number 120.*

Halliday, J., Cummings, V. 2011. Mahurangi Estuary Ecological Monitoring Programme: Report on data collected from July 1994 to January 2011. Prepared by NIWA for Auckland Council. *Auckland Council Technical Report 2012/003.*

Halliday, J., Cummings, V. 2011 Mahurangi Estuary Ecological Monitoring Programme-report on data collected from July 1994 to January 20011. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 2012/003.*

Hewitt, J. E. 2000. Design of a state of the environment monitoring programme for the Auckland marine region. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 271.*

Hewitt, J. E., Thrush, S. F. 2007. Effective long-term monitoring using spatially and temporally nested sampling. *Environmental monitoring and assessment 133:* 295-307.

Hewitt, J. E. Thrush, S.F. 2009. Do species' abundances become more spatially variable with stress? *Open Ecology Journal.*

Hewitt, J. E., Norkko, J. 2007. Incorporating temporal variability of stressors into studies: An example using suspension-feeding bivalves and elevated suspended sediment concentrations. *Journal of Experimental Marine Biology,* 341(1): 131-141.

Hewitt, J. E., Anderson, M. J., Hickey, C., Kelly, S., Thrush, S. F. (2009). Enhancing the ecological significance of contamination guidelines through integration with community analysis. *Environmental Science and Technology* 43: 2118-2123.

Hewitt, J. E., Ellis, J. 2010. Assessment of the benthic health model. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report 2010/034.*

Hewitt, J. E., Lohrer, D., Townsend, M. 2012 Health of Estuarine Soft-sediment Habitats: continued testing and refinement of State of the Environment indicators. Prepared by NIWA for Auckland Regional Council. *Auckland Council Technical Report TR2012/012.*

Hewitt, J. E., Thrush, S. F., Gibbs, M., Lohrer, D., Norkko, A. 2006. Indirect effects of on water column nitrogen and oxygen fluxes: the role of benthic macrofauna and microphytes. *JEMBE*, 330: 261-273.

Hewitt, J. E., Thrush, S. F., Legendra, P., Cummings, V. J., Norkko, A. 2002. Integrating heterogeneity across spatial scales: interactions between *Atrina zelandic* and benthic macrofauna. *Marine Ecology Progress Series, 239: 115-128.*

Hewitt, J. E., Funnell, G. A. 2005. Benthic marine habitats and communities of the southern Kaipara. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication No. 275.*

Lohrer, D., Rodil, I. F. 2011. Suitability of a New Functional Traits Index as a State of the Environment Indicator. Prepared by NIWA for Auckland Council. *Auckland Council Technical Publication TR2011/004.*

Lohrer, A. M., Rodil, I. F., Townsend, M., Chiaroni, L. D., Hewitt, J. E., Thrush, S. F. 2013. Biogenic habitat transitions influence facilitation in a marine soft-sediment ecosystem. *Ecology,* 94: 136-145.

Lohrer, A. M., Chiaroni, L. D., Thrush, S. F., Hewitt, J. E. 2010. Isolated and interactive effects of two key species on ecosystem function and trophic linkages in New Zealand soft-sediment habitats. *New Zealand Aquatic Environment and Biodiversity Report*, No. 44: 69.

Norkko, A., Hewitt, J. E., Thrush, S. F., Funnell, G. A. 2006. Conditional outcomes of facilitation by a habitat-modifying subtidal bivalve. *Ecology*, 87: 226-234.

Norkko, A., Hewitt, J. E., Thrush, S. F., Funnell, G. A. 2002. Benthic pelagic coupling and suspension-feeding bivalves: linking site-specific sediment flux and biodeposition to benthic community structure. *Limnology and Oceanography,* 46(8): 2067-2072.

Norkko, A., Talman, S., Ellis, J., Nicholls, P., Thrush, S. 2001. Macrofaunal sensitivity to fine sediments in the Whitford embayment. Report prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Publication Number 158.*

Nikora, V., Green, M. O., thrush, S. F., Hume, T. M., Goring, D. 2002. Structure of the internal boundary layer over a patch of horse mussels (*Atrina zelandica*) in an estuary. *J. Mar. Res.,* 60: 121-150.

Pridmore, R. D., Thrush, S. F., Hewitt, J. E., Roper, D.,S. 1990. Macrobenthic community composition of six intertidal sandflats in Manukau Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 24: 81-96.

Rodil, I. F., Lohrer, A. M., Hewitt, J. E., Townsend, M., Thrush, S. F., Carbines, M. In press. Tracking environmental stress gradients using three biotic integrity indices: advantages of a locally-developed traits-based approach. Submitted 7-Feb-2013 to Ecological Indicators (accepted June 2013).

Sartory, D. P. 1982. Spectrophotometric analysis of chlorophyll *a* in freshwater plankton. Department of Environmental Affairs Hydrological Research Institute, Pretoria, South Africa. *Technical Report TR 115.*

SAS/ETS Users Guide, Version 8, Volumes 1 and 2. SAS Institute Inc.

ter Braak, C.J.F. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology,* 67: 1167-1179.

Thrush, S. F., Pridmore, R. D., Hewitt, J. E., Roper, D. S. 1988. Design of an ecological monitoring programme for the Manukau Harbour. Report prepared by the Water Quality Centre for Auckland Regional Water Board, Auckland Regional Authority. *Technical Publication Number 79*: 62.

Thrush, S. F., Pridmore, R. D., Hewitt, J. E. 1994. Impacts on soft-sediment macrofauna: The effects of spatial variation on temporal trends. *Ecological Applications,* 4: 31-41.

van Houte-Howes, K., Lohrer, D. 2010. State of Environment Indicators for intertidal habitats in the Auckland Region. Prepared by NIWA for Auckland Regional Council. *Auckland Regional Council Technical Report 2010/035.*

7.0 Appendices

7.1 Appendix 1: The taxa monitored at the intertidal sites

The taxa monitored at the intertidal sites. Sediment preferences are derived from Tables 5 and 6 in Gibbs and 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 petersenae	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]

[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*

7.2 Appendix 2: Results of grain size analysis for the intertidal sites

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

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
Gravel/	1995	Apr	0.04	0.37	0.64	3.50	0.24	
Shell hash	1996	Apr	0.00	0.00	0.00	0.00	0.00	
	1997	Apr	0.00	21.42	6.56	10.14	0.00	
	1998	Apr	1.16	16.08	1.78	1.94	0.01	
	1999	Apr	0.00	5.04	1.50	0.83	0.12	
	2000	Apr	0.18	8.61	0.67	0.43	0.00	
		Jul	0.00	18.96	0.00	3.72	0.00	
		Oct	0.00	7.98	0.10	1.79	0.00	
	2001	Jan	0.04	0.65	0.19	1.60	0.00	
		Apr	0.00	8.5	0.33	0.00	0.04	
		Jul	0.00	0.13	0.46	0.06	0.00	
		Oct	0.00	3.27	0.43	0.68	0.00	
	2002	Jan	0.00	1.79	0.02	1.58	0.00	
		Apr	0.00	0.17	2.38	0.32	0.25	
		Jul	7.34	0.26	0.35	0.00	0.00	
		Oct	0.06	0.02	4.02	31.18	0.16	
	2003	Jan	0.01	0.51	0.07	0.76	0.40	
		Apr	0.00	0.19	1.80	0.46	0.29	
		Jul	0.00	2.88	0.19	0.09	0.07	
		Oct	0.00	19.72	0.16	0.50	0.03	
	2004	Jan	0.00	17.17	0.43	3.93	0.00	
		Apr	0.00	12.01	4.99	0.35	0.00	
		Jul	0.00	5.34	0.51	0.34	1.95	
		Oct	0.02	8.03	0.56	0.65	0.00	
	2005	Jan	0.00	2.83	0.97	2.70	0.00	
		Apr	0.00	3.04	0.79	0.00	0.00	
		Jul	0.00	5.70	0.97	1.04	0.00	
		Oct	0.00	7.14	0.11	21.57	0.00	1.83
	2006	Jan	0.00	9.30	0.50	0.55	0.00	0.28
		Apr	0.00	17.44	0.09	0.00	5.12	0.25
		Jul	0.39	2.64	0.10	5.38	0.00	0.78
		Oct	0.00	22.54	0.00	0.62	0.00	1.51
	2007	Jan	0.00	8.72	0.68	4.36	0.62	1.46
		Apr	0.00	4.20	0.10	1.20	0.07	0.67
		Jul	0.00	18.05	0.48	0.85	0.00	0.41
		Oct	0.00	10.93	0.48	1.00	0.00	2.22
	2008	Jan	0.09	6.34	0.65	0.79	0.12	1.03
		Apr	0.00	0.79	0.00	1.30	0.19	2.56
		Jul	0.00	15.09	0.05	1.33	0.00	0.46
		Oct	0.00	18.04	0.27	14.38	0.02	0.19
	2009	Jan	0.00	3.32	0.62	0.49	0.01	0.99
		Apr	0.03	10.69	0.49	3.76	0.08	0.90
		Jul	0.00	0.70	0.04	0.37	0.00	1.65

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
		Oct	0.14	3.01	0.00	11.28	0.00	0.63
	2010	Jan	0.00	0.00	1.32	2.54	0.05	1.02
		Apr	0.00	0.55	0.00	1.67	0.00	0.84
		Jul	0.00	0.01	0.06	0.07	0.37	1.70
		Oct	0.08	1.24	0.09	0.33	0.12	1.32
	2011	Jan	0.00	0.92	0.00	0.10	0.03	0.00
		Apr	0.00	1.11	0.05	0.03	0.23	0.35
		Jul	0.00	11.46	0.00	0.09	0.27	0.14
		Oct	0.00	3.01	0.00	0.00	4.58	0.11
	2012	Jan	0.00	0.93	0.00	0.09	1.05	1.25
		Apr	0.00	0.07	0.01	0.00	12.00	0.67
		Jul	0.00	8.33	0.00	0.01	1.19	0.74
		Oct	0.00	0.75	0.00	0.00	1.54	0.45
	2013	Jan	0.00	3.53	0.15	0.13	0.99	0.57
Coarse sand	1995	Apr	0.17	0.27	0.20	3.58	0.22	
	1996	Apr	1.47	21.11	6.17	5.99	1.73	
	1997	Apr	0.34	6.02	1.43	0.18	0.03	
	1998	Apr	0.93	11.36	0.34	0.62	0.15	
	1999	Apr	0.21	2.06	0.17	0.08	0.07	
	2000	Apr	0.32	14.01	0.33	0.24	0.14	
		Jul	0.23	9.33	0.13	0.29	0.10	
		Oct	0.08	4.37	0.62	0.23	0.16	
	2001	Jan	0.17	0.65	0.34	0.07	0.09	
		Apr	0.06	18.88	0.05	0.35	0.21	
		Jul	0.15	0.30	0.54	0.09	0.34	
		Oct	0.00	2.80	0.05	0.07	0.00	
	2002	Jan	0.00	7.48	0.00	0.14	0.00	
		Apr	0.10	1.32	0.18	0.09	0.07	
		Jul	3.06	0.14	0.96	0.09	0.04	
		Oct	0.06	0.11	7.86	0.13	0.16	
	2003	Jan	0.12	0.49	0.12	0.49	0.17	
		Apr	0.09	1.50	0.13	0.17	0.08	
		Jul	0.26	2.27	0.20	0.31	0.07	
		Oct	0.12	10.22	0.05	0.09	0.09	
	2004	Jan	0.00	12.67	0.26	1.09	0.15	
		Apr	0.12	7.69	0.54	0.19	0.08	
		Jul	0.02	10.69	0.24	0.41	0.05	
		Oct	0.22	7.54	0.19	0.37	0.14	
	2005	Jan	0.07	7.74	0.00	0.37	0.14	
		Apr	0.00	11.18	0.31	0.53	0.48	
		Jul	0.10	5.78	0.07	0.06	0.04	
		Oct	0.21	16.07	0.33	0.16	0.08	0.24
	2006	Jan	0.08	11.48	0.25	0.19	0.08	0.28
		Apr	0.11	10.14	0.32	0.11	0.30	0.25
		Jul	0.07	4.78	0.12	0.31	0.06	0.14
		Oct	0.12	5.83	0.19	0.04	0.00	0.12
	2007	Jan	0.04	12.73	0.21	0.10	0.01	0.15
		Apr	0.16	0.04	6.69	0.14	2.41	0.18
		Jul	0.00	12.22	0.10	0.45	0.06	0.36
		Oct	0.00	7.95	0.28	0.25	0.08	0.30

