Auckland Regional Council
TE RAUHĪTANGA TAIAO

Mahurangi Harbour Biological Monitoring Programme

Report on Data Collected During the First Year of Monitoring

April TR 2009/039

Auckland Regional Council
Technical Report No.039 April 2009
ISSN 1179-0504 (Print)
ISSN 1179-0512 (Online)
ISBN 978-1-877528-48-4

This report is part of a series of reports that were commissioned during the period 1993-1999 that were used to support the establishment of the Mahurangi Action Plan. They are being made available following a review of technical information.

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Recommended Citation:

Cummings, V.J.; Hewitt, J.E..; Wilkinson, M.R.; Thrush, S.F. and Turner, S.J. (1995). Mahurangi Harbour Biological Monitoring Programme: Report of Data Collected During the First Year of Monitoring. Prepared by the National Institute of Water and Atmospheric Research for Auckland Regional Council. Auckland Regional Council TR 2009/039

Mahurangi Harbour Biological Monitoring Programme: Report on Data Collected During the First Year of Monitoring

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NIWA Consultancy Report
Report No. ARC309
Hamilton

Contents

1 Executive Summary

In July 1994 a long-term biological monitoring programme was initiated in Mahurangi Harbour to document the natural variability of the harbour's intertidal and subtidal benthic communities. This monitoring programme was initiated as part of a major study of the harbour and its catchment, after the area was identified by ARC Environment as having high potential for increasing pressure on land and water use in the near future. Five permanent intertidal sites and three permanent subtidal sites were established in locations predetermined from an initial survey of the harbour. In this report we have:

1. Presented data collected at intertidal and subtidal monitoring sites in Mahurangi Harbour in 1994/95;
2. Described the taxa collected at each of the monitored sites and their relative abundances;
3. Shown that some species not included in the list of taxa to be monitored following the 1993 survey occurred in moderate abundances during 1994/95, suggesting that taxa in Mahurangi Harbour may exhibit large fluctuations in abundance;
4. Suggested that a review of the list of monitored taxa at the intertidal sites may be appropriate once more data have been collected;
5. Provided information on the size and density of the horse mussel (*Atrina zelandica*) beds and their associated macrofauna at each of the subtidal monitoring sites.

2 Introduction

In July 1994 a biological monitoring programme was initiated in Mahurangi Harbour to document the natural variability of the harbour's intertidal and subtidal benthic communities. This monitoring programme was initiated as part of a major study of the harbour and its catchment, after the area was identified by ARC Environment as having high potential for increasing pressure on land and water use in the near future. Five permanent intertidal sites and This monitoring programme has been designed to:

- assess the overall condition of Mahurangi Harbour in terms of its benthic communities, and document any ecological changes which may occur as a direct/indirect consequence of catchment and harbour development;
- provide stocktaking of the resources under stewardship; and
- provide information on the ecology of the intertidal and subtidal benthic communities for the Mahurangi Harbour Management Plan.

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

This report presents data collected during the first year of the Mahurangi Harbour biological monitoring programme. The Manukau Harbour biological monitoring programme has demonstrated that, in order to identify trends and cycles in abundance and to assess their ecological significance, at least 5 years of data is necessary (see Hewitt et al. 1994). With five years of data, suggestions of trends which occur on a three to four year cycle (i.e., more than a generation for some taxa) can be detected (Hewitt et al. 1994). Usually, more than thirty data points are required to identify true trends (Lettenmaier et al. 1982). Therefore, it is not appropriate at such an early stage in this programme to make any conclusions about trends and patterns in the abundances of the benthic populations, or to attribute these to either natural variability or to some facet of catchment/harbour development. This report concentrates on the variation in species' abundance observed between sites around the harbour with the data collected thus far.

3 Methods

Five permanent intertidal and three permanent subtidal sites (Fig. 1) were established for long-term biological monitoring at locations selected on the basis of the results of an initial survey of the harbour (see Cummings et al. 1994). Methods for positioning and sampling of the sites were based upon techniques used in Manukau Harbour (Hewitt et al. 1993; Pridmore et al. 1990; Thrush et al. 1989, 1994). Following the procedure established in the Manukau Harbour monitoring programme, sediment samples were collected for grain size analysis, to provide baseline information against which any changes in infauna can be assessed. These results will be presented in the next report.

3.1 Intertidal sites

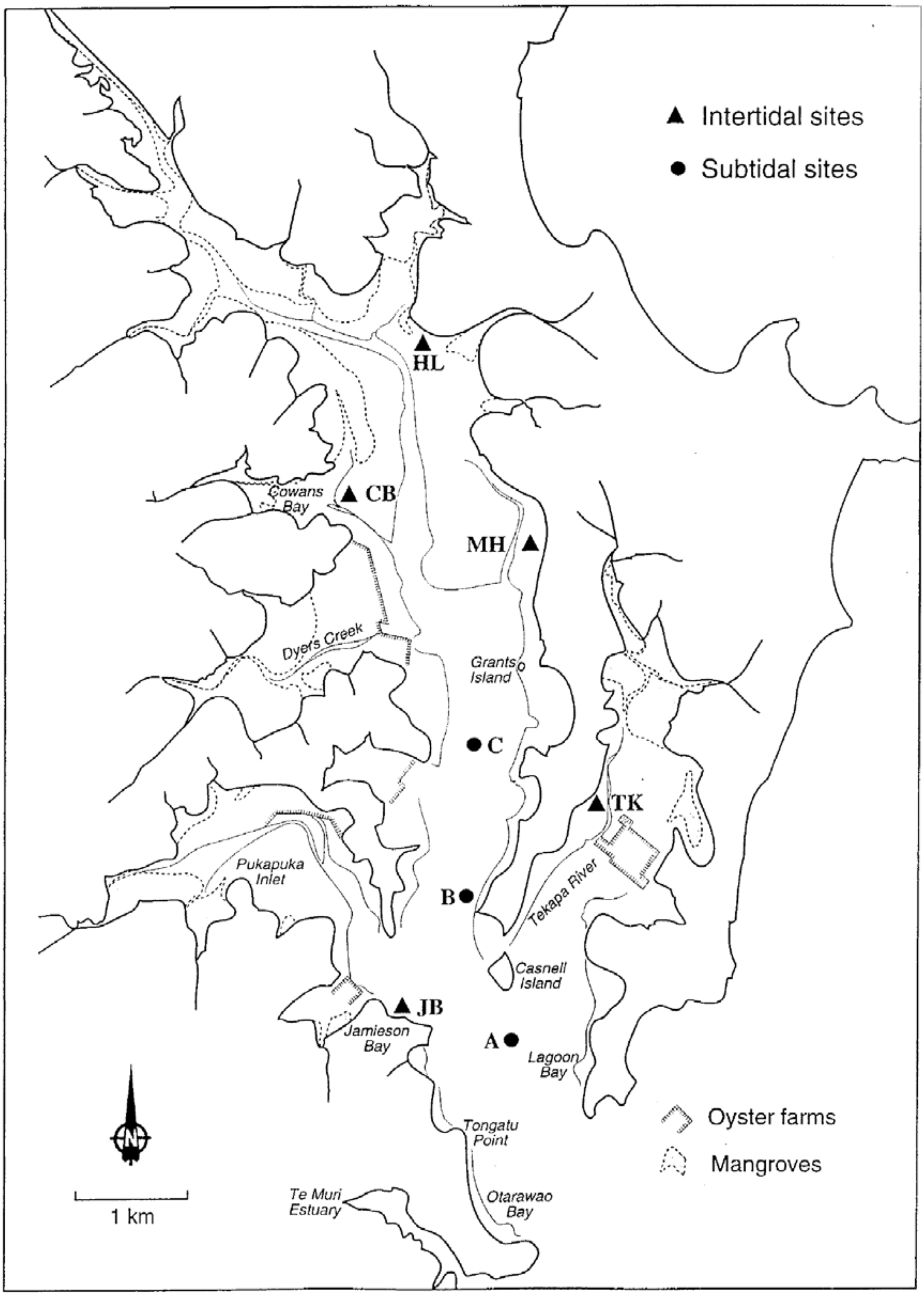
The intertidal sites were placed so that they encompassed much of the local environment and biological variation of the predetermined locations, and were thus representative of the biological community in that habitat. To aid relocation of sites, line-of-sight bearings and satellite navigation (GPS) readings were taken.

Four of the five intertidal sites cover areas of 9000 m^2, and have dimensions of either 50 m X 180 m or 90 m X 100 m, depending on what was best suited to the geometry of the site. These sites are situated at about mid-tide level, and their corners are marked by small wooden posts. The fifth intertidal site (Jamieson Bay) is constrained by the size of the bay, and occupies a slightly smaller area (7200 m^2; 60 m X 120 m) than the remaining sites. This site covers a greater tidal range than the other sites, due to the steep gradient of the beach. One of the intertidal sites differs from that recommended for monitoring in the 1994 report; a site in Cowans Bay has been substituted for the recommended Dyers Creek site, as the extensive oyster farms in Dyers Creek made access very difficult. Cowans Bay is situated near to Dyers Creek (Fig 1), and is considered to be as suitable for monitoring as the previously recommended site.

Intertidal sites were sampled at three-monthly intervals, beginning in July 1994. On each sampling occasion, core samples (13 cm diameter, 10 cm deep) were collected at each of 12 predetermined locations at each site. To provide adequate dispersion over the site, each site was divided into 12 equal sectors and one core sample taken from a random location within each sector. To reduce the influence of previous sampling activity and spatial autocorrelation, samples were not positioned within a 5 m radius of each other or of any samples collected over the previous 12 months.

