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The Long Bay Monitoring Program Report 2002-2003

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1. Executive Summary

During 2002 and 2003 both intertidal soft sediments and subtidal rocky reefs at Long Bay and in the surrounding area were surveyed as part of ongoing monitoring of the Long Bay-Okura Marine Reserve. Benthic infauna were sampled on beaches and benthic fauna, flora, substrate types and sedimentation were sampled on subtidal reefs. Data gathered was then analysed over both spatial and temporal scales.

Intertidal soft sediment

There were significant differences in macrofaunal communities between the four beaches surveyed and between the mid and low shore tidal zones. Significant differences were also present in macrofaunal communities between sampling times (September 2002 and March 2003) when each beach was analysed separately, but not when data from all beaches were combined. Therefore, although differences were seen at individual beaches over time, no consistent regional differences were seen between the macrofaunal communities over the sampling period.

On all beaches the dominant species usually contributed to the spatial and temporal differences in community structure. These dominant species were *Hesionidae* sp. (a small polychaete), *Colorustylus lemurnum* (a cumacean, a small type of crustacean), *Paphies* spp. (pipi and tuatua, 2 types of bivalves), *Waitangi* sp. (an amphipod) and nematodes.

Variation in community structure was large at Long Bay and Browns Bay, whereas Mairangi showed little variation. The community at Torbay was highly variable in September 2002, but showed very little variation in March 2003.

Long Bay beach was analysed to a greater extent than the other four beaches, due to its potential to be impacted by sedimentation. Long Bay beach showed both along-shore spatial and vertical zonal difference in macrofaunal communities. There was a difference between transects along the beach which indicated that the northern and the southern halves of the beach could be considered biologically different. These spatial differences on Long Bay beach were mainly due to differences in 2 of the most abundant species, *Hesionidae* sp. and *Waitangi* sp..

The sampling methodology used during the first half of this report period used a 1mm sieve size until March 2002 inclusive. Therefore direct comparisons of this year's data (which used a 0.5mm mesh size) with the previous years data is not possible. However some general comparisons may be tentatively made. Last year's report recorded many more pipis at Torbay than the other beaches, which is consistent with this years findings. Species densities were highest at Browns Bay and lowest at Mairangi Bay this year, a pattern that was consistent with last years survey. There was no detectable seasonal variation over all these beaches in this or last year.

One of the main species contributing to differences in this year's analysis was the small polychaete *Hesionidae* sp. that had not been detected using the previous methodology

Subtidal Rocky Reefs

Subtidal rocky reefs continued to be dominated, in terms of the canopy kelps, by the brown algae *Carpophyllum maschalocarpum*, and in areal substrate coverage by the red algae crustose coralline algae (CCA). The numerically dominant fauna on these reefs continued to be the herbivorous gastropod *Turbo smaragdus*.

The community structure of the subtidal benthic organisms was significantly different between locations; most notably Waiwera was different to all the other locations. Variations were also seen between years over the region; most notably 2003 was significantly different to all other years. *Carpophyllum plumosum* and *Carpophyllum flexuosum* were the main species contributing to these differences between years.

Long Bay reefs showed no variation in community structure that was significantly different to other locations within the region (with the exception of Waiwera). *Evechinus chloroticus* and *Sargassum sinclairii* are both species that are thought to be sensitive to sedimentation, and both showed no significant variation over time. Therefore any impact of future increases in sedimentation that may occur within the reserve should be detectable by monitoring changes in the densities or size structures of these species. This impact of sedimentation upon *Evechinus chloroticus* is being pursued as part Jarrod Walkers doctoral studies through the University of Auckland.

The rate of sedimentation over the past 2 years, measured using sediment traps, had not increased over time, however the proportion of trapped sediment which was less than 63 µm (that most likely to be from terrestrial origin) showed an increase over the whole monitoring period (since 1999). Sedimentation rate was lowest at Stanmore and highest at both Campbells and Long Bay, and was consistent, at all locations over time.

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2. Introduction

New Zealand's population is increasing and it is projected that by 2050 Auckland's population alone will have doubled (Auckland Regional Growth Strategy 1999). The level of urban development required to accommodate the increasing population is likely to have a detrimental effect on the natural environment. This report concentrates on establishing a baseline with which to detect any flow on or downstream effects, mainly siltation, due to terrestrial runoff, of the future urban development of the catchment of Long Bay. Long Bay has been earmarked by the ARC as a future area for urban development to help accommodate Auckland's expanding population (Auckland Regional Growth Strategy 1999). It has been claimed that in estuaries where human densities are high the associated shorelines tend to be dominated by mudflats, including some that may have historically been sandflats (Edgar & Barrett 2000). As estuaries flow into the marine environment any siltation occurring in the estuary may also have flow-on effects to the open coast. When fine sediment accumulation on shorelines is of terrestrial or terrigenous clay origin, the effects may occur rapidly and be long lasting (Norkko et. al 2002). For instance, sudden deposits of terrestrial sediments in Okura Estuary lead to declines in the abundance of infaunal animals of up to 50% within three days of being smothered. Mortality increased to 90% after only 10 days. Recovery of these communities took up to 408 days or longer after a sedimentation event (Norkko et. al 2002).

Long Bay/Okura Marine Reserve is an area of coastline 20 minutes drive north of Auckland's CBD which has been monitored annually since 1998. The Long Bay/Okura marine reserve is an area of coastline stretching from Toroa Point in the south to the Okura Estuary in the north and has been fully protected since 1995 (Honeywill et al 2002). The Long Bay catchment area was recently rezoned to be within metropolitan urban limits (Auckland Regional Growth Strategy 1999). This rezoning allows for urban development along the cliff tops above the beach and along the streams, in particular Awaruku Stream (at the southern end of the beach). Monitoring was initiated due to concerns over terrestrial sediment entering the Long Bay marine environment during or after heavy rain events via either Awaruku (at the southern end of the beach or Vaughans (at the northern end of the beach) streams as well as via the Okura and Weiti Estuaries. Long Bay has a diverse array of habitat types within its boundaries. The marine reserve contains sandy beaches, intertidal reefs, shallow subtidal reefs, deeper soft bottom areas and muddy estuarine habitats making it a representative sub-sample of the habitat types in the greater Hauraki Gulf area (Walker et. al. 2001).

2.a. The present report

This reports concentrates on two major areas of the marine environment, firstly the macro infauna of the intertidal beach environments and secondly on sedimentation rates and community structure of the near shore subtidal environment surrounding and including Long Bay Marine Reserve.

The Long Bay Development Effects monitoring program has now been in place for six consecutive years. This document is the fifth report to date (Babcock et al. 1999a, 1999b, Walker et al. 2000, 2001) and details the results of sampling during September 2001 and 2002 and March 2002 and 2003, whilst placing those results in the context of previous data. Sampling of subtidal rocky reef environments followed protocols recommended previously (Babcock et al.1999a). Within the intertidal portion of the survey during the period in which this report is pertinent (mid 2001-mid 2003), there have been changes to the sampling protocols following a review by NIWA (Lohrer et al. 2002). These changes were made firstly to bring the protocols into line with other ARC monitoring surveys and secondly to streamline the project whilst ensuring sufficient data is collected to detect any differences that may occur. Results presented within this report include both multivariate and univariate analyses of temporal and spatial variability which will continue to add information to the baseline for assessing future trends in the marine communities sampled.

2.b. Intertidal Soft Sediments

The Long Bay monitoring project has been designed to enable the detection of ecological change to marine habitats within and surrounding the Long Bay Marine Reserve. Monitoring for these areas was set in place to occur prior to, during and post urban development of the surrounding catchment area (Walker et. al. 2001).

These comparisons included analyses between beaches, between tidal heights and between sampling times. Long Bay was additionally analysed to detect any spatial differences between the northern and southern halves of the beach. The number of cores per replicates needed to detect any differences was also examined.

2.c. Subtidal Rocky Reefs

Investigations into the subtidal community structure on the shallow subtidal reefs of the inner Hauraki Gulf were undertaken during the period, May - June 2003. This was done in accordance with the Long Bay Development Effects monitoring program, with 6 sites from Waiwera in the north to Campbells Bay in the south (including the Long Bay/Okura Marine Reserve).

Analyses of trap sedimentation were also continued at each of the monitored sites. The threat of increased sedimentation and turbidity is a major concern for the Long Bay marine environment. Studies have shown that effects such as smothering and abrasion from sediments can have profound consequences on the arrangement and composition of subtidal reef communities (Schiel & Foster 1986). Species diversity can also be diminished as a result of sedimentation (Gorostiaga 1998). Information on the types and quantities of sediment entering the marine ecosystem is therefore needed. To address this, a monitoring program has been ongoing since 1999 to quantify sedimentation in the same areas where subtidal sampling is undertaken to assess community structure.

3. Methods

3.a. Intertidal monitoring

3.a.1. Site selection and sampling design

Intertidal monitoring was conducted at Long Bay beach and 3 other beaches in the North Shore region; Torbay, Browns Bay and Mairangi Bay (see Appendix A for Global Positioning Systems (GPS) coordinates). Sampling was carried out in September 2001 and March 2002 and employed a similar sampling design as was used in the 2000-2001 year (Walker *et al.* 2001). In September 2002 and March 2003 a new methodology was implemented as recommended in the NIWA rationalization of beach monitoring methods report (Lohrer et al. 2002).

September 2001 & March 2002

The methods used between March 2000 and March 2002 involved sampling 6 transects at Long Bay, and 4 transects at Torbay, Browns Bay and Mairangi Bay. These transects ran perpendicularly from the foot of the dunes to the mark of the Mean Low Water Springs (MLWS), with 3 sampling stations spaced evenly (at 40m intervals) down each transect at high, mid and low shore stations.

September 2002 & March 2003

The revised design increased the number of transects at all beaches. At Long Bay, the beach was divided into North and South areas and in each area the number of transects was increased from 3 to 5. Three transects remained consistent with previous monitoring (1-3 in the north, 4-6 in the south) and 2 extra transects were added between these (1a & 2a, 4a & 5a). At Torbay, Browns Bay and Mairangi Bay the number of transects was increased from 4 to 6 (transects 1a & 3a were added at each beach). Transects labelled 1 at all beaches were located at the northern end of the beach and numbering ran consecutively to the southern end.

At all beaches the number of sampling stations on each transect was decreased from 3 to 2, with the high shore station omitted. Mid-shore stations were positioned 80m from the dune edge for Long Bay North and South, and at 60m from the dune edge for Torbay, Mairangi and Browns Bay. Low shore stations were positioned at 120m from the dune edge for Long Bay north and south, 110m from the dune edge for Torbay and Browns Bay and 85m from the dune edge for Mairangi Bay (Table 3a.1).

Tables 3a.1. Comparisons of old (a) and new (b) design for beach fauna sampling

a. Old design for beach fauna sampling

Location	Number of transects per beach	Number of cores per sampling station	Sampling station distance from dune edge (m):		
			High-shore	Mid-shore	Low-shore
Long Bay	6	1	40	80	120
Torbay	4	1	40	80	120
Browns Bay	4	1	40	80	120
Mairangi Bay	4	1	40	80	120

b. New design for beach fauna sampling

Location	Number of transects per beach	Number of cores per sampling station	Sampling station distance from dune edge (m):		
			High-shore	Mid-shore	Low-shore
Long Bay NORTH	5	3	Removed	80	120
Long Bay SOUTH	5	3	Removed	80	120
Torbay	6	3	Removed	60	110
Browns Bay	6	3	Removed	60	110
Mairangi Bay	6	3	Removed	60	85

By removing the high shore station on transects, variation in macrofaunal communities on beaches was decreased. This provides a more reliable data set, increasing the power with which data can be analysed. The change in sampling design also made this monitoring program more comparable with other related programs in the region. However, as the new sampling scheme has only been in place for 2 sampling times only limited temporal analysis is possible for this monitoring period.