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
	2008	Jan	0.12	7.27	0.42	0.24	0.15	0.32
		Apr	0.14	3.08	0.09	0.59	0.35	0.25
		Jul	0.11	6.31	0.18	0.27	0.13	0.25
		Oct	0.06	5.59	0.06	0.28	0.02	0.14
	2009	Jan	0.17	3.03	0.20	0.75	0.08	0.24
		Apr	0.10	6.97	0.10	0.17	0.15	0.16
		Jul	0.11	5.44	0.14	0.40	0.09	0.31
		Oct	0.27	5.82	0.05	0.20	0.12	0.38
	2010	Jan	0.00	0.59	0.03	0.65	0.30	0.25
		Apr	0.08	1.18	0.12	0.37	0.12	0.16
		Jul	0.28	0.40	0.24	0.20	0.44	0.29
		Oct	0.17	0.72	0.25	0.59	0.25	0.19
	2011	Jan	0.18	0.74	0.07	0.26	0.13	0.10
		Apr	0.12	0.30	0.13	0.13	0.22	0.12
		Jul	0.13	8.07	0.00	0.15	0.55	0.37
		Oct	0.02	10.30	0.09	0.04	0.53	0.20
	2012	Jan	0.03	0.82	0.16	0.13	0.22	0.12
		Apr	0.11	0.98	0.15	0.11	0.32	0.14
		Jul	0.01	11.87	0.10	0.12	0.49	0.27
		Oct	0.05	0.26	0.10	0.04	0.35	0.20
	2013	Jan	0.03	5.38	0.16	0.09	0.35	0.17
Medium sand	1995	Apr	30.74	64.93	43.64	38.15	39.60	
	1996	Apr	15.71	32.19	39.50	26.03	13.42	
	1997	Apr	1.08	15.78	5.63	2.19	3.56	
	1998	Apr	5.18	22.67	6.29	2.48	0.50	
	1999	Apr	3.43	11.08	2.26	1.82	2.43	
	2000	Apr	4.81	46.93	4.19	1.10	1.72	
		Jul	1.08	11.94	4.80	2.24	0.33	
		Oct	0.74	33.67	8.10	2.83	1.66	
	2001	Jan	4.52	6.08	5.64	2.05	1.73	
		Apr	0.70	39.23	2.08	0.48	1.50	
		Jul	0.81	5.01	7.4	1.83	1.38	
		Oct	0.13	10.89	5.04	2.17	0.88	
	2002	Jan	0.61	19.77	15.08	1.65	1.28	
		Apr	2.70	7.28	2.75	1.42	1.10	
		July	1.85	3.16	0.90	0.20	0.61	
		Oct	0.34	3.11	19.76	1.53	1.69	
	2003	Jan	0.26	3.44	2.75	1.66	1.34	
		Apr	2.41	8.30	2.08	0.94	1.29	
		Jul	0.53	26.98	2.25	2.93	1.45	
		Oct	0.25	18.79	3.91	1.17	0.77	
	2004	Jan	0.23	20.72	4.51	1.67	1.78	
		Apr	0.35	16.03	2.72	1.32	1.57	
		Jul	0.30	24.34	7.73	1.67	1.10	
		Oct	0.37	15.02	3.27	1.66	1.41	
	2005	Jan	0.23	18.71	3.43	1.63	1.73	
		Apr	0.86	33.90	4.03	1.60	1.29	
		Jul	0.38	15.21	3.43	1.51	1.52	
		Oct	0.47	30.88	3.65	1.72	1.61	1.65
	2006	Jan	0.32	22.64	3.69	0.60	0.90	2.08

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
		Apr	0.27	19.59	3.38	1.32	1.06	2.07
		Jul	0.24	13.44	3.12	1.53	1.49	2.16
		Oct	0.24	13.25	3.67	1.26	1.41	1.97
	2007	Jan	0.34	21.34	3.82	1.22	1.24	1.25
		Apr	0.29	27.39	3.02	1.58	1.23	1.80
		Jul	0.28	21.59	6.33	3.02	1.34	2.92
		Oct	1.27	14.94	3.42	2.44	1.62	1.91
	2008	Jan	0.55	13.55	4.78	2.03	1.74	2.42
		Apr	0.38	10.52	3.26	2.83	2.37	2.31
		Jul	0.41	15.11	2.77	1.41	1.33	2.34
		Oct	0.19	16.73	3.24	2.04	0.60	2.07
	2009	Jan	0.48	12.56	2.86	3.03	1.16	2.44
		Apr	0.39	19.45	4.09	1.67	1.35	1.88
		Jul	0.25	15.39	2.87	1.21	1.69	2.47
		Oct	4.33	23.85	0.38	1.78	2.52	3.61
	2010	Jan	0.33	4.05	3.52	1.94	3.27	2.76
		Apr	0.20	7.69	2.56	1.66	2.67	2.33
		Jul	0.30	2.94	3.10	1.64	1.52	1.81
		Oct	0.34	5.10	4.47	1.53	2.91	1.65
	2011	Jan	0.15	3.91	3.36	1.46	1.75	2.82
		Apr	0.33	2.60	2.28	1.36	1.90	1.52
		Jul	1.29	16.77	3.51	2.71	3.39	2.82
		Oct	0.09	31.41	2.97	1.41	2.42	1.88
	2012	Jan	0.13	3.09	2.45	1.30	1.81	2.67
		Apr	0.39	4.67	3.03	1.86	1.65	1.85
		Jul	0.13	12.04	3.00	1.34	2.23	2.19
		Oct	0.16	3.84	2.95	0.77	1.28	1.88
	2013	Jan	0.16	19.03	3.50	1.27	1.87	2.11
Fine sand	1995	Apr	26.50	24.65	33.05	24.41	29.34	
	1996	Apr	19.08	19.11	26.16	16.90	19.79	
	1997	Apr	33.23	52.17	72.05	73.46	67.23	
	1998	Apr	52.91	47.18	80.72	75.12	58.41	
	1999	Apr	52.55	74.14	81.09	68.21	70.32	
	2000	Apr	60.20	29.26	79.84	79.29	63.18	
		Jul	42.73	56.13	74.69	87.48	54.48	
		Oct	51.56	50.38	86.93	75.16	60.85	
	2001	Jan	62.16	84.19	85.25	85.81	62.42	
		Apr	56.02	31.69	62.62	53.70	62.77	
		July	50.02	87.15	60.77	79.95	60.87	
		Oct	44.40	71.37	83.77	82.89	61.61	
	2002	Jan	57.74	63.83	74.17	79.31	65.13	
		Apr	55.98	80.65	78.88	83.52	64.96	
		Jul	58.54	73.40	76.53	45.41	63.87	
		Oct	49.23	83.39	61.47	56.65	65.82	
	2003	Jan	55.57	84.20	86.93	79.10	76.72	
		Apr	49.97	92.01	59.49	77.47	76.09	
		Jul	47.82	58.73	74.61	82.82	64.66	
		Oct	48.10	45.71	87.08	77.57	57.06	
	2004	Jan	43.87	42.37	86.83	82.64	63.57	
		Apr	45.03	56.77	80.87	83.56	59.64	

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
		Jul	50.00	54.36	84.43	89.73	58.56	
		Oct	54.08	62.39	86.23	88.12	63.54	
	2005	Jan	57.91	62.94	88.30	86.59	60.75	
		Apr	55.64	46.57	82.99	85.16	60.63	
		Jul	48.36	64.64	82.74	87.18	62.11	
		Oct	57.06	42.74	87.60	67.63	62.70	88.03
	2006	Jan	51.57	50.78	86.95	79.99	58.34	89.15
		Apr	57.74	46.08	78.40	69.60	77.61	90.25
		Jul	51.92	69.24	81.99	76.93	62.65	89.10
		Oct	51.85	47.61	81.14	84.42	64.19	89.37
	2007	Jan	59.35	51.26	83.41	82.07	63.86	79.48
		Apr	53.82	54.71	80.46	87.11	60.80	90.65
		Jul	49.34	41.09	76.39	84.50	61.78	91.60
		Oct	49.86	58.84	82.30	88.53	71.85	91.71
	2008	Jan	55.20	64.84	82.33	88.25	70.71	91.83
		Apr	52.75	74.92	75.91	85.39	70.45	87.25
		Jul	48.40	56.12	73.99	82.61	61.39	90.71
		Oct	47.58	50.84	85.00	73.90	41.98	92.24
	2009	Jan	50.32	73.07	81.88	86.26	67.21	90.14
		Apr	51.95	59.24	78.05	77.56	72.12	89.25
		Jul	54.27	72.55	77.25	83.73	65.74	89.01
		Oct	83.46	60.16	62.89	70.02	65.00	85.31
	2010	Jan	55.13	87.57	85.18	71.63	60.70	84.89
		Apr	43.46	76.20	77.06	79.91	69.19	85.91
		Jul	55.41	77.32	73.13	81.40	74.45	83.45
		Oct	67.02	83.22	85.61	76.24	62.34	87.74
	2011	Jan	57.22	78.19	81.59	81.66	65.40	89.47
		Apr	53.93	80.86	82.26	66.22	81.24	83.26
		Jul	57.37	52.68	81.49	67.79	78.40	84.54
		Oct	51.18	46.84	79.30	62.62	82.51	87.39
	2012	Jan	46.32	75.77	76.99	66.58	82.10	86.36
		Apr	55.12	83.98	81.09	71.35	74.67	85.75
		Jul	49.18	53.57	79.14	64.51	83.80	85.24
		Oct	52.13	79.33	82.46	69.19	84.38	88.59
	2013	Jan	50.55	59.08	82.79	68.25	81.70	85.20
Silt	1995	Apr	34.03	6.44	18.37	27.38	23.63	
	1996	Apr	46.32	19.30	19.69	33.01	48.03	
	1997	Apr	39.04	4.09	7.78	7.27	21.66	
	1998	Apr	29.06	2.38	6.71	12.75	29.93	
	1999	Apr	27.77	7.56	8.73	17.98	19.41	
	2000	Apr	20.37	0.30	9.94	12.50	27.58	
		Jul	54.62	3.79	17.36	4.27	34.20	
		Oct	41.08	3.06	3.88	16.76	19.14	
	2001	Jan	28.10	8.00	7.10	7.93	29.95	
		Apr	40.19	0.04	31.70	36.64	29.83	
		Jul	47.46	7.36	30.22	17.02	35.93	
		Oct	48.63	11.09	3.31	11.83	32.13	
	2002	Jan	35.24	6.75	8.09	14.72	29.48	
		Apr	37.26	7.05	10.28	12.78	29.32	
		Jul	17.34	20.52	14.17	30.34	26.90	