Figure 1

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



Core samples were sieved (500 µm mesh) and the residues stained with rose bengal and preserved in 70 % isopropyl alcohol. Samples were then sorted, identified to the lowest possible/practical taxonomic level, counted and stored in 70 % isopropyl alcohol.

3.2 Subtidal sites

The three subtidal sites were situated adjacent to the main channel, in approximately 6 - 10 m of water (Fig. 1). All sites support beds of the horse mussel, *Atrina zelandica*.

Each subtidal site covers an area of approximately 400 m^2, and is marked by subsurface buoys attached to anchor weights. This is a smaller area than that occupied by the intertidal sites, principally due to the practical limitations of sample collection. In addition, the medium-scale (i.e., 10 - 100 m) variation in community composition is less apparent in subtidal than intertidal environments. Subtidal sites were sampled at six-monthly intervals, (i.e., in October of 1994 and April of 1995) rather than three-monthly as at the intertidal sites. The longer time interval between samplings at the subtidal sites is due to the fact that the major reason for sampling the subtidal sites was to monitor the *Atrina zelandica*. We believe that monitoring these animals and their associated communities every six months should be a sufficient length of time to detect change.

Each site was located at the surface via a combination of GPS and visual line-of-sight bearings and a weight with a line attached dropped to the harbour floor. Core samples (10 cm diameter, 16 cm deep) were collected randomly by SCUBA divers within a 10 m radius of the weight. Samples were processed as described for those from the intertidal sites (see above).

Estimates of size and density of the horse mussel (*Atrina zelandica*) at each subtidal site were obtained using visual methods. Quadrats (0.25 m^2) were placed on the harbour floor, and the number and sizes (measured as maximum shell width) of the mussels contained in each quadrat were recorded. The number of quadrats sampled at each site on each occasion are given in Appendix 3. On the second sampling occasion, several 50 m transects of the mussels and their associated fauna were videotaped at each site. Information gained from the video was used to supplement the quadrat data and to provide a visual archive of the community associated with the horse mussel beds.

4 Results and Discussion

4.1 Intertidal Sites

4.1.1 Results of monitoring

The densities of the monitored taxa found between July 1994 and April 1995 at each of the intertidal sites are given in Appendix 1 and summarised in Table 1. Of the 19 taxa recommended for monitoring in Mahurangi Harbour, at least 14 were collected at each site at some time in this first year of sampling (Table 1). Not much can be said about variations in abundance of the taxa which occurred in low numbers at the intertidal sites at this early stage in the monitoring programme. However, the crab *Macrophthalmus hirtipes* was collected at all sites in this first year of sampling. *Macrophthalmus* never reached densities of more than 1 core $^{-1}$*, but its presence was consistent. Crab burrows were observed at all monitored sites. Common species (i.e., taxa for which we found high (> 10 core^{-1}) or moderate (1 - 10 core^{-1}) densities; see Table 1) are discussed below:

4.1.1.1 **Cowans Bay**

The Cowans Bay monitoring site is very muddy, and is situated adjacent to a large oyster farm, in the North-West of Mahurangi Harbour (Fig. 1).

Cossura sp. was the most abundant taxon at Cowans Bay on each sampling occasion. This polychaete accounted for between 48 and 75 % (in July 1994 and April 1995 respectively) of all monitored individuals collected at this site during the year, and numbers were high (i.e., > 10 core $^{-1}$) on each occasion. The polychaete *Heteromastus filiformis* and the bivalve *Arthritica bifurca* were also common at this site. An average of more than 10 *Heteromastus* were found per core during July and October of 1994 and January 1995, but this polychaete was absent on the final sampling date (April 1995). Densities of *Arthritica* were high during January 1995 (13.4 core $^{-1}$) and moderate during the rest of the year (i.e., July 1994 = 7.5 core $^{-1}$; October 1994 = 2 core $^{-1}$; April 1995 = 1.4 core $^{-1}$). The amphipod *Torridoharpinia hurleyi* and Polydorid polychaetes were also common; they were found in moderate abundances on all but one date (April 1995), when their densities were low or absent, respectively. The bivalve *Nucula hartvigiana* was found in moderate densities on two of the four sampling occasions, while the polychaete *Aricidea* sp. and Nemerteans were moderately abundant on only one date.

* number core $^{-1}$ throughout this report refers to a mean value, calculated by: sum of individuals collected in all cores/12

Table 1

Monitored species found at each of the 5 intertidal sites in the Mahurangi Harbour from July 1994 to April 1995. Taxa were assigned an 'L' (< 1 individual per core), 'M' (1 – 10 individuals per core) or 'H' (> 10 individuals per core) if they recorded this level of abundance on any sampling occasion throughout this time period. Site abbreviations are as follows: CB = Cowans Bay; HL = Hamilton Landing; JB = Jamieson Bay; MH = Mid harbour; TK = Te Kapa Inlet

	Site				
Taxa	**CB**	**HL**	**JB**	**MH**	**TK**
Aonides oxycephala	-	-	M	L	-
Aquilaspio aucklandica	L	M	M	L	M
Aricidea sp.	M	M	M	M	M
Arthritica bifurca	H	M	L	M	M
Austrovenus stutchburyi	L	H	M	L	H
Cossura sp.	H	M	M	H	H
Heteromastus filiformis	H	M	M	H	H
Macomona liliana	L	M	M	M	M
Macrophthalmus hirtipes	L	L	L	L	L
Nemerteans	M	L	M	M	L
Notoacmea sp.	-	-	L	-	M
Nucula hartvigiana	M	M	H	H	H
Oligochaetes	L	L	M	L	L
Owenia fusiformis	-	-	L	-	-
Paracalliope novizealandiae	-	M	L	-	L
Perinereis nuntia	-	L	L	L	-
Polydorids	M	M	H	M	M
Scoloplos cylindrifer	L	M	-	-	L
Torridoharpinia hurleyi	M	L	M	M	M
Number of taxa	14	16	18	15	16

In the 1993 survey, the area occupied by Cowans Bay was characterised as polychaete dominated with muddy substrates (Cummings et al. 1994). *Heteromastus filiformis*, *Aricidea* sp., and *Cossura* sp., were amongst the most dominant taxa at that time. *Cossura* sp. was the most dominant taxa in this first year of monitoring.

4.1.1.2 Hamilton Landing

Hamilton Landing is the northern most monitored site, and is situated at the junction of Dawsons Creek and the main channel (Fig. 1). The substrate at this site is extremely muddy, and often smells of sewage.

The cockle *Austrovenus stutchburyi* was the dominant taxon at Hamilton Landing on all sampling dates. Densities of this bivalve were always high, ranging from 16 core $^{-1}$ in October 1994, to 10 core $^{-1}$ during April 1995. The polychaetes *Cossura* sp. and Polydorids, and the bivalves *Arthritica bifurca* and *Macomona liliana* were also common at this site, all exhibiting densities of more than 1 core $^{-1}$ on each sampling occasion. The polychaete *Heteromastus filiformis* was found in moderate (July and October 1994) to low (January 1995) numbers at this site and was absent in April 1995. The bivalve *Nucula hartvigiana* was moderately abundant on two of the four sampling occasions; densities of the polychaetes *Aquilaspio aucklandica*, *Aricidea* sp. and *Scoloplos cylindrifer* and the amphipod *Paracalliope novizealandia*e were moderate on only one occasion.

The 1993 survey characterised this area of the harbour as polychaete dominated (i.e., *Heteromastus filiformis*, *Aricidea* sp., and *Cossura* sp.) with muddy substrates. While these taxa were still collected in 1994/95 (in moderate - low densities), the bivalve *Austrovenus stutchburyi* was the most dominant taxa. During the 1993 survey, *Austrovenus* was collected in very low numbers (see Appendix 1 in Cummings et al. 1994).

4.1.1.3 Jamieson Bay

The monitoring site at Jamieson Bay occupies almost the entire bay. The substrate varies from mud to shelly to stony. There is a small boat mooring area immediately out from the bay.

The Jamieson Bay site was dominated by the bivalve *Nucula hartvigiana* and Polydorid polychaetes. Densities of *Nucula hartvigiana* were consistently high at this site, and ranged from 12 core $^{-1}$ (October 1994) to 27 core $^{-1}$ (January 1995). Polydorid abundance was more variable; these polychaetes occurred in very high numbers in July (93 core $^{-1}$) and October (27 core $^{-1}$) of 1994, decreased in January 1995 (1 core $^{-1}$) and increased again in April 1995 (16 core $^{-1}$). Densities of *Macomona liliana*, *Cossura* sp., and the amphipod *Torridoharpinia hurleyi* were consistently between 1 - 10 core $^{-1}$ throughout the year. The bivalve *Austrovenus stutchburyi* occurred in moderate densities on two of the four sampling dates. The polychaetes *Aonides oxycephala*, *Aquilaspio aucklandica*, *Aricidea* sp. and *Heteromastus filiformis*, and Nemerteans and Oligochaetes all occurred in moderate densities at this site on only one sampling date.

The 1993 survey characterised Jamieson Bay as bivalve dominated (i.e., *Austrovenus stutchburyi*, *Nucula hartvigiana*, *Macomona liliana*; with the polychaete *Aquilaspio aucklandica* also amongst the dominant taxa) with sandy substrates. In 1994/95, the bivalve *Nucula hartvigiana* and Polydorid polychaetes were the most abundant taxa, and moderate (1 - 10 core^{-1}) densities of *Austrovenus stutchburyi*, *Macomona liliana* and *Aquilaspio aucklandica* were also observed. Numbers of Polydorids were low at this site in the 1993 survey (see Appendix 1 in Cummings et al. 1994)

4.1.1.4 Mid harbour

This site is situated on the eastern side of the harbour, north of Grants Island (Fig. 1), and has a sand-mud substrate.

The bivalve *Nucula hartvigiana* was the dominant taxon at the Mid harbour site on all but the first sampling date. On the January and April 1995 sampling dates this bivalve was found in very high numbers (45 and 28 core $^{-1}$, respectively). Densities on the first 2 dates were moderate (6 - 10 core $^{-1}$, respectively). In July 1994, the site was dominated by *Heteromastus filiformis* (15 core $^{-1}$); this polychaete was found in moderate densities in October 1994 and January 1995, and was absent in April 1995. Abundance of the polychaete *Cossura* sp. was high (i.e., > 10 core $^{-1}$) in July 1994 and January 1995, and moderate on the remaining dates. *Cossura* sp. was the second most abundant taxon on all sampling occasions. Densities of the bivalves *Arthritica bifurca* and *Macomona liliana* were moderate throughout the year. Polydorid polychaetes were found in moderate densities on all sampling occasions except January 1995, when its densities were low. A few species (i.e., the polychaete Aricidea sp., the amphipod *Torridoharpinia hurleyi*, and Nemerteans) were found in moderate densities on only one occasion at this site.

The 1993 survey characterised the Mid harbour area of Mahurangi Harbour as bivalve dominated (i.e., *Austrovenus stutchburyi*, *Nucula hartvigiana,* with the polychaete *Aquilaspio aucklandica also* dominant) with muddy substrates. *Nucula* and *Heteromastus filiformis* dominated this site during 1994/95.

4.1.1.5 Te Kapa Inlet

The Te Kapa Inlet monitoring site is situated in the eastern most inhabited bay of the Inlet. This site is unusual in that half of it has sandy substrate, while the other half is muddy. When sampling this site, we noted which substrate type each core was collected from.

The relative abundances of different taxa at the Te Kapa Inlet site were generally more similar than at the other intertidal sites. Instead of one taxon being obviously numerically dominant, the four most abundant species accounted for between 11 and 29 % of the total number of individuals collected. The bivalve *Austrovenus stutchburyi* was the most abundant taxon on all but the January 1995 sampling date. Numbers of this bivalve were high on the first two sampling dates (17 and 18 core $^{-1}$ respectively) and moderate on the latter two dates (8 core $^{-1}$). *Heteromastus filiformis* abundances were high (13 - 21 core $^{-1}$) on all but the April 1995 sampling occasion, when numbers dropped below 1 core $^{-1}$. *Cossura* sp. and *Nucula hartvigiana* densities were high on only one of the 4 sampling occasions, and moderate on the remaining dates. *Aquilaspio aucklandica*, Polydorids and *Macomona liliana* were all found in moderate densities throughout the year. *Aricidea* sp. was collected in moderate abundances on all but the April 1995 sampling occasion, when densities of this polychaete were low.

Numbers of the bivalve *Arthritica bifurca* and the limpet *Notoacmea* sp. were moderate on two of the four sampling occasions, while the amphipod *Paracalliope novizealandiae* was found in medium densities on only one date.

This area of Te Kapa Inlet was characterised by the 1993 survey as bivalve dominated (i.e., dominant taxa were *Austrovenus stutchburyi*, *Nucula hartvigiana*, *Macomona liliana*, and the polychaete *Aquilaspio aucklandica*) with sandy substrates. In 1994/95, these taxa were all collected in high to moderate abundances. The polychaetes *Heteromastus filiformis* and *Cossura* sp. were also common. This difference will be partially explained by the fact that the monitoring site covers two substrate types, while the 1993 survey only sampled the 'sand' area.

4.1.2 General Patterns

4.1.2.1 Temporal patterns in abundance

Because data have so far been collected only on four occasions over a one year time period, it is inappropriate to discuss temporal patterns in abundance of the monitored species. However, there appear to be some wide-spread patterns apparent even at this early stage in the monitoring programme. The polychaete Heteromastus filiformis showed a decrease in abundance at all sites in April 1995. Polydorid polychaetes were most abundant during July 1994 at all sites except Te Kapa Inlet. The bivalve Nucula hartvigiana exhibited its highest densities in January 1995 at all but the Jamieson Bay site. Macomona liliana abundances were highest during July 1994 and lowest in April 1995 at all sites except Mid harbour.

4.1.2.2 Survey vs. 1994/95 monitoring programme

Differences can be seen between the dominant taxa recorded in the 1993 survey and in the first year of monitoring at each of the sites. These differences can be attributed to two factors. Firstly, each of the monitoring sites covers a much larger area than each site sampled in the 1993 survey. Secondly, the survey was conducted on one occasion only, two years before the monitoring programme began. However, they do suggest that species abundances in Mahurangi Harbour may fluctuate considerably. The recommended list of species to be monitored was compiled based on the 1993 survey results. Taxa chosen included taxa such as predators, which potentially influence the structure and function of the community, species which occupy a variety of niches (e.g., deposit and suspension feeders), 'prey' species (i.e., taxa consumed by humans, birds, or fish), and taxa which respond to disturbance and pollution stress (Cummings et al. 1994). Abundant species, as well as rarer ones were included. The 'non-monitored' taxa found during processing of the 1994/95 samples were collected in the 1993 survey, but at that time were not considered worthy of inclusion on this list.

While the number of individuals collected at the Hamilton Landing site was relatively consistent between sampling dates, this was not the case for the remaining sites (Table 2). We also examined the total numbers of individuals of taxa not routinely monitored (Table 2). Similar variation was noted even after considering numbers of non-monitored taxa. This is to be expected and is not considered to be of concern, as only one year of data has been collected, and temporal variation is expected. Several years of data are needed to separate short-term variation from longer-term trends in abundance, and to identify trends which may potentially be due to some human impact. The total numbers of individuals recorded at the different Manukau Harbour biological monitoring sites is also variable (Hewitt et al. 1994). Whilst identifying samples over the next year of monitoring, we will count the number of non-monitored individuals collected from each site, it may be appropriate to review the list of monitored taxa in the future. In fact, a change to the list of taxa monitored in Manukau Harbour was recently made (Hewitt et al. 1994). At this stage, however, we recommend no change to this list in Mahurangi Harbour.

Table 2

Total number of individuals of all monitored taxa collected at each of the intertidal sites on each sampling occasion. Total number of individuals of non moitored taxa are shown in parentheses

	July '94	October '94	January '95	April '95
Cowans Bay	672 (212)	853 (122)	1109 (190)	178 (36)
Hamilton Landing	489 (112)	468 (48)	342 (51)	256 (58)
Jamieson Bay	1481 (376)	952 (595)	497 (205)	581 (184)
Mid harbour	550 (96)	310 (74)	845 (46)	475 (43)
Te Kapa Inlet	800 (150)	795 (173)	872 (109)	336 (81)

The Manukau Harbour biological monitoring programme currently being conducted by NIWA for ARC Environment has been running since 1987. The monitored sites in Manukau Harbour have shown relative consistency in terms of community composition over the period of the study (Turner et al. in press). Mahurangi Harbour is a more truly estuarine system than Manukau Harbour in terms of freshwater input, and the variability in taxa and in their abundances could be due to the movement of the salt wedge up and down the harbour. However, Manukau Harbour species' abundances are also quite variable in at shorter time scales; the relative densities of the more dominant taxa fluctuate from year to year due to cycles in abundance (e.g., see Hewitt et al. 1994). More data are needed for Mahurangi Harbour to determine whether the observed fluctuations in taxa abundances continue. In both harbours, these types of comparisons do point to the importance of collecting appropriate time series data to identify trends in the ecological condition of the harbour.

The community classification map constructed for Mahurangi Harbour from the 1993 survey results (see Cummings et al. 1994) reveals some differences dependent on the level of taxonomic classification when compared to the results of the first year of this monitoring programme. The Mid Harbour, Jamieson Bay and Te Kapa Inlet sites were all classified as bivalve dominated (predominantly Austrovenus stutchburyi) in 1993, and this is still true. However, at the Mid harbour and Jamieson Bay sites, the actual bivalve species dominant was Nucula hartvigiana rather than Austrovenus. Cowans Bay and Hamilton Landing were both classified as polychaete dominated in the 1993 survey. This is still true for Cowans Bay, although the dominant polychaete is different to that collected in 1993. The most dominant taxa at Hamilton Landing in 1994/95 was a bivalve (Austrovenus). These changes reflect, not only biological variation, but also the comparison between data collected using different sampling strategies, and therefore emphasise the importance of the scale and intensity of sampling.

4.2 Subtidal Sites

The three subtidal sites are situated adjacent to the main harbour channel, in approximately 6 - 10 m of water (Fig. 1). Site A, the outermost site, is immediately south of Casnell Island at the entrance to Te Kapa Inlet. Site B is situated immediately adjacent to a large boat mooring area, north of Scotts Landing. The innermost site, Site C, is on the eastern side of the harbour, south of Grants Island.

4.2.1 Atrina zelandica

Little is known about the life cycle and ecology of the horse mussel *Atrina zelandica. Atrina* live in a variety of habitats; they occur in both muddy and sandy sediments, and are found on open coasts as well as in harbours. They appear to be prolific and fast growing: they are now prevalent in the mid-to-outer Mahurangi Harbour, but conversations with local people indicate they were rare 10 - 15 years ago. *Atrina* form extensive, often dense beds, characterised by fine sediments, with associated macrofauna such as sponges, ascidians, bryozoans, and sea cucumbers. They live partially buried in the sediment, with approximately the top third of their shell protruding above the surface. *Atrina* are likely to affect the flow conditions near the harbour floor and influence the stability, deposition and transportation of sediment. The increased habitat complexity they create on the sea floor may provide an important nursery/refuge area for fish. We have observed large numbers of small fish and juveniles of other fish species (e.g., snapper) around horse mussel beds throughout the harbour. *Atrina* influence the ecology of their local environment by providing shelter, habitats and settling/attachment surfaces for organisms which otherwise could not survive in such locations (e.g., fish, sea cucumbers, sponges and soft corals). *Atrina* are filter feeders, and are likely to be negatively effected by large scale depositions of sediment. The potentially important ecological role of *Atrina* shows the value of their continued monitoring.

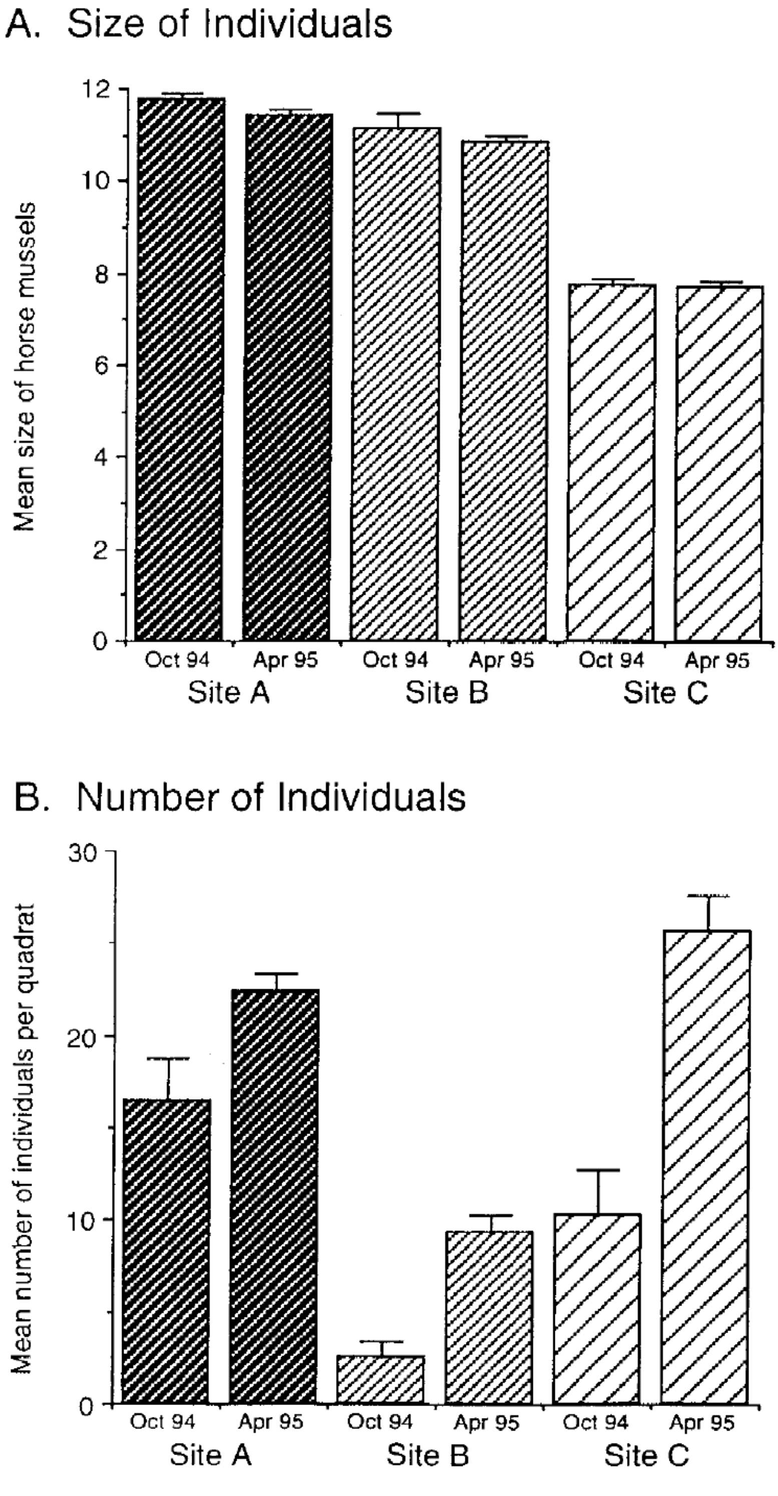
By monitoring the sizes of the horse mussels found at each of the subtidal sites we hope to generate information on their growth rates. Data collected so far in the monitoring programme has shown similar sized *Atrina zelandica* at Sites A and B (approx. 11 cm; Fig 2A), while at Site C (the inner harbour site) the mussels were considerably smaller (average = 7 cm; Fig. 2A). This may reflect different age classes in different locations, or variations in growth rate associated with, for example, differences in sedimentation regimes or food supply. The sizes of the *Atrina* recorded at a particular site were consistent between sampling occasions.

The densities of the mussels found at the monitored sites also showed differences between sites (Fig 2B). During October of 1994, the highest densities were found at Site A. During April of 1995, however, Site C had the greatest average number of *Atrina* per quadrat. Site B exhibited the lowest *Atrina* densities on both sampling occasions (Fig 2B). *Atrina* densities were considerably higher during April 1995 at each site (Fig. 2B).

Video footage taken in April 1995 showed large burrows (probably crab and polychaete burrows) were common between the *Atrina zelandica* at each site. However, there were visual differences between the subtidal sites. At Site A many *Atrina* had sponges and soft corals growing on their shells. Sea cucumbers nudibranchs, starfish and bullies were also noted. Video footage of Site B showed that the majority of the mussels were dead. The dead *Atrina* were either lying on the sediment surface, or were still in situ but damaged and filled with sediment. In October 1994 the majority of the *Atrina* were alive. It is possible that the *Atrina* died in the interval between sampling occasions. The shells of the *Atrina* at Site B also had soft corals and sponge growing on them, but the instance and extent of this growth was much higher than at Site A. Sea cucumbers, nudibranchs and large, free standing sponge colonies were also noted at this site. At Site C, very few of the mussels had any associated sponge or soft coral growth. The surrounding sediments were littered with dead shell matter, and empty, intact *Maoricolpus roseus* shells. *Atrina* at this site appeared more patchy, and in the areas of sediment between the mussels, crab tracks were evident. Nudibranchs were also noted.

Figure 2

Mean size (± standard error) and number (± standard error) of *Atrina zelandica* in a 0.25m quadrat at each subtidal site in October 1994 and April 1995. See Appendix 3 for data set.



4.2.2 Small macrofauna

Few taxa were collected at the subtidal sites when compared with the intertidal sites, and those taxa collected were found in relatively low numbers. The highest number of individuals collected all year was 6.5 per core (*Torridoharpinia hurleyi* at Site A in April 1995). Despite the low numbers of macrofauna found at the subtidal sites, only three of the taxa recommended for monitoring in our previous report were not collected at all (i.e., *Aricidea* sp., Corophidae-complex and Cumacean sp. 4) (Table 3). The actual abundances of taxa monitored at the subtidal sites on each sampling date are given in Appendix 2. As the subtidal sites have only been sampled on two occasions, any comments on the relative abundances of particular taxa within and between sites would be premature.

Table 3

Monitored species found at each of the 3 subtidal sites in Mahurangi Harbour during October 1994 and April 1995. Taxa were assigned an 'L' if they occurred in average abundances of < 1 individual per core, or an 'M" if their average abundance was between 1 and 10 individuals per core.

Taxa	Site A		Site B		Site C	
	Oct '94	Apr '95	Oct '94	Apr '95	Oct '94	Apr '95
Aricidea sp.	-	-	-	-	-	-
Armandia maculata	-	-	L	-	L	-
Arthritica bifurca	L	-	L	L	M	M
Cirratulids	L	-	M	-	L	-
Corophidae - complex	-	-	-	-	-	-
Cumacean sp.4	-	-	-	-	-	-
Nucula hartvigiana	L	M	-	M	L	M
Oligochaetes	L	-	-	-	-	-
Polydorids	L	-	-	-	L	L
Prionospio sp.	M	L	L	-	M	L
Tawera spissa	-	-	-	-	L	-
Theora lubrica	M	L	M	M	L	L
Torridoharpinia hurleyi	M	M	L	-	M	L
Number of taxa	8	4	6	3	9	6

The total number of individuals of monitored taxa collected from Site B was considerably lower than at the two remaining sites on each sampling date (Table 4). Numbers of individuals were consistent between sampling dates at sites A and B. However, the total number of individuals collected at Site C in April 1995 was less than half that recorded during October 1994 (Table 4). As at the intertidal sites, the total number of non-monitored individuals collected during this first year of monitoring were counted (Table 4). Unlike the intertidal sites, only low numbers of non-monitored individuals were collected (Table 4).

Table 4

Total number of individuals of all monitored taxa collected at each of the subtidal sites on each sampling occasion. Total number of individuals of non-monitored taxa are shown in parentheses.

	Oct '94	Apr '95
Site A	127 (8)	103 (4)
Site B	53 (9)	37 (3)
Site C	139 (29)	52 (8)

5 Conclusions

In summary, this report has:

1. Presented data collected at intertidal and subtidal monitoring sites in Mahurangi Harbour in 1994/95;
2. Described the taxa collected at each of the monitored sites and their relative abundances;
3. Shown that some species not included in the list of taxa to be monitored following the 1993 survey occurred in moderate abundances during 1994/95, suggesting that taxa in Mahurangi Harbour may exhibit large fluctuations in abundance;
4. Suggested that a review of the list of monitored taxa at the intertidal sites may be appropriate once more data have been collected;
5. Provided information on the size and density of the horse mussel (*Atrina zelandica*) beds and their associated macrofauna at each of the subtidal monitoring sites.

6 Acknowledgements

Mike Taylor, Paul Wilkinson, Carly Milburn, Janna Jansen, David Foster, Gail Dickie and Tania Sherburn helped in sorting samples. ARC Environment provided help with sample collection on one sampling occasion.

7 References

Cummings, V.J., Pridmore, R.D., Thrush, S.F., Hewitt, J.E. 1994. Mahurangi Harbour soft-sediment communities: predicting and assessing the effects of harbour and catchment development. Unpublished report prepared for the Auckland Regional Council. NIWA Consultancy Report No. ARC222. 42 p.

Hewitt, J.E., Thrush, S.F., Pridmore, R.D., Cummings, V.J. 1994. Ecological monitoring programme for Manukau Harbour: analysis and interpretation of data collected October 1987 to February 1993. Unpublished report prepared for the Auckland Regional Council. NIWA Ecosystems Consultancy Report No. ARC120/5. 81 p.

Lettenmaier, D.P., Conquest, L.L., Hughes, J.P. 1982. Routine streams and rivers water quality trend monitoring review. Charles W. Harris Hydraulics Laboratory Technical Report No. 75, University of Seattle, Washington. 223 p.

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.

Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Roper, D.S. 1988. Design of an ecological monitoring programme for the Manukau Harbour. Unpublished report prepared for the Auckland Regional Water Board. Water Quality Centre Consultancy Report No. 7099. 62 p.

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(1): 31 - 41.

Turner, S.J., Thrush, S.F., Pridmore, R.D., Hewitt, J.E., Cummings, V.J., Maskery, M.R. in press. Are soft-sediment communities stable? An example from a windy harbour. Marine Ecology Progress Series.

Appendix 1

Summary of temporal results at the intertidal sites

TAXA	SITE[1]	TIME	TOTAL[2]	MEDIAN	RANGE[3]	MEAN
Aonides oxycephala	CB	Jul '94	0	0.0	0	0.00
Aonides oxycephala	CB	Oct '94	0	0.0	0	0.00
Aonides oxycephala	CB	Jan '95	0	0.0	0	0.00
Aonides oxycephala	CB	Apr '95	0	0.0	0	0.00
Aonides oxycephala	HL	Jul '94	0	0.0	0	0.00
Aonides oxycephala	HL	Oct '94	0	0.0	0	0.00
Aonides oxycephala	HL	Jan '95	0	0.0	0	0.00
Aonides oxycephala	HL	Apr '95	0	0.0	0	0.00
Aonides oxycephala	JB	Jul '94	0	0.0	0	0.00
Aonides oxycephala	JB	Oct '94	10	0.0	8	0.83
Aonides oxycephala	JB	Jan '95	23	0.0	22	1.92
Aonides oxycephala	JB	Apr '95	9	0.0	6	0.75
Aonides oxycephala	MH	Jul '94	0	0.0	0	0.00
Aonides oxycephala	MH	Oct '94	2	0.0	1	0.17
Aonides oxycephala	MH	Jan '95	1	0.0	1	0.08
Aonides oxycephala	MH	Apr '95	0	0.0	0	0.00
Aonides oxycephala	TK	Jul '94	0	0.0	0	0.00
Aonides oxycephala	TK	Oct '94	0	0.0	0	0.00
Aonides oxycephala	TK	Jan '95	0	0.0	0	0.00
Aonides oxycephala	TK	Apr '95	0	0.0	0	0.00
Aquilaspio aucklandica	CB	Jul '94	1	0.0	1	0.08
Aquilaspio aucklandica	CB	Oct '94	11	1.0	2	0.92
Aquilaspio aucklandica	CB	Jan '95	4	0.0	2	0.33
Aquilaspio aucklandica	CB	Apr '95	2	0.0	1	0.17
Aquilaspio aucklandica	HL	Jul '94	4	0.0	1	0.33
Aquilaspio aucklandica	HL	Oct '94	13	1.0	3	1.08
Aquilaspio aucklandica	HL	Jan '95	6	0.0	3	0.50
Aquilaspio aucklandica	HL	Apr '95	4	0.0	2	0.33
Aquilaspio aucklandica	JB	Jul '94	3	0.0	1	0.25
Aquilaspio aucklandica	JB	Oct '94	31	2.0	8	2.58
Aquilaspio aucklandica	JB	Jan '95	10	0.0	7	0.83
Aquilaspio aucklandica	JB	Apr '95	3	0.0	2	0.25
Aquilaspio aucklandica	MH	Jul '94	1	0.0	1	0.08
Aquilaspio aucklandica	MH	Oct '94	0	0.0	0	0.00
Aquilaspio aucklandica	MH	Jan '95	1	0.0	1	0.08
Aquilaspio aucklandica	MH	Apr '95	0	0.0	0	0.00
Aquilaspio aucklandica	TK	Jul '94	42	2.0	14	3.50
Aquilaspio aucklandica	TK	Oct '94	45	2.5	10	3.75
Aquilaspio aucklandica	TK	Jan '95	70	4.0	22	5.83
Aquilaspio aucklandica	TK	Apr '95	46	2.0	15	3.82
Aricidea sp.	CB	Jul '94	24	1.0	10	2.00
Aricidea sp.	CB	Oct '94	6	0.0	4	0.50
Aricidea sp.	CB	Jan '95	8	0.0	3	0.67
Aricidea sp.	CB	Apr '95	0	0.0	0	0.00
Aricidea sp.	HL	Jul '94	19	1.0	6	1.58
Aricidea sp.	HL	Oct '94	1	0.0	1	0.08
Aricidea sp.	HL	Jan '95	0	0.0	0	0.00

[1] Site abbreviations are as follows: CB = Cowans Bay; HL = Hamilton Landing; JB = Jamieson Bay; MH = Mid harbour; TK = Te Kapa Inlet.

[2] Total number is the total number of individuals found in 12 samples. Calculated by mean x 12.

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

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Aricidea sp.	HL	4	1	0.0	1	0.08
Aricidea sp.	JB	Jul '94	0	0.0	0	0.00
Aricidea sp.	JB	Oct '94	46	2.0	22	3.83
Aricidea sp.	JB	Jan '95	0	0.0	0	0.00
Aricidea sp.	JB	Apr '95	0	0.0	0	0.00
Aricidea sp.	MH	Jul '94	12	1.0	2	1.00
Aricidea sp.	MH	Oct '94	0	0.0	0	0.00
Aricidea sp.	MH	Jan '95	6	0.0	4	0.50
Aricidea sp.	MH	Apr '95	0	0.0	0	0.00
Aricidea sp.	TK	Jul '94	117	10.0	18	9.75
Aricidea sp.	TK	Oct '94	60	4.0	19	5.00
Aricidea sp.	TK	Jan '95	96	8.5	13	8.00
Aricidea sp.	TK	Apr '95	1	0.0	1	0.09
Arthritica bifurca	CB	Jul '94	90	8.0	12	7.50
Arthritica bifurca	CB	Oct '94	24	1.0	9	2.00
Arthritica bifurca	CB	Jan '95	161	12.0	25	13.42
Arthritica bifurca	CB	Apr '95	17	1.0	8	1.42
Arthritica bifurca	HL	Jul '94	31	1.0	13	2.58
Arthritica bifurca	HL	Oct '94	28	2.0	6	2.33
Arthritica bifurca	HL	Jan '95	32	1.5	11	2.67
Arthritica bifurca	HL	Apr '95	35	0.5	28	2.92
Arthritica bifurca	JB	Jul '94	0	0.0	0	0.00
Arthritica bifurca	JB	Oct '94	9	0.0	8	0.75
Arthritica bifurca	JB	Jan '95	3	0.0	1	0.25
Arthritica bifurca	JB	Apr '95	2	0.0	1	0.17
Arthritica bifurca	MH	Jul '94	30	2.0	7	2.50
Arthritica bifurca	MH	Oct '94	24	1.0	6	2.00
Arthritica bifurca	MH	Jan '95	87	5.0	20	7.25
Arthritica bifurca	MH	Apr '95	15	0.0	5	1.25
Arthritica bifurca	TK	Jul '94	7	0.0	2	0.58
Arthritica bifurca	TK	Oct '94	3	0.0	3	0.25
Arthritica bifurca	TK	Jan '95	21	0.0	7	1.75
Arthritica bifurca	TK	Apr '95	12	0.0	5	1.00
Austrovenus stutchburyi	CB	Jul '94	0	0.0	0	0.00
Austrovenus stutchburyi	CB	Oct '94	0	0.0	0	0.00
Austrovenus stutchburyi	CB	Jan '95	1	0.0	1	0.08
Austrovenus stutchburyi	CB	Apr '95	0	0.0	0	0.00
Austrovenus stutchburyi	HL	Jul '94	156	9.5	27	13.00
Austrovenus stutchburyi	HL	Oct '94	192	13.5	22	16.00
Austrovenus stutchburyi	HL	Jan '95	174	15.5	22	14.50
Austrovenus stutchburyi	HL	Apr '95	118	9.0	20	9.83
Austrovenus stutchburyi	JB	Jul '94	8	0.0	3	0.67
Austrovenus stutchburyi	JB	Oct '94	23	0.0	8	1.92
Austrovenus stutchburyi	JB	Jan '95	13	0.5	6	1.08
Austrovenus stutchburyi	JB	Apr '95	5	0.0	4	0.42
Austrovenus stutchburyi	MH	Jul '94	0	0.0	0	0.00
Austrovenus stutchburyi	MH	Oct '94	0	0.0	0	0.00
Austrovenus stutchburyi	MH	Jan '95	1	0.0	1	0.08
Austrovenus stutchburyi	MH	Apr '95	1	0.0	1	0.08
Austrovenus stutchburyi	TK	Jul '94	202	14.5	41	16.83
Austrovenus stutchburyi	TK	Oct '94	214	11.5	48	17.83
Austrovenus stutchburyi	TK	Jan '95	99	2.5	31	8.25
Austrovenus stutchburyi	TK	Apr '95	92	3.0	25	7.64
Cossura sp.	CB	Jul '94	323	24.0	39	26.92
Cossura sp.	CB	Oct '94	607	47.5	80	50.58
Cossura sp.	CB	Jan '95	633	54.0	51	52.75
Cossura sp.	CB	Apr '95	135	7.0	34	11.25
Cossura sp.	HL	Jul '94	67	6.0	13	5.58
Cossura sp.	HL	Oct '94	53	4.0	8	4.42

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Cossura sp.	HL	Jan '95	32	2.5	6	2.67
Cossura sp.	HL	Apr '95	39	3.0	13	3.25
Cossura sp.	JB	Jul '94	41	3.0	11	3.42
Cossura sp.	JB	Oct '94	29	2.0	6	2.42
Cossura sp.	JB	Jan '95	29	1.5	11	2.42
Cossura sp.	JB	Apr '95	29	1.5	8	2.42
Cossura sp.	MH	Jul '94	134	8.5	25	11.17
Cossura sp.	MH	Oct '94	75	5.5	17	6.25
Cossura sp.	MH	Jan '95	133	12.0	13	11.08
Cossura sp.	MH	Apr '95	52	5.0	7	4.33
Cossura sp.	TK	Jul '94	36	2.0	14	3.00
Cossura sp.	TK	Oct '94	56	3.0	18	4.67
Cossura sp.	TK	Jan '95	143	10.0	31	11.92
Cossura sp.	TK	Apr '95	52	3.0	12	4.36
Heteromastus filiformis	CB	Jul '94	121	9.5	18	10.08
Heteromastus filiformis	CB	Oct '94	139	10.0	25	11.58
Heteromastus filiformis	CB	Jan '95	154	14.0	28	12.83
Heteromastus filiformis	CB	Apr '95	0	0.0	0	0.00
Heteromastus filiformis	HL	Jul '94	44	3.0	16	3.67
Heteromastus filiformis	HL	Oct '94	16	1.0	4	1.33
Heteromastus filiformis	HL	Jan '95	7	0.0	2	0.58
Heteromastus filiformis	HL	Apr '95	0	0.0	0	0.00
Heteromastus filiformis	JB	Jul '94	0	0.0	0	0.00
Heteromastus filiformis	JB	Oct '94	115	5.5	36	9.58
Heteromastus filiformis	JB	Jan '95	7	0.0	3	0.58
Heteromastus filiformis	JB	Apr '95	0	0.0	0	0.00
Heteromastus filiformis	MH	Jul '94	186	14.0	32	15.50
Heteromastus filiformis	MH	Oct '94	23	2.0	6	1.92
Heteromastus filiformis	MH	Jan '95	23	0.0	16	1.92
Heteromastus filiformis	MH	Apr '95	0	0.0	0	0.00
Heteromastus filiformis	TK	Jul '94	155	11.0	19	12.92
Heteromastus filiformis	TK	Oct '94	181	14.0	16	15.08
Heteromastus filiformis	TK	Jan '95	253	21.0	44	21.08
Heteromastus filiformis	TK	Apr '95	10	0.0	9	0.82
Macomona liliana	CB	Jul '94	8	0.5	3	0.67
Macomona liliana	CB	Oct '94	6	0.0	3	0.50
Macomona liliana	CB	Jan '95	7	0.0	3	0.58
Macomona liliana	CB	Apr '95	4	0.0	1	0.33
Macomona liliana	HL	Jul '94	28	2.0	7	2.33
Macomona liliana	HL	Oct '94	26	1.5	6	2.17
Macomona liliana	HL	Jan '95	27	2.0	5	2.25
Macomona liliana	HL	Apr '95	17	2.0	3	1.42
Macomona liliana	JB	Jul '94	76	3.5	14	6.33
Macomona liliana	JB	Oct '94	50	4.0	12	4.17
Macomona liliana	JB	Jan '95	36	2.0	5	3.00
Macomona liliana	JB	Apr '95	19	1.5	4	1.58
Macomona liliana	MH	Jul '94	17	1.5	3	1.42
Macomona liliana	MH	Oct '94	39	3.0	5	3.25
Macomona liliana	MH	Jan '95	33	3.0	4	2.75
Macomona liliana	MH	Apr '95	27	1.5	4	2.25
Macomona liliana	TK	Jul '94	47	5.0	7	3.92
Macomona liliana	TK	Oct '94	38	3.5	6	3.17
Macomona liliana	TK	Jan '95	33	3.0	6	2.75
Macomona liliana	TK	Apr '95	21	1.0	6	1.73
Macrophthalmus hirtipes	CB	Jul '94	0	0.0	0	0.00
Macrophthalmus hirtipes	CB	Oct '94	10	0.5	2	0.83
Macrophthalmus hirtipes	CB	Jan '95	10	0.5	4	0.83
Macrophthalmus hirtipes	CB	Apr '95	0	0.0	0	0.00
Macrophthalmus hirtipes	HL	Jul '94	2	0.0	1	0.17
Macrophthalmus hirtipes	HL	Oct '94	9	1.0	2	0.75

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Macrophthalmus hirtipes	HL	Jan '95	2	0.0	1	0.17
Macrophthalmus hirtipes	HL	Apr '95	2	0.0	1	0.17
Macrophthalmus hirtipes	JB	Jul '94	0	0.0	0	0.00
Macrophthalmus hirtipes	JB	Oct '94	1	0.0	1	0.08
Macrophthalmus hirtipes	JB	Jan '95	2	0.0	2	0.17
Macrophthalmus hirtipes	JB	Apr '95	1	0.0	1	0.08
Macrophthalmus hirtipes	MH	Jul '94	4	0.0	2	0.33
Macrophthalmus hirtipes	MH	Oct '94	2	0.0	1	0.17
Macrophthalmus hirtipes	MH	Jan '95	1	0.0	1	0.08
Macrophthalmus hirtipes	MH	Apr '95	0	0.0	0	0.00
Macrophthalmus hirtipes	TK	Jul '94	8	0.0	3	0.67
Macrophthalmus hirtipes	TK	Oct '94	2	0.0	1	0.17
Macrophthalmus hirtipes	TK	Jan '95	3	0.0	2	0.25
*Macrophthalmus hirtipes**	TK	Apr '95	1	0.0	1	0.09
Nemerteans	CB	Jul '94	17	1.0	4	1.42
Nemerteans	CB	Oct '94	1	0.0	1	0.08
Nemerteans	CB	Jan '95	6	0.0	2	0.50
Nemerteans	CB	Apr '95	0	0.0	0	0.00
Nemerteans	HL	Jul '94	6	0.0	2	0.50
Nemerteans	HL	Oct '94	4	0.0	3	0.33
Nemerteans	HL	Jan '95	2	0.0	1	0.17
Nemerteans	HL	Apr '95	0	0.0	0	0.00
Nemerteans	JB	Jul '94	4	0.0	2	0.33
Nemerteans	JB	Oct '94	14	0.5	4	1.17
Nemerteans	JB	Jan '95	4	0.0	2	0.33
Nemerteans	JB	Apr '95	3	0.0	3	0.25
Nemerteans	MH	Jul '94	19	2.0	4	1.58
Nemerteans	MH	Oct '94	1	0.0	1	0.08
Nemerteans	MH	Jan '95	0	0.0	0	0.00
Nemerteans	MH	Apr '95	0	0.0	0	0.00
Nemerteans	TK	Jul '94	10	1.0	2	0.83
Nemerteans	TK	Oct '94	10	0.5	3	0.83
Nemerteans	TK	Jan '95	7	0.0	3	0.58
Nemerteans	TK	Apr '95	0	0.0	0	0.00
Notoacmea sp.	CB	Jul '94	0	0.0	0	0.00
Notoacmea sp.	CB	Oct '94	0	0.0	0	0.00
Notoacmea sp.	CB	Jan '95	0	0.0	0	0.00
Notoacmea sp.	CB	Apr '95	0	0.0	0	0.00
Notoacmea sp.	HL	Jul '94	0	0.0	0	0.00
Notoacmea sp.	HL	Oct '94	0	0.0	0	0.00
Notoacmea sp.	HL	Jan '95	0	0.0	0	0.00
Notoacmea sp.	HL	Apr '95	0	0.0	0	0.00
Notoacmea sp.	JB	Jul '94	1	0.0	1	0.08
Notoacmea sp.	JB	Oct '94	5	0.0	5	0.42
Notoacmea sp.	JB	Jan '95	0	0.0	0	0.00
Notoacmea sp.	JB	Apr '95	1	0.0	1	0.08
Notoacmea sp.	MH	Jul '94	0	0.0	0	0.00
Notoacmea sp.	MH	Oct '94	0	0.0	0	0.00
Notoacmea sp.	MH	Jan '95	0	0.0	0	0.00
Notoacmea sp.	MH	Apr '95	0	0.0	0	0.00
Notoacmea sp.	TK	Jul '94	39	0.0	29	3.25
Notoacmea sp.	TK	Oct '94	12	0.0	5	1.00
Notoacmea sp.	TK	Jan '95	0	0.0	0	0.00
Notoacmea sp.	TK	Apr '95	0	0.0	0	0.00
Nucula hartvigiana	CB	Jul '94	5	0.0	2	0.42

* Note that this taxa name has been corrected from that recorded as "*Helice crassa*" in the 1993 survey (Cummings et al. 1994).

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Nucula hartvigiana	CB	Oct '94	10	0.0	5	0.83
Nucula hartvigiana	CB	Jan '95	49	4.0	5	4.08
Nucula hartvigiana	CB	Apr '95	13	0.5	3	1.08
Nucula hartvigiana	HL	Jul '94	14	0.0	7	1.17
Nucula hartvigiana	HL	Oct '94	6	0.0	4	0.50
Nucula hartvigiana	HL	Jan '95	39	0.5	23	3.25
Nucula hartvigiana	HL	Apr '95	4	0.0	3	0.33
Nucula hartvigiana	JB	Jul '94	174	15.0	22	14.50
Nucula hartvigiana	JB	Oct '94	152	11.5	32	12.67
Nucula hartvigiana	JB	Jan '95	329	27.0	46	27.42
Nucula hartvigiana	JB	Apr '95	270	21.5	52	22.50
Nucula hartvigiana	MH	Jul '94	74	3.0	27	6.17
Nucula hartvigiana	MH	Oct '94	118	9.0	20	9.83
Nucula hartvigiana	MH	Jan '95	549	40.5	49	45.75
Nucula hartvigiana	MH	Apr '95	345	26.0	46	28.75
Nucula hartvigiana	TK	Jul '94	86	5.0	28	7.17
Nucula hartvigiana	TK	Oct '94	123	4.0	35	10.25
Nucula hartvigiana	TK	Jan '95	107	6.5	31	8.92
Nucula hartvigiana	TK	Apr '95	81	1.0	25	6.73
Oligochaetes	CB	Jul '94	8	0.0	8	0.67
Oligochaetes	CB	Oct '94	3	0.0	2	0.25
Oligochaetes	CB	Jan '95	0	0.0	0	0.00
Oligochaetes	CB	Apr '95	0	0.0	0	0.00
Oligochaetes	HL	Jul '94	2	0.0	2	0.17
Oligochaetes	HL	Oct '94	0	0.0	0	0.00
Oligochaetes	HL	Jan '95	0	0.0	0	0.00
Oligochaetes	HL	Apr '95	0	0.0	0	0.00
Oligochaetes	JB	Jul '94	0	0.0	0	0.00
Oligochaetes	JB	Oct '94	32	0.0	29	2.67
Oligochaetes	JB	Jan '95	0	0.0	0	0.00
Oligochaetes	JB	Apr '95	0	0.0	0	0.00
Oligochaetes	MH	Jul '94	8	0.0	3	0.67
Oligochaetes	MH	Oct '94	0	0.0	0	0.00
Oligochaetes	MH	Jan '95	0	0.0	0	0.00
Oligochaetes	MH	Apr '95	0	0.0	0	0.00
Oligochaetes	TK	Jul '94	0	0.0	0	0.00
Oligochaetes	TK	Oct '94	2	0.0	1	0.17
Oligochaetes	TK	Jan '95	10	0.0	6	0.83
Oligochaetes	TK	Apr '95	0	0.0	0	0.00
Owenia fusiformis	CB	Jul '94	0	0.0	0	0.00
Owenia fusiformis	CB	Oct '94	0	0.0	0	0.00
Owenia fusiformis	CB	Jan '95	0	0.0	0	0.00
Owenia fusiformis	CB	Apr '95	0	0.0	0	0.00
Owenia fusiformis	HL	Jul '94	0	0.0	0	0.00
Owenia fusiformis	HL	Oct '94	0	0.0	0	0.00
Owenia fusiformis	HL	Jan '95	0	0.0	0	0.00
Owenia fusiformis	HL	Apr '95	0	0.0	0	0.00
Owenia fusiformis	JB	Jul '94	9	1.0	2	0.75
Owenia fusiformis	JB	Oct '94	5	0.0	2	0.42
Owenia fusiformis	JB	Jan '95	3	0.0	1	0.25
Owenia fusiformis	JB	Apr '95	3	0.0	2	0.25
Owenia fusiformis	MH	Jul '94	0	0.0	0	0.00
Owenia fusiformis	MH	Oct '94	0	0.0	0	0.00
Owenia fusiformis	MH	Jan '95	0	0.0	0	0.00
Owenia fusiformis	MH	Apr '95	0	0.0	0	0.00
Owenia fusiformis	TK	Jul '94	0	0.0	0	0.00
Owenia fusiformis	TK	Oct '94	0	0.0	0	0.00
Owenia fusiformis	TK	Jan '95	0	0.0	0	0.00
Owenia fusiformis	TK	Apr '95	0	0.0	0	0.00

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Paracalliope novizealandiae	CB	Jul '94	0	0.0	0	0.00
Paracalliope novizealandiae	CB	Oct '94	0	0.0	0	0.00
Paracalliope novizealandiae	CB	Jan '95	0	0.0	0	0.00
Paracalliope novizealandiae	CB	Apr '95	0	0.0	0	0.00
Paracalliope novizealandiae	HL	Jul '94	0	0.0	0	0.00
Paracalliope novizealandiae	HL	Oct '94	27	2.0	6	2.25
Paracalliope novizealandiae	HL	Jan '95	0	0.0	0	0.00
Paracalliope novizealandiae	HL	Apr '95	1	0.0	1	0.08
Paracalliope novizealandiae	JB	Jul '94	1	0.0	1	0.08
Paracalliope novizealandiae	JB	Oct '94	3	0.0	2	0.25
Paracalliope novizealandiae	JB	Jan '95	0	0.0	0	0.00
Paracalliope novizealandiae	JB	Apr '95	0	0.0	0	0.00
Paracalliope novizealandiae	MH	Jul '94	0	0.0	0	0.00
Paracalliope novizealandiae	MH	Oct '94	0	0.0	0	0.00
Paracalliope novizealandiae	MH	Jan '95	0	0.0	0	0.00
Paracalliope novizealandiae	MH	Apr '95	0	0.0	0	0.00
Paracalliope novizealandiae	TK	Jul '94	1	0.0	1	0.08
Paracalliope novizealandiae	TK	Oct '94	5	0.0	2	0.42
Paracalliope novizealandiae	TK	Jan '95	0	0.0	0	0.00
Paracalliope novizealandiae	TK	Apr '95	0	0.0	0	0.00
Perinereis nuntia	CB	Jul '94	0	0.0	0	0.00
Perinereis nuntia	CB	Oct '94	0	0.0	0	0.00
Perinereis nuntia	CB	Jan '95	0	0.0	0	0.00
Perinereis nuntia	CB	Apr '95	0	0.0	0	0.00
Perinereis nuntia	HL	Jul '94	0	0.0	0	0.00
Perinereis nuntia	HL	Oct '94	1	0.0	1	0.08
Perinereis nuntia	HL	Jan '95	0	0.0	0	0.00
Perinereis nuntia	HL	Apr '95	1	0.0	1	0.08
Perinereis nuntia	JB	Jul '94	1	0.0	1	0.08
Perinereis nuntia	JB	Oct '94	1	0.0	1	0.08
Perinereis nuntia	JB	Jan '95	0	0.0	0	0.00
Perinereis nuntia	JB	Apr '95	1	0.0	1	0.08
Perinereis nuntia	MH	Jul '94	1	0.0	1	0.08
Perinereis nuntia	MH	Oct '94	0	0.0	0	0.00
Perinereis nuntia	MH	Jan '95	0	0.0	0	0.00
Perinereis nuntia	MH	Apr '95	0	0.0	0	0.00
Perinereis nuntia	TK	Jul '94	0	0.0	0	0.00
Perinereis nuntia	TK	Oct '94	0	0.0	0	0.00
Perinereis nuntia	TK	Jan '95	0	0.0	0	0.00
Perinereis nuntia	TK	Apr '95	0	0.0	0	0.00
Polydorids	CB	Jul '94	36	3.0	9	3.00
Polydorids	CB	Oct '94	13	0.5	5	1.08
Polydorids	CB	Jan '95	14	1.0	3	1.17
Polydorids	CB	Apr '95	7	0.0	2	0.58
Polydorids	HL	Jul '94	115	7.5	19	9.58
Polydorids	HL	Oct '94	71	4.5	19	5.92
Polydorids	HL	Jan '95	20	1.5	4	1.67
Polydorids	HL	Apr '95	33	3.0	8	2.75
Polydorids	JB	Jul '94	1117	63.5	326	93.08
Polydorids	JB	Oct '94	329	26.0	65	27.42
Polydorids	JB	Jan '95	19	1.0	5	1.58
Polydorids	JB	Apr '95	202	13.0	33	16.83
Polydorids	MH	Jul '94	36	2.0	12	3.00
Polydorids	MH	Oct '94	22	1.0	7	1.83
Polydorids	MH	Jan '95	10	0.5	4	0.83
Polydorids	MH	Apr '95	30	2.0	6	2.50
Polydorids	TK	Jul '94	33	1.5	9	2.75
Polydorids	TK	Oct '94	38	2.5	8	3.17
Polydorids	TK	Jan '95	28	2.0	6	2.33

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Polydorids	TK	Apr '95	19	1.0	6	1.55
Scoloplos cylindrifer	CB	Jul '94	1	0.0	1	0.08
Scoloplos cylindrifer	CB	Oct '94	0	0.0	0	0.00
Scoloplos cylindrifer	CB	Jan '95	0	0.0	0	0.00
Scoloplos cylindrifer	CB	Apr '95	0	0.0	0	0.00
Scoloplos cylindrifer	HL	Jul '94	0	0.0	0	0.00
Scoloplos cylindrifer	HL	Oct '94	20	1.0	5	1.67
Scoloplos cylindrifer	HL	Jan '95	1	0.0	1	0.08
Scoloplos cylindrifer	HL	Apr '95	0	0.0	0	0.00
Scoloplos cylindrifer	JB	Jul '94	0	0.0	0	0.00
Scoloplos cylindrifer	JB	Oct '94	0	0.0	0	0.00
Scoloplos cylindrifer	JB	Jan '95	0	0.0	0	0.00
Scoloplos cylindrifer	JB	Apr '95	0	0.0	0	0.00
Scoloplos cylindrifer	MH	Jul '94	0	0.0	0	0.00
Scoloplos cylindrifer	MH	Oct '94	0	0.0	0	0.00
Scoloplos cylindrifer	MH	Jan '95	0	0.0	0	0.00
Scoloplos cylindrifer	MH	Apr '95	0	0.0	0	0.00
Scoloplos cylindrifer	TK	Jul '94	0	0.0	0	0.00
Scoloplos cylindrifer	TK	Oct '94	1	0.0	1	0.08
Scoloplos cylindrifer	TK	Jan '95	0	0.0	0	0.00
Scoloplos cylindrifer	TK	Apr '95	0	0.0	0	0.00
Torridopharpinia hurleyi	CB	Jul '94	38	3.0	6	3.17
Torridopharpinia hurleyi	CB	Oct '94	23	1.0	6	1.92
Torridopharpinia hurleyi	CB	Jan '95	62	4.5	13	5.17
Torridopharpinia hurleyi	CB	Apr '95	0	0.0	0	0.00
Torridopharpinia hurleyi	HL	Jul '94	1	0.0	1	0.08
Torridopharpinia hurleyi	HL	Oct '94	1	0.0	1	0.08
Torridopharpinia hurleyi	HL	Jan '95	0	0.0	0	0.00
Torridopharpinia hurleyi	HL	Apr '95	1	0.0	1	0.08
Torridopharpinia hurleyi	JB	Jul '94	46	1.0	15	3.83
Torridopharpinia hurleyi	JB	Oct '94	97	8.0	20	8.08
Torridopharpinia hurleyi	JB	Jan '95	19	0.0	7	1.58
Torridopharpinia hurleyi	JB	Apr '95	33	2.0	5	2.75
Torridopharpinia hurleyi	MH	Jul '94	28	2.5	5	2.33
Torridopharpinia hurleyi	MH	Oct '94	4	0.0	2	0.33
Torridopharpinia hurleyi	MH	Jan '95	0	0.0	0	0.00
Torridopharpinia hurleyi	MH	Apr '95	5	0.0	1	0.42
Torridopharpinia hurleyi	TK	Jul '94	17	1.0	5	1.42
Torridopharpinia hurleyi	TK	Oct '94	5	0.0	3	0.42
Torridopharpinia hurleyi	TK	Jan '95	2	0.0	2	0.17
Torridopharpinia hurleyi	TK	Apr '95	1	0.0	1	0.09

Appendix 2

Summary of temporal results at the subtidal sites

TAXA	SITE	TIME	TOTAL[1]	MEDIAN	RANGE[2]	MEAN
Aricidea sp.	A	Oct '94	0	0.0	0	0.00
Aricidea sp.	A	Apr '95	0	0.0	0	0.00
Aricidea sp.	B	Oct '94	0	0.0	0	0.00
Aricidea sp.	B	Apr '95	0	0.0	0	0.00
Aricidea sp.	C	Oct '94	0	0.0	0	0.00
Aricidea sp.	C	Apr '95	0	0.0	0	0.00
Armandia maculata	A	Oct '94	0	0.0	0	0.00
Armandia maculata	A	Apr '95	0	0.0	0	0.00
Armandia maculata	B	Oct '94	1	0.0	1	0.08
Armandia maculata	B	Apr '95	0	0.0	0	0.00
Armandia maculata	C	Oct '94	1	0.0	1	0.08
Armandia maculata	C	Apr '95	0	0.0	0	0.00
Arthritica bifurca	A	Oct '94	1	0.0	1	0.08
Arthritica bifurca	A	Apr '95	0	0.0	0	0.00
Arthritica bifurca	B	Oct '94	11	0.0	3	0.92
Arthritica bifurca	B	Apr '95	5	0.0	1	0.42
Arthritica bifurca	C	Oct '94	52	4.5	12	4.33
Arthritica bifurca	C	Apr '95	16	0.5	5	1.33
Cirratulids	A	Oct '94	4	0.0	1	0.33
Cirratulids	A	Apr '95	0	0.0	0	0.00
Cirratulids	B	Oct '94	14	1.0	5	1.17
Cirratulids	B	Apr '95	0	0.0	0	0.00
Cirratulids	C	Oct '94	9	0.0	3	0.75
Cirratulids	C	Apr '95	0	0.0	0	0.00
Corophidae - complex	A	Oct '94	0	0.0	0	0.00
Corophidae - complex	A	Apr '95	0	0.0	0	0.00
Corophidae - complex	B	Oct '94	0	0.0	0	0.00
Corophidae - complex	B	Apr '95	0	0.0	0	0.00
Corophidae - complex	C	Oct '94	0	0.0	0	0.00
Corophidae - complex	C	Apr '95	0	0.0	0	0.00
Nucula hartvigiana	A	Oct '94	1	0.0	1	0.08
Nucula hartvigiana	A	Apr '95	14	0.0	8	1.17
Nucula hartvigiana	B	Oct '94	0	0.0	0	0.00
Nucula hartvigiana	B	Apr '95	18	0.5	5	1.50
Nucula hartvigiana	C	Oct '94	6	0.0	4	0.50
Nucula hartvigiana	C	Apr '95	18	1.0	5	1.50
Oligochaetes	A	Oct '94	4	0.0	3	0.33
Oligochaetes	A	Apr '95	0	0.0	0	0.00
Oligochaetes	B	Oct '94	0	0.0	0	0.00
Oligochaetes	B	Apr '95	0	0.0	0	0.00
Oligochaetes	C	Oct '94	0	0.0	0	0.00
Oligochaetes	C	Apr '95	0	0.0	0	0.00
Polydorids	A	Oct '94	1	0.0	1	0.08
Polydorids	A	Apr '95	0	0.0	0	0.00
Polydorids	B	Oct '94	0	0.0	0	0.00
Polydorids	B	Apr '95	0	0.0	0	0.00
Polydorids	C	Oct '94	2	0.0	1	0.17
Polydorids	C	Apr '95	5	0.0	2	0.42
Prionospio sp.	A	Oct '94	58	3.5	12	4.83
Prionospio sp.	A	Apr '95	4	0.0	2	0.33

[1] Total number is the total number of individuals found in 12 samples. Calculated by mean x 12

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

TAXA	SITE	TIME	TOTAL	MEDIAN	RANGE	MEAN
Prionospio sp.	B	Oct '94	6	0.0	2	0.50
Prionospio sp.	B	Apr '95	0	0.0	0	0.00
Prionospio sp.	C	Oct '94	42	2.0	15	3.50
Prionospio sp.	C	Apr '95	1	0.0	1	0.08
Tawera spissa	A	Oct '94	0	0.0	0	0.00
Tawera spissa	A	Apr '95	0	0.0	0	0.00
Tawera spissa	B	Oct '94	0	0.0	0	0.00
Tawera spissa	B	Apr '95	0	0.0	0	0.00
Tawera spissa	C	Oct '94	4	0.0	2	0.33
Tawera spissa	C	Apr '95	0	0.0	0	0.00
Theora lubrica	A	Oct '94	33	2.5	7	2.75
Theora lubrica	A	Apr '95	7	0.5	2	0.58
Theora lubrica	B	Oct '94	14	1.0	3	1.17
Theora lubrica	B	Apr '95	14	1.0	3	1.17
Theora lubrica	C	Oct '94	8	0.0	4	0.67
Theora lubrica	C	Apr '95	10	1.0	2	0.83
Torridoharpinia hurleyi	A	Oct '94	25	1.5	5	2.08
Torridoharpinia hurleyi	A	Apr '95	78	2.5	39	6.50
Torridoharpinia hurleyi	B	Oct '94	7	0.0	3	0.58
Torridoharpinia hurleyi	B	Apr '95	0	0.0	0	0.00
Torridoharpinia hurleyi	C	Oct '94	15	0.5	6	1.25
Torridoharpinia hurleyi	C	Apr '95	2	0.0	1	0.17

Appendix 3

Size of *Atrina zelandica* [1]

	Site A		Site B		Site C	
	Oct '94	Apr '95	Oct '94	Apr '95[3]	Oct '94	Apr '95
Number of *Atrina* measured	32	50	7	50	21	50
Mean size (cm)	11.781	11.430	11.143	10.820	7.738	7.680
Standard deviation	0.819	0.889	0.833	1.038	0.666	1.178
Standard error	0.145	0.126	0.315	0.147	0.145	0.167

Density of *Atrina zelandica* [2]

	Site A		Site B		Site C	
	Oct '94	Apr '95	Oct '94	Apr '95[3]	Oct '94	Apr '95
Number of quadrats	8	10	5	10	15	10
Mean number per quadrat	16.500	22.400	2.600	9.300	10.333	25.700
Standard deviation	6.225	3.040	1.744	3.068	9.141	5.917
Standard error	2.201	0.961	0.780	0.970	2.360	1.871

[1] During October 1994, sizes of *Atrina* were compiled from measurements of individuals along transects (Site A) or adjacent quadrats (Site B and C). During April 1995, sizes of *Atrina* were compiled from measurements of individuals inside quadrats.
[2] Densities = number of *Atrina zelandica* per 50cm x 50cm quadrat
[3] During April 1995 at Site B, densities of *Atrina* are dead individuals