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Report on Data Collected up unitl February 2009

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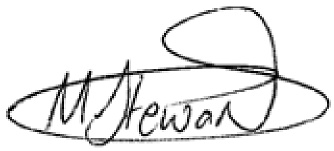

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Manukau Harbour Ecological Monitoring Programme: Report on data collected up until February 2009

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Prepared for
Auckland Regional Council

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1 Executive Summary

This report updates the results of the Manukau Harbour Ecological Monitoring Programme, established in October 1987 as an initiative of the Auckland Regional Council. The original programme was designed to provide: stocktaking of resources under stewardship; feedback on harbour management activities; and a baseline against which future cause-effect or impact studies could be conducted. The programme is a temporally nested design with two sites permanently monitored (Auckland Airport and Clarks Beach). Elletts Beach, Karaka Point and Puhinui Stream sites alternate monitored with unmonitored years on a cycle of five years off, two years on. The Cape Horn site initially followed that cycle, but has been continuously monitored since removal of the waste water treatment ponds at Mangere. The most recent two year monitoring period of Elletts Beach, Karaka Point and Puhinui Stream began in June 2006 and concluded in June 2008, while the bimonthly monitoring of Auckland Airport, Clarks Beach and Cape Horn has continued.

Most of the changes observed at the continuously monitored sites of Auckland Airport and Clarks Beach have been multiyear cycles with no overall change in community composition. The most significant changes that have been observed, over the monitored period, have occurred at the Cape Horn site. Most of these changes occurred between 2000 and 2005 as a result of a strong El Niño Southern Oscillation (ENSO) and the decommissioning of the Mangere waste water treatment ponds in May 2001. These changes are largely stabilised and a new stable community has evolved.

While no overall change in community composition has occurred at the Puhinui Stream site, communities at the Karaka Point and Elletts Beach sites have changed over the last seven years. However, comparison with population dynamics observed at the other sites suggests that most of these changes are multiyear cycles, rather than trends.

There have been no major changes in the sediment characteristics during the last two years, with sediment chlorophyll *a* concentrations, grain size and percentage organic matter maintaining levels observed in February 2007. None of the changes in species abundances observed are consistent with responses to heavy metal contamination or sedimentation, and there is no evidence of increased variability in community composition (often an early warning of the likelihood of sudden degradative change).

Overall, there is no evidence of detrimental effects on ecosystem health within the extensive intertidal flats that make up the main body of the Manukau Harbour. Thus, the current management initiatives being implemented by the Auckland Regional Council to minimise effects of changing anthropogenic practices are effectively maintaining the health of these important areas.

2 Introduction

In October 1987, the Water Quality Centre (now NIWA) was commissioned to design and implement a biological monitoring programme for the Manukau Harbour (see Thrush et al. 1988 for details). This was initiated in light of concerns for the Harbour, due to changing land developments and potential impacts that anthropogenic catchment practices may have on harbour health. Six sites around the Harbour were chosen as representative sandflats and these were associated with the main inlets in the Harbour (Figure 3.1). The sites are monitored in order to document changes in the ecology of the intertidal sandflat communities on a harbour-wide basis and to provide information important for ecosystem management. This was the first harbour-wide ecological monitoring conducted in New Zealand. For cost effectiveness, it was based on the abundance of 21 taxa. These taxa were selected, as they would provide a range of responses to different anthropogenic impacts, thus increasing the ability of the monitoring programme to detect important changes, and for their likely importance to the rest of the community.

When monitoring was initiated, it was envisaged that the programme would be maintained in its original form, with six sites continuously monitored, for five years. The monitoring programme was reduced in 1993 to monitoring only the Auckland Airport and Clarks Beach sites (based on recommendations from Hewitt et al. 1994). Resumption of the full monitoring programme commenced in August 1999 and ran for two years, up until April 2001. After April 2001, the monitoring programme was again reduced; this time to the continuously monitored sites at Auckland Airport and Clarks Beach and the Cape Horn site. Cape Horn was included as the Auckland Regional Council (ARC) wished to investigate whether improvements in water treatment of the discharge into the Manukau at Mangere had any effects on health of the benthic macrofauna. In August 2006, monitoring began again at Elletts Beach, Karaka Point and Puhinui Stream. Since June 2008, monitoring has been reduced again to Auckland Airport, Clarks Beach and Cape Horn.

This report presents the results of data collected from the first monitoring in October 1987 until February 2009. The report focuses on trends in abundance of the monitored taxa and sediment data at all full and intermittently monitored sites.

3 Methods

3.1 Sample collection and identification

Sites AA and CB (Figure 3.1, Table 3.1) have been sampled bimonthly between October 1987 and April 2009. Two sampling occasions were missed (October and December 1988) due to a lack of continuity of funding. The sites at CH, EB, KP and PS have been sampled for the ARC from October 1987 to February 1993, and again from August 1999 to April 2001. Sampling continued at site CH from April 2001 to monitor the effects of improvements in water quality discharging from Mangere. Additional sampling was carried out at Cape Horn by NIWA, without funding by the ARC, from February 1993 to December 1995. This data was collected as part of studies conducted on Te Tau Bank, and funded via the Foundation for Research Science and Technology. Sampling at sites at EB, KP and PS commenced again in June 2006 on the recommendation of Funnell et al. (2005) for 2 years until June 2008, whilst Auckland Airport, Clarks Beach and Cape Horn sampling has remained ongoing.

Figure 3.1:
Map of Manukau Harbour showing the positions of sites Auckland Airport (AA), Clarks Beach (CB), Cape Horn (CH), Elletts Beach (EB), Karaka Point (KP) and Puhinui Stream (PS). The asterisk denotes the two continuously monitored sites, while the others are monitored intermittently.

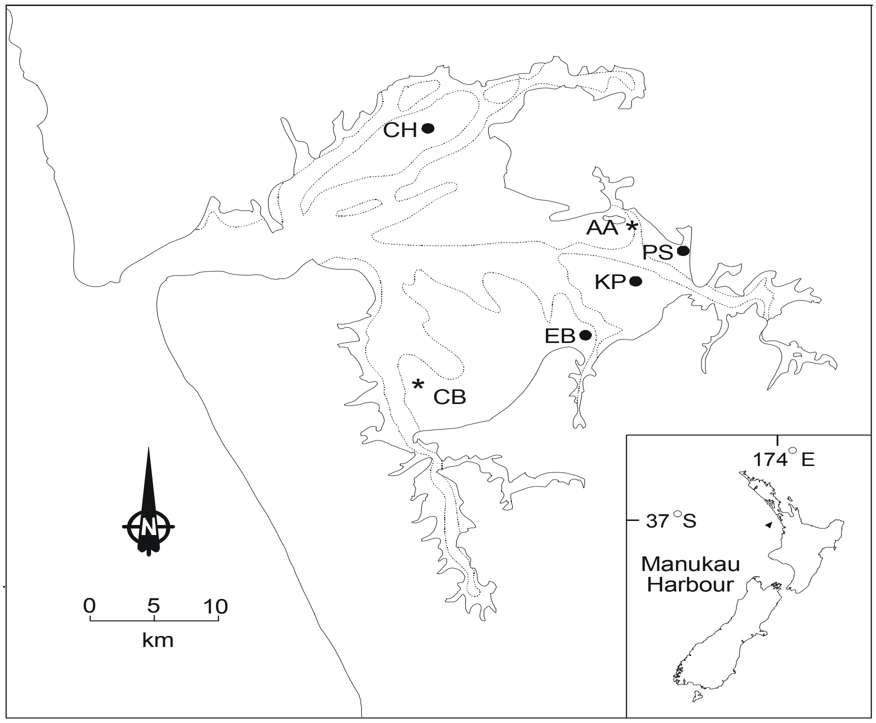


Table 3.1:

Samples are collected and processed as follows. Each site (9000 m^2) is divided into 12 equal sectors and one core sample (13 cm diameter, 15 cm depth) is taken from a

Dates sites AA, CB, CH, EB, KP and PS have been monitored since the commencement of the Manukau Ecological Monitoring Programme in October 1987.

	Monitoring Dates
AA Auckland Airport	Oct 1987 – Feb 2009 (excluding Oct and Dec 1988)
CB Clarks Beach	Oct 1987 – Feb 2009 (excluding Oct and Dec 1988)
CH Cape Horn	Oct 1987 – Dec 1995, Aug 1999 – Feb 2009
EB Elletts Beach	Oct 1987 – Feb 1993, Aug 1999 – Apr 2001, Jun 2006 – Jun 2008
KP Karaka Point	Oct 1987 – Feb 1993, Aug 1999 – Apr 2001, Jun 2006 – Jun 2008
PS Puhinui Stream	Oct 1987 – Feb 1993, Aug 1999 – Apr 2001, Jun 2006 – Jun 2008

random location within each sector. To limit the influence of spatial autocorrelation (see Thrush et al. 1989) and preclude any localised modification of populations by previous sampling events, core samples are not positioned within a 5 m radius of each other or of any samples collected in the preceding six months. After collection, the macrobenthos are separated from the sediments by sieving (500 μm mesh), preserved with 70% isopropyl alcohol in seawater and stained with rose Bengal. The macrofauna are then sorted, and the 21 monitored taxa are identified, counted and stored in 50% isopropyl alcohol.

3.2 Bivalve size class analysis

After identification, all monitored bivalve species (*Austrovenus stutchburyi*, *Macomona liliana*, *Nucula hartvigiana* and *Soletellina siliqua*) are measured (longest shell dimension). Until 2007, monitored bivalves were individually measured (with calipers or digitising under a dissecting microscope) and the results were summarized into the following size classes: ≤1 mm, 1-2 mm, 2-4 mm, 4-8 mm, 8-11 mm, 11-16 mm, 16-22 mm and >22 mm. However, in consultation with ARC, this methodology and the size classes used have been modified to enable direct comparison with the Mahurangi and Waitemata Ecological Monitoring Programmes. Individual bivalves are now allotted a size class under a dissecting microscope and large individuals (>10 mm) are measured using electronic callipers. Size class groupings used now are ≤1 mm, 1-5 mm, 5-10 mm, 10-20 mm, 20-30 mm, 30-40 mm, 40-50 mm and >50 mm.

3.3 Site characteristics

During each visit, attention is paid to the appearance of the site and the surrounding sandflat. In particular, surface sediment characteristics and the presence of ray pits, birds, gastropods and plants are noted.

Between 1995 and 1998, a pooled sample of surface sediment (<2 cm deep) was collected by haphazardly sampling areas within the site for grain size analysis (October times only). Since August 1999, scoops have been taken from every second core location, on each sampling occasion. A composite sample is made for each site, homogenised and a subsample taken. Organic matter is removed from the sample by digestion in hydrogen peroxide. Sediment grain size analysis is then carried out by wet sieving into fractions of gravel (particles >2 mm), coarse sand (particles 500 μm-2 mm); medium sand (particles 250 μm-500 μm); fine sand (particles 63 μm- 250 μm); and mud (particles <63 μm), which are then dried and weighed. Before drying, the mud fraction is analysed by pipette analysis for proportions of silt and clay. A similar procedure was used to determine the sediment characteristics for each site in October 1987, although only the gravel, sand and mud fractions were determined. To determine the organic content, the remainder of the homogenised sediment sample collected for grain size analysis is dried at 60°C to a constant weight and combusted for 5.5 hours at 400 °C. Organic content is determined by the difference in weight of the sample prior to and after combustion. In addition, on each sampling occasion, six core samples (2.5 cm diameter and 2 cm deep) adjacent to every second macrofauna core, are collected and bulked for Chlorophyll *a* analysis. Chlorophyll *a* (a proxy of microalgae abundance and food supply to benthic animals) is extracted by freeze-drying the sediment, boiling in 90% ethanol and measured spectrophotometrically. An acidification step is used to separate degradation products from Chlorophyll *a* (Sartory, 1982).

3.4 Statistical analysis

The analysis of monitoring programmes is strongly dependent on the length of time the data has been collected. Initially, little can be done other than to graphically determine cyclic patterns. As the time series extends, statistical analysis of trends becomes more important. However, as the time series lengthens still more, statistical trend analysis becomes ever more likely to detect very small changes and in particular, changes that on inspection are obviously part of longer-term cycles. For this reason, although statistical analyses were performed to identify significant linear trends, step trends or changes in temporal cycles, these analyses were only done when species abundances were trending monotonically over the monitored period or when they had moved outside the previously observed limits:

1. For all monitored populations at a site, graphs of abundance versus time were drawn and limits of natural variability based on 95% confidence limits of the first 15 years of data determined.

2. The time series of each population was tested to determine whether the variation in the temporal series contained a cyclic component (Chatfield, 1980).

3. Trend analyses were conducted on:

   a. The raw time series data.

   b. The residuals if a cyclic model could be fitted.

   c. The basal population where a basal period can be detected. The basal period is a time when peaks in recruitment are not affecting estimates of abundance, i.e., consistent periods of the year when the population is relatively constant. As such, the basal population can contain both adults and juveniles as some species recruit through out the year, while still exhibiting definite times when recruitment is at a maximum.

   d. Annual averages for those species where a basal period could not be detected and the raw time series data suggested that long-term cyclic variability in recruitment might allow a trend in the raw time series to be detected.

4. When a dataset exhibited statistically significant temporal autocorrelation, adjustments were made to the calculation of standard errors and significant values using autoregressive techniques.

5. For all macrofaunal populations in which a trend in abundance is detected, the fit of the trend to the observed data was examined by analysis of the residuals.

6. Cross-correlation analysis was conducted to determine the lag period between ENSO (El Niño - Southern Oscillation Index) and Z1 (pressure difference between Auckland and Christchurch) and their effect (if any) on the population abundances of taxa exhibiting trends in abundance at each site (AA, CB and CH). Regression analysis was used to determine the significance of any relationship and to derive predicted time series for those populations exhibiting similarity in patterns of abundance across sites.

7. Ordinations of all taxa observed at each site in every October were conducted using Multidimensional Scaling Analysis (MDS; Primer; Clarke and Gorley, 2006) on log-transformed data.

4 Present Status of the Benthic Communities of Manukau Harbour

The Manukau Harbour Ecological Monitoring Programme was designed to answer the following questions over a long time scale:

1. Are populations at the monitored sites generally exhibiting similar patterns?
2. Do any of the observed patterns in population abundances indicate important changes in the benthic communities?

These questions are extremely broad and in order to answer them, a series of more specific questions must be posed:

4.1 Have there been any changes in the general appearance of the sites or the nearby area?

Site characteristics such as appearance and sediment characteristics provide a background against which changes in macrofauna can be described. Changes to site characteristics such as expansion of seagrass beds into the monitored site and disturbance by eagle rays may help explain natural variability. For example, large changes in predominantly sandy sediment becoming muddy or deoxygenation under decomposing algal mats may signal dramatic changes in macrofauna. For this reason, a brief description of site appearance and sediment characteristics is given here, although they are not the focus of the monitoring programme.

4.1.1 General site descriptions[1]

Site AA (Auckland Airport) – The appearance of this site is largely unchanged since monitoring began in 1987 and is consistent with that described by Hewitt and Hailes (2007). The sediment surface is usually covered with sand ripples (period 4-8 cm) and sometimes it appears as a mosaic of ripples and flat sediment (Fig 4.1). The surface topography of this site is often dominated by the presence of ray pits that are typically observed in abundance during the summer months (December–April). Small sparse patches of seagrass were reported in June and August of 2005, but have not been recorded since. Diatom mats were recorded to cover half of the site in August 2006, and interestingly this was repeated in August 2007 and then again in June 2008. Furthermore, sparse mangrove seedlings (approximately 100 mm in height) are still present at the access to the site.

[1] Over the past eight years, site description reports have been completed by ARC staff

Figure 4.1:
Photographs of site AA: (a) site and (b) sediment surface.

a)

b)

Site CB (Clarks Beach) – The sediment topography of this site is much the same as was recorded in 2007; a mosaic of ripples, flat sand and a lumpy surficial mud layer (Fig 4.2) (Hewitt & Hailes 2007). The presence of surficial mud and/or a diatom mat is still consistent throughout the year, as is the presence of shell hash. However, there have been no sightings of tubeworms on the sediment surface since December 2007, compared to being a common feature throughout 2005-2007. Ray pits are common during the warmer months of the year. Large patches of *Zostera muelleri* are still common around the sampling area and have been present since October 1998 (Funnell et al. 1999).

Figure 4.2:
Photographs of site CB: (a) site and (b) the sediment surface with a clearly visible diatom mat.

a)

b)

Site CH (Cape Horn) – The site is situated approximately 80 m from the boat access point, approximately 0.5 m away from the low water mark. Sometimes during westerly wind conditions, the site is submerged for longer than the tide charts indicate (Fig 4.3a). Ripples (approximately 1-3 cm in height with a period of 2-4 cm) are still a common feature at this site, along with numerous polychaete tubes (*Macroclymenella stewartensis*) and bivalve (*Macomona liliana*) feeding tracks (Fig 4.3b). Ray pits (usually low frequency) have been observed during the warmer months. During the sampling in October 2008, a diatom mat was present, which is common at this site, particularly at this time of the year (Fig 4.3c). In addition, dense patches of *Gracilaria* sp. have been observed (Fig 4.3d). Recently, *Gracilaria* sp. has been found to be distinct (through molecular sequencing techniques) but morphologically very similar to the widespread native *Gracilaria chilensis* (Wilcox et al. 2001, 2007).

Figure 4.3:
Photographs of site CH: a) site, b) sediment with ripples and tube worms, c) surficial muddy sediment layer and diatom mat and d) large dense patches of *Gracilaria* sp.

a)

b)

c)

d)

Site EB (Elletts Beach) – This site is predominantly sandy with ripples (Fig 4.4 a, b) throughout the year, however diatom mats are often present during the winter months (Fig 4.4 c, d). Whole shells, shell hash and gastropods are common on the sediment surface throughout the year. During the warmer months it is common to see ray pits with associated shell hash. Around the outside of the site, there has been little change, however in June 2008 a mixture of Soleriaceae and *Gracilaria* sp. (as found at site CH) was recorded.

Figure 4.4:
Photographs of site EB: (a) site and (b) sediment surface taken in August 2007 and (c) site and (d) sediment surface taken in June 2007 when a diatom mat was present.

a)

b)

c)

d)

Site KP (Karaka Point) – Consistent with previous descriptions (Funnell et al. 2001; Hewitt & Hailes 2007), site KP is a mosaic of sand ripples and surficial mud (Fig 4.5). Shell hash, whole shells and gastropods (e.g., *Zeacumantus lutulentus*) have been observed on most sampling occasions since June 2007. Similar to other sites, ray pits are common during the summer months of December and February. Outside the site was recorded to be similar to inside up until April 2008 when it became considerably muddier and a diatom mat was observed. *Ulva lactuca* was recorded by Hewitt and Hailes (2007) to be abundant outside the site in December 2006 but this has not been observed outside the site since.

Figure 4.5:
Photographs of site KP: (a) site and (b) the sediment surface.

a)

b)

Site PS (Puhinui Stream) – Characterised by a mosaic of sand ripples (period of approximately 10-15 cm) and large numbers of gastropods (*Zeacumantus lutulentus* and *Cominella glandiformis*), the surface topography at site PS remains relatively unchanged (Fig 4.6). During the winter months, a diatom mat is consistently recorded. As observed at the other monitored sites, abundant ray pits are observed during the summer months.

Figure 4.6:
Photographs of site PS: (a) site and (b) the sediment surface.

a)

b)

4.1.1.1 Sediment characteristics

The bimonthly results of sediment grain size, chlorophyll *a* and percent organic content for each of the monitored sites are given in Appendices 1-3.

4.1.1.2 Grain Size

Over the monitored period, no changes have occurred in sediment type at any of the monitored sites, with all sites being predominantly sandy (Fig. 4.7 & 4.8, Table 4.1). The percentage of mud is lowest at sites AA, CH, KP and PS (average percentage mud 1.21, 2.09, 3.86 and 1.77, respectively). Furthermore, the percent mud at sites CB and EB is extremely variable (e.g., 1.44 - 21.18 and 0.72 - 23.93, respectively) and they have a greater average percentage mud compared to the other sites (e.g., mean percent mud 6.99 and 7.89, respectively).

Figure 4.7:

Sediment mud content (% weight) at the monitored sites from 1987 to 2009.

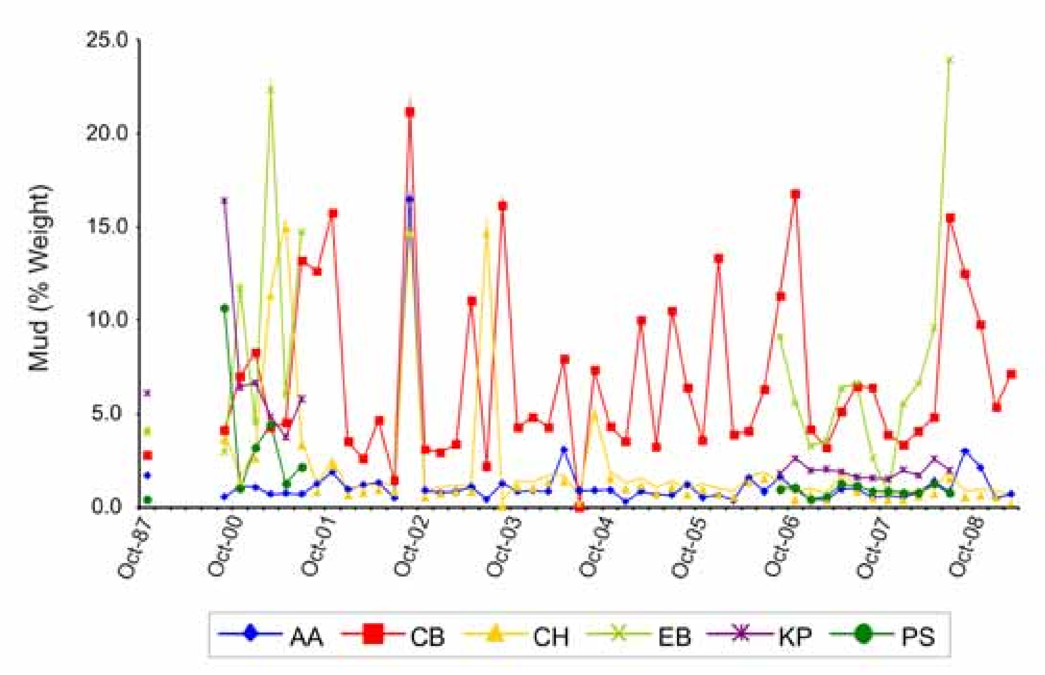


Figure 4.8:

Changes in the proportions of gravel/shell (>500 µm), sand (fine 63 µm – coarse 500 µm) and mud (i.e., silt/clay; <63 µm) content at each of the monitored sites (Auckland Airport, Clarks Beach, Cape Horn, Elletts Beach, Karaka Point and Puhinui Stream) over the monitoring period (October months only).

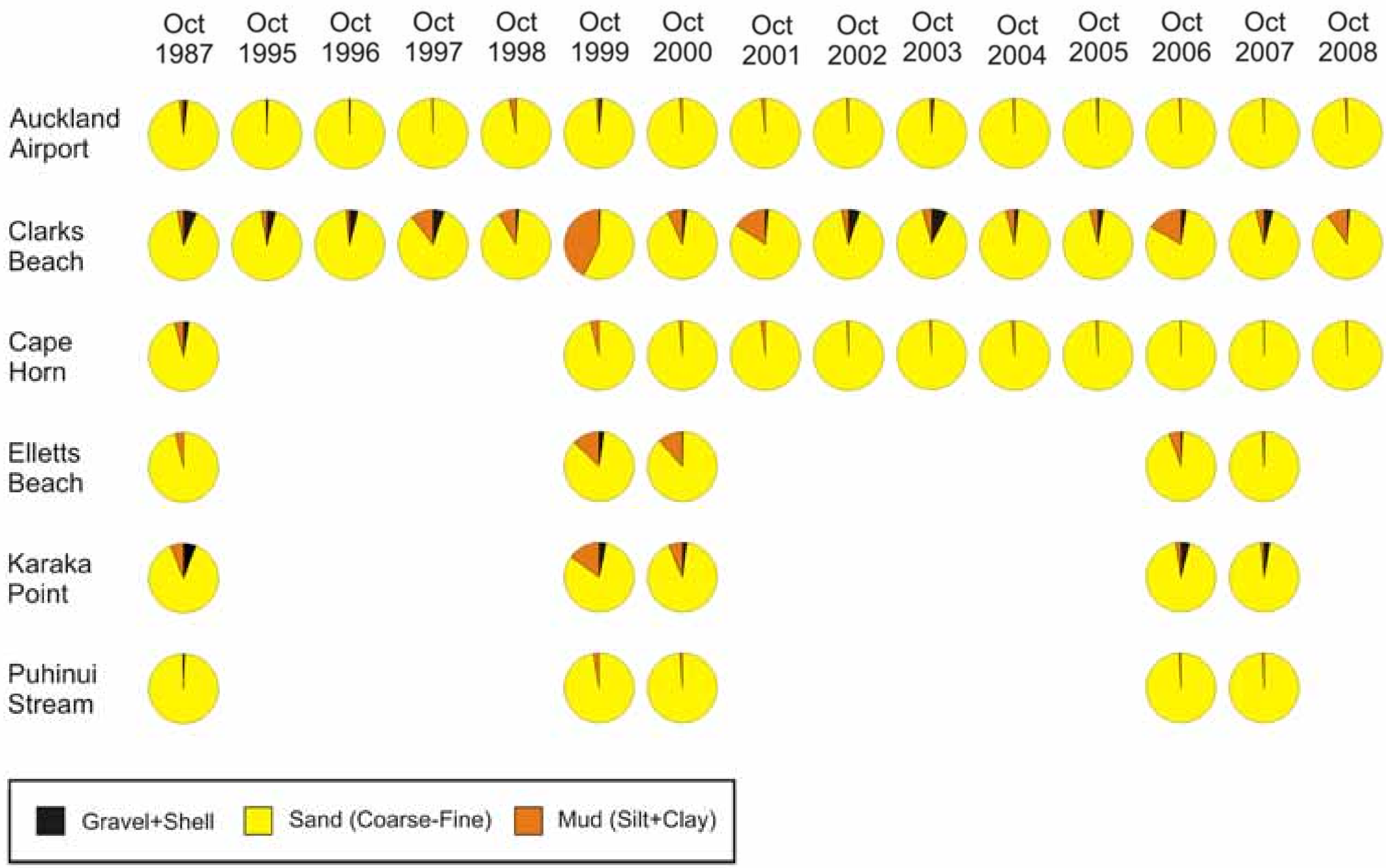


Table 4.1:

Sediment grain size (percent composition) of samples collected every October. The size of the gravel (%G), sand (%S) and mud (%M) particles are >2 mm, 63 μm-2 mm and <63 μm, respectively. Due to rounding, overall pecents for some samples at a particulr time may not be exactly 100.

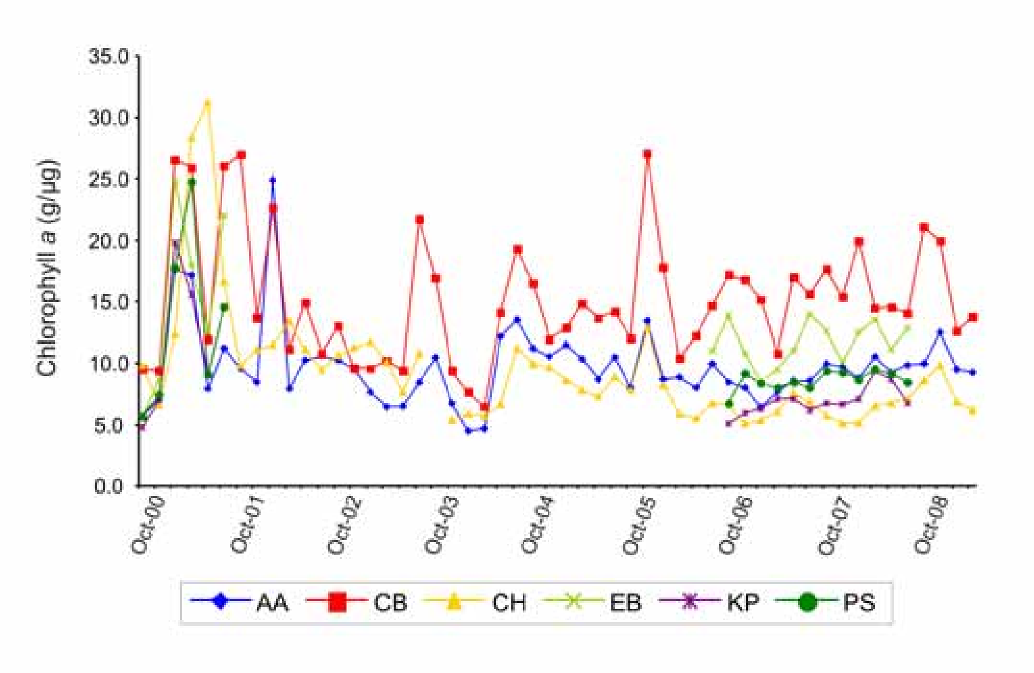
		Oct 1987	Oct 1995	Oct 1996	Oct 1997	Oct 1998	Oct 1999	Oct 2000	Oct 2001	Oct 2002	Oct 2003	Oct 2004	Oct 2005	Oct 2006	Oct 2007	Oct 2008
Auckland Airport (AA)	%G	1.6	0.6	0.4	0.0	0.3	1.3	0.0	0.0	0.1	1.0	0.0	0.2	0.0	0.0	0.0
	%S	96.7	99.1	99.3	99.5	96.7	98.5	98.9	98.1	99.0	98.2	99.1	99.2	99.0	99.4	98.9
	%M	1.7	0.3	0.3	0.5	3.0	1.2	1.1	1.9	0.9	0.8	0.9	0.5	1.0	0.6	1.0
Clarks Beach (CB)	%G	6.1	4.3	3.9	5.2	1.3	0.5	2.1	1.5	5.2	7.6	1.8	2.9	2.5	4.1	1.1
	%S	91.1	93.2	94.3	84.2	90.3	56.9	90.9	82.7	91.7	88.2	93.9	93.5	80.7	92.1	89.1
	%M	2.8	2.5	1.8	10.7	8.4	42.5	7.0	15.8	3.1	4.3	4.3	3.6	16.8	3.9	9.7
Cape Horn (CH)	%G	2.5					0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%S	93.3					95.6	98.7	97.8	99.5	98.9	98.5	99.1	99.6	99.7	99.4
	%M	4.2					4.3	1.3	2.2	0.5	1.0	1.5	0.9	0.4	0.4	0.6
Elletts Beach (EB)	%G	0.1					2.1	0.2						0.8	0.4	
	%S	95.9					85.0	88.1						93.6	98.9	
	%M	4.0					12.9	11.7						5.6	0.7	
Karaka Point (KP)	%G	5.8					3.3	2.1						3.8	2.9	
	%S	88.1					81.7	91.4						93.6	95.6	
	%M	6.1					15	6.5						2.6	1.5	
Puhinui Stream (PS)	%G	0.6					0.1	0.0						0.1	0.0	
	%S	99.0					97.1	99.0						98.9	99.1	
	%M	0.4					2.8	1.0						1.1	0.9	

4.1.1.3 Chlorophyll *a*

Sediment chlorophyll *a* concentrations at all sites are similar to those reported by Hewitt and Hailes (2007) (Fig 4.9). Over the monitored period, the only trend in chlorophyll *a* concentrations that has been observed was the decreasing trend reported for site CH up to 2007. However, this trend has not continued over the last two years and sediment chlorophyll *a* concentrations at this site seem stable at around 7.50 g/µg.

Figure 4.9:

Chlorophyll *a* levels of sediment collected from the monitored sites from 2000 until 2009.

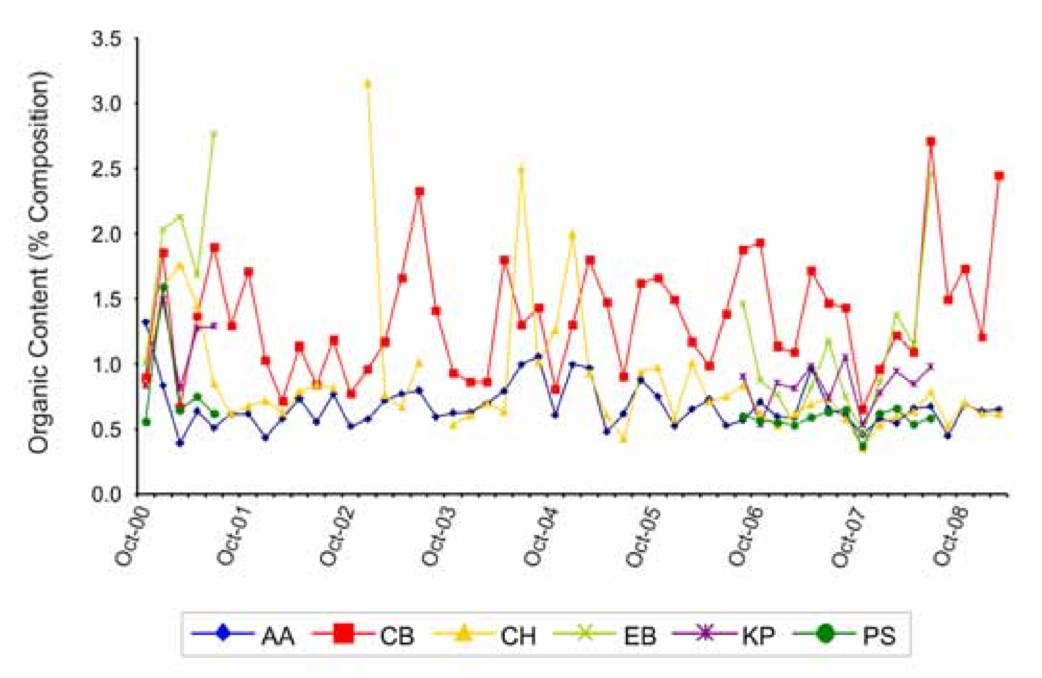


4.1.1.4 Organic Content

Percent composition of sediment organic content at all monitored sites has continued to be low and varied little throughout the year (Fig 4.10 and see Appendix 2). The larger than usual peaks at site CH in December 2002 (3.16%), June 2004 (2.50%) and December 2004 (2.00%) are not likely to be significant as percent organic composition is still relatively low. Furthermore, they do not relate to the decommissioning of the wastewater treatment plant at Mangere, as an increase in sediment organic content would be expected to start earlier. During 2008, the sediment organic content at site EB closely mirrored that of site CB nearby. Both sites had similar average organic content (1.58 and 1.66%) and similar minimum (0.66 and 0.46%) and maximum values (2.72 and 2.47%), respectively. All sites show seasonal peaks in percent sediment organic content during the winter months and then declining during the warmer summer months.

Figure 4.10:

Percentage organic content of the sediment collected from the monitored sites from 2000 until 2009.



4.2 Are cyclic patterns in macrofaunal abundance being maintained?

A number of species from all sites exhibited seasonality in abundance with definite recruitment peaks; however, they tend to be inconsistent in terms of timing and magnitude (Hewitt & Thrush, 2007). While detecting trends in species abundance can be confounded by temporal and annual cycles, a number of techniques have been utilised in both the design and analysis of the monitoring programme to increase the ability to detect important changes.

For example:

Population dynamics can be analysed relative to long-term, broad-scale variations in climate (e.g., El Niño Southern Oscillation cycles), local changes in wind and water temperature (Hewitt & Thrush in press) and management activities. In particular, several species show cyclic patterns in abundance that are correlated to ENSO at one or more sites (Table 4.2). For example, the abundance of *Magelona dakini* is clearly showing a greater than annual cycle (Fig. 4.11) which correlates well with ENSO throughout the monitored period (Fig 4.12).

Figure 4.11:

Abundance of *Magelona dakini* at all monitored sites. Greater than annual cycles of abundance are evident, as is the large increase in abundance from 2002.

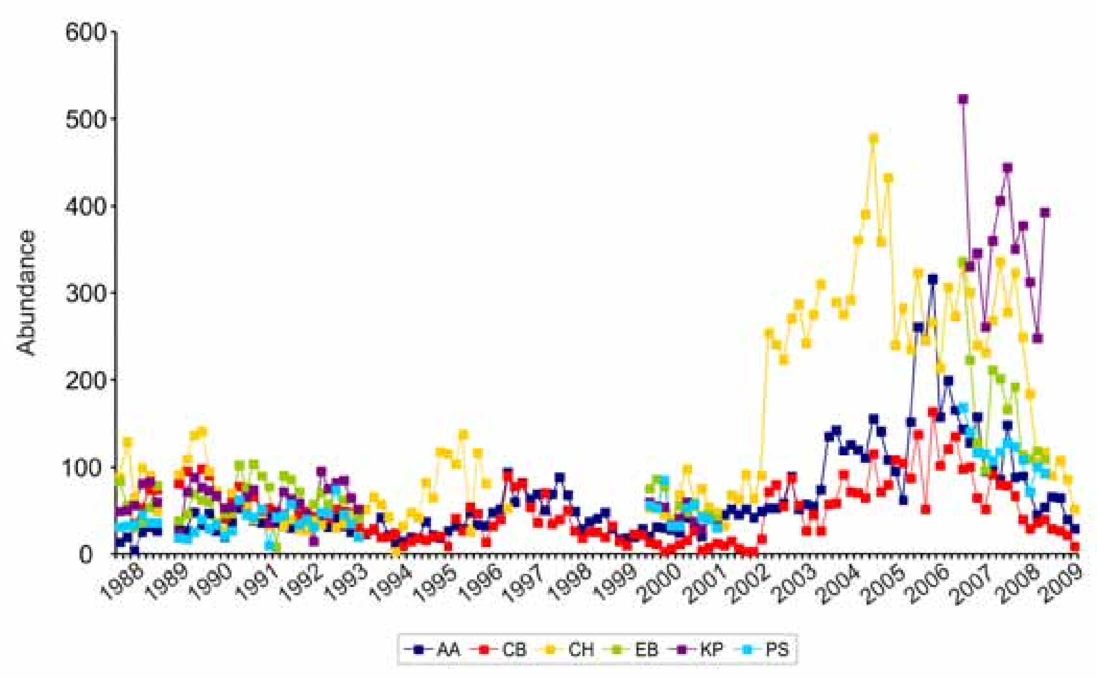
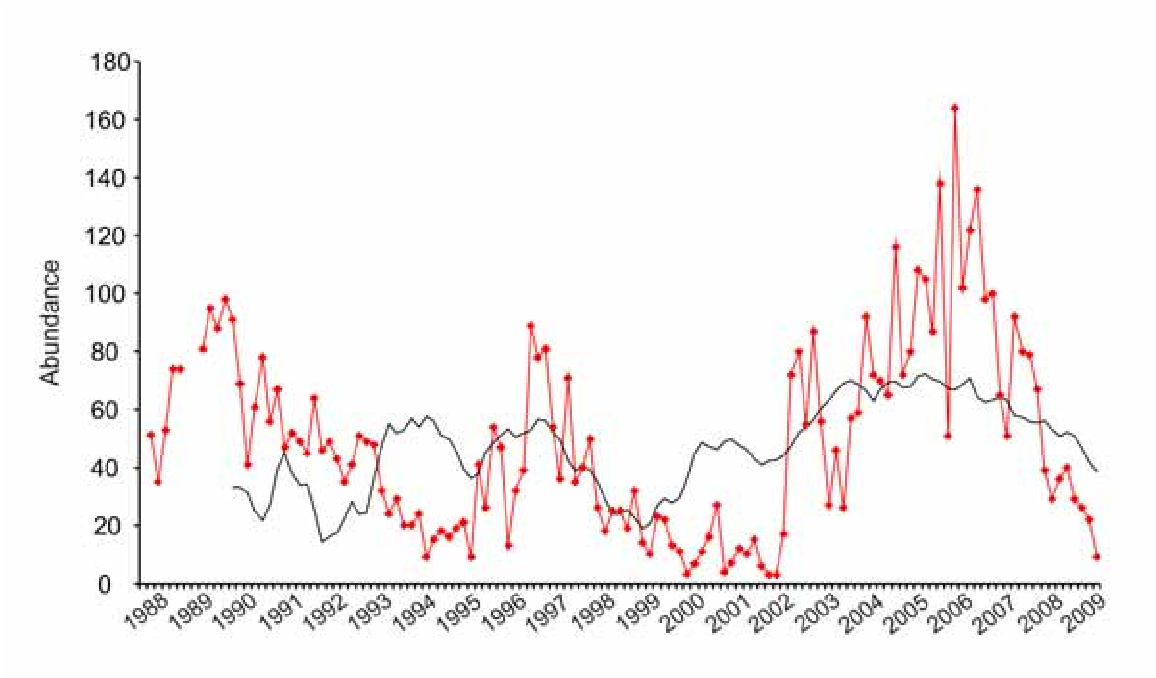


Figure 4.12:

The actual average abundance of *Magelona dakini* (red) and the predicted abundance from ENSO variables (black) at site CB.



Analysis of size classes can help resolve changes in overall population dynamics. At site AA, the abundance of *Macomona liliana* while variable, shows no overall trend (Fig 4.13). However, since 2002 the abundance of adult *Macomona liliana* has increased slightly, probably due to higher recruitment of juveniles in 1998, 2002 and 2003 (Fig 4.14).

Figure 4.13:

Abundance of *Macomona liliana* (adults and juveniles) at site AA since monitoring began in 1987[2].

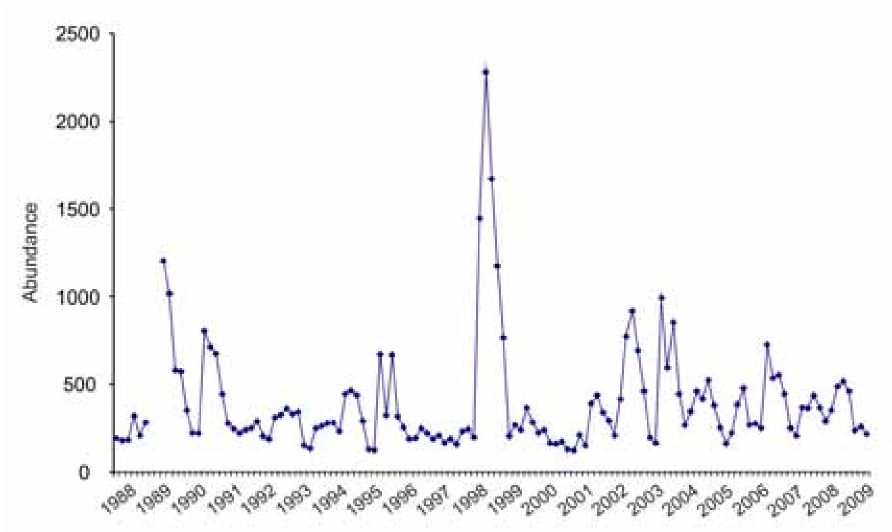
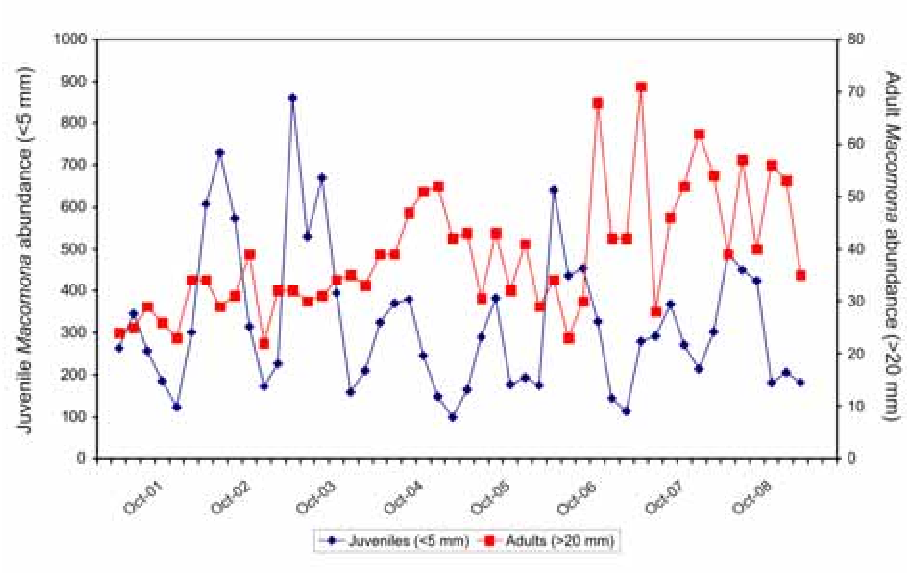


Figure 4.14:

Abundance of juvenile (<5 mm) (blue diamonds and adult (>20 mm) (red squares) *Macomona liliana* at site AA from April 2001 until February 2009.

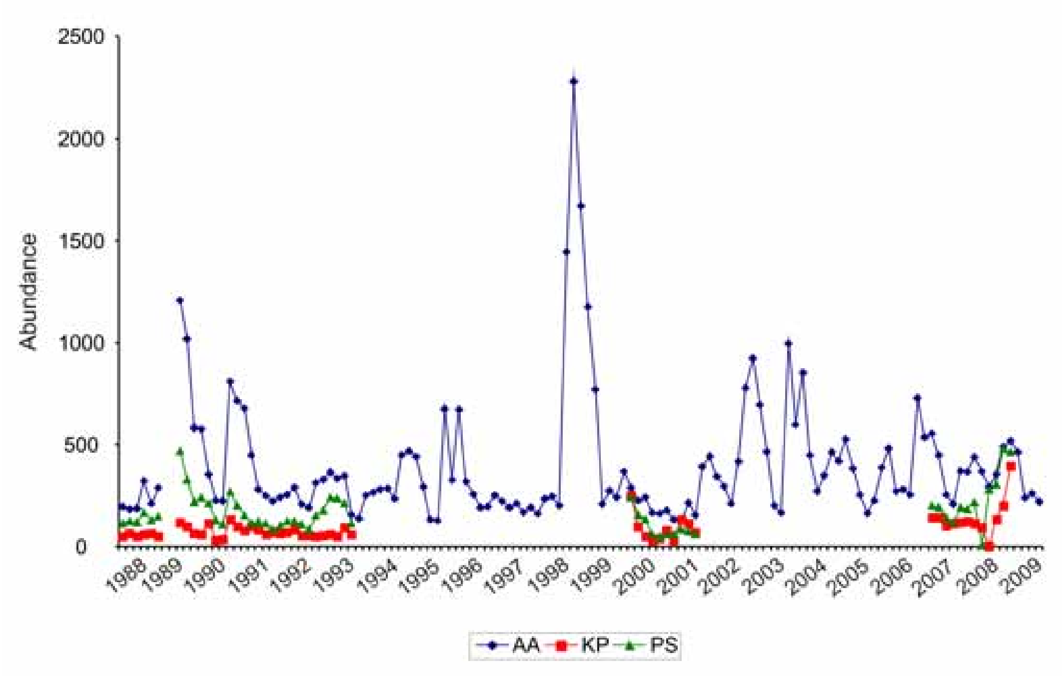


[2] Bivalve size class measurements were not made during the first five years of monitoring

Finally, cyclic patterns in abundance at intermittently monitored sites can be resolved by comparisons with the patterns observed for the same species at the continuously monitored sites (Fig 4.15).

Figure 4.15:

Abundances of *Macomona liliana* at sites AA (continuously monitored), KP and PS, exhibit similar seasonal variations although the magnitude is variable.



A number of species at sites AA, CB and CH are exhibiting cyclic patterns, often at more than one site. Table 4.2 lists the species and the type of cyclic pattern (or no pattern -) observed at each site.

Table 4.2: Monitored species and the types of cyclic patterns observed.

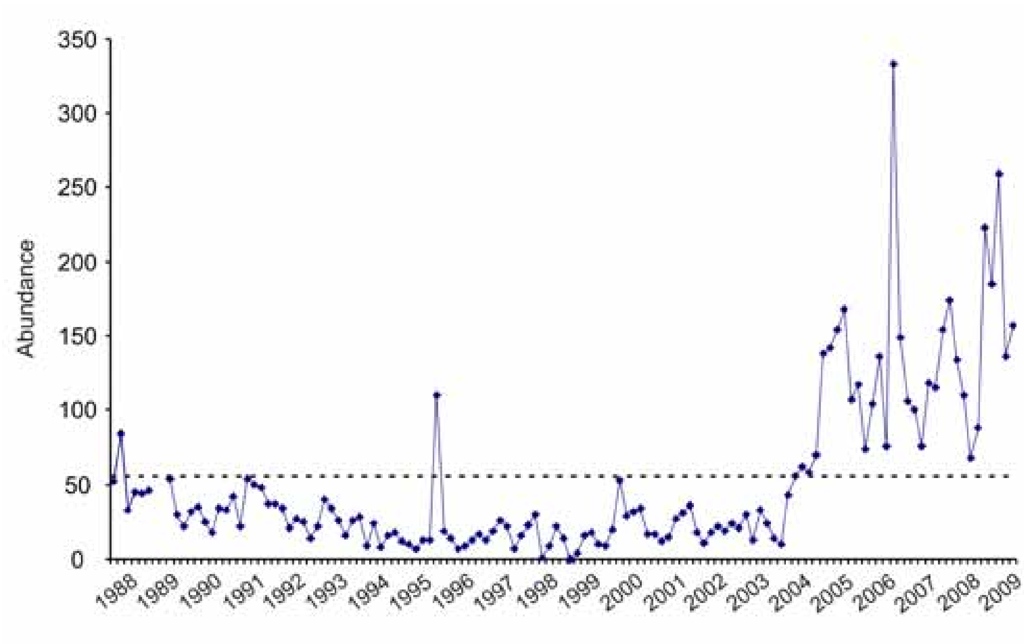
Monitored Species	AA	CB	CH
Aglaophamus macroura	-	-	ENSO,
Austrovenus stutchburyi	ENSO, Multi-year cycle (7-9 years)	ENSO	ENSO
Boccardia syrtis	-	ENSO, Multi-year cycle (5-7 years)	ENSO
Colorostylis lemurum	-	Multi-year cycle	-
Glycinde dorsalis	*	Multi-year cycle (3-6 years)	ENSO
Macomona liliana	ENSO, Multi-year cycle	ENSO	Seasonal cycle
Macroclymenella stewartnesis	-	Multi-year cycle (3-5 years)	-
Magelona dakini	ENSO, Multi-year cycle	ENSO, Multi-year cycle	ENSO, Multi-year cycle
Nucula hartvigiana	ENSO, Multi-year cycle	ENSO	ENSO
Owenia fusiformis	-	-	ENSO
Prionospio aucklandica	Multi-year cycle (2-6 years)	-	-
Soletellina siliqua	ENSO, Multi-year cycle (7-9 years)	ENSO, Multi-year cycle (7-9 years)	-
Travisia olens	Multi-year cycle (5-6 years)	-	-
Waitangi brevirostris	ENSO, Multi-year cycle (4-6 years)	-	ENSO

4.3 Are trends in abundance being maintained?

4.3.1 Site AA

In 2007 no trends in abundance were reported for site AA, however, this year there is evidence of a marked increase in abundances of *Aonides trifida* from 2004 (Fig 4.16) .

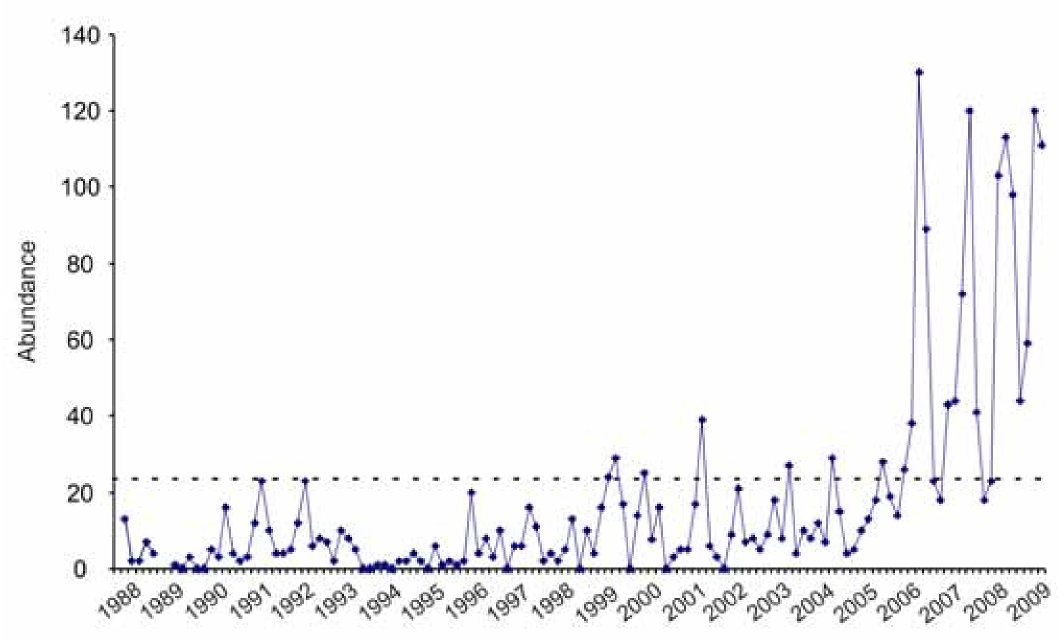
Figure 4.16:
Abundance of *Aonides trifida* at site AA. Dashed line is the 95% percentile for the first 15 years.



4.3.2 Site CB

In the last report (Hewitt and Hailes 2007) a significant negative trend in the abundance of *Aglaophamus macroura* was detected, however, it was thought likely that this was part of a small multi-year cyclical pattern occurring. Data collected over the last two years has proven this to be the case. Only one trend was apparent at this site; an increasing trend in the abundance of *Anthopleura aureoradiata* (Fig 4.17).

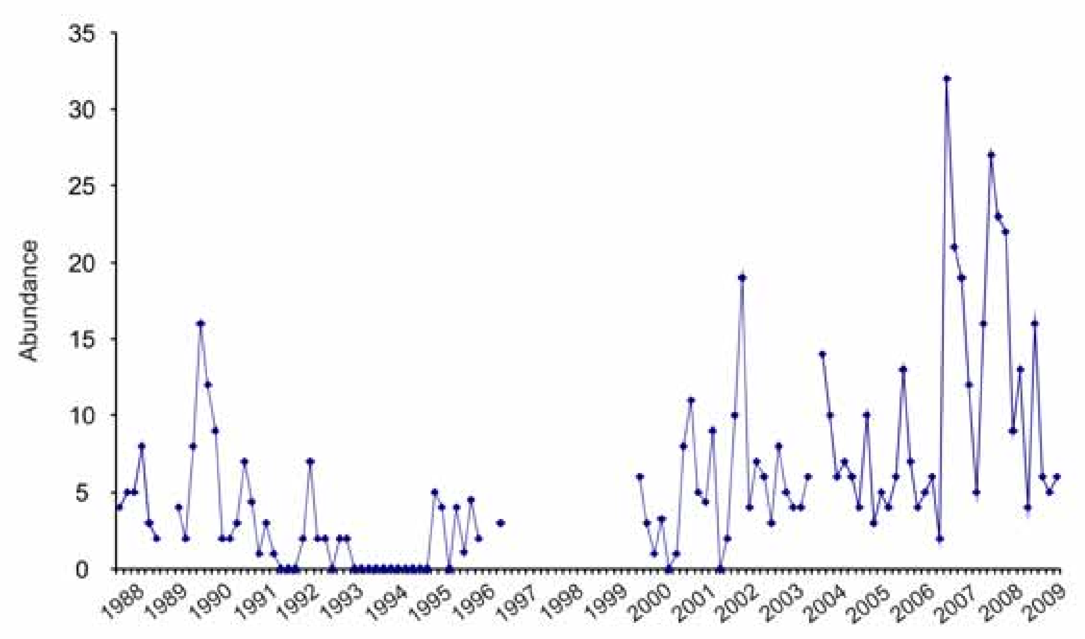
Figure 4.17:
Abundance of *Anthopleura aureoradiata* at site CB. Dashed line is the 95% percentile for the first 15 years.



4.3.3 Site CH

In 2007, five species, whose changes in abundance had been predicted to some degree by changes to the wastewater treatment, were still exhibiting trends in abundance: *Aglaophamus macroura, Glycinde dorsalis, Magelona dakini*, *Waitangi brevirostris*, and *Owenia fusiformis.* For the latter three species, changes in their abundance were also associated with ENSO and all three abundances have decreased. Abundances of the other two species are now stable: *Glycinde dorsalis* is rarely found and *Aglaophamus macroura* is found in slightly higher densities than before the changes to the wastewater treatment (Fig 4.18).

Figure 4.18:
Abundance of *Aglaophamus macroura* at Site CH.



4.3.4 Sites EB, KP and PS

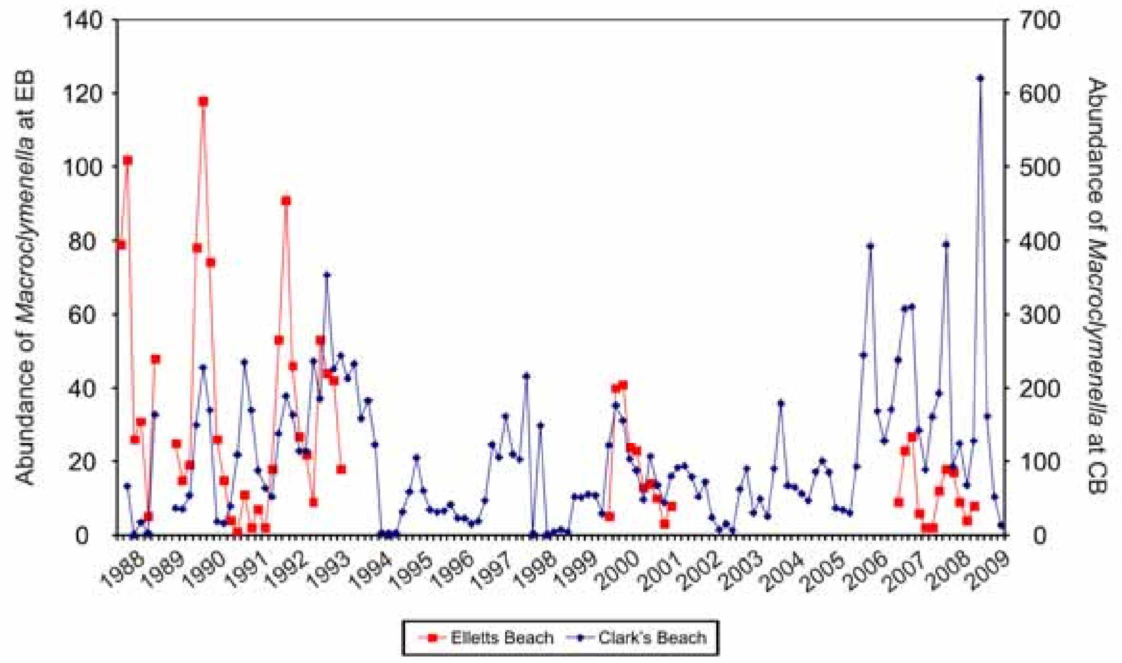
Hewitt and Thrush (2007) describe the advantages of the spatially and temporally nested design used for the Manukau monitoring programme. The comparison of long-term data from sites exhibiting long-term trends and cycles avoids analysing several smaller blocks of data that can inaccurately detect trends or mask chronic and/or cumulative impacts. Hewitt and Thrush (2007) reported incorrect assignment of trends to actual multi-year cycles for 30 – 50% of detected changes when species abundances at sites EB, KP and PS were analysed without consideration of patterns at sites AA, CB and CH.

As a result of these comparisons, three species are exhibiting trends in abundance at site EB, *Aonides trifida* is exhibiting an increasing trend in abundance and *Aglaophamus macroura* and *Macroclymenella stewartensis* (Fig 4.19) are showing trends of decreasing abundance over time.

At Karaka Point, the abundances of *Owenia fusiformis* and *Macroclymenella stewartensis* are exhibiting a trend of decreasing abundance. However, if abundances of these species continue to show a time lag in their dynamics relative to site CB these trends are likely to be part of long-term cycles.

Species at site PS are not exhibiting trends in abundance; rather they are maintaining their abundances over time within the limits of natural variation.

Figure 4.19:
Abundance of *Macroclymenella stewartensis* at sites EB and CB.



4.4 Have any of the sites exhibited differences in community composition over time?

Variation in community composition observed at all sites each October, provides an indication of whether communities are changing over time and also how similar the macrofaunal communities from each site are to each other.

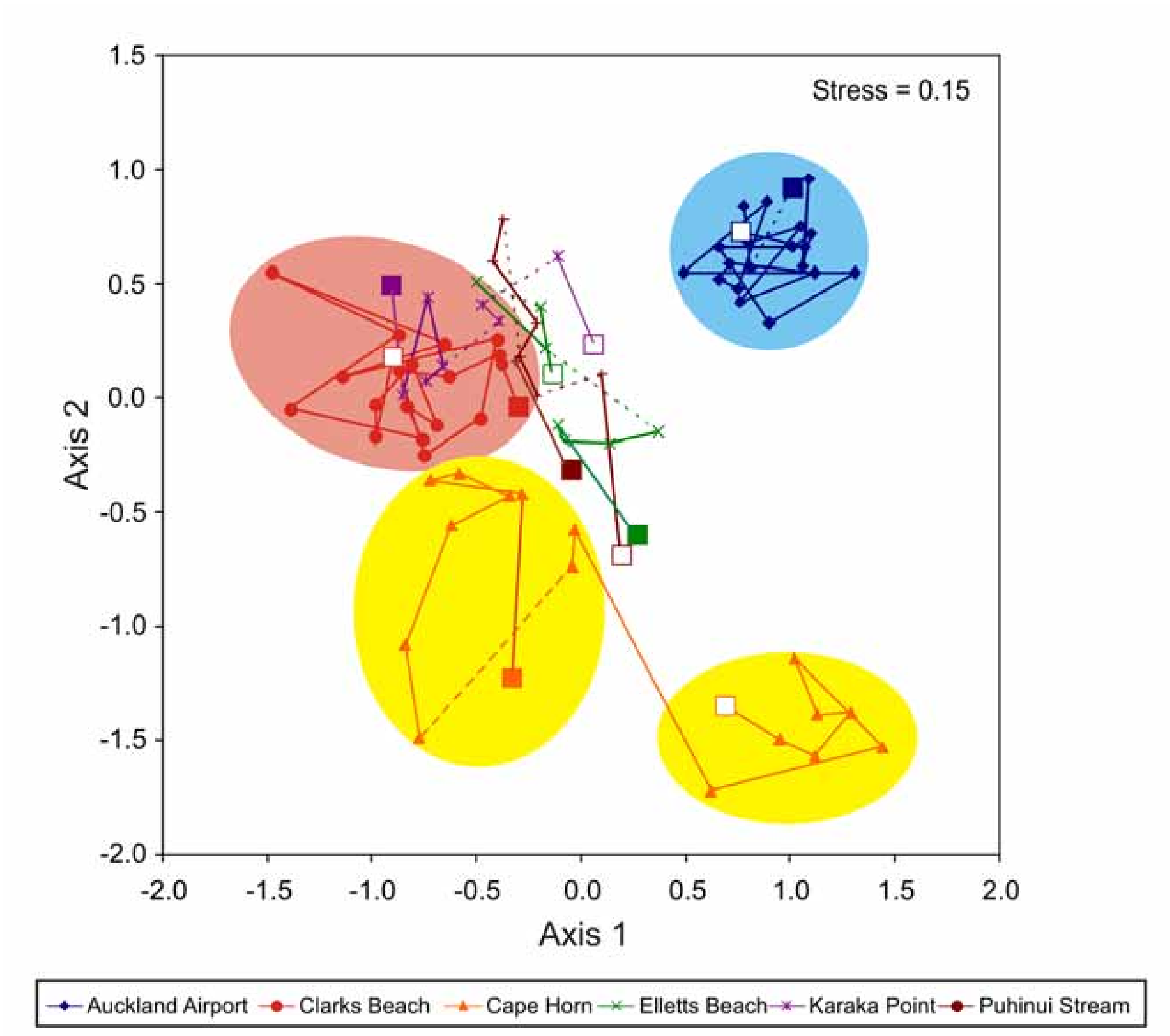
At site AA the community is largely dominated by bivalves *Macomona liliana*, *Soletellina siliqua*, *Austrovenus stutchbuyi* and *Nucula harvigiana* (Appendix 4). The community composition at site AA, has been the most constant of the monitored sites, (Fig 4.20). Site CB is dominated by a mix of bivalves (*Macomona liliana* and *Nucula hartvigiana)* and polychaetes (i.e., *Macroclymenella stewartensis*, *Boccardia syrtis* and *Magelona dakini*) (Appendix 4) and although it can be variable over time it remains relatively distinct from the other sites (Fig 4.20).

Conversely, the community at site CH has changed markedly over time (Fig 4.20). Analysis suggests that the change between 2000 and 2001 is related to some extent to the Mangere wastewater treatment plant upgrade (Hewitt and Hailes 2007). During the last two years of sampling, the community composition has remained relatively constant, with the dominant species being *Magelona dakini*, *Macroclymenella stewartensis* and *Colorostylis lemurum* (Appendix 4).

Site PS is dominated by both bivalves and polychaetes. Neither the rank abundance for the three dominant species nor the community composition has changed considerably over the years (Fig 4.20). The community compositions at sites KP and EB has changed over the last 7 years (ANOSIM; differences between the initial and most recent community compositions for KP and EB are statistically significant, $p=0.001$) (Fig 4.20), although the analysis of individual species abundances suggests that this is likely to be related to cyclic patterns.

Figure 4.20:

Multi-dimensional Scaling (MDS) plot (stress = 0.15; indicates that the high dimensional relationships among samples should be interpreted with caution) displaying the dissimilarity in macrofaunal communities across sites over time (1987-2009) for each October. The earliest sampling occasion is marked by a closed square and the most recent sampling time marked by an open square. Coloured ovals represent the total area of community movement over time at Auckland Airport (blue), Clarks Beach (pink) and Cape Horn (yellow). The further away the points are in the ordination space, the more dissimilar the community composition is. Thus, the tightly clustered points represent similar communities



Ecological theory suggests that an early warning for abrupt degradative change may be increased temporal variability in community dynamics (Anderson et al. 2008; Carpenter & Brock 2006). Both within and between year variability was assessed for increases by comparing the Bray-Curtis percentage similarities (calculated for log-transformed data) from the initial 5 years and the last 2 years of data for each site.

Overall, the within year and between year percent community similarities for all sites are relatively high and consistent over time, with the highest being site AA in both periods analysed (Table 4.3).

Table 4.3:

Average percent similarity (within years and between years) of the community composition at all monitored sites for the initial sampling period (years 1987-1991) and final two years.

	AA	CB	CH	EB	KP	PS
Within Year Similarity						
Initial Sampling Period	81.20	82.60	80.40	80.60	83.20	83.80
Final Sampling Period	86.00	83.30	80.52	86.62	84.19	85.56
Between Year Similarity						
Initial Sampling Period	76.00	72.90	71.00	63.50	67.00	65.10
Final Sampling Period	84.50	79.48	74.95	81.49	81.57	84.31

4.5 Are there changes in Manukau related to sediment or heavy metal contamination?

As reported by Thrush et al. (1990), the monitored species were chosen for monitoring based on their abundance and their potential roles in the ecology of sandflat communities, but more importantly as potential indicators of changes related to pollution. Therefore, it is important to consider whether any species has started to increase in density at sites where it was previously rare or absent and vice versa, as the change may indicate the effects of either a specific event in time or cumulative and chronic pollution (Hewitt & Thrush, 2007).

Over the past few years, sensitivities of many of the monitored species to increases in sedimentation rates and heavy metal contamination have been determined (Gibbs and Hewitt (2004) and Table 4.4). None of the few trends in abundance presently observed are consistent with predicted responses to either increased sediment loading or storm water contamination.

Table 4.4:

Monitored species for which an EC50 (i.e., reduction in abundance) was predicted to occur below the sediment effect level guideline (TEL) determined by MacDonal (1996) for copper, lead and zinc. Taxa are given in order of sensitivity with the most sensitive species first (Hewitt et al. in press).

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

5 Conclusions

5.1 Are populations at the sites generally exhibiting similar patterns?

Long term cyclic patterns of abundance are occurring and many of these are related to environmental factors such as broad-scale climatic changes (ENSO, temperature) and more local scale changes to water temperature and wave climate (Hewitt and Thrush, in press). These relationships result in many cyclic patterns being consistent between sites (although timing and magnitude can vary) (Table 5.1).

Table 5.1:

Species abundances exhibiting similarities in long-term trends across sites. Note that Auckland Airport (AA) is contiguous with Karaka Point (KP) and Puhinui Stream (PS) and Clark's Beach (CB) is contiguous with Elletts Beach (EB). Cape Horn is abbreviated CH. Significance and trends determined by p values <0.05.

Monitored Species	Sites Exhibiting Long-Term Trends in Abundance
Agloaphamus macroura	CB
Anthopleura aureoradiata	AA, KP, PS
Aonides trifida	AA, CB, PS
Austrovenus stutchburyi	AA, CH, KP
Boccardia syrtis	AA, CB, KP
Exosphaeroma spp.	CB, EB
Glycinde dorsalis	CH
Soletellina siliqua	AA, CB, CH, EB, KP, PS
Macomona liliana	AA, CB, CH, EB, PS
Macroclymenella stewartensis	EB, PS
Magelona dakini	AA, CB, CH, EB, KP, PS
Methalimedon sp.	CB, PS
Notocmea helmsi	CB, KP
Nucula hartvigiana	AA, CB, CH, PS
Orbinia papillosa	AA, CB, EB, PS
Owenia fusiformis	CH, PS
Torridoharpinia hurlyi	AA, CB
Trochodota dendyi	KP, PS

5.2 Do any of the observed patterns in population abundances indicate important changes in benthic communities?

Threats to the health of the harbour should result in a number of species showing trends consistent with response to a particular stressor at one or more sites. The more sites affected, the larger the scale of the impact. Trends occurring in the abundance of only a few species, at only one site and which don't correlate well with predicted stress responses, are unlikely to indicate serious changes to the health of the harbour.

During the last two years, there is no evidence to suggest that there have been any detrimental effects on ecosystem health within the extensive intertidal flats that make up the main body of the Manukau Harbour. The maximum number of trends in species abundance detected at a site is three and none of these changes are consistent with a response to known anthropogenic activity.

Effective management requires diligent monitoring and assessment of the status of the ecosystem and changes to aspects within the ecosystem. The ecological monitoring of the Manukau Harbour has allowed the Auckland Regional Council to state with authority that despite on-going urbanisation and industrialisation around the Manukau the extensive sandflats that make up the large proportion of the Harbour are not being degraded. While tidal creeks are not monitored and may be degraded in some instances, degradation is not extending from them out into the main body of the Harbour. Moreover, the data gained from the long term and uninterrupted monitoring at Auckland Airport and Clark's Beach provide an invaluable resource for determining inter- and intra-annual cycles in abundance of several taxa across all sites. The data and information gained from such a strong data set can be, and has been, applied and used as a comparison for other studies (e.g., Mahurangi and Waitemata Monitoring Programmes) that have been carried out on behalf of the Auckland Regional Council.

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8 Appendices

8.1 Appendix 1: Sediment grain size (% weight) results since April 2007. Size fractions are gravel (>2 mm), sand (2 mm – 63 μm) and silt/clay (<63 μm)

	Auckland Airport (AA)			Clarks Beach (CB)			Cape Horn (CH)			Elletts Beach (EB)			Karaka Point (KP)			Puhinui Stream (PS)		
	Gravel	Sand	Silt/Clay	Gravel	Sand	Silt/Clay	Gravel	Sand	Silt/Clay	Gravel	Sand	Silt/Clay	Gravel	Sand	Silt/Clay	Gravel	Sand	Silt/Clay
Apr-07	0.1	98.9	1.0	0.2	94.6	5.1	0.0	98.6	1.4	0.4	93.2	6.4	3.1	95.0	1.9	0.8	97.9	1.2
Jun-07	0.1	98.9	1.0	4.8	88.7	6.5	0.0	99.2	0.8	0.4	92.9	6.7	0.5	97.9	1.6	0.0	98.8	1.1
Aug-07	0.5	98.9	0.5	0.2	93.4	6.4	0.0	99.5	0.5	0.2	97.2	2.6	1.9	96.5	1.6	0.5	98.7	0.8
Oct-07	0.0	99.4	0.6	4.1	92.1	3.9	0.0	99.6	0.4	0.4	98.8	0.7	2.9	95.6	1.5	0.0	99.1	0.9
Dec-07	0.1	99.4	0.5	2.2	94.4	3.4	0.0	99.6	0.4	0.3	94.1	5.5	1.5	96.6	2.0	0.0	99.2	0.8
Feb-08	0.0	99.2	0.8	0.5	95.5	4.1	0.0	99.4	0.6	0.3	93.1	6.6	5.8	92.5	1.7	0.0	99.2	0.8
Apr-08	0.3	98.3	1.4	1.1	94.1	4.8	0.0	99.3	0.7	0.5	90.0	9.6	2.9	94.5	2.6	0.1	98.7	1.2
Jun-08	0.0	99.2	0.8	0.2	84.3	15.5	0.0	98.5	1.5	0.2	75.8	23.9	0.5	97.5	2.0	0.0	99.3	0.7
Aug-08	1.4	95.6	3.0	0.5	87.0	12.5	0.1	99.4	0.5	-	-	-	-	-	-	-	-	-
Oct-08	0.0	97.9	2.1	1.1	89.1	9.7	0.0	99.4	0.6	-	-	-	-	-	-	-	-	-
Dec-08	0.0	99.5	0.5	0.9	93.7	5.4	0.0	99.5	0.5	-	-	-	-	-	-	-	-	-
Feb-09	0.0	99.3	0.7	0.9	91.9	7.2	0.0	99.8	0.2	-	-	-	-	-	-	-	-	-

8.2 Appendix 2: Sediment Organic Content (%) results since April 2007.

	Auckland Airport (AA)	Clarks Beach (CB)	Cape Horn (CH)	Elletts Beach (EB)	Karaka Point (KP)	Puhinui Stream (PS)
Apr-07	0.97	1.72	0.69	0.82	0.99	0.59
Jun-07	0.65	1.47	0.74	1.17	0.74	0.63
Aug-07	0.61	1.43	0.58	0.75	1.06	0.65
Oct-07	0.46	0.66	0.35	0.46	0.53	0.37
Dec-07	0.58	0.96	0.53	0.86	0.78	0.62
Feb-08	0.55	1.22	0.60	1.38	0.95	0.66
Apr-08	0.66	1.09	0.63	1.15	0.85	0.53
Jun-08	0.67	2.72	0.79	2.47	0.98	0.59
Aug-08	0.45	1.49	0.53	-	-	-
Oct-08	0.69	1.73	0.70	-	-	-
Dec-08	0.64	1.20	0.62	-	-	-
Feb-09	0.65	2.45	0.61	-	-	-

8.3 Appendix 3: Sediment Chlorophyll *a* levels (µg/g sediment) since April 2007.

	Auckland Airport (AA)	Clarks Beach (CB)	Cape Horn (CH)	Elletts Beach (EB)	Karaka Point (KP)	Puhinui Stream (PS)
Apr-07	8.60	16.96	7.56	11.01	7.11	8.48
Jun-07	8.60	15.59	6.88	13.98	6.19	8.02
Aug-07	9.97	17.66	5.73	12.61	6.76	9.40
Oct-07	9.74	15.36	5.10	10.08	6.65	9.28
Dec-07	8.83	19.94	5.16	12.49	7.11	8.71
Feb-08	10.54	14.45	6.53	13.52	9.40	9.52
Apr-08	9.29	14.56	6.76	11.12	8.71	9.17
Jun-08	9.86	13.99	7.11	12.84	6.76	8.48
Aug-08	9.97	21.09	8.60	-	-	-
Oct-08	12.50	19.95	9.86	-	-	-
Dec-08	9.52	12.61	6.88	-	-	-
Feb-09	9.28	13.76	6.19	-	-	-

8.4 Appendix 4: The three most abundant species found in October each year at the monitored sites a) AA, b) CB, c) CH, d) EB, f) KP and g) PS[3].

a) AA			
Year			
1987	*Macomona liliana*	*Soletellina siliqua*	*Austrovenus stutchburyi*
1989	*Macomona liliana*	*Austrovenus stutchburyi*	*Magelona dakini*
1990	*Macomona liliana*	*Soletellina siliqua*	*Austrovenus stutchburyi*
1991	*Macomona liliana*	*Austrovenus stutchburyi*	*Nucula hartvigiana*
1992	*Macomona liliana*	*Travisia olens*	*Austrovenus stutchburyi*
1993	*Macomona liliana*	*Austrovenus stutchburyi*	*Travisia olens*
1994	*Macomona liliana*	*Austrovenus stutchburyi*	*Travisia olens*
1995	*Macomona liliana*	*Austrovenus stutchburyi*	*Soletellina siliqua*
1996	*Macomona liliana*	*Soletellina siliqua*	*Magelona dakini*
1997	*Macomona liliana*	*Soletellina siliqua*	*Austrovenus stutchburyi*
1998	*Macomona liliana*	*Soletellina siliqua*	*Austrovenus stutchburyi*
1999	*Macomona liliana*	*Orbinia papillosa*	*Soletellina siliqua*
2000	*Macomona liliana*	*Soletellina siliqua*	*Orbinia papillosa*
2001	*Macomona liliana*	*Magelona dakini*	*Trochodota dendyi*
2002	*Macomona liliana*	*Magelona dakini*	*Trochodota dendyi*
2003	*Macomona liliana*	*Magelona dakini*	*Nucula hartvigiana*
2004	*Macomona liliana*	*Soletellina siliqua*	*Aonides oxycephala*
2005	*Macomona liliana*	*Magelona dakini*	*Soletellina siliqua*
2006	*Macomona liliana*	*Soletellina siliqua*	*Colurostylis lemurum*
2007	*Soletellina siliqua*	*Macomona liliana*	*Aonides oxycephala*
2008	*Aonides trifida*	*Macomona liliana*	*Soletellina siliqua*

[3] *Macroclymenella stewartensis*, for convenience, is referred to by genus only in these tables

b) CB			
Year			
1989	*Macroclymenella*	*Macomona liliana*	*Torridoharpinia hurleyi*
1990	*Nucula hartvigiana*	*Boccardia syrtis*	*Macroclymenella*
1991	*Nucula hartvigiana*	*Macomona liliana*	*Macroclymenella*
1992	*Macroclymenella*	*Macomona liliana*	*Torridoharpinia hurleyi*
1993	*Macroclymenella*	*Boccardia syrtis*	*Nucula hartvigiana*
1994	*Macomona liliana*	*Macroclymenella*	*Torridoharpinia hurleyi*
1995	*Nucula hartvigiana*	*Magelona dakini*	*Macroclymenella*
1996	*Nucula hartvigiana*	*Boccardia syrtis*	*Torridoharpinia hurleyi*
1997	*Nucula hartvigiana*	*Boccardia syrtis*	*Macomona liliana*
1998	*Nucula hartvigiana*	*Macomona liliana*	*Torridoharpinia hurleyi*
1999	*Macroclymenella*	*Nucula hartvigiana*	*Macomona liliana*
2000	*Nucula hartvigiana*	*Macomona liliana*	*Macroclymenella*
2001	*Macomona liliana*	*Nucula hartvigiana*	*Macroclymenella*
2002	*Nucula hartvigiana*	*Macomona liliana*	*Magelona dakini*
2003	*Macroclymenella*	*Nucula hartvigiana*	*Macomona liliana*
2004	*Macroclymenella*	*Magelona dakini*	*Macomona liliana*
2005	*Macroclymenella*	*Nucula hartvigiana*	*Torridoharpinia hurleyi*
2006	*Nucula hartvigiana*	*Macroclymenella*	*Macomona liliana*
2007	*Macroclymenella*	*Torridoharpinia hurleyi*	*Nucula hartvigiana*
2008	*Nucula hartvigiana*	*Macroclymenella*	*Macomona liliana*

c) CH			
Year			
1987	*Magelona dakini*	*Glycinde dorsalis*	*Macroclymenella*
1989	*Boccardia syrtis*	*Magelona dakini*	*Macroclymenella*
1990	*Boccardia syrtis*	*Macomona liliana*	*Macroclymenella*
1991	*Boccardia syrtis*	*Macroclymenella*	*Macomona liliana*
1992	*Macroclymenella*	*Colurostylis lemurum*	*Torridoharpinia hurleyi*
1993	*Macroclymenella*	*Torridoharpinia hurleyi*	*Magelona dakini*
1994	*Macroclymenella*	*Magelona dakini*	*Glycinde dorsalis*
1995	*Boccardia syrtis*	*Magelona dakini*	*Glycinde dorsalis*
:			
1999	*Torridoharpinia hurleyi*	*Macroclymenella*	*Magelona dakini*
2000	*Magelona dakini*	*Boccardia syrtis*	*Colurostylis lemurum*
2001	*Magelona dakini*	*Macroclymenella*	*Colurostylis lemurum*
2002	*Magelona dakini*	*Colurostylis lemurum*	*Soletellina siliqua*
2003	*Magelona dakini*	*Macroclymenella*	*Colurostylis lemurum*
2004	*Magelona dakini*	*Macroclymenella*	*Colurostylis lemurum*
2005	*Magelona dakini*	*Macroclymenella*	*Waitangi brevirostris*
2006	*Magelona dakini*	*Macroclymenella*	*Soletellina siliqua*
2007	*Magelona dakini*	*Macroclymenella*	*Colurostylis lemurum*
2008	*Colurostylis lemurum*	*Magelona dakini*	*Macroclymenella*

d) EB			
Year			
1987	*Magelona dakini*	*Macroclymenella*	*Torridoharpinia hurleyi*
1989	*Macroclymenella*	*Soletellina siliqua*	*Macomona liliana*
1990	*Soletellina siliqua*	*Magelona dakini*	*Nucula hartvigiana*
1991	*Soletellina siliqua*	*Macroclymenella*	*Methalimedon* sp.
1992	*Torridoharpinia hurleyi*	*Soletellina siliqua*	*Macomona liliana*
:			
1999	*Macomona liliana*	*Austrovenus stutchburyi*	*Magelona dakini*
2000	*Macomona liliana*	*Austrovenus stutchburyi*	*Nucula hartvigiana*
:			
2006	*Macomona liliana*	*Nucula hartvigiana*	*Magelona dakini*
2007	*Magelona dakini*	*Macomona liliana*	*Soletellina siliqua*

e) KP			
Year			
1987	*Anthopleura aureoradiata*	*Magelona dakini*	*Macomona liliana*
1989	*Macomona liliana*	*Nucula hartvigiana*	*Magelona dakini*
1990	*Nucula hartvigiana*	*Macomona liliana*	*Magelona dakini*
1991	*Nucula hartvigiana*	*Macomona liliana*	*Magelona dakini*
1992	*Magelona dakini*	*Nucula hartvigiana*	*Macomona liliana*
:			
1999	*Nucula hartvigiana*	*Macomona liliana*	*Torridoharpinia hurleyi*
2000	*Macomona liliana*	*Nucula hartvigiana*	*Magelona dakini*
:			
2006	*Magelona dakini*	*Macomona liliana*	*Soletellina siliqua*
2007	*Magelona dakini*	*Soletellina siliqua*	*Macomona liliana*

f) PS			
Year			
1987	*Macomona liliana*	*Soletellina siliqua*	*Exosphaeroma falcatum*
1989	*Macomona liliana*	*Nucula hartvigiana*	*Soletellina siliqua*
1990	*Nucula hartvigiana*	*Soletellina siliqua*	*Macomona liliana*
1991	*Macomona liliana*	*Nucula hartvigiana*	*Exosphaeroma falcatum*
1992	*Macomona liliana*	*Exosphaeroma falcatum*	*Boccardia syrtis*
:			
1999	*Nucula hartvigiana*	*Macomona liliana*	*Boccardia syrtis*
2000	*Nucula hartvigiana*	*Macomona liliana*	*Boccardia syrtis*
:			
2006	*Macomona liliana*	*Magelona dakini*	*Nucula hartvigiana*
2007	*Magelona dakini*	*Exosphaeroma falcatum*	*Orbinia papillosa*