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
		Oct	38.81	9.88	4.14	7.88	25.73	
	2003	Jan	35.03	8.66	6.75	7.20	12.82	
		Apr	27.12	20.00	19.50	26.00	26.15	
		Jul	45.58	7.53	15.59	9.23	32.11	
		Oct	47.52	2.78	5.28	11.00	32.54	
	2004	Jan	54.95	6.70	4.16	4.57	26.93	
		Apr	33.74	3.70	3.11	9.72	31.33	
		Jul	44.03	3.36	3.86	4.58	36.34	
		Oct	33.05	4.82	5.85	4.60	28.56	
	2005	Jan	31.90	3.59	3.13	6.66	23.01	
		Apr	29.00	4.25	6.99	6.35	29.43	
		Jul	33.36	4.34	7.10	6.50	26.86	
		Oct	22.14	1.06	0.00	6.69	22.66	5.25
	2006	Jan	38.42	3.12	5.33	9.72	31.56	5.18
		Apr	33.00	4.70	13.50	21.65	10.97	3.62
		Jul	33.06	6.85	9.77	9.90	27.60	5.85
		Oct	32.49	3.32	9.29	8.19	24.36	5.37
	2007	Jan	31.68	3.78	6.16	8.01	27.30	12.79
		Apr	25.01	3.71	7.56	6.35	24.71	2.55
		Jul	35.03	4.02	13.50	8.49	29.11	2.36
		Oct	40.92	3.67	7.37	3.89	19.40	2.08
	2008	Jan	36.59	5.46	6.82	5.56	21.10	0.34
		Apr	36.91	9.16	18.60	8.14	17.24	4.48
		Jul	36.01	1.47	13.07	9.40	29.03	2.84
		Oct	45.36	5.86	6.43	5.65	36.78	2.68
	2009	Jan	41.05	5.10	10.67	6.15	24.82	2.89
		Apr	29.71	1.82	16.41	9.24	18.89	4.30
		Jul	31.84	4.51	14.29	6.63	25.80	3.28
		Oct	8.21	4.38	26.32	8.95	28.87	7.55
	2010	Jan	31.26	4.28	3.87	11.25	29.75	6.16
		Apr	46.39	9.42	15.76	7.95	20.96	6.28
		Jul	33.65	14.00	15.65	15.78	14.63	8.06
		Oct	28.79	9.71	5.48	11.63	35.76	8.40
	2011	Jan	42.45	14.21	12.60	10.32	30.97	5.50
		Apr	30.99	11.64	9.07	28.33	8.99	9.11
		Jul	32.80	8.01	11.67	21.62	11.25	6.42
		Oct	36.22	6.45	12.70	30.54	7.03	5.21
	2012	Jan	48.73	15.23	17.27	27.74	8.30	5.40
		Apr	33.82	10.31	10.78	19.13	6.12	8.43
		Jul	30.88	10.20	10.15	19.80	4.99	5.61
		Oct	32.93	9.04	8.62	18.75	5.06	3.17
	2013	Jan	28.15	7.54	6.90	19.52	7.07	4.95
Clay	1995	Apr	4.96	3.34	4.10	2.98	6.98	
	1996	Apr	17.42	8.29	8.48	18.07	17.03	
	1997	Apr	26.33	0.51	6.54	6.76	7.52	
	1998	Apr	10.77	0.32	4.18	7.09	11.00	
	1999	Apr	16.05	0.14	6.25	11.09	7.65	
	2000	Apr	14.12	0.90	5.03	6.43	7.37	
		Jul	1.34	0.11	3.01	2.00	10.89	
		Oct	6.54	0.53	0.37	3.22	18.19	

% sediment composition	Year	Month	HL	JB	MH	TK (sand)	TK (mud)	DC
	2001	Jan	5.02	0.45	1.47	2.55	5.82	
		Apr	3.04	1.67	3.23	8.83	5.65	
		Jul	1.55	0.05	0.62	1.06	1.49	
		Oct	6.83	0.58	7.40	2.35	5.38	
	2002	Jan	6.41	0.37	2.64	2.61	4.11	
		Apr	3.95	3.53	5.53	1.88	4.31	
		Jul	11.87	2.52	7.09	23.95	8.59	
		Oct	11.50	3.49	2.76	2.63	6.43	
	2003	Jan	9.01	2.64	3.38	10.79	8.55	
		Apr	2.88	10.00	10.50	4.00	3.85	
		Jul	5.82	1.61	7.16	4.62	1.63	
		Oct	4.00	2.78	3.52	9.68	9.52	
	2004	Jan	0.95	0.37	3.81	6.09	7.57	
		Apr	20.77	3.74	7.77	4.86	7.37	
		Jul	5.64	1.92	3.22	3.27	1.98	
		Oct	12.24	2.19	3.90	4.60	6.35	
	2005	Jan	9.90	4.19	4.17	2.05	14.38	
		Apr	14.50	1.06	4.89	6.35	8.17	
		Jul	17.79	4.34	5.68	3.71	9.48	
		Oct	20.13	2.12	8.32	2.23	12.95	3.00
	2006	Jan	9.61	2.68	3.28	7.95	9.12	3.19
		Apr	8.88	2.06	4.32	7.42	4.94	3.01
		Jul	14.33	3.05	4.89	5.94	8.20	1.95
		Oct	15.29	7.46	5.71	5.46	10.03	1.65
	2007	Jan	8.58	2.16	5.72	4.24	6.97	4.87
		Apr	20.84	3.30	8.69	3.59	13.04	4.18
		Jul	15.37	3.02	3.20	2.68	7.72	2.36
		Oct	7.96	3.67	6.14	3.89	7.05	1.78
	2008	Jan	7.45	2.55	5.00	3.13	6.17	4.06
		Apr	9.84	1.53	2.15	1.75	9.40	3.15
		Jul	15.07	5.90	9.93	4.98	8.13	3.40
		Oct	6.80	2.93	5.00	3.76	20.60	2.68
	2009	Jan	7.98	2.91	3.76	3.31	6.71	3.30
		Apr	17.83	1.82	0.86	7.92	7.09	3.52
		Jul	13.53	1.41	5.42	7.18	7.17	3.28
		Oct	3.59	2.79	10.37	7.03	4.23	2.52
	2010	Jan	13.28	3.50	6.08	10.66	7.26	4.93
		Apr	9.87	4.96	4.50	7.42	8.06	4.48
		Jul	10.35	5.33	7.83	1.03	8.47	4.70
		Oct	3.60	0.00	4.11	8.30	0.00	0.70
	2011	Jan	0.00	2.03	2.36	5.90	2.02	2.12
		Apr	14.63	3.49	6.21	3.93	7.41	5.64
		Jul	8.41	3.00	3.33	7.63	6.14	5.71
		Oct	12.49	1.98	4.94	5.39	2.93	5.21
	2012	Jan	4.78	4.15	3.14	4.16	6.52	4.20
		Apr	10.57	0.00	4.94	7.55	5.24	3.16
		Jul	19.80	3.99	7.61	14.23	7.30	5.96
		Oct	14.73	6.78	5.87	11.25	7.39	5.71
	2013	Jan	21.11	5.44	6.50	10.74	8.02	7.01

7.3 Appendix 3: A. Organic content and B. Chlorophyll a content

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

	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Jul00	3.87	1.29	1.40	1.87	0.90	
Oct00	3.22	1.00	0.88	2.32	1.57	
Jan01	2.49	1.44	1.38	2.33	1.49	
Apr01	4.60	1.59	3.38	3.06	11.93*	
Jul01	6.35	1.45	2.72	2.90	1.59	
Oct01	4.16	1.32	1.83	2.58	1.20	
Jan02	3.92	2.06	2.17	1.84	2.53	
Apr02	3.47	1.70	1.84	1.40	2.22	
Jul02	1.58	1.71	4.94*	2.46	2.13	
Oct02	5.02	2.13	1.53	3.41	4.62	
Jan03	4.07	1.72	1.50	2.59	1.68	
Apr03	5.54	1.48	2.96	2.31	1.37	
Jul03	3.89	1.38	1.79	2.18	1.32	
Oct03	3.85	1.45	1.42	2.46	2.08	
Jan04	4.69	1.70	1.49	2.54	1.79	
Apr04	6.65*	3.59*	2.23	4.66*	2.53	
Jul04	4.87	2.34	1.57	2.69	1.85	
Oct04	5.04	2.31	2.40	3.99	2.29	
Jan05	2.55	1.41	1.63	4.10	1.70	
Apr05	4.13	1.44	1.59	2.63	1.73	
Jul05	4.27	2.15	2.02	1.91	1.54	
Oct05	4.60	1.31	1.88	2.53	1.70	0.76
Jan06	3.95	1.68	1.60	2.68	2.14	1.34
Apr06	3.72	1.89	2.48	1.63	2.06	0.88
Jul06	4.35	2.08	2.34	2.52	1.96	1.20
Oct06	4.35	2.78	2.19	2.75	1.97	1.25
Jan07	3.64	1.52	2.09	2.39	1.43	1.05
Apr07	4.35	2.26	2.00	2.74	1.48	1.24
Jul07	5.17	1.86	2.78	2.87	1.98	1.29
Oct07	4.87	2.00	2.32	2.36	1.66	1.27
Jan08	4.99	1.84	2.11	2.62	1.75	1.16
Apr08	5.02	1.94	2.57	2.36	1.79	1.25
Jul08	4.94	1.92	2.54	2.70	1.61	1.10
Oct08	3.98	2.47	1.52	2.05	2.21	1.03
Jan09	4.14	1.81	1.95	2.56	1.68	1.29
Apr-09	4.17	1.41	1.86	2.58	1.79	1.19
Jul-09	4.05	1.24	2.02	2.45	1.54	1.10
Oct-10	1.92	1.81	3.97	2.64	2.14	1.60
Jan-10	3.89	1.58	1.69	2.89	2.60	1.44
Apr-10	4.39	2.30	2.24	2.42	2.40	1.27
Jul-10	4.75	2.40	2.72	2.73	1.91	1.94

	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Oct-10	2.37	0.86	1.30	2.82	1.92	1.21
Jan-11	3.83	2.15	1.91	2.30	2.33	1.05
Apr-11	4.31	2.23	2.00	2.19	1.93	1.88*
Jul-11	3.75	1.74	2.00	2.62	1.81	1.71
Oct-11	4.56	1.61	1.90	2.34	1.92	1.45
Jan-12	3.83	1.44	1.28	2.02	1.58	0.93
Apr-11	3.34	1.61	1.91	2.03	1.25	1.36
Jul-12	4.49	2.15	1.68	2.46	1.66	1.36
Oct-12	4.07	1.76	1.49	1.92	1.13	0.75
Jan-13	2.83	1.24	1.17	1.49	1.19	0.91

B. Chlorophyll a

	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Jul00	12.14	4.59	10.03	14.74	6.35	
Oct00	11.32	3.97	7.33	8.40	15.39	
Jan01	10.04	3.44	6.54	5.94	9.62	
Apr01	12.63	1.76	10.38	13.11	ns	
Jul01	16.74	6.76	10.46	17.41*	9.99	
Oct01	8.32	3.65	6.55	12.63	5.22	
Jan02	8.21	2.75	4.53	9.15	5.23	
Apr02	13.13	6.15	9.76	14.32	6.30	
Jul02	6.41	4.58	10.99	14.16	6.14	
Oct02	7.27	3.14	8.59	9.91	6.48	
Jan03	10.07	5.04	9.02	11.38	7.32	
Apr03	5.93	3.66	7.05	9.11	7.60	
Jul03	6.19	3.50	3.09	9.65	6.76	
Oct03	7.70	5.50	8.98	9.06	5.50	
Jan04	10.78	3.09	8.49	6.07	17.43*	
Apr04	12.35	2.86	10.67	5.96	9.85	
Jul04	10.86	3.38	7.05	7.22	14.10	
Oct04	7.62	3.23	2.53	4.03	7.62	
Jan05	8.48	4.61	10.93	6.90	9.05	
Apr05	6.62	3.74	9.13	11.03	7.30	
Jul05	12.82	4.76	7.43	6.82	13.89	
Oct05	10.94	2.71	8.42	6.46	9.66	8.10
Jan06	9.87	3.09	7.33	6.06	9.23	7.36
Apr06	9.50	4.13	8.36	5.73	3.20	7.23
Jul06	6.44	3.38	8.71	8.48	4.76	5.22
Oct06	8.60	3.21	6.65	10.77	4.93	5.16
Jan07	10.78	3.10	7.80	11.46	5.39	6.99
Apr07	11.69	4.47	11.35	12.04	5.50	8.14
Jul07	11.47	2.58	9.51	11.92	6.53	7.56
Oct07	10.54	6.76	7.56	11.00	4.93	7.10
Jan08	12.03	3.78	7.22	9.40	7.11	7.68
Apr08	10.43	5.04	7.22	10.55	5.50	8.94
Jul08	10.20	4.24	7.79	12.72	7.11	9.06
Oct08	9.63	4.24	5.85	8.83	6.19	6.99
Jan09	9.97	4.58	9.86	10.55	6.19	9.17

	Hamilton Landing	Jamieson Bay	Mid Harbour	Te Kapa mud	Te Kapa sand	Dyers Creek
Apr-09	11.46	5.62	12.15*	12.38	8.02	9.40
Jul-09	14.22	4.59	8.60	13.07	6.65	9.86*
Oct-10	7.11	4.53	11.92	9.28	6.19	9.40
Jan-10	9.97	6.30	7.79	9.17	7.68	6.65
Apr-10	13.52	8.94*	9.40	14.67	6.65	7.22
Jul-10	11.12	4.93	7.11	10.78	5.50	7.57
Oct-10	11.12	4.47	8.25	12.95	6.19	6.76
Jan-11	8.71	5.85	7.79	11.35	7.68	7.34
Apr-11	16.05	6.42	10.43	12.15	7.34	6.31
Jul-11	18.11*	6.31	11.46	13.30	8.83	8.02
Oct-11	17.88	4.36	9.86	13.07	6.65	7.34
Jan-12	12.61	5.22	8.60	12.26	7.91	6.42
Apr-12	13.99	6.42	9.28	16.28	7.33	6.88
Jul-12	18.11	6.31	8.48	16.74	8.37	5.73
Oct-12	13.07	8.71*	8.94	15.36	10.09	7.34
Jan-13	13.30	5.50	8.37	10.09	9.17	8.25

7.4 Appendix 4: Summary of temporal results at the intertidal sites from April 2009

Summary of temporal results at the intertidal sites from April 2009 (Time = 68) to January 2011 (Time = 75). DC = Dyers Creek, HL = Hamilton Landing, JB = Jamieson Bay, MH = Mid Harbour, TK = Te Kapa Inlet.

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Aonides trifida	DC	68	0	0	0	0.00
Aonides trifida	DC	69	0	0	0	0.00
Aonides trifida	DC	70	2	0	1	0.17
Aonides trifida	DC	71	1	0	1	0.08
Aonides trifida	DC	72	1	0	1	0.08
Aonides trifida	DC	73	1.1	0	1	0.09
Aonides trifida	DC	74	0	0	0	0.00
Aonides trifida	DC	75	0	0	0	0.00
Aonides trifida	HL	68	0	0	0	0.00
Aonides trifida	HL	69	0	0	0	0.00
Aonides	HL	70	2	0	2	0.17

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

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

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
trifida						
Aonides trifida	HL	71	0	0	0	0.00
Aonides trifida	HL	72	6	0	4	0.50
Aonides trifida	HL	73	0	0	0	0.00
Aonides trifida	HL	74	0	0	0	0.00
Aonides trifida	HL	75	0	0	0	0.00
Aonides trifida	JB	68	14	0	13	1.17
Aonides trifida	JB	69	15	0	6	1.25
Aonides trifida	JB	70	11	0	11	0.92
Aonides trifida	JB	71	26	0	12	2.17
Aonides trifida	JB	72	2	0	1	0.17
Aonides trifida	JB	73	1	0	1	0.08
Aonides trifida	JB	74	0	0	0	0.00
Aonides trifida	JB	75	3	0	1	0.25
Aonides trifida	MH	68	0	0	0	0.00
Aonides trifida	MH	69	0	0	0	0.00
Aonides trifida	MH	70	0	0	0	0.00
Aonides trifida	MH	71	0	0	0	0.00
Aonides trifida	MH	72	1	0	1	0.08
Aonides trifida	MH	73	0	0	0	0.00
Aonides trifida	MH	74	0	0	0	0.00
Aonides trifida	TK	68	0	0	0	0.00
Aonides trifida	TK	69	0	0	0	0.00
Aonides trifida	TK	70	0	0	0	0.00
Aonides trifida	TK	71	0	0	0	0.00
Aonides trifida	TK	72	5	0	2	0.42
Aonides trifida	TK	73	0	0	0	0.00
Aonides trifida	TK	74	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Aonides trifida	TK	75	1	0	1	0.08
Aonides trifida	DC	68	0	0	0	0.00
Aonides trifida	DC	69	0	0	0	0.00
Aonides trifida	DC	70	2	0	1	0.17
Aonides trifida	DC	71	1	0	1	0.08
Aonides trifida	DC	72	1	0	1	0.08
Aonides trifida	DC	73	1.1	0	1	0.09
Aonides trifida	DC	74	0	0	0	0.00
Aonides trifida	DC	75	0	0	0	0.00
Aonides trifida	HL	68	0	0	0	0.00
Aonides trifida	HL	69	0	0	0	0.00
Aonides trifida	HL	70	2	0	2	0.17
Aonides trifida	HL	71	0	0	0	0.00
Aonides trifida	HL	72	6	0	4	0.50
Aonides trifida	HL	73	0	0	0	0.00
Aonides trifida	HL	74	0	0	0	0.00
Aonides trifida	HL	75	0	0	0	0.00
Aonides trifida	JB	68	14	0	13	1.17
Aonides trifida	JB	69	15	0	6	1.25
Aonides trifida	JB	70	11	0	11	0.92
Aonides trifida	JB	71	26	0	12	2.17
Aonides trifida	JB	72	2	0	1	0.17
Aonides trifida	JB	73	1	0	1	0.08
Aonides trifida	JB	74	0	0	0	0.00
Aonides trifida	JB	75	3	0	1	0.25
Aonides trifida	MH	68	0	0	0	0.00
Aonides trifida	MH	69	0	0	0	0.00
Aonides	MH	70	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
trifida						
Aonides trifida	MH	71	0	0	0	0.00
Aonides trifida	MH	72	1	0	1	0.08
Aonides trifida	MH	73	0	0	0	0.00
Aonides trifida	MH	74	0	0	0	0.00
Aonides trifida	TK	68	0	0	0	0.00
Aonides trifida	TK	69	0	0	0	0.00
Aonides trifida	TK	70	0	0	0	0.00
Aonides trifida	TK	71	0	0	0	0.00
Aonides trifida	TK	72	5	0	2	0.42
Aonides trifida	TK	73	0	0	0	0.00
Aonides trifida	TK	74	0	0	0	0.00
Aonides trifida	TK	75	1	0	1	0.08
Aricidea sp.	DC	68	33	2	12	2.75
Aricidea sp.	DC	69	52	4.5	8	4.33
Aricidea sp.	DC	70	41	3	7	3.42
Aricidea sp.	DC	71	42	2	11	3.50
Aricidea sp.	DC	72	48	3.5	7	4.00
Aricidea sp.	DC	73	53.5	4	8	4.45
Aricidea sp.	DC	74	65	6	12	5.42
Aricidea sp.	DC	75	76.8	6	10	6.40
Aricidea sp.	HL	68	99	7.5	12	8.25
Aricidea sp.	HL	69	133	11	13	11.08
Aricidea sp.	HL	70	123	9.5	8	10.25
Aricidea sp.	HL	71	135	11	14	11.25
Aricidea sp.	HL	72	134	12	16	11.17
Aricidea sp.	HL	73	252	24	27	21.00
Aricidea sp.	HL	74	270	18	39	22.50
Aricidea sp.	HL	75	342	24.5	44	28.50
Aricidea sp.	JB	68	18	1	5	1.50
Aricidea sp.	JB	69	36	2	9	3.00
Aricidea sp.	JB	70	49	2.5	15	4.08
Aricidea sp.	JB	71	25	1.5	7	2.08
Aricidea sp.	JB	72	27	2	6	2.25
Aricidea sp.	JB	73	59	5	10	4.92
Aricidea sp.	JB	74	40	1.5	18	3.33
Aricidea sp.	JB	75	58	4.5	12	4.83
Aricidea sp.	MH	68	26	1.5	6	2.17
Aricidea sp.	MH	69	42	3	9	3.50
Aricidea sp.	MH	70	47	3.5	11	3.92
Aricidea sp.	MH	71	36	3	7	3.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Aricidea sp.	MH	72	25	2	6	2.08
Aricidea sp.	MH	73	61	4	7	5.08
Aricidea sp.	MH	74	33	3	5	2.75
Aricidea sp.	MH	75	28	2	5	2.33
Aricidea sp.	TK	68	81	6	21	6.75
Aricidea sp.	TK	69	312	21.5	57	26.00
Aricidea sp.	TK	70	139	10	22	11.58
Aricidea sp.	TK	71	69	2.5	20	5.75
Aricidea sp.	TK	72	149	11.5	23	12.42
Aricidea sp.	TK	73	244	17	52	20.33
Aricidea sp.	TK	74	210	16.5	36	17.50
Aricidea sp.	TK	75	107	4	37	8.92
Aricidea sp.	DC	68	33	2	12	2.75
Aricidea sp.	DC	69	52	4.5	8	4.33
Arthritica bifurca	DC	68	6	0	2	0.50
Arthritica bifurca	DC	69	39	2.5	12	3.25
Arthritica bifurca	DC	70	93	4.5	28	7.75
Arthritica bifurca	DC	71	46	2.5	19	3.83
Arthritica bifurca	DC	72	83	3	22	6.92
Arthritica bifurca	DC	73	29.5	1	10	2.45
Arthritica bifurca	DC	74	57	2.5	14	4.75
Arthritica bifurca	DC	75	67.2	4.5	18	5.60
Arthritica bifurca	HL	68	0	0	0	0.00
Arthritica bifurca	HL	69	14	1	8	1.17
Arthritica bifurca	HL	70	16	0.5	10	1.33
Arthritica bifurca	HL	71	6	0	6	0.50
Arthritica bifurca	HL	72	3	0	1	0.25
Arthritica bifurca	HL	73	8.7	1	3	0.73
Arthritica bifurca	HL	74	27	1	18	2.25
Arthritica bifurca	HL	75	2	0	1	0.17
Arthritica bifurca	JB	68	15	0	15	1.25
Arthritica bifurca	JB	69	9	0	6	0.75
Arthritica bifurca	JB	70	24	1	7	2.00
Arthritica bifurca	JB	71	2	0	1	0.17

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Arthritica bifurca	JB	72	15	0	7	1.25
Arthritica bifurca	JB	73	7	0	2	0.58
Arthritica bifurca	JB	74	62	1.5	33	5.17
Arthritica bifurca	JB	75	35	1.5	13	2.92
Arthritica bifurca	MH	68	54	4	9	4.50
Arthritica bifurca	MH	69	80	6.5	17	6.67
Arthritica bifurca	MH	70	94	6.5	14	7.83
Arthritica bifurca	MH	71	267	22	32	22.25
Arthritica bifurca	MH	72	249	19.5	36	20.75
Arthritica bifurca	MH	73	169	14	27	14.08
Arthritica bifurca	MH	74	174	12	39	14.50
Arthritica bifurca	MH	75	158	10.5	39	13.17
Arthritica bifurca	TK	68	26	2	6	2.17
Arthritica bifurca	TK	69	33	2	8	2.75
Arthritica bifurca	TK	70	103	6.5	35	8.58
Arthritica bifurca	TK	71	58	2.5	16	4.83
Arthritica bifurca	TK	72	62	3.5	18	5.17
Arthritica bifurca	TK	73	66	5.5	11	5.50
Arthritica bifurca	TK	74	51	4	10	4.25
Arthritica bifurca	TK	75	30	2.5	6	2.50
Austrovenus stutchburyi	DC	68	179	14	18	14.92
Austrovenus stutchburyi	DC	69	214	17	31	17.83
Austrovenus stutchburyi	DC	70	260	19.5	38	21.67
Austrovenus stutchburyi	DC	71	254	23	30	21.17
Austrovenus stutchburyi	DC	72	330	22	44	27.50
Austrovenus stutchburyi	DC	73	307.6	25	44	25.64
Austrovenus stutchburyi	DC	74	227	16.5	51	18.92
Austrovenus	DC	75	415.2	36	29	34.60

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Austrovenus stutchburyi						
Austrovenus stutchburyi	HL	68	0	0	0	0.00
Austrovenus stutchburyi	HL	69	1	0	1	0.08
Austrovenus stutchburyi	HL	70	6	0	2	0.50
Austrovenus stutchburyi	HL	71	1	0	1	0.08
Austrovenus stutchburyi	HL	72	2	0	1	0.17
Austrovenus stutchburyi	HL	73	3.3	0	2	0.27
Austrovenus stutchburyi	HL	74	8	0	3	0.67
Austrovenus stutchburyi	HL	75	12	1	2	1.00
Austrovenus stutchburyi	JB	68	9	0	8	0.75
Austrovenus stutchburyi	JB	69	8	0	4	0.67
Austrovenus stutchburyi	JB	70	6	0	2	0.50
Austrovenus stutchburyi	JB	71	2	0	2	0.17
Austrovenus stutchburyi	JB	72	0	0	0	0.00
Austrovenus stutchburyi	JB	73	4	0	2	0.33
Austrovenus stutchburyi	JB	74	28	0	24	2.33
Austrovenus stutchburyi	JB	75	33	1	10	2.75
Austrovenus stutchburyi	MH	68	0	0	0	0.00
Austrovenus stutchburyi	MH	69	0	0	0	0.00
Austrovenus stutchburyi	MH	70	0	0	0	0.00
Austrovenus stutchburyi	MH	71	2	0	1	0.17
Austrovenus stutchburyi	MH	72	0	0	0	0.00
Austrovenus stutchburyi	MH	73	0	0	0	0.00
Austrovenus stutchburyi	MH	74	1	0	1	0.08
Austrovenus stutchburyi	MH	75	4	0	1	0.33
Austrovenus stutchburyi	TK	68	94	0.5	89	7.83
Austrovenus stutchburyi	TK	69	154	1	57	12.83
Austrovenus stutchburyi	TK	70	113	2.5	60	9.42

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Austrovenus stutchburyi	TK	71	42	2	15	3.50
Austrovenus stutchburyi	TK	72	39	0	35	3.25
Austrovenus stutchburyi	TK	73	36	0	34	3.00
Austrovenus stutchburyi	TK	74	144	3	107	12.00
Austrovenus stutchburyi	TK	75	247	9.5	142	20.58
Hemiplax hirtipes	DC	68	3	0	2	0.25
Hemiplax hirtipes	DC	69	6	0	2	0.50
Hemiplax hirtipes	DC	70	4	0	1	0.33
Hemiplax hirtipes	DC	71	0	0	0	0.00
Hemiplax hirtipes	DC	72	6	0	3	0.50
Hemiplax hirtipes	DC	73	1.1	0	1	0.09
Hemiplax hirtipes	DC	74	4	0	1	0.33
Hemiplax hirtipes	DC	75	2.4	0	1	0.20
Hemiplax hirtipes	HL	68	0	0	0	0.00
Hemiplax hirtipes	HL	69	6	0	2	0.50
Hemiplax hirtipes	HL	70	0	0	0	0.00
Hemiplax hirtipes	HL	71	0	0	0	0.00
Hemiplax hirtipes	HL	72	2	0	1	0.17
Hemiplax hirtipes	HL	73	1.1	0	1	0.09
Hemiplax hirtipes	HL	74	0	0	0	0.00
Hemiplax hirtipes	HL	75	0	0	0	0.00
Hemiplax hirtipes	JB	68	0	0	0	0.00
Hemiplax hirtipes	JB	69	2	0	1	0.17
Hemiplax hirtipes	JB	70	1	0	1	0.08
Hemiplax hirtipes	JB	71	0	0	0	0.00
Hemiplax hirtipes	JB	72	0	0	0	0.00
Hemiplax hirtipes	JB	73	0	0	0	0.00
Hemiplax	JB	74	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
hirtipes						
Hemiplax hirtipes	JB	75	3	0	2	0.25
Hemiplax hirtipes	MH	68	0	0	0	0.00
Hemiplax hirtipes	MH	69	2	0	1	0.17
Hemiplax hirtipes	MH	70	1	0	1	0.08
Hemiplax hirtipes	MH	71	3	0	3	0.25
Hemiplax hirtipes	MH	72	3	0	1	0.25
Hemiplax hirtipes	MH	73	0	0	0	0.00
Hemiplax hirtipes	MH	74	10	1	2	0.83
Hemiplax hirtipes	MH	75	1	0	1	0.08
Hemiplax hirtipes	TK	68	0	0	0	0.00
Hemiplax hirtipes	TK	69	2	0	1	0.17
Hemiplax hirtipes	TK	70	0	0	0	0.00
Hemiplax hirtipes	TK	71	3	0	1	0.25
Hemiplax hirtipes	TK	72	0	0	0	0.00
Hemiplax hirtipes	TK	73	0	0	0	0.00
Hemiplax hirtipes	TK	74	0	0	0	0.00
Hemiplax hirtipes	TK	75	1	0	1	0.08
Heteromastus filiformis	DC	68	5	0	2	0.42
Heteromastus filiformis	DC	69	4	0	3	0.33
Heteromastus filiformis	DC	70	21	1.5	4	1.75
Heteromastus filiformis	DC	71	34	2	7	2.83
Heteromastus filiformis	DC	72	34	2.5	7	2.83
Heteromastus filiformis	DC	73	38.2	3	8	3.18
Heteromastus filiformis	DC	74	32	2	8	2.67
Heteromastus filiformis	DC	75	37.2	3	6	3.10
Heteromastus filiformis	HL	68	94	9.5	13	7.83
Heteromastus filiformis	HL	69	113	7.5	21	9.42

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Heteromastus filiformis	HL	70	174	14.5	17	14.50
Heteromastus filiformis	HL	71	193	17	21	16.08
Heteromastus filiformis	HL	72	188	16.5	23	15.67
Heteromastus filiformis	HL	73	115.6	10	12	9.64
Heteromastus filiformis	HL	74	191	16	32	15.92
Heteromastus filiformis	HL	75	242	19	28	20.17
Heteromastus filiformis	JB	68	30	1	8	2.50
Heteromastus filiformis	JB	69	55	4	12	4.58
Heteromastus filiformis	JB	70	155	10	26	12.92
Heteromastus filiformis	JB	71	59	4	15	4.92
Heteromastus filiformis	JB	72	73	5	17	6.08
Heteromastus filiformis	JB	73	78	6	14	6.50
Heteromastus filiformis	JB	74	39	1	16	3.25
Heteromastus filiformis	JB	75	81	3	29	6.75
Heteromastus filiformis	MH	68	35	2.5	7	2.92
Heteromastus filiformis	MH	69	28	2	4	2.33
Heteromastus filiformis	MH	70	68	6.5	7	5.67
Heteromastus filiformis	MH	71	88	7.5	13	7.33
Heteromastus filiformis	MH	72	80	6	10	6.67
Heteromastus filiformis	MH	73	65	6	8	5.42
Heteromastus filiformis	MH	74	19	1.5	5	1.58
Heteromastus filiformis	MH	75	33	2	8	2.75
Heteromastus filiformis	TK	68	0	0	0	0.00
Heteromastus filiformis	TK	69	95	7	21	7.92
Heteromastus filiformis	TK	70	112	9.5	11	9.33
Heteromastus filiformis	TK	71	137	10	20	11.42
Heteromastus filiformis	TK	72	152	11.5	20	12.67
Heteromastus	TK	73	116	6.5	30	9.67

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
filiformis						
Heteromastus filiformis	TK	74	207	15.5	33	17.25
Heteromastus filiformis	TK	75	113	7.5	24	9.42
Macomona liliana	DC	68	22	1.5	4	1.83
Macomona liliana	DC	69	29	2	5	2.42
Macomona liliana	DC	70	25	2	7	2.08
Macomona liliana	DC	71	34	3	7	2.83
Macomona liliana	DC	72	28	2	7	2.33
Macomona liliana	DC	73	37.1	3	6	3.09
Macomona liliana	DC	74	27	2	5	2.25
Macomona liliana	DC	75	33.6	3	5	2.80
Macomona liliana	HL	68	1	0	1	0.08
Macomona liliana	HL	69	2	0	1	0.17
Macomona liliana	HL	70	0	0	0	0.00
Macomona liliana	HL	71	2	0	1	0.17
Macomona liliana	HL	72	2	0	1	0.17
Macomona liliana	HL	73	6.5	0	2	0.55
Macomona liliana	HL	74	3	0	2	0.25
Macomona liliana	HL	75	19	1	5	1.58
Macomona liliana	JB	68	15	1	3	1.25
Macomona liliana	JB	69	10	0.5	3	0.83
Macomona liliana	JB	70	13	1	3	1.08
Macomona liliana	JB	71	7	0	3	0.58
Macomona liliana	JB	72	7	0	2	0.58
Macomona liliana	JB	73	14	1	3	1.17
Macomona liliana	JB	74	15	0.5	4	1.25
Macomona liliana	JB	75	17	1	4	1.42
Macomona liliana	MH	68	6	0.5	1	0.50

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Macomona liliana	MH	69	0	0	0	0.00
Macomona liliana	MH	70	0	0	0	0.00
Macomona liliana	MH	71	3	0	1	0.25
Macomona liliana	MH	72	4	0	2	0.33
Macomona liliana	MH	73	3	0	1	0.25
Macomona liliana	MH	74	1	0	1	0.08
Macomona liliana	MH	75	8	0.5	2	0.67
Macomona liliana	TK	68	10	0	5	0.83
Macomona liliana	TK	69	17	1	6	1.42
Macomona liliana	TK	70	6	0	2	0.50
Macomona liliana	TK	71	1	0	1	0.08
Macomona liliana	TK	72	8	0	3	0.67
Macomona liliana	TK	73	9	1	2	0.75
Macomona liliana	TK	74	6	0	2	0.50
Macomona liliana	TK	75	8	0	3	0.67
Nemerteans	DC	68	16	1	3	1.33
Nemerteans	DC	69	16	0.5	6	1.33
Nemerteans	DC	70	14	1	5	1.17
Nemerteans	DC	71	17	1	4	1.42
Nemerteans	DC	72	21	1.5	6	1.75
Nemerteans	DC	73	16.4	1	4	1.36
Nemerteans	DC	74	13	0.5	5	1.08
Nemerteans	DC	75	18	1	4	1.50
Nemerteans	HL	68	11	1	3	0.92
Nemerteans	HL	69	24	1	10	2.00
Nemerteans	HL	70	24	1.5	5	2.00
Nemerteans	HL	71	12	1	3	1.00
Nemerteans	HL	72	15	1	4	1.25
Nemerteans	HL	73	26.2	2	5	2.18
Nemerteans	HL	74	13	1	3	1.08
Nemerteans	HL	75	36	2	9	3.00
Nemerteans	JB	68	6	0	4	0.50
Nemerteans	JB	69	25	1	7	2.08
Nemerteans	JB	70	37	1.5	17	3.08
Nemerteans	JB	71	8	0	6	0.67
Nemerteans	JB	72	36	2	10	3.00
Nemerteans	JB	73	16	1	6	1.33
Nemerteans	JB	74	29	1.5	6	2.42

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Nemerteans	JB	75	41	1	14	3.42
Nemerteans	MH	68	5	0	2	0.42
Nemerteans	MH	69	3	0	2	0.25
Nemerteans	MH	70	6	0	2	0.50
Nemerteans	MH	71	25	2	6	2.08
Nemerteans	MH	72	23	2	5	1.92
Nemerteans	MH	73	21	1	9	1.75
Nemerteans	MH	74	8	0.5	2	0.67
Nemerteans	MH	75	6	0	2	0.50
Nemerteans	TK	68	15	1	4	1.25
Nemerteans	TK	69	60	5.5	10	5.00
Nemerteans	TK	70	28	2	8	2.33
Nemerteans	TK	71	12	1	3	1.00
Nemerteans	TK	72	26	1.5	6	2.17
Nemerteans	TK	73	55	4	12	4.58
Nemerteans	TK	74	17	1.5	3	1.42
Nemerteans	TK	75	19	1	6	1.58
Notoacmea scapha	DC	68	0	0	0	0.00
Notoacmea scapha	DC	69	1	0	1	0.08
Notoacmea scapha	DC	70	6	0	2	0.50
Notoacmea scapha	DC	71	4	0	1	0.33
Notoacmea scapha	DC	72	8	0	3	0.67
Notoacmea scapha	DC	73	16.4	0	8	1.36
Notoacmea scapha	DC	74	31	2	9	2.58
Notoacmea scapha	DC	75	4.8	0	2	0.40
Notoacmea scapha	HL	68	0	0	0	0.00
Notoacmea scapha	HL	69	0	0	0	0.00
Notoacmea scapha	HL	70	0	0	0	0.00
Notoacmea scapha	HL	71	0	0	0	0.00
Notoacmea scapha	HL	72	0	0	0	0.00
Notoacmea scapha	HL	73	0	0	0	0.00
Notoacmea scapha	HL	74	0	0	0	0.00
Notoacmea scapha	HL	75	1	0	1	0.08
Notoacmea scapha	JB	68	0	0	0	0.00
Notoacmea scapha	JB	69	0	0	0	0.00
Notoacmea	JB	70	6	0	4	0.50

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
scapha						
Notoacmea scapha	JB	71	4	0	2	0.33
Notoacmea scapha	JB	72	0	0	0	0.00
Notoacmea scapha	JB	73	4	0	2	0.33
Notoacmea scapha	JB	74	0	0	0	0.00
Notoacmea scapha	JB	75	6	0	3	0.50
Notoacmea scapha	MH	68	0	0	0	0.00
Notoacmea scapha	MH	69	0	0	0	0.00
Notoacmea scapha	MH	70	0	0	0	0.00
Notoacmea scapha	MH	71	0	0	0	0.00
Notoacmea scapha	MH	72	0	0	0	0.00
Notoacmea scapha	MH	73	0	0	0	0.00
Notoacmea scapha	MH	74	0	0	0	0.00
Notoacmea scapha	MH	75	2	0	1	0.17
Notoacmea scapha	TK	68	0	0	0	0.00
Notoacmea scapha	TK	69	10	0	3	0.83
Notoacmea scapha	TK	70	0	0	0	0.00
Notoacmea scapha	TK	71	0	0	0	0.00
Notoacmea scapha	TK	72	2	0	2	0.17
Notoacmea scapha	TK	73	12	0	12	1.00
Notoacmea scapha	TK	74	9	0	9	0.75
Notoacmea scapha	TK	75	1	0	1	0.08
Nucula hartvigiana	DC	68	8	0	2	0.67
Nucula hartvigiana	DC	69	30	1.5	14	2.50
Nucula hartvigiana	DC	70	59	3.5	15	4.92
Nucula hartvigiana	DC	71	63	4	17	5.25
Nucula hartvigiana	DC	72	204	13	53	17.00
Nucula hartvigiana	DC	73	200.7	19	38	16.73

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Nucula hartvigiana	DC	74	195	12.5	34	16.25
Nucula hartvigiana	DC	75	262.8	19	32	21.90
Nucula hartvigiana	HL	68	0	0	0	0.00
Nucula hartvigiana	HL	69	0	0	0	0.00
Nucula hartvigiana	HL	70	0	0	0	0.00
Nucula hartvigiana	HL	71	1	0	1	0.08
Nucula hartvigiana	HL	72	0	0	0	0.00
Nucula hartvigiana	HL	73	2.2	0	1	0.18
Nucula hartvigiana	HL	74	3	0	2	0.25
Nucula hartvigiana	HL	75	16	1	4	1.33
Nucula hartvigiana	JB	68	92	4.5	22	7.67
Nucula hartvigiana	JB	69	56	5.5	11	4.67
Nucula hartvigiana	JB	70	84	6	22	7.00
Nucula hartvigiana	JB	71	68	2.5	17	5.67
Nucula hartvigiana	JB	72	39	1	13	3.25
Nucula hartvigiana	JB	73	37	3	9	3.08
Nucula hartvigiana	JB	74	69	3.5	20	5.75
Nucula hartvigiana	JB	75	105	4.5	34	8.75
Nucula hartvigiana	MH	68	187	13	34	15.58
Nucula hartvigiana	MH	69	85	5.5	15	7.08
Nucula hartvigiana	MH	70	92	6	16	7.67
Nucula hartvigiana	MH	71	58	4.5	9	4.83
Nucula hartvigiana	MH	72	24	1.5	4	2.00
Nucula hartvigiana	MH	73	24	2	4	2.00
Nucula hartvigiana	MH	74	26	2	5	2.17
Nucula hartvigiana	MH	75	38	3	8	3.17
Nucula hartvigiana	TK	68	14	0	11	1.17
Nucula	TK	69	37	0.5	17	3.08

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Nucula hartvigiana						
Nucula hartvigiana	TK	70	15	0	10	1.25
Nucula hartvigiana	TK	71	11	0.5	3	0.92
Nucula hartvigiana	TK	72	14	0	7	1.17
Nucula hartvigiana	TK	73	23	1	12	1.92
Nucula hartvigiana	TK	74	40	1	28	3.33
Nucula hartvigiana	TK	75	60	2.5	32	5.00
Oligochaetes	DC	68	12	0	5	1.00
Oligochaetes	DC	69	27	1	8	2.25
Oligochaetes	DC	70	17	0.5	5	1.42
Oligochaetes	DC	71	7	0	2	0.58
Oligochaetes	DC	72	22	1	10	1.83
Oligochaetes	DC	73	14.2	1	4	1.18
Oligochaetes	DC	74	2	0	1	0.17
Oligochaetes	DC	75	13.2	0.5	4	1.10
Oligochaetes	HL	68	50	4	8	4.17
Oligochaetes	HL	69	113	5.5	29	9.42
Oligochaetes	HL	70	23	1.5	4	1.92
Oligochaetes	HL	71	16	1	4	1.33
Oligochaetes	HL	72	74	4	25	6.17
Oligochaetes	HL	73	77.5	4	16	6.45
Oligochaetes	HL	74	12	0.5	6	1.00
Oligochaetes	HL	75	54	4	9	4.50
Oligochaetes	JB	68	12	0	6	1.00
Oligochaetes	JB	69	26	0	13	2.17
Oligochaetes	JB	70	8	0	8	0.67
Oligochaetes	JB	71	4	0	3	0.33
Oligochaetes	JB	72	1	0	1	0.08
Oligochaetes	JB	73	16	0.5	6	1.33
Oligochaetes	JB	74	9	0	5	0.75
Oligochaetes	JB	75	27	1.5	8	2.25
Oligochaetes	MH	68	2	0	1	0.17
Oligochaetes	MH	69	0	0	0	0.00
Oligochaetes	MH	70	2	0	1	0.17
Oligochaetes	MH	71	3	0	1	0.25
Oligochaetes	MH	72	1	0	1	0.08
Oligochaetes	MH	73	16	0	7	1.33
Oligochaetes	MH	74	2	0	1	0.17
Oligochaetes	MH	75	0	0	0	0.00
Oligochaetes	TK	68	3	0	1	0.25
Oligochaetes	TK	69	7	0	4	0.58
Oligochaetes	TK	70	4	0	2	0.33
Oligochaetes	TK	71	0	0	0	0.00
Oligochaetes	TK	72	22	0	14	1.83
Oligochaetes	TK	73	7	0	3	0.58
Oligochaetes	TK	74	3	0	2	0.25

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Oligochaetes	TK	75	4	0	4	0.33
Owenia petersenae	DC	68	0	0	0	0.00
Owenia petersenae	DC	69	0	0	0	0.00
Owenia petersenae	DC	70	0	0	0	0.00
Owenia petersenae	DC	71	0	0	0	0.00
Owenia petersenae	DC	72	2	0	1	0.17
Owenia petersenae	DC	73	0	0	0	0.00
Owenia petersenae	DC	74	0	0	0	0.00
Owenia petersenae	DC	75	0	0	0	0.00
Owenia petersenae	HL	68	0	0	0	0.00
Owenia petersenae	HL	69	0	0	0	0.00
Owenia petersenae	HL	70	0	0	0	0.00
Owenia petersenae	HL	71	0	0	0	0.00
Owenia petersenae	HL	72	0	0	0	0.00
Owenia petersenae	HL	73	0	0	0	0.00
Owenia petersenae	HL	74	0	0	0	0.00
Owenia petersenae	HL	75	0	0	0	0.00
Owenia petersenae	JB	68	0	0	0	0.00
Owenia petersenae	JB	69	2	0	1	0.17
Owenia petersenae	JB	70	1	0	1	0.08
Owenia petersenae	JB	71	0	0	0	0.00
Owenia petersenae	JB	72	0	0	0	0.00
Owenia petersenae	JB	73	5	0	2	0.42
Owenia petersenae	JB	74	2	0	1	0.17
Owenia petersenae	JB	75	8	0	4	0.67
Owenia petersenae	MH	68	0	0	0	0.00
Owenia petersenae	MH	69	0	0	0	0.00
Owenia petersenae	MH	70	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Owenia petersenae	MH	71	0	0	0	0.00
Owenia petersenae	MH	72	0	0	0	0.00
Owenia petersenae	MH	73	0	0	0	0.00
Owenia petersenae	MH	74	0	0	0	0.00
Owenia petersenae	MH	75	3	0	1	0.25
Owenia petersenae	TK	68	0	0	0	0.00
Owenia petersenae	TK	69	0	0	0	0.00
Owenia petersenae	TK	70	0	0	0	0.00
Owenia petersenae	TK	71	0	0	0	0.00
Owenia petersenae	TK	72	0	0	0	0.00
Owenia petersenae	TK	73	0	0	0	0.00
Owenia petersenae	TK	74	0	0	0	0.00
Owenia petersenae	TK	75	0	0	0	0.00
Paracalliope novizelandiae	DC	68	0	0	0	0.00
Paracalliope novizelandiae	DC	69	2	0	1	0.17
Paracalliope novizelandiae	DC	70	5	0	2	0.42
Paracalliope novizelandiae	DC	71	29	1	14	2.42
Paracalliope novizelandiae	DC	72	2	0	1	0.17
Paracalliope novizelandiae	DC	73	20.7	1	7	1.73
Paracalliope novizelandiae	DC	74	110	1	79	9.17
Paracalliope novizelandiae	DC	75	12	0.5	6	1.00
Paracalliope novizelandiae	HL	68	0	0	0	0.00
Paracalliope novizelandiae	HL	69	5	0	4	0.42
Paracalliope novizelandiae	HL	70	10	1	3	0.83
Paracalliope novizelandiae	HL	71	1	0	1	0.08
Paracalliope novizelandiae	HL	72	1	0	1	0.08
Paracalliope novizelandiae	HL	73	7.6	0	4	0.64
Paracalliope	HL	74	7	0	2	0.58

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
novizelandiae						
Paracalliope novizelandiae	HL	75	3	0	1	0.25
Paracalliope novizelandiae	JB	68	4	0	3	0.33
Paracalliope novizelandiae	JB	69	12	0	5	1.00
Paracalliope novizelandiae	JB	70	25	0	14	2.08
Paracalliope novizelandiae	JB	71	35	1	11	2.92
Paracalliope novizelandiae	JB	72	148	7.5	55	12.33
Paracalliope novizelandiae	JB	73	12	0	7	1.00
Paracalliope novizelandiae	JB	74	2	0	1	0.17
Paracalliope novizelandiae	JB	75	7	0	3	0.58
Paracalliope novizelandiae	MH	68	0	0	0	0.00
Paracalliope novizelandiae	MH	69	0	0	0	0.00
Paracalliope novizelandiae	MH	70	2	0	1	0.17
Paracalliope novizelandiae	MH	71	20	1	4	1.67
Paracalliope novizelandiae	MH	72	0	0	0	0.00
Paracalliope novizelandiae	MH	73	8	0	4	0.67
Paracalliope novizelandiae	MH	74	2	0	1	0.17
Paracalliope novizelandiae	MH	75	10	1	2	0.83
Paracalliope novizelandiae	TK	68	21	0	21	1.75
Paracalliope novizelandiae	TK	69	4	0	2	0.33
Paracalliope novizelandiae	TK	70	5	0	4	0.42
Paracalliope novizelandiae	TK	71	2	0	2	0.17
Paracalliope novizelandiae	TK	72	4	0	2	0.33
Paracalliope novizelandiae	TK	73	3	0	1	0.25
Paracalliope novizelandiae	TK	74	12	0.5	3	1.00
Paracalliope novizelandiae	TK	75	5	0	5	0.42
Perinereis vallata	DC	68	3	0	1	0.25
Perinereis vallata	DC	69	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Perinereis vallata	DC	70	2	0	1	0.17
Perinereis vallata	DC	71	0	0	0	0.00
Perinereis vallata	DC	72	0	0	0	0.00
Perinereis vallata	DC	73	1.1	0	1	0.09
Perinereis vallata	DC	74	0	0	0	0.00
Perinereis vallata	DC	75	1.2	0	1	0.10
Perinereis vallata	HL	68	2	0	1	0.17
Perinereis vallata	HL	69	0	0	0	0.00
Perinereis vallata	HL	70	0	0	0	0.00
Perinereis vallata	HL	71	4	0	1	0.33
Perinereis vallata	HL	72	7	0	2	0.58
Perinereis vallata	HL	73	1.1	0	1	0.09
Perinereis vallata	HL	74	1	0	1	0.08
Perinereis vallata	HL	75	6	0	2	0.50
Perinereis vallata	JB	68	7	0	6	0.58
Perinereis vallata	JB	69	0	0	0	0.00
Perinereis vallata	JB	70	0	0	0	0.00
Perinereis vallata	JB	71	5	0	3	0.42
Perinereis vallata	JB	72	1	0	1	0.08
Perinereis vallata	JB	73	1	0	1	0.08
Perinereis vallata	JB	74	0	0	0	0.00
Perinereis vallata	JB	75	3	0	1	0.25
Perinereis vallata	MH	68	0	0	0	0.00
Perinereis vallata	MH	69	0	0	0	0.00
Perinereis vallata	MH	70	0	0	0	0.00
Perinereis vallata	MH	71	0	0	0	0.00
Perinereis vallata	MH	72	0	0	0	0.00
Perinereis	MH	73	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
vallata						
Perinereis vallata	MH	74	0	0	0	0.00
Perinereis vallata	MH	75	0	0	0	0.00
Perinereis vallata	TK	68	0	0	0	0.00
Perinereis vallata	TK	69	7	0	3	0.58
Perinereis vallata	TK	70	1	0	1	0.08
Perinereis vallata	TK	71	2	0	1	0.17
Perinereis vallata	TK	72	1	0	1	0.08
Perinereis vallata	TK	73	3	0	2	0.25
Perinereis vallata	TK	74	5	0	2	0.42
Perinereis vallata	TK	75	3	0	3	0.25
Polydorids	DC	68	11	1	3	0.92
Polydorids	DC	69	42	4	6	3.50
Polydorids	DC	70	13	1	3	1.08
Polydorids	DC	71	10	1	2	0.83
Polydorids	DC	72	21	1.5	5	1.75
Polydorids	DC	73	15.3	1	4	1.27
Polydorids	DC	74	10	0.5	2	0.83
Polydorids	DC	75	8.4	1	2	0.70
Polydorids	HL	68	2	0	1	0.17
Polydorids	HL	69	64	5	8	5.33
Polydorids	HL	70	12	1	3	1.00
Polydorids	HL	71	12	1	4	1.00
Polydorids	HL	72	4	0	1	0.33
Polydorids	HL	73	17.5	1	5	1.45
Polydorids	HL	74	1	0	1	0.08
Polydorids	HL	75	24	1.5	5	2.00
Polydorids	JB	68	233	5	130	19.42
Polydorids	JB	69	151	3	38	12.58
Polydorids	JB	70	97	4	34	8.08
Polydorids	JB	71	124	4	48	10.33
Polydorids	JB	72	341	11	160	28.42
Polydorids	JB	73	77	4.5	26	6.42
Polydorids	JB	74	74	6.5	13	6.17
Polydorids	JB	75	857	77.5	170	71.42
Polydorids	MH	68	22	1	6	1.83
Polydorids	MH	69	19	1.5	3	1.58
Polydorids	MH	70	11	1	2	0.92
Polydorids	MH	71	101	5	32	8.42
Polydorids	MH	72	17	1.5	4	1.42
Polydorids	MH	73	15	1	3	1.25
Polydorids	MH	74	21	1.5	4	1.75

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Polydorids	MH	75	156	10	29	13.00
Polydorids	TK	68	1	0	1	0.08
Polydorids	TK	69	11	0.5	4	0.92
Polydorids	TK	70	5	0	2	0.42
Polydorids	TK	71	2	0	1	0.17
Polydorids	TK	72	6	0	2	0.50
Polydorids	TK	73	8	1	2	0.67
Polydorids	TK	74	9	1	2	0.75
Polydorids	TK	75	15	0	8	1.25
Prionospio aucklandica	DC	68	68	5	18	5.67
Prionospio aucklandica	DC	69	81	6	18	6.75
Prionospio aucklandica	DC	70	64	5	7	5.33
Prionospio aucklandica	DC	71	95	9	14	7.92
Prionospio aucklandica	DC	72	121	9.5	21	10.08
Prionospio aucklandica	DC	73	98.2	8	11	8.18
Prionospio aucklandica	DC	74	66	5.5	11	5.50
Prionospio aucklandica	DC	75	81.6	6	16	6.80
Prionospio aucklandica	HL	68	11	1	3	0.92
Prionospio aucklandica	HL	69	17	1	5	1.42
Prionospio aucklandica	HL	70	28	2.5	6	2.33
Prionospio aucklandica	HL	71	35	2.5	8	2.92
Prionospio aucklandica	HL	72	20	1	4	1.67
Prionospio aucklandica	HL	73	16.4	1	4	1.36
Prionospio aucklandica	HL	74	9	1	2	0.75
Prionospio aucklandica	HL	75	82	7	9	6.83
Prionospio aucklandica	JB	68	10	1	2	0.83
Prionospio aucklandica	JB	69	6	0	3	0.50
Prionospio aucklandica	JB	70	9	0.5	3	0.75
Prionospio aucklandica	JB	71	13	1	5	1.08
Prionospio aucklandica	JB	72	8	0.5	3	0.67
Prionospio aucklandica	JB	73	9	1	3	0.75
Prionospio	JB	74	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
aucklandica						
Prionospio aucklandica	JB	75	167	14	33	13.92
Prionospio aucklandica	MH	68	0	0	0	0.00
Prionospio aucklandica	MH	69	1	0	1	0.08
Prionospio aucklandica	MH	70	0	0	0	0.00
Prionospio aucklandica	MH	71	3	0	1	0.25
Prionospio aucklandica	MH	72	5	0	2	0.42
Prionospio aucklandica	MH	73	7	0	2	0.58
Prionospio aucklandica	MH	74	2	0	1	0.17
Prionospio aucklandica	MH	75	1	0	1	0.08
Prionospio aucklandica	TK	68	38	2	10	3.17
Prionospio aucklandica	TK	69	81	5	15	6.75
Prionospio aucklandica	TK	70	46	2.5	11	3.83
Prionospio aucklandica	TK	71	55	3.5	18	4.58
Prionospio aucklandica	TK	72	82	6.5	20	6.83
Prionospio aucklandica	TK	73	86	4	37	7.17
Prionospio aucklandica	TK	74	45	2.5	12	3.75
Prionospio aucklandica	TK	75	90	6	22	7.50
Scoloplos cylindrifer	DC	68	11	0.5	4	0.92
Scoloplos cylindrifer	DC	69	8	0	4	0.67
Scoloplos cylindrifer	DC	70	15	0	5	1.25
Scoloplos cylindrifer	DC	71	8	0	8	0.67
Scoloplos cylindrifer	DC	72	16	1	5	1.33
Scoloplos cylindrifer	DC	73	24	0	15	2.00
Scoloplos cylindrifer	DC	74	7	0	6	0.58
Scoloplos cylindrifer	DC	75	0	0	0	0.00
Scoloplos cylindrifer	HL	68	0	0	0	0.00
Scoloplos cylindrifer	HL	69	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Scoloplos cylindrifer	HL	70	0	0	0	0.00
Scoloplos cylindrifer	HL	71	1	0	1	0.08
Scoloplos cylindrifer	HL	72	0	0	0	0.00
Scoloplos cylindrifer	HL	73	0	0	0	0.00
Scoloplos cylindrifer	HL	74	0	0	0	0.00
Scoloplos cylindrifer	HL	75	0	0	0	0.00
Scoloplos cylindrifer	JB	68	2	0	1	0.17
Scoloplos cylindrifer	JB	69	21	0	10	1.75
Scoloplos cylindrifer	JB	70	4	0	3	0.33
Scoloplos cylindrifer	JB	71	7	0	6	0.58
Scoloplos cylindrifer	JB	72	2	0	2	0.17
Scoloplos cylindrifer	JB	73	0	0	0	0.00
Scoloplos cylindrifer	JB	74	0	0	0	0.00
Scoloplos cylindrifer	JB	75	26	0	12	2.17
Scoloplos cylindrifer	MH	68	0	0	0	0.00
Scoloplos cylindrifer	MH	69	0	0	0	0.00
Scoloplos cylindrifer	MH	70	0	0	0	0.00
Scoloplos cylindrifer	MH	71	0	0	0	0.00
Scoloplos cylindrifer	MH	72	0	0	0	0.00
Scoloplos cylindrifer	MH	73	0	0	0	0.00
Scoloplos cylindrifer	MH	74	0	0	0	0.00
Scoloplos cylindrifer	MH	75	0	0	0	0.00
Scoloplos cylindrifer	TK	68	7	0	7	0.58
Scoloplos cylindrifer	TK	69	10	0	5	0.83
Scoloplos cylindrifer	TK	70	3	0	3	0.25
Scoloplos cylindrifer	TK	71	0	0	0	0.00
Scoloplos cylindrifer	TK	72	2	0	2	0.17
Scoloplos	TK	73	11	0	11	0.92

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
cylindrifer						
Scoloplos cylindrifer	TK	74	1	0	1	0.08
Scoloplos cylindrifer	TK	75	11	0	11	0.92
Torridoharpinia hurleyi	DC	68	0	0	0	0.00
Torridoharpinia hurleyi	DC	69	0	0	0	0.00
Torridoharpinia hurleyi	DC	70	0	0	0	0.00
Torridoharpinia hurleyi	DC	71	0	0	0	0.00
Torridoharpinia hurleyi	DC	72	0	0	0	0.00
Torridoharpinia hurleyi	DC	73	5.5	0	4	0.45
Torridoharpinia hurleyi	DC	74	2	0	1	0.17
Torridoharpinia hurleyi	DC	75	0	0	0	0.00
Torridoharpinia hurleyi	HL	68	0	0	0	0.00
Torridoharpinia hurleyi	HL	69	0	0	0	0.00
Torridoharpinia hurleyi	HL	70	0	0	0	0.00
Torridoharpinia hurleyi	HL	71	0	0	0	0.00
Torridoharpinia hurleyi	HL	72	1	0	1	0.08
Torridoharpinia hurleyi	HL	73	1.1	0	1	0.09
Torridoharpinia hurleyi	HL	74	1	0	1	0.08
Torridoharpinia hurleyi	HL	75	9	0	4	0.75
Torridoharpinia hurleyi	JB	68	7	0	4	0.58
Torridoharpinia hurleyi	JB	69	5	0	2	0.42
Torridoharpinia hurleyi	JB	70	8	0	6	0.67
Torridoharpinia hurleyi	JB	71	18	0.5	7	1.50
Torridoharpinia hurleyi	JB	72	20	1	4	1.67
Torridoharpinia hurleyi	JB	73	15	0.5	9	1.25
Torridoharpinia hurleyi	JB	74	23	1.5	6	1.92
Torridoharpinia hurleyi	JB	75	55	1.5	17	4.58
Torridoharpinia hurleyi	MH	68	0	0	0	0.00

Taxa	Site	Time	Total[5]	Median	Range[6]	Mean
Torridoharpinia hurleyi	MH	69	0	0	0	0.00
Torridoharpinia hurleyi	MH	70	1	0	1	0.08
Torridoharpinia hurleyi	MH	71	0	0	0	0.00
Torridoharpinia hurleyi	MH	72	0	0	0	0.00
Torridoharpinia hurleyi	MH	73	1	0	1	0.08
Torridoharpinia hurleyi	MH	74	4	0	2	0.33
Torridoharpinia hurleyi	MH	75	2	0	1	0.17
Torridoharpinia hurleyi	TK	68	0	0	0	0.00
Torridoharpinia hurleyi	TK	69	3	0	2	0.25
Torridoharpinia hurleyi	TK	70	5	0	2	0.42
Torridoharpinia hurleyi	TK	71	10	0	3	0.83
Torridoharpinia hurleyi	TK	72	4	0	2	0.33
Torridoharpinia hurleyi	TK	73	18	1	7	1.50
Torridoharpinia hurleyi	TK	74	11	0	4	0.92
Torridoharpinia hurleyi	TK	75	5	0	3	0.42

7.5 Appendix 5: The three dominant taxa collected at Dyers Creek from October 2005 and January 2013

The three dominant taxa collected at Dyers Creek from October 2005 and January 2013. 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 11	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Macomona liliana*
Apr 11	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Aricidea sp.*
Jul 11	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Aricidea sp.*
Oct 11	*Austrovenus stutchburyi*	*Arthritica bifurca*	*Prionospio aucklandica*
Jan 12	*Austrovenus stutchburyi*	*Prionospio aucklandica*	*Nucula hartvigiana*
Apr 12	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Prionospio aucklandica*
Jul 12	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Prionospio aucklandica*
Oct 12	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Paracalliope novizealandiae*
Jan 13	*Austrovenus stutchburyi*	*Nucula hartvigiana*	*Prionospio aucklandica*

7.6 Appendix 6: The three dominant taxa collected at Hamilton Landing between July 1994 and January 2013

The three dominant taxa collected at Hamilton Landing between July 1994 and January 2013. 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*	*Hemiplax 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.
Apr 11	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jul 11	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 11	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jan 12	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.

Apr 12	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 12	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 12	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 13	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*

7.7 Appendix 7: The three dominant taxa collected at Jamieson Bay between July 1994 and January 2013

The three dominant taxa collected at Jamieson Bay between July 1994 and January 2013. 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*
Apr 11	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Jul 11	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Oct 11	*Heteromastus filiformis*	Polydorids	*Nucula hartvigiana*
Jan 12	Polydorids	*Nucula hartvigiana*	*Heteromastus filiformis*
Apr 12	Polydorids	*Paracalliope novizealandiae*	*Heteromastus filiformis*
Jul 12	*Heteromastus filiformis*	Polydorids	*Aricidea* sp.
Oct 12	Polydorids	*Nucula hartvigiana*	*Arthritica bifurca*
Jan 13	Polydorids	*Prionospio aucklandica*	*Nucula hartvigiana*

7.8 Appendix 8: The three dominant taxa collected at Mid Harbour between July 1994 and January 2013

The three dominant taxa collected at Mid Harbour between July 1994 and January 2013. 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*
Apr 11	*Nucula hartvigiana*	*Cossura consimilis*	*Arthritica bifurca*
Jul 11	*Nucula hartvigiana*	*Arthritica bifurca*	*Cossura consimilis*
Oct 11	*Arthritica bifurca*	*Nucula hartvigiana*	*Heteromastus filiformis*
Jan 12	*Arthritica bifurca*	Polydorids	*Heteromastus filiformis*
Apr 12	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Jul 12	*Arthritica bifurca*	*Cossura consimilis*	*Heteromastus filiformis*
Oct 12	*Arthritica bifurca*	*Cossura consimilis*	*Arthritica bifurca*
Jan 13	*Arthritica bifurca*	Polydorids	*Cossura consimilis*

7.9 Appendix 9: The three dominant taxa collected at Te Kapa Inlet between July 1994 and January 2013

The three dominant taxa collected at Te Kapa Inlet between July 1994 and January 2013. 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*
Apr 11	*Cossura consimilis*	*Austrovenus stutchburyi*	*Aricidea* sp.
Jul 11	*Aricidea sp.*	*Cossura consimilis*	*Austrovenus stutchburyi*
Oct 11	*Cossura consimilis*	*Aricidea* sp.	*Austrovenus stutchburyi*
Jan 12	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Apr 12	*Cossura consimilis*	*Heteromastus filiformis*	*Aricidea* sp.
Jul 12	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Oct 12	*Cossura consimilis*	*Aricidea* sp.	*Heteromastus filiformis*
Jan 13	*Cossura consimilis*	*Austrovenus stutchburyi*	*Heteromastus filiformis*