3. a. 2. Abundance and size distribution of macroinvertebrates

September 2001 & March 2002:

One core (132.6 cm^2 x 15cm deep) at each station was dug out. The sample was sieved through a 1mm mesh and the retained material was preserved in 10% formalin and 0.001%Rose Bengal. Macrobenthic organisms were counted and identified to the lowest possible taxonomic level. All bivalves were classed into 3 different sizes, < 4mm, 4-15mm or >15mm.

September 2002 & March 2003:

At each station, replicates were increased to 3. Each sample was extracted using the same corer (132.6 cm^2 x 15cm deep). The sample was then sieved through a 0.5mm mesh, which was finer than the previous 1mm mesh. Material retained on sieves was transferred to jars then preserved in a solution of 10% formalin in seawater with 0.001%Rose Bengal. Macrobenthic organisms were picked out of samples and identified to the lowest possible taxonomic level.

It was recommended by NIWA that the mesh size used to sieve samples be decreased from 1.0mm to 0.5mm. This recommendation was based on previous data from Torbay that showed that samples would include nearly twice as many individuals from groups such as polychaetes and crustaceans when the finer mesh was used. Greater retention of juvenile *Paphies sp.*was also expected using the finer mesh size thus augmenting information about recruitment and year class strength (Lohrer et al. 2002).

3. b. Subtidal monitoring

3. b. 1. Area and site locations

Subtidal community structure and sedimentation rates were investigated at Long Bay and five surrounding locations; Waiwera, Stanmore Bay, Little Manly, Torbay and Campbells Bay (Fig. 3b.1, also Appendix B for position coordinates). This continued the monitoring program developed in 1999 (Babcock et al. 1999a). In each location, 5 sites (30 in total) were monitored every 4-6 weeks (when possible) for sedimentation rates and annually for benthic community structure. These sites were situated on rocky subtidal reefs, dominated by macroalgae, at depths of less than 2.5m (Chart Datum).

3. b. 2. Macroalgal and macroinvertebrate abundance and size distribution

The annual survey of macroalgal / macroinvertebrate abundance and size distribution was consistent with previous monitoring (Babcock et al. 1999a, 1999b, Walker et al. 2000, 2001). At each site, seven $1m^{-2}$ quadrats were placed randomly on the subtidal reef, within 20m of the sediment collectors. In each quadrat substratum percent coverage was visually estimated; common components of this coverage included algae (turfing, encrusting, large brown algae), bare rock, sediment, sponges etc. Macroalgae and macroinvertebrates (usually larger than 5mm) were identified and counted in all seven quadrats, and measured to the nearest 5 cm (algae) or 5 mm (invertebrates) in 5 of the quadrats. Mobile organisms (e.g. crabs) were not enumerated.

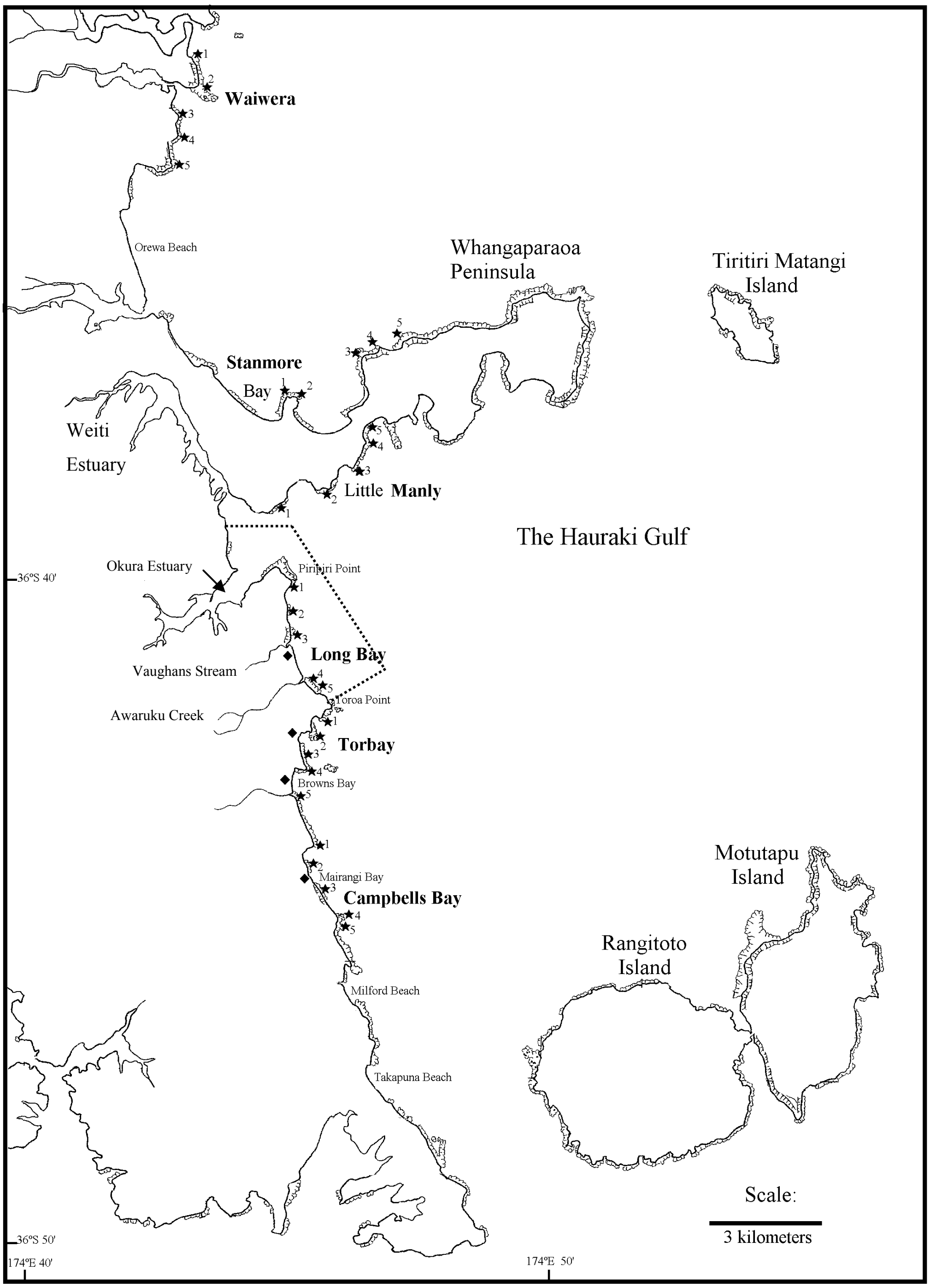


Figure 3b.1. The location and sampling sites of the Long Bay Marine Reserve monitoring program. Dotted line indicates the approximate boundary of the Marine Reserve, stars indicate subtidal rocky reef sites, diamonds indicate intertidal sand sites (adapted from Walker and Babcock, 2001).

3. b. 3. Sediment sampling method

Sedimentation rate was investigated by deploying sediment traps at each of the 30 sites and analysing contents on an approximately monthly basis. The traps have been designed to retain sediment deposited from the water column and avoid potential resuspension (Walker *et al.* 2001).

Problems retrieving sediment traps have been encountered both in this monitoring period and previously, due either to disturbance by extreme weather events or public interference. At some sites, soft rock substrate made it difficult to secure traps. Several different trap designs were implemented, but unfortunately many traps were lost. The most recent method has been most effective, where larger, heavier steel base plates were constructed to contain the traps and were deployed in May 2003. To decrease the influence of swell, a 1m length of chain was incorporated between the base and the buoy line, and smaller, lighter floats were used to mark the sites.

On collection, water was separated from the contents of sediment traps by filtering through Faggs coffee filter bags (1x4). These were tested against 1.2 m pore size filter paper and found to be 99% comparable. The sediment and filter bag were then oven dried at 65-80 C for 24 hours, cooled and weighed to obtain a total dry weight. The average dry weights from traps at the same site were converted to a daily rate of sedimentation (grams/day/cm^{-2}). To quantify the proportion of sediment of size < 63 m (material most likely to be of terrestrial origin) samples were analysed using a laser particle size analyser.

Due to the uneven replication, and sometimes sparse monthly data, sedimentation data was generated as an average for each site. These site averages were generated for each time period prior to a trap collection. The yearly averages were then generated from these 'site averages'.

Rationalisation of Sediment Pretreatment for grain size analysis

As a follow-up to the rationalization of benthic ecology methods for ARC monitoring programs (Ford et al. 2003) the influence of organic material on grain size analysis was investigated. Thirty-one sediment samples from sediment traps collected at both Long Bay and Meola Reef (encompassing the range of grain sizes), were analysed using 2 methods of pre-treatment. Samples were split and a subsample from each was analysed for grain size directly using a laser particle size analyser. A second subsample was pretreated using 10% hydrogen peroxide to remove organic material by digestion. Hydrogen peroxide was added to subsamples, left until frothing ceased and then analysed for grain size.

Results of pretreating sediment

A comparison of the percentage volume of particles less than 63 µm (fines) from pretreated and untreated samples revealed a strong correlation (r_s = 0.957, n = 29, p <0.001). Two outliers were removed from the data set, assuming an error in subsampling. A linear regression was used to model the relationship between treated and untreated samples (Fig. 3b.2). Pretreatment resulted in a decrease in the < 63 µm fraction in virtually all samples.

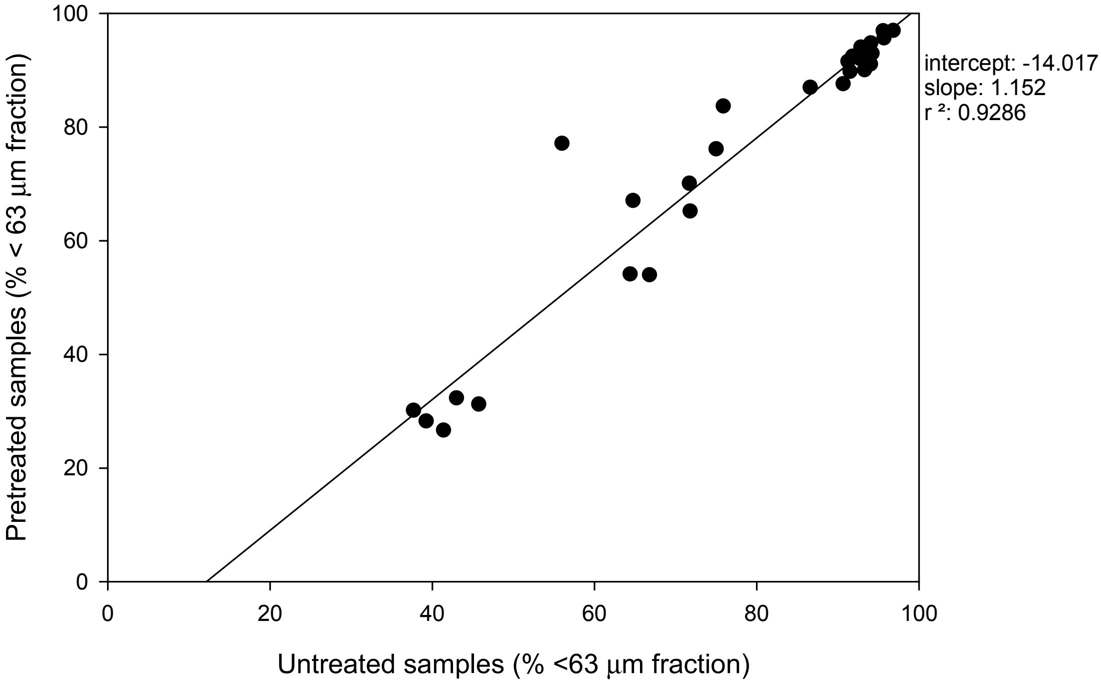


Figure 3b.2. Less than 63 µm sediment grain size fraction: sediment untreated versus pretreated with H_2O_2 prior to grain size analysis

Discussion of pre-treating sediment

Extrapolation of data to the zero percent untreated fines gives a negative value of pretreated fines (shown by a negative intercept) indicate that fine sediment grains in untreated samples may actually be organic material. At increasing levels of fines per sample however, the relationship between untreated and pre-treated becomes closer. This is shown by the greater than 1 slope. Therefore samples with higher proportions of fine sediment (in untreated samples) are less likely to be organic material (e.g. 50 % untreated fine gives 44% pre-treated and 100% is approximately equivalent). The samples analysed in this comparison were in the range of 38 to 97% fines in untreated samples; the lowest in the untreated range (38%) contained only 8% more fines than in the equivalent pre-treated samples.

According to these results, previous analyses conducted without the use of a pretreatment to remove organics will have resulted in a small over-estimation of fine grains (<63 µm). However due to the strong relationship between pre-treated and untreated sediments, untreated can be converted using the regression model above. However, care must be taken in ensuring data lies within the range modelled here (38 to 97% fines untreated).

3. c. Statistical analysis

Multivariate analysis

Community level analysis was undertaken using multivariate techniques. To identify areas that had similar species composition, a Bray Curtis similarity matrix was computed on log x+1 transformed data (PRIMER version 5). These types of transformations effectively ensure that all species, abundant or rare, contribute to the triangular matrix, while reducing the effects of the large amounts of zeros in the data set.

Multi-Dimensional Scaling (MDS) was used as a visual means of interpreting relationships among monitored areas. Count data from each site (3 cores for beaches and 7 quadrats for reefs) were pooled for analyses. Transect comparisons at Long Bay were not pooled. To explain the patterns seen in the MDS, an Analysis of Similarity (ANOSIM) was performed on the Bray Curtis matrix. ANOSIMs show significant differences below the p=5% level (equivalent to p=0.05). ANOSIMs that showed significant differences were further analysed using a Similarity of Percentages Analysis (SIMPER, within PRIMER) to determine species responsible for similarities or dissimilarities between samples. Percentage values in SIMPER are relative, the higher the number, the stronger the dissimilarities and the more distinct the community.

Cannonical Analysis of Principal Coordinates (CAP) analyses (a constrained ordination) were completed to graphically show differences between tidal zones that were not obvious using MDS plots (an unconstrained ordination, Anderson and Willis 2001). The constrained ordination will portray axes that best show the difference between set groups (in this case tidal zones), the constrained ordination will show the axes that display the most variation.

In order to compare the 2 and 3 replicate core per replicate beach designs estimates of variance can be generated. Non-overlapping confidence intervals for estimates of variance will indicate that the different designs will produce significantly different outcomes. Pseudo estimates of multivariate variance components were obtained by bootstrapping based on the sums of squared Bray-Curtis dissimilarities (Anderson, 2001) for all samples collected in the 2002 – 2003 year (2 and 3 core per replicate designs).

Univariate analysis

Two-factor Analysis of Variance (ANOVA) were used to analyse differences between locations and years (and the interactions between these) at the species level. Where data sets were un-balanced General Linear Models were used instead of ANOVA. ANOVA and General Linear Models show a significant difference at the $p<0.05$ level. Data were transformed (log(x+1)) for normal distribution where necessary to fulfil assumptions of normality and homogeneity of variance.

4. Results

4. a. Intertidal Soft Sediments

The following sections refer to a comparison between beaches, a comparison between the 2 sampling months September 2002 and March 2003 and an evaluation of the effect of tidal zones.
These sections are then followed by the assessment and analysis of each beach separately followed by specifics of bivalve communities and an evaluation of the number of cores needed per replicate.

4. a. 1. Regional comparison: comparison between beaches

The beach with the least number of species was Mairangi Bay and the beach with the highest number of species was Browns Bay (Fig. 4a.1). The number of species at each beach was relatively consistent between sampling months (Fig. 4a.1).

The pattern in number of individuals at beaches was much more variable than the pattern seen in the number of species. In September 2002, there was a similar number of individuals at Browns Bay and Torbay which were both approximately double the number of individuals found at Long Bay and Mairangi Bay (Fig. 4a.2). In March 2003 however, there was almost double the number of individuals in samples on Mairangi Bay than all other beaches (Fig. 4a.2). Mairangi Bay had the least number of individuals in September 2002 and Long Bay had the least number of individuals in March 2003.

Polychaetes were the most abundant group of organisms found on Mairangi Bay and Long Bay beaches in both September 2002 and March 2003 and also on Browns Bay in March 2003 (Figs 4a.3 a, b, c, d, f, see also Appendix C for list of species). Pipis (*Paphies australis*) and *Paphies* spp. (*P. australis* and *P. subtriangulata*, generally too small to identify to species level, or larger destroyed individuals) were the most abundant organism found on Torbay in both months (Figs 4a.3 g, h). The pipi (*Paphies australis*) was the 2nd most abundant organism in all beaches in September 2002 and *Paphies* species were the 2nd most abundant organism in all beaches in March 2003. Amphipods were the most abundant organism on Browns Bay in September 2002 (Figs 4a.3 e). *Waitangi* sp. was the most common amphipod found.

Specifically *Hesionidae* sp., a small polychaete worm was the most dominant species found across all beaches in both September 2002 and March 2003. Although *Hesionidae* sp. was the most abundant species found overall, there were very few found on Torbay in both sampling months and few on Browns Bay in March 2003.

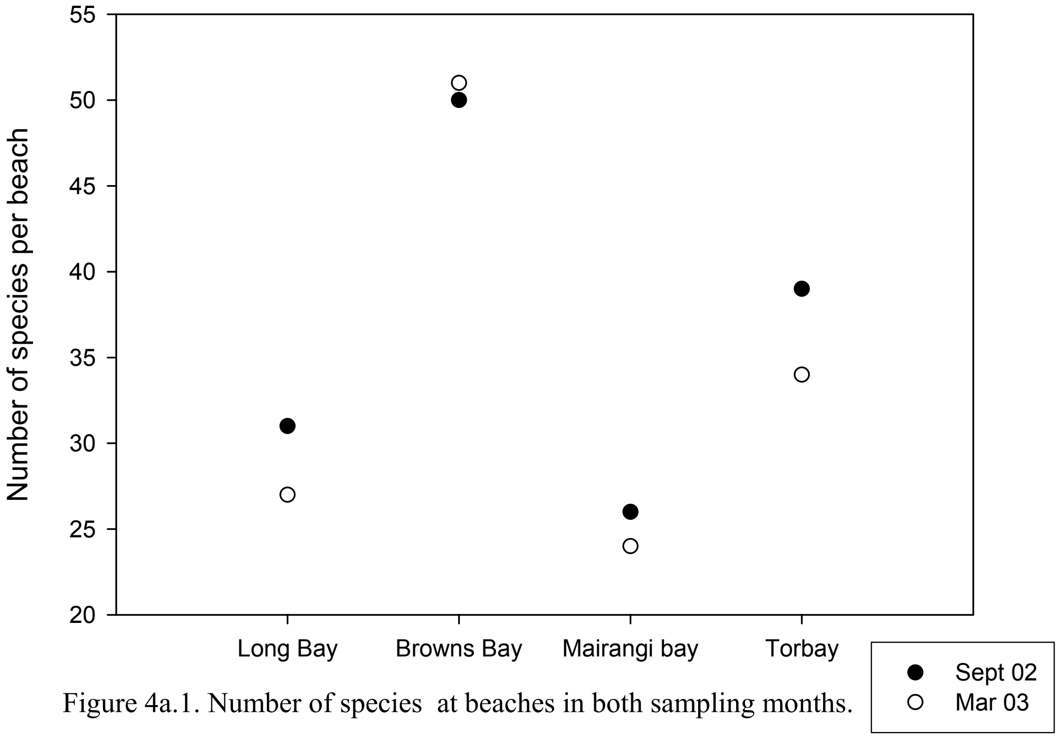


Figure 4a.1. Number of species at beaches in both sampling months.

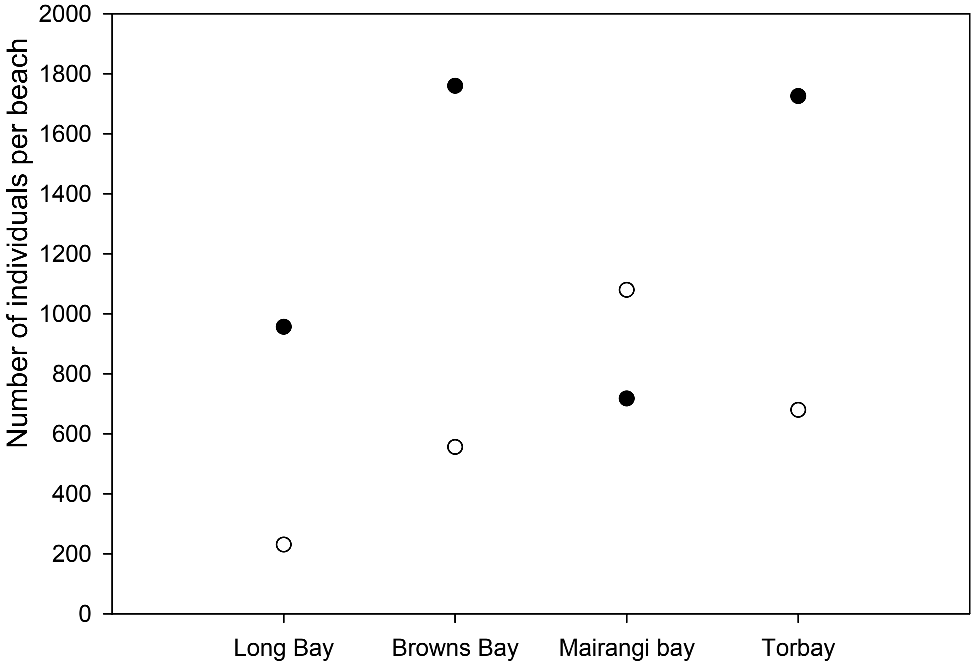


Figure 4a.2. Number of individuals at beaches in both sampling months.

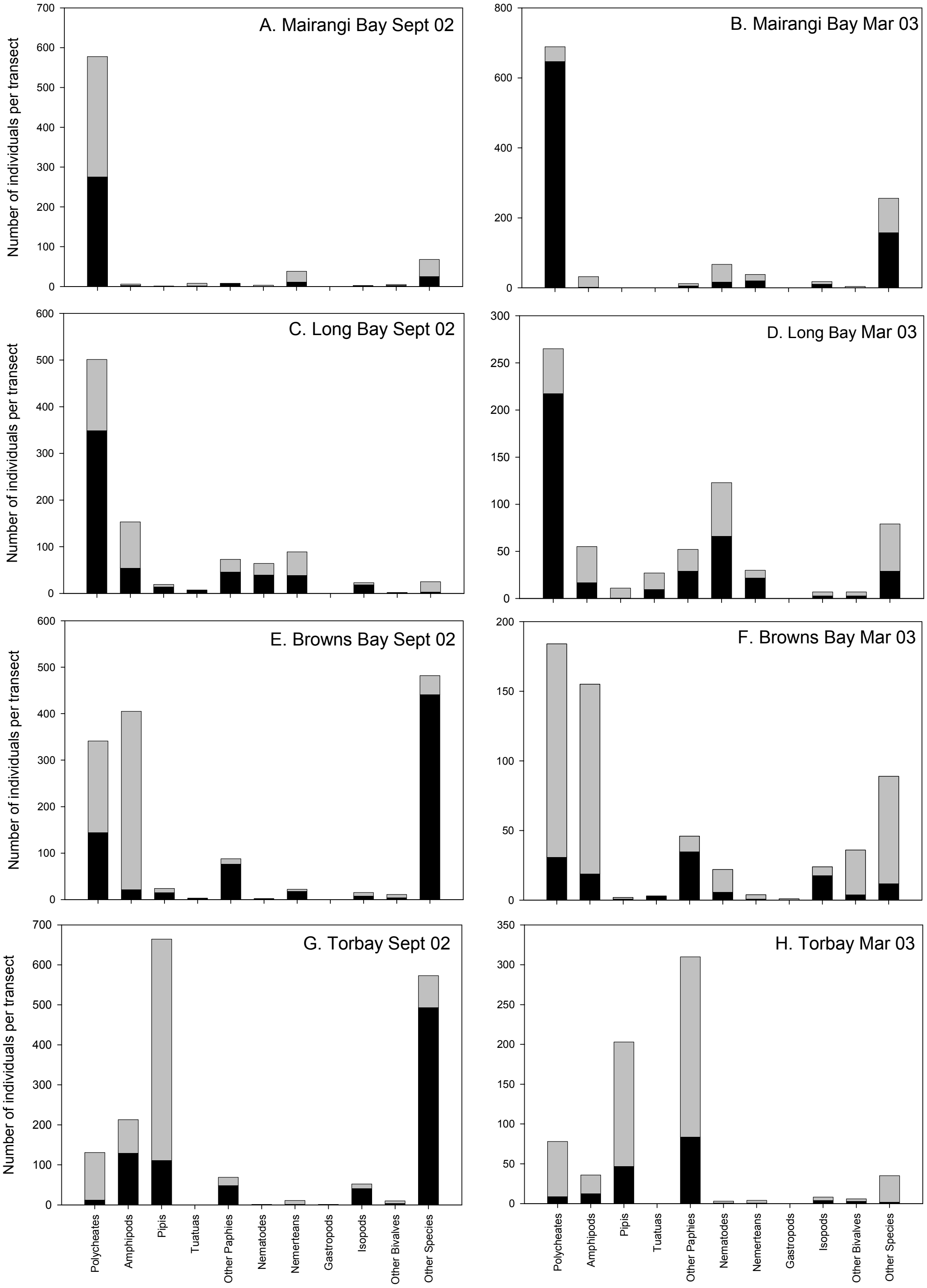


Figure 4a.3. Groups of macrofaunal individuals at each beach at each sampling time. N.B. Scales are not equal.

There were stronger significant differences in macrofaunal communities between beaches sampled in September 2002 (ANOSIM R= 0.6, P= 0.1%) than in March 2003 (ANOSIM R= 0.491, p=0.1%) (See also MDS plots; Figs 4a.4 and 4a.5). The beaches that differed most from each other were Mairangi and Torbay beaches at both sampling times (see Table 4a.1 and 4a.2). All other beaches were significantly different from each other. The weakest significant difference was between Long Bay and Mairangi bay beaches in March 2003.

Table 4a.1. Statistics for ANOSIM analysis on differences between beach fauna and major species contributing to dissimilarity (SIMPER) for September 2002. Significant differences are <p=5% level.

September 2002	Long Bay	Torbay	Mairangi Bay
Browns Bay	p = 0.1% R = 0.361 Waitangi	p = 0.1% R = 0.632 Paphies australis	p = 0.1% R = 0.626 Hesionidae
Mairangi Bay	p = 0.1% R = 0.506 Hesionidae	p = 0.1% R = 0.987 Paphies australis	
Torbay	p = 0.1% R = 0. 648 Paphies australis		

Table 4a.2. Statistics for ANOSIM analysis on differences between beach fauna and major species contributing to dissimilarity (SIMPER) for March 2003

March 2003	Long Bay	Torbay	Mairangi Bay
Browns Bay	p = 0.1% R = 0.373 Nematodes	p = 0.2% R = 0.433 Paphies australis	p = 0.2% R = 0.339 Hesionidae
Mairangi Bay	p = 1.6% R =0.197 Hesionidae	p = 0.1% R = 0.807 Hesionidae	
Torbay	p = 0.1% R = 0. 684 Paphies australis		

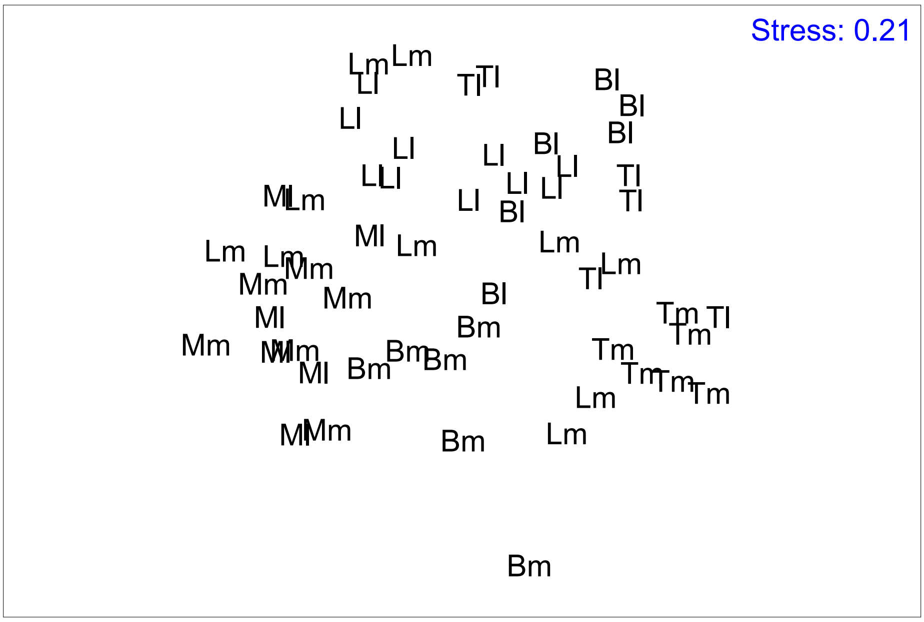
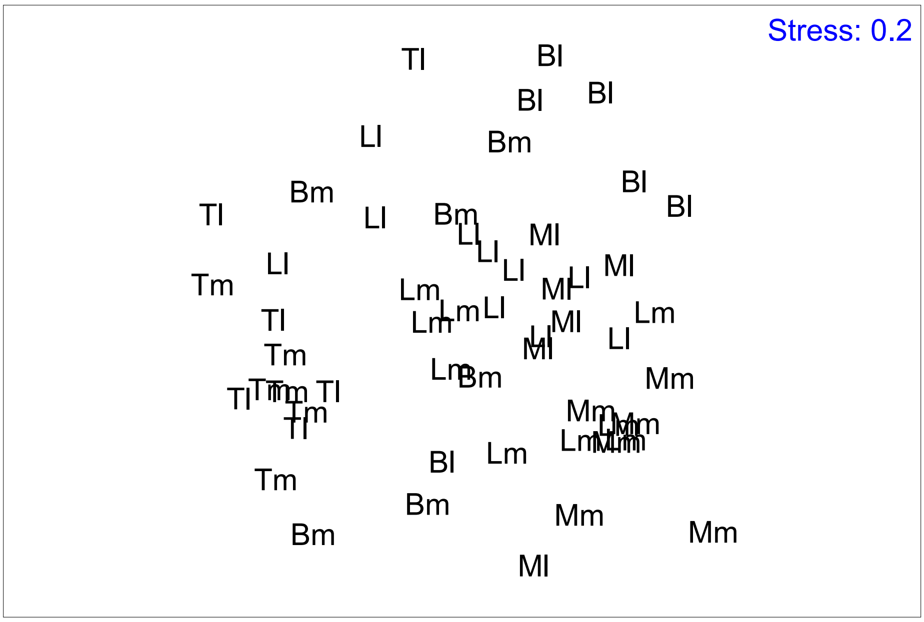


Figure 4a.4. MDS of the macrofaunal communities on all beaches in September 2002 showing the distinction between beaches and tidal zonation. Letters are beach followed by tidal zone; i.e. Bm = Browns Bay mid, Tl = Torbay low, Mm =



Mairangi Bay mid, Ll= Long Bay low.

Figure 4a.5. MDS of the macrofaunal communities on all beaches in March 2003 showing the distinction between beaches and tidal zonation. Letters as above

In September 2002, Mairangi Bay had the most distinctive community (SIMPER 45.60%,) when compared to Long Bay, Torbay and Browns Bay (SIMPER 27.60, 26.90, 20.25% respectively). In March 2003, Torbay, Mairangi Bay and Long Bay (SIMPER 47.02%, 45.04%, 42.61% respectively) had more distinctive communities than Browns Bay (SIMPER 27.83%).

4. a. 2. Temporal study

There was no significant difference between the macrofaunal communities in September 2002 than those in March 2003 (R=0.5 p=7.4%) when all beaches were combined. However when each beach was analysed separately, strongly significant differences were seen that varied in strength between these months (see above).

4. a. 3. Tidal zonation: mid and low shore

Over all beaches, there was a significant difference between tidal zones in both September 2002 and March 2003 (ANOSIM R=0.265, p= 0.1%; ANOSIM R=0.221, p=0.1%, respectively). This zonal difference was not as strong as the difference between beaches (see below). When data from each beach was analysed separately there was significant differences between tidal zones and times, and again consistently stronger differences between times than between zones (see above).

4. a. 4. Within beach analysis

There was a significant difference in macrofaunal communities between tidal zones and a stronger significant difference between sampling times on each beach (Table 4a.3, Figs 4a.6 – 4a.10). The differences were then studied in more detail using SIMPER (Table 4a.3) followed by pairwise tests to investigate which species contributed most to the differences (see each beach section for details). In general the most abundant species contributed most to the similarities and differences between beaches.

Table 4a.3. Statistics on the community structure differences at each beach showing significant dissimilarities between both zone and time factors. R and p values refer to ANOSIM statistics (a higher R indicates greater difference between factors and p percentages are significant below 5%); SIMPER percentages (SIM) are relative with higher values indicating stronger dissimilarities.

	Long Bay	Browns Bay	Mairangi Bay	Torbay
Tidal zones (mid vs low)	R=0.14, p=0.8% SIM=67.08%	R=0.382, p=0.4% SIM=76.05%	R=0.242, p=0.5% SIM=60.45%	R=0.369, p=0.2% SIM=65.43%
Sampling times (Sep 02 vs Mar 03)	R=0.369, p=0.1% 6 SIM=9.80%	R=0.314, p=0.1% SIM=75.24%	R=0.572, p=0.1% SIM=64.77%	R=0.616, p=0.1% SIM=67.98%
See Figures	4a.6, 4a.7	4a.8	4a.9	4a.10

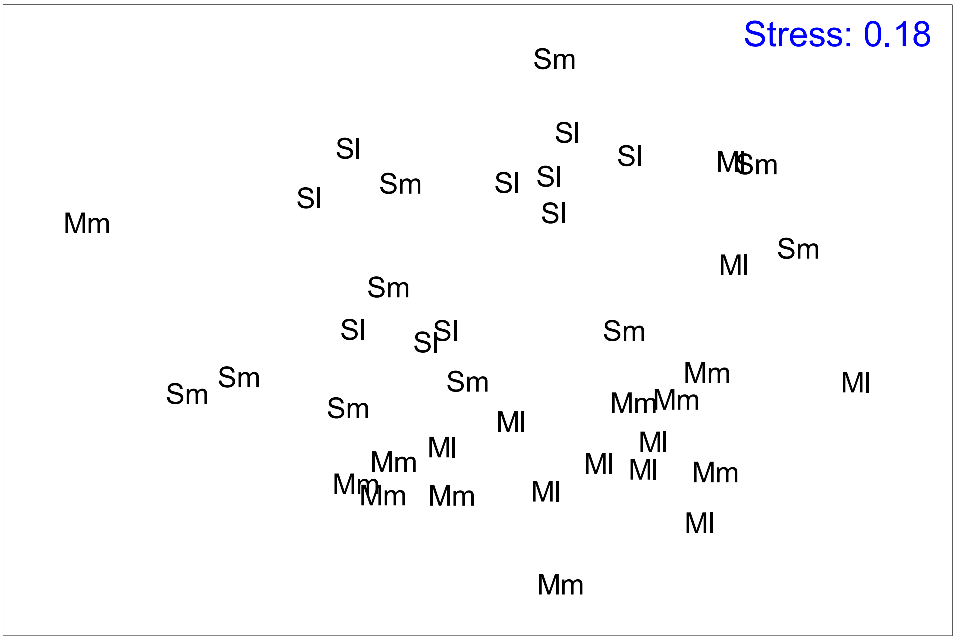


Figure 4a.6. MDS of Long Bay beach macrofaunal communities showing the distinction between sampling months. Letters are month followed by tidal zone; Sm = September mid, Sl = Sept low, Mm = March mid, Ml= March low.

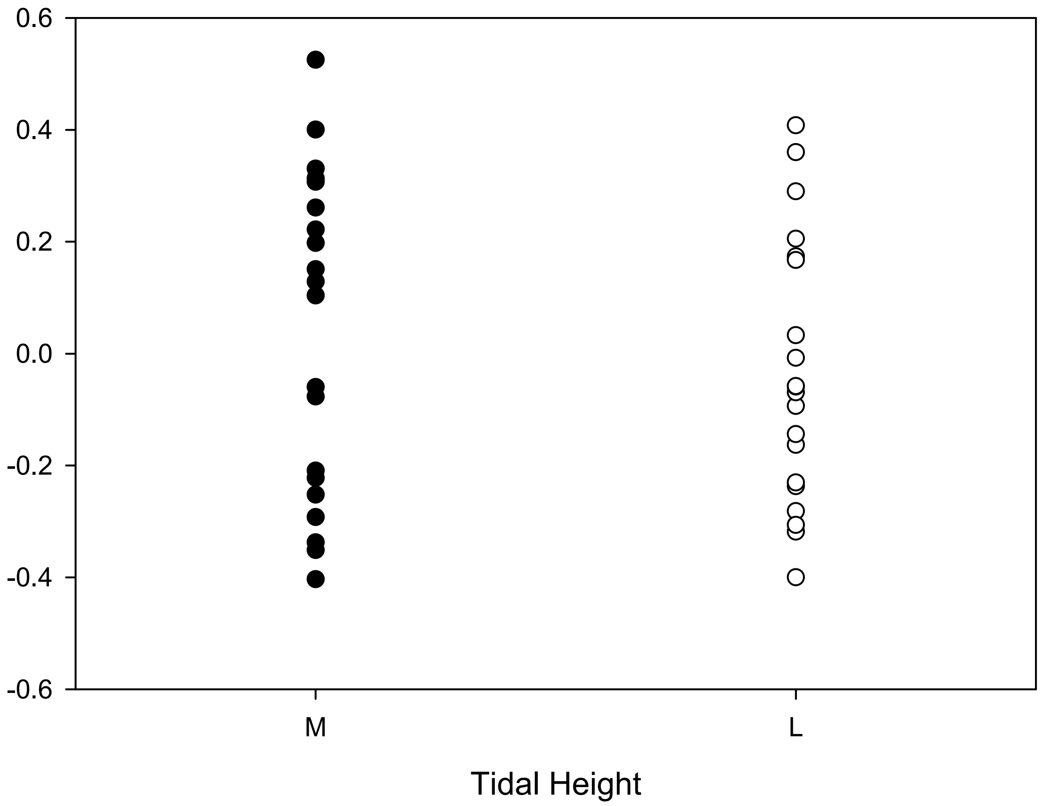


Figure 4a.7. CAP analysis of Long Bay beach macrofaunal communities showing the distinction between tidal zones. m=mid, l=low shore zones.

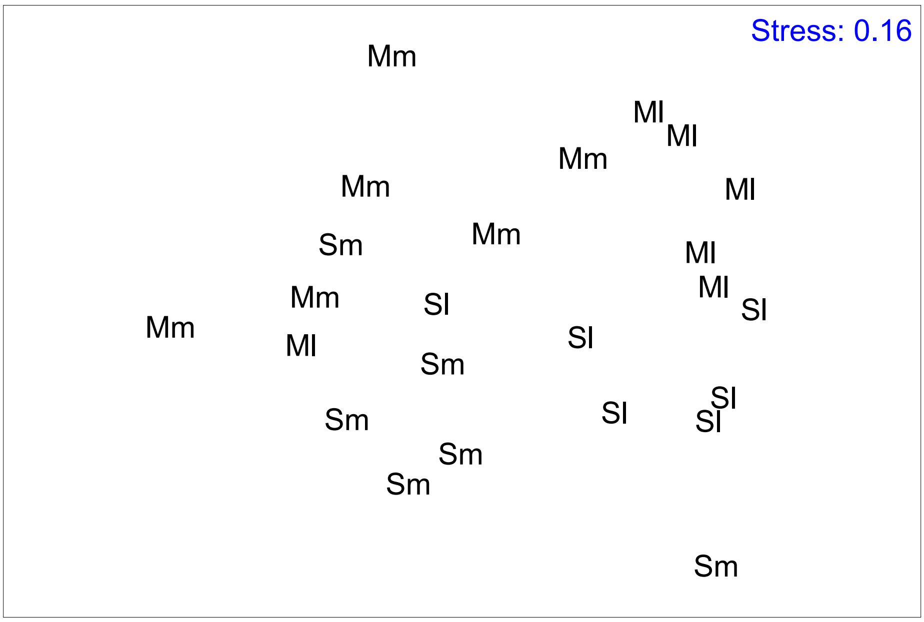


Figure 4a.8. MDS Browns Bay beach macrofaunal communities showing the distinction between the sampling times and tidal zonation. Letters are month followed by tidal zone; Sm = September mid, Sl = Sept low, Mm = March mid, Ml= March low.

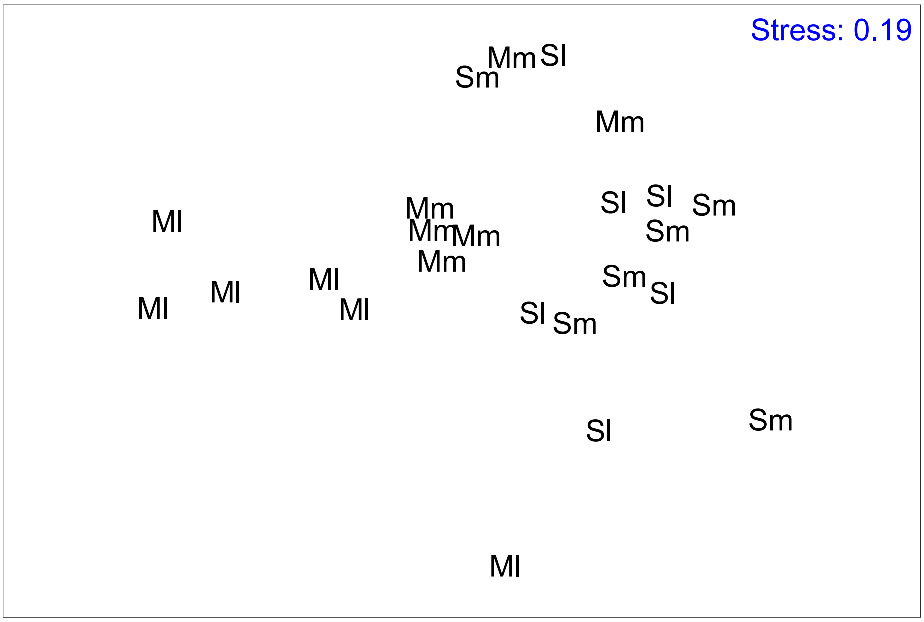


Figure 4a.9. MDS Mairangi Bay beach macrofaunal communities showing the distinction between the sampling times and tidal zonation. Letters are month followed by tidal zone; Sm = September mid, Sl = Sept low, Mm = March mid, Ml= March low.

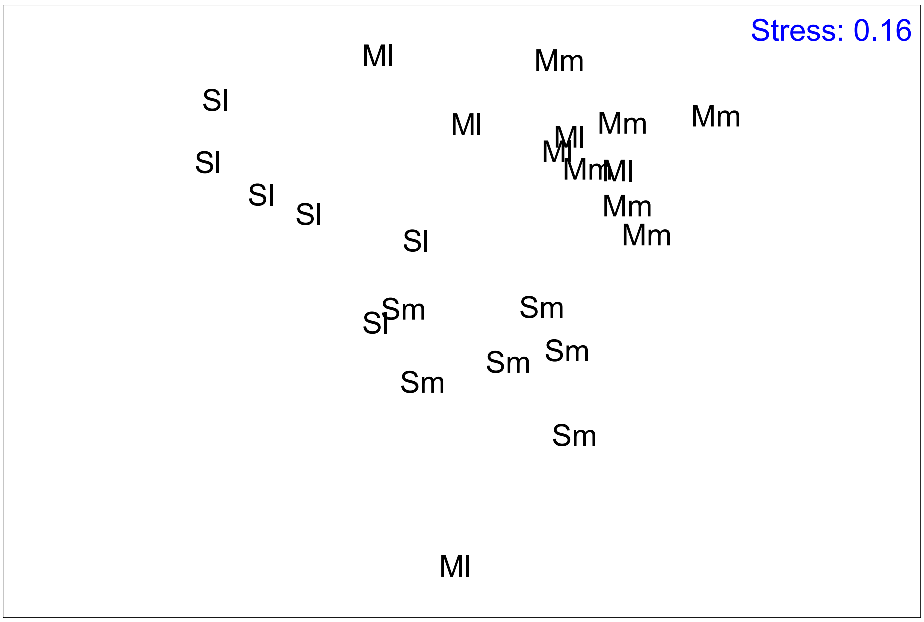


Figure 4a.10. MDS Torbay beach macrofaunal communities showing the distinction between the sampling times and tidal zonation. Letters are month followed by tidal zone; Sm = September mid, Sl = Sept low, Mm = March mid, Ml= March low

4. a. 5. Long Bay

The significant but relatively weak difference (Table 4a.3) between zones on Long Bay beach, when compared to the difference between tidal zones on all other beaches, was predominantly due to larger densities of *Hesionidae* sp. and Nematodes and lower densities of *Waitangi* sp. in the mid shore zone than in the low shore zone (which contributed to the dissimilarity 11.56, 9.59 and 9.58% respectively). The significant difference between the times was mainly due to higher densities of *Hesionidae* sp. and 'Spionid X', and lower densities of Nematodes in September (which contributed to the dissimilarity 11.06, 9.85 and 10.29% respectively) (Table 4a.3).

The mid shore zone was dominated by the polychaete *Hesionidae* sp. at both sampling times and the low shore zone was dominated by the amphipod *Waitangi* sp. in September 2002 and by nematodes in March 2003.

In September 2002 and March 2003, Long Bay beach was characterised as 39.15% and 39.41% (SIMPER) similar respectively within the beach. These values are within the range of similarities found within the other 3 beaches. In September 2002 the beach was mainly characterised by the polychaete 'Spionid X', nemerteans and the amphipod *Waitangi* sp. (contributing 20.32, 16.76 and 16.54% respectively to the similarity). In March 2003 the beach was mainly characterised by the nematodes, small *Paphies* species and *Waitangi* sp. (contributing 28.68, 21.45 and 16.23% respectively to the similarity).

Significant differences between the north and south ends of Long Bay beach were found at both sampling times this sampling year (ANOSIM R=0.635, p=0.1% in September 2002; R=0.346, p=0.1% in March 2003) (Figs 4a.11 & 4a.12). These dissimilarities (SIMPER 67.93% in September 2002 and 67.88% in March 2003) were predominantly due to larger densities of *Hesionidae* sp. and lower densities of *Waitangi* sp. at the south end than the north end of the beach (which contributed to the dissimilarities 13.80, 17.83% respectively in September 2002 and 16.47, 9.65% respectively in March 2003). Nemerteans were also present in higher densities in September 2002 (contributing 11.13%) than March 03. Nematode densities were higher in March 2003 (contributing 10.21%) at the south end of the beach than at the northern end. The abundance of the main contributing species are shown in Fig. 4a.13.

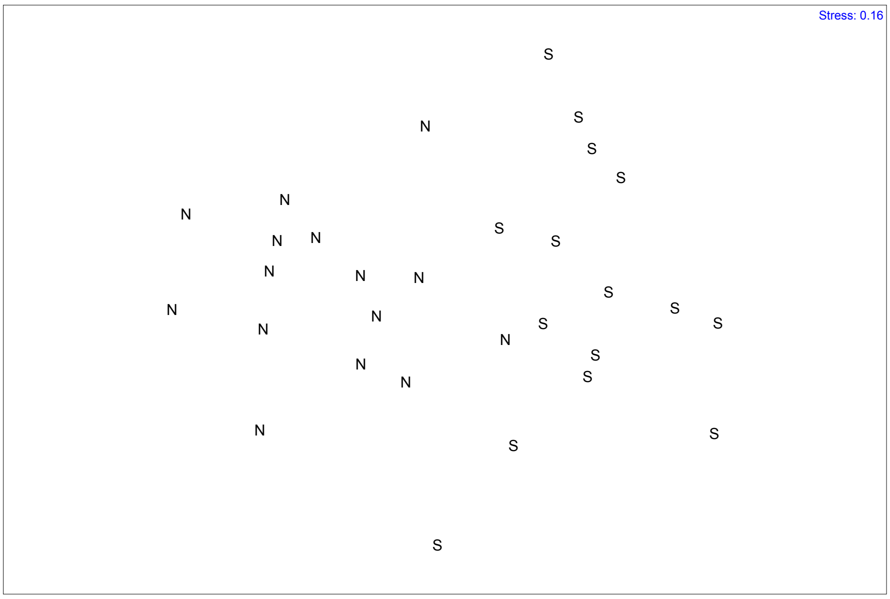


Figure 4a.11. MDS of Long Bay beach macrofaunal communities in September 2002 showing the distinction between the North and South halves of the beach.

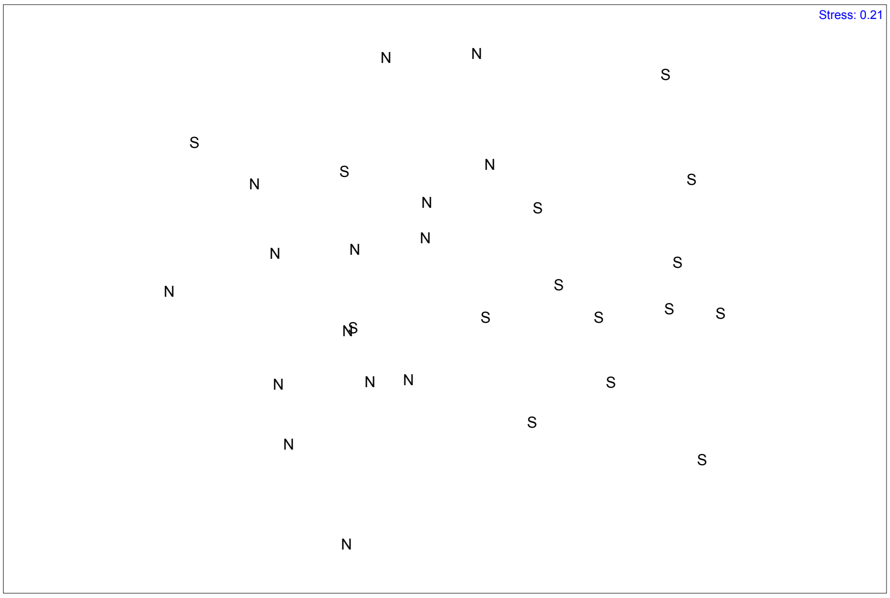


Figure 4a.12. MDS of Long Bay beach macrofaunal communities in March 2003 showing the distinction between the North and South halves of the beach.

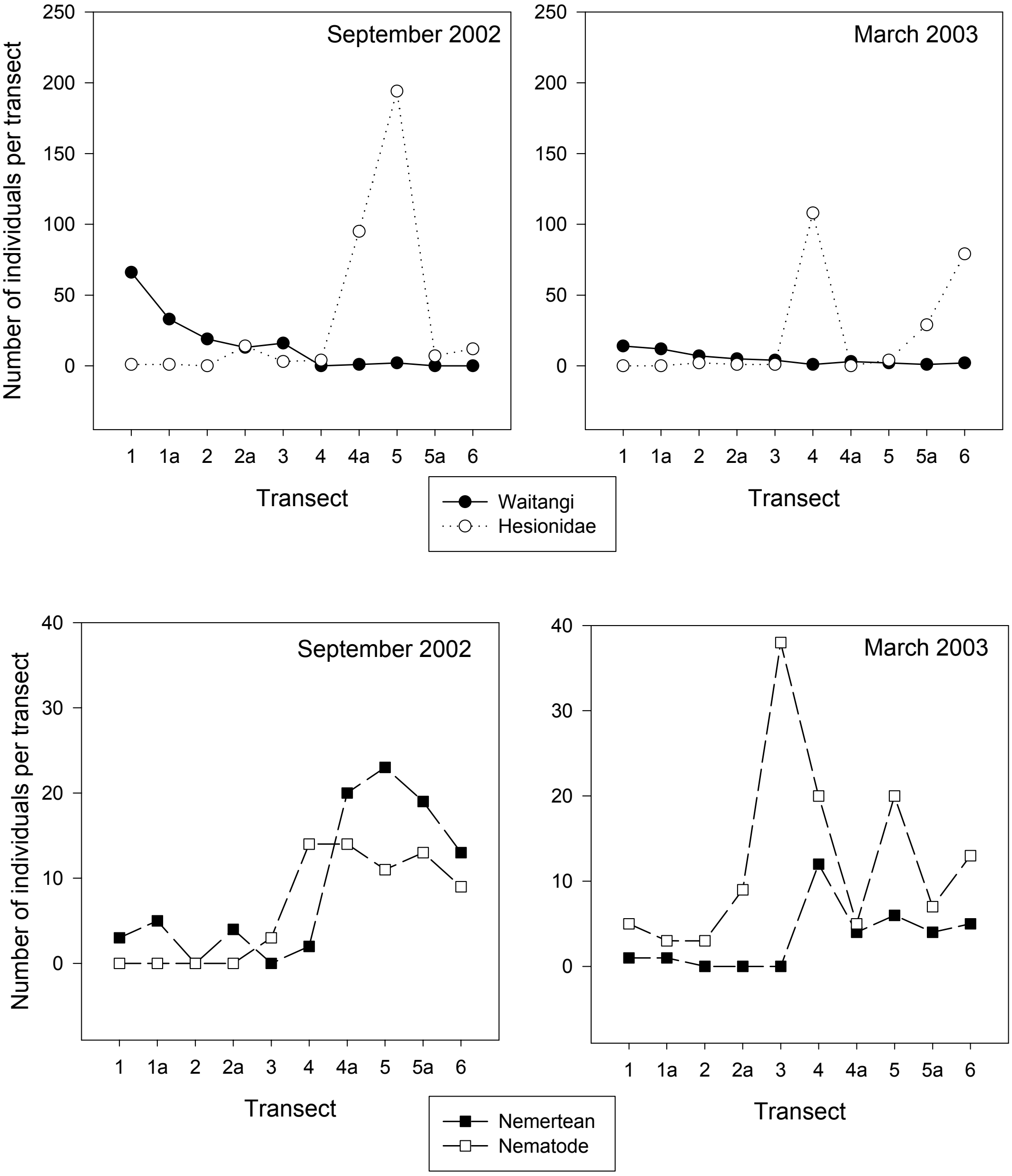


Figure 4a.13. Species which contributed most to the dissimilarities between transects on Long Bay.

Long Bay has 2 streams entering the beach, one at the north end and one at the south end. Analysis between transects along the beach was undertaken to examine any stream effects There was a significant difference between transects (ANOSIM R=0.569, p=0.1% for September 2002; R=0.485, p=0.1% for March 2003) (Figs 4a.14 & 15). In September 2002, transect 1 (at the north end of the beach) had the strongest differences to all other transect except the 2 closest (1a and 2) (Table 4a.4 and 4a.5). Transect 6 (at the south end of the beach) had relatively strong differences to transects 1 to 3. The majority of the differences were between transects on the south end of the beach and transects on the north end of the beach. Similar differences between transects were seen in March 2003, although they were not as strong as those seen in September 2002 (Table 4a.5). *Hesionidae* sp. and the major contributing species in about half of the SIMPER pairwise tests between transects in both months, *Waitangi* sp. was also contributed to many of the dissimilarities in September 2002. In summary, clear stream effects were not seen, however transects at either end of the beach were least different to their neighbouring transects. These results reinforce the decision to treat Long Bay North and Long Bay South as two separate beaches.

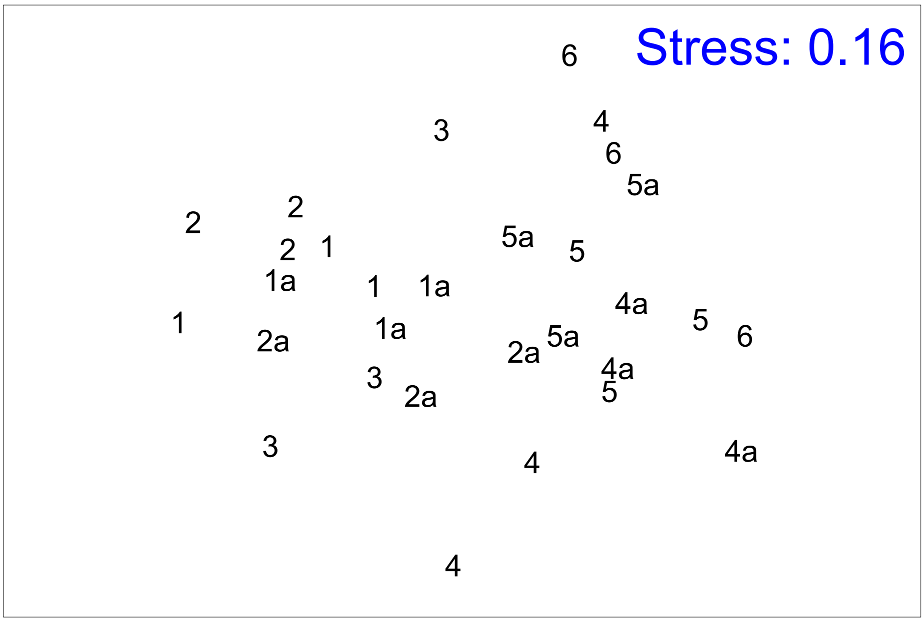


Figure 4a.14. MDS of Long Bay beach macrofaunal communities in September 2002 showing the distinction between transects, 1 is at the North end of the beach.

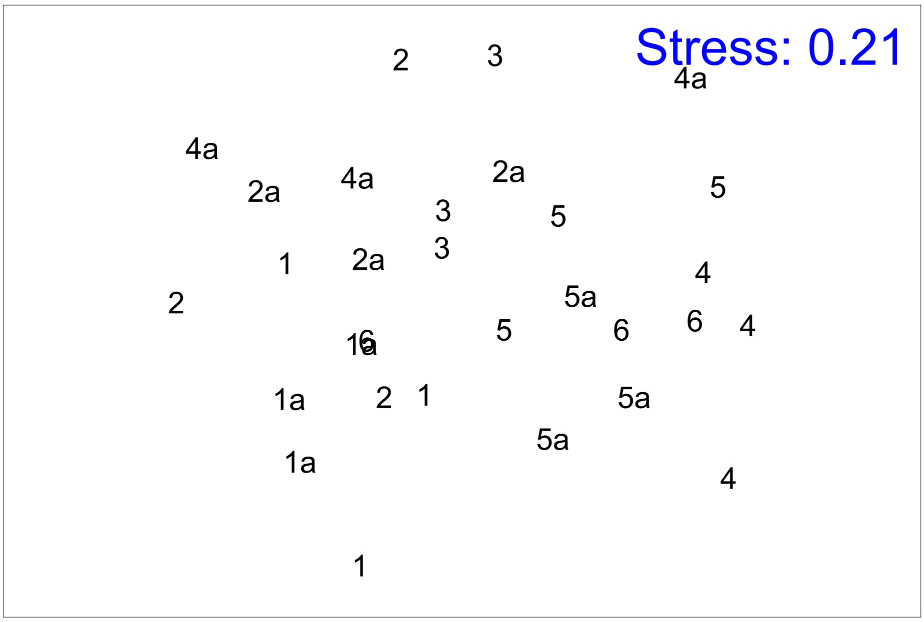


Figure 4a.15. MDS of Long Bay beach macrofaunal communities in March 2003 showing the distinction between transects, 1 is at the North end of the beach

Table 4a.4 and 4a.5. ANOSIM Pairwise comparisons between transects on Long Bay beach, R values are shown but significance levels are not as there were not enough possible permutations to get a strict test of significance, therefore the results should be viewed with caution. R values in bold indicate the strongest differences and those in italics indicate lowest differences.

4a.4. September 2002

	1a	**2**	**2a**	**3**	**4**	**4a**	**5**	**5a**	**6**
1	*0.111*	*0.185*	**0.519**	**0.630**	**0.815**	**1.000**	**1.000**	**0.926**	**0.889**
1a		0.407	*-0.037*	0.407	**0.704**	**1.000**	**1.000**	**0.667**	**0.815**
2			**0.815**	0.370	**0.815**	**1.000**	**1.000**	**1.000**	**0.926**
2a				*0.074*	0.481	0.370	**0.593**	**0.593**	**0.556**
3					*0.222*	**0.852**	**0.741**	**0.778**	**0.593**
4						**0.593**	**0.556**	0.259	*0.148*
4a							*-0.333*	*0.000*	*0.222*
5								0.407	0.296
5a									*0.037*

4a.5. March 2003

	1a	**2**	**2a**	**3**	**4**	**4a**	**5**	**5a**	**6**
1	*-0.074*	*0.074*	*0.148*	0.407	**0.926**	*0.148*	0.333	**0.630**	0.444
1a		*0.000*	0.481	**0.815**	**1.000**	0.444	**0.667**	**0.852**	**0.519**
2			0.259	0.444	**0.929**	*-0.296*	**0.741**	**0.704**	**0.519**
2a				**0.519**	**0.963**	*0.074*	**0.481**	**0.815**	**0.630**
3					**1.000**	0.444	**0.593**	**0.704**	**0.778**
4						**0.667**	**0.815**	0.333	0.333
4a							**0.556**	*0.063*	0.481
5								*0.000*	0.259
5a									*0.074*

4. a. 6. Browns Bay

Relatively strong significant differences between tidal zones (Table 4a.3) were mainly due to higher densities of *Waitangi* sp., *Magelona dakini* and lower densities of small *Paphies* spp. on the low shore (contributing 8.26, 6.36 and 5.67 respectively) than the mid shore zone. Significant but relatively weak differences between times were mainly due to higher densities of *Waitangi* sp., calanoid copepods and small *Paphies* spp. in September 2002 (contributing 7.52, 6.81 and 5.74 respectively) than in March 2003 (Table 4a.3).

The mid shore zone was dominated by mysid shrimps in September 2002 and small *Paphies* species in March 2003, the low shore zone was dominated by the amphipod *Waitangi* sp. in both sampling months.

In September 2002 and March 2003 Browns Bay beach was characterised as 20.25% and 27.83% (SIMPER) similar, respectively, within the beach. These values are 2 of the 3 lowest values seen for similarities within all four beaches, indicating that Browns Bay beach has the most variable biological community. In September 2002 the beach was mainly characterised by *Waitangi* sp. calanoid copepods and *Hesionidae* sp. (SIMPER contributing 38.46, 13.23 and 11.57% respectively to the similarity). In March 2003 the beach was mainly characterised by small *Paphies* species *Hesionidae* sp. and *Waitangi* sp. (SIMPER contributing 18.95, 16.2 and 11.96% respectively to the similarity).

4. a. 7. Mairangi Bay

Significant differences between tidal zones (Table 4a.3) were mainly due to lower numbers of *Hesionidae* sp. and oligocheates and higher numbers of nematodes on the low shore (contributing 15.52, 7.27 and 8.05 respectively). Significant differences between times were mainly due to higher numbers of *Hesionidae* sp. nematodes and *Colorustylus lemernum* in March 2003 (contributing 13.81, 10.02 and 7.07 respectively) (Table 4a.3).

The mid shore zone was dominated by *Hesionidae* sp. in both months and the low shore zone was dominated again by *Hesionidae* sp. in September 2002 and by the cumacean *Colorustylus lemernum* in March 2003.

In both September 2002 and March 2003 there were relatively strong similarities between samples on Mairangi Bay beach (SIMPER 45.6% and 45.04% respectively). The similarities within both months were due mainly to the polychaetes *Hesionidae* sp. and nemerteans (contributing 87.26 and 3.99% in September and 32.74 and 17.22% in March respectively to the similarities).

In September 2002 and March 2003 Mairangi Bay beach was characterised as 45.6% and 45.04% (SIMPER) similar respectively within the beach. Only one SIMPER value for beaches examined exceeds these indicating that over the whole year Mairangi Bay beach had the least variable biologically community. In September 2002 the beach was mainly characterised by polychaete *Hesionidae* sp. (SIMPER contributing 87.26, to the similarity). In March 2003 the beach was mainly characterised by small polychaetes *Hesionidae* sp., nemerteans and nematodes (SIMPER contributing 32.74, 17.22 and 16.40% respectively to the similarity).

4. a. 8. Torbay

Significant differences were seen between tidal zones in Torbay beach. These differences were mainly due to higher densities of small *Paphies* species and *Paphies australis* and lower densities of *Colorustylus lemurnum* on the low shore (contributing 10.98, 9.59 and 9.18% respectively). Strongly significant dissimilarities between times were mainly due to higher densities of *Colorustylus lemurnum* and *Paphies australis* and lower densities of small *Paphies* species in September 2002 (contributing 12.81, 11.66 and 8.98% respectively) (Table 4a.3).

On Torbay beach in September 2002, the mid shore zone was dominated by *Colorustylus lemurnum* and the low shore zone was dominated by the pipi *Paphies australis*. In March 2003, the mid and low shore zones were both dominated by the small *Paphies* sp.

In September 2002 and March 2003 Torbay beach was characterised as 26.9% and 47.02% (SIMPER) similar respectively within the beach. In September 2002 the relatively weak similarity between samples on Torbay beach (SIMPER 26.9%) was due mainly to the pipi *Paphies australis,* the cumacean *Colorustylus lemurnum* and the amphipod *Waitangi* sp. (SIMPER contributing 50.28, 23.36 and 9.93% respectively to the similarity). In March 2003 the relatively strong similarity between samples on Torbay beach (SIMPER 47.02%) was due mainly to the small *Paphies* species and larger *Paphies australis* (SIMPER contributing 43.41 and 35.55% respectively to the similarity).

4. a. 9. Bivalves

Larger Pipis (>4 mm *Paphies australis*) and small *Paphies* sp. were most common on Torbay in both September 2002 and March 2003 (Figs 4a.16 a-h). Few small *Paphies* sp. were found on Browns and Long Bay beaches. Tuatua (*Paphies subtriangulata*) were found on Long Bay beach, but in very low densities. Densities of any *Paphies* sp. were very low on all other beaches, with extremely low densities found at Mairangi Bay. On Torbay beach the majority of *Paphies* sp. and *Paphies australis* were found on the low intertidal, but at Browns Bay smaller *Paphies* sp. were found mainly on the mid shore zone. More juvenile *Paphies* sp. and less medium sized pipis were found on Torbay in March 2003 than in September 2002.

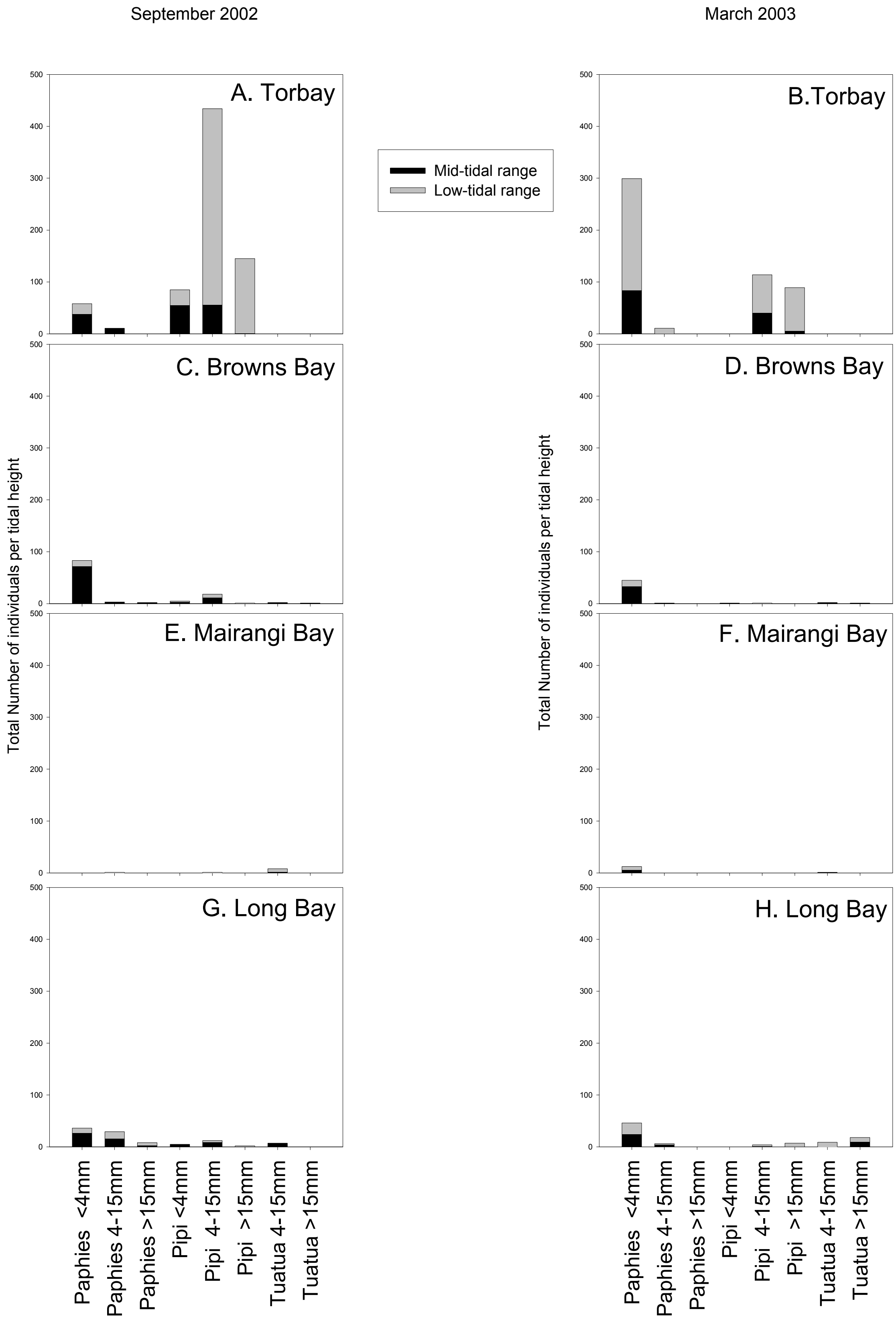


Figure 4a.16. Bivalve size classes on beaches in both sampling months

4. a. 10. Replication comparison

A comparison between replicates consisting of 2 cores pooled and 3 cores pooled was made using ANOSIM and SIMPER analyses. Similar significant differences were found using either 3 or 2 replicates for zonal or beach differences (Table 4a.6). SIMPER analyses for both 2 or 3 replicates had the same major species contributing to the dissimilarities for all beach pairwise tests (Table 4a.6).

Table 4a.6. A comparison of the statistics for ANOSIM analysis (R value and significance level p) on differences between macrofaunal communities and the major species contributing to dissimilarity (SIMPER) for March 2003.

Comparison between	3 reps	2 reps
Zones	R=0.491 p=0.1%	R=0.491 p=0.1%
All beaches	R=0.491 p=0.1%	R=0.487 p=0.1%
Browns Bay Mairangi Bay	R = 0.339 p = 0.2% Hesionidae	R = 0.404 p = 0.2% Hesionidae
Browns Bay Torbay	R = 0.433 p = 0.2% *Paphies australis*	R = 0.440 p = 0.1% *Paphies australis*
Browns Bay Long Bay	R = 0.373 p = 0.1% Nematodes	R = 0.367 p = 0.1% Nematodes
Mairangi Bay Torbay	R = 0.807 p = 0.1% Hesionidae	R = 0.819 p = 0.1% Hesionidae
Mairangi Bay Long Bay	R =0.197 p = 1.6% Hesionidae	R = 0.192 p = 0.8% Hesionidae
Torbay Long Bay	R = 0. 684 p = 0.1% *Paphies australis*	R = 0.644 p = 0.1% *Paphies australis*

Estimates of multivariate variance were also not significantly different between the 2 core per replicate and 3 core per replicate designs for any factors, as the confidence intervals of these estimates overlapped (Fig 4a.17)

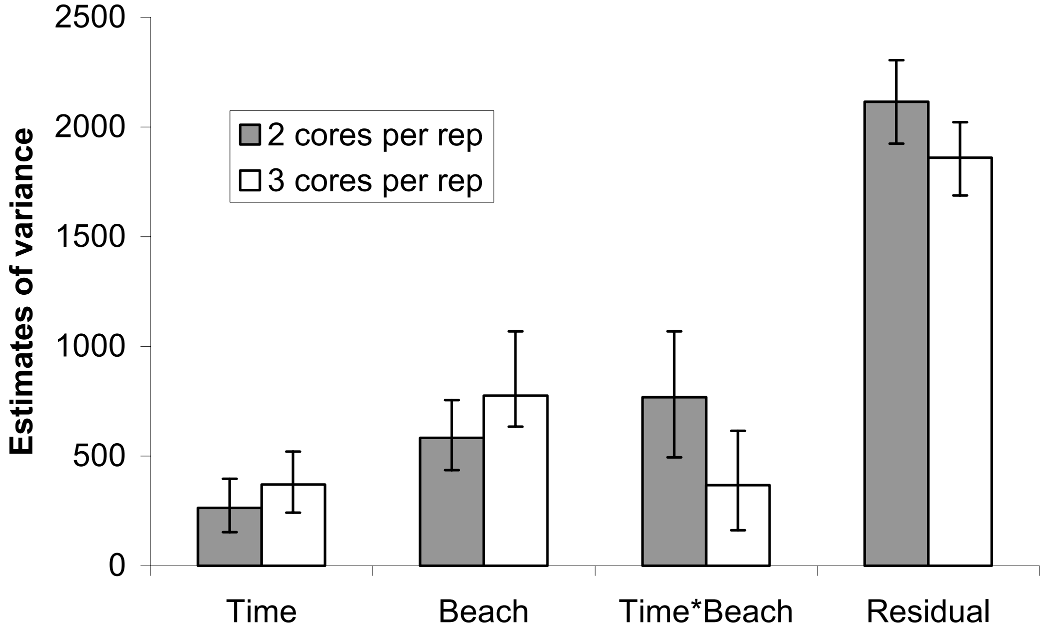


Figure 4a.17. A comparison of psuedo-estimates of multivariate variance components (including 95% confidence intervals) for the 2 core per replicate and 3 core per replicate designs.

When 3 core replicates were collected 61 species were found across all beaches, however when a dataset was analysed using 2 random cores per replicates subset (of the 3 replicate sampling) 56 species in total were collected across all beaches (Table 4a.7).

Table 4a.7. A comparison of species and individuals densities between 3 and 2 core per replicate samples.

	Number of Species		Number of Individuals	
	3 reps	2 reps	3 reps	2 reps
Torbay	35	31	679	455
Long Bay	29	28	630	477
Browns Bay	52	47	556	411
Mairangi Bay	26	19	1079	722
All beaches	*61*	*56*	*2944*	*2059*

4. b. Subtidal Rocky Reefs

Comparisons were made of percent cover and/or individual densities of benthic species between both monitored years (1999-2003) and 6 subtidal locations, including Long Bay. Comparisons between groups of benthic organisms/substrate types and size frequency distributions for the key species were then made for the most recent monitoring period (2002 and 2003). Examination of the sediment trapped at all locations for the whole monitoring period is also presented.

The number of benthic subtidal species recorded for the monitoring period (1999-2003) across all locations was 68 (see Appendix D for list of species). More species were recorded over the past 2 years (both 55) than in previous years (39-45). However, the number of species recorded was relatively consistent between locations (ranging between 49-53).

At all locations across all monitored years (1999-2003) the most dominant substrate cover was the organism crustose coralline algae (CCA) (Fig. 4b.1) followed by sediment, which generally had highest coverage at Manly and lowest coverage at Stanmore. Over all locations there was generally a lower coverage of sediment in 2001 and a higher coverage in 2000 when compared to other years (Fig. 4b.1). Sediment on the reef ranged between 6-26% cover on average per location, for details on sedimentation please see section on sediment trap analysis. The most numerous organisms in order of decreasing abundance were *Carpophyllum maschalocarpum* (a large brown alga; common flapjack), *Turbo smaragdus* (a herbivorous gastropod), *Zonaria turneriana* (a brown alga; fan weed) and *C. plumosum* (a large brown; flexible flapjack) (Figs 4b.2, 4b.3).

4. b. 1 Community structure

Community structure was analysed using multivariate techniques. There were significant differences in community structure between locations and between years (ANOSIM R= 0.194, p=0.1% and R= 0.185, p=0.1% respectively)(Fig. 4b.5). Community structure at Waiwera (in all years) grouped apart from the other survey data at the top of the MDS plot (Fig. 4b.5), pairwise testing also showed that Waiwera was significantly different from all other locations (Table 4b.1). Campbells (the most southerly location surveyed) was significantly different to the 3 most northerly sites (Waiwera, Stanmore and Manly). These 3 most northerly sites were also significantly different to each other. Long Bay and Torbay were the most similar sites (Table 4b.1). Differences in densities of the species *Carpophyllum plumosum* and *C. flexuosum* were the main species contributing to locational differences.

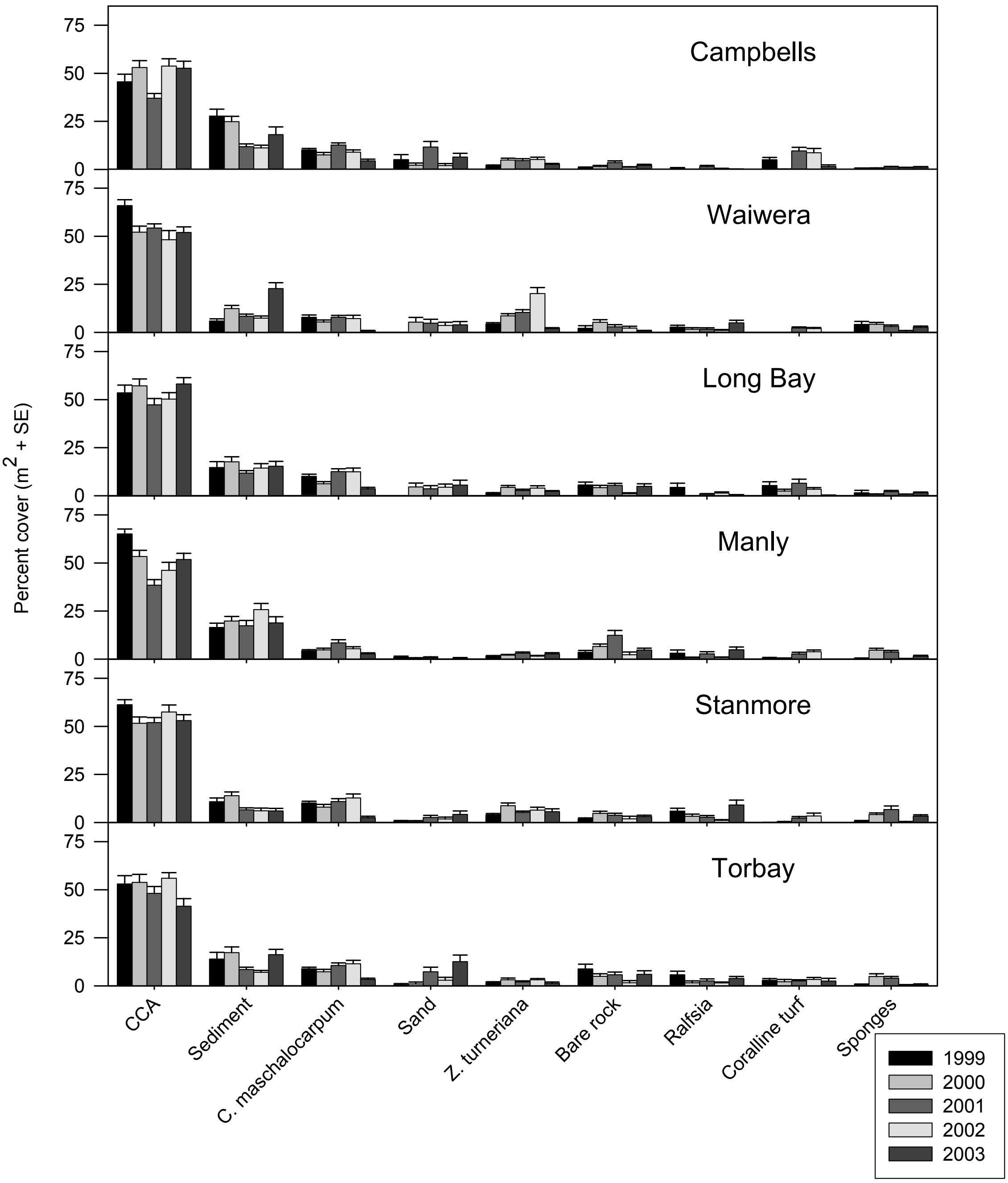


Figure 4b.1. Percent cover of substratum of dominant species. The most dominant species are shown to the left and the least dominant species to the right of the horizontal axis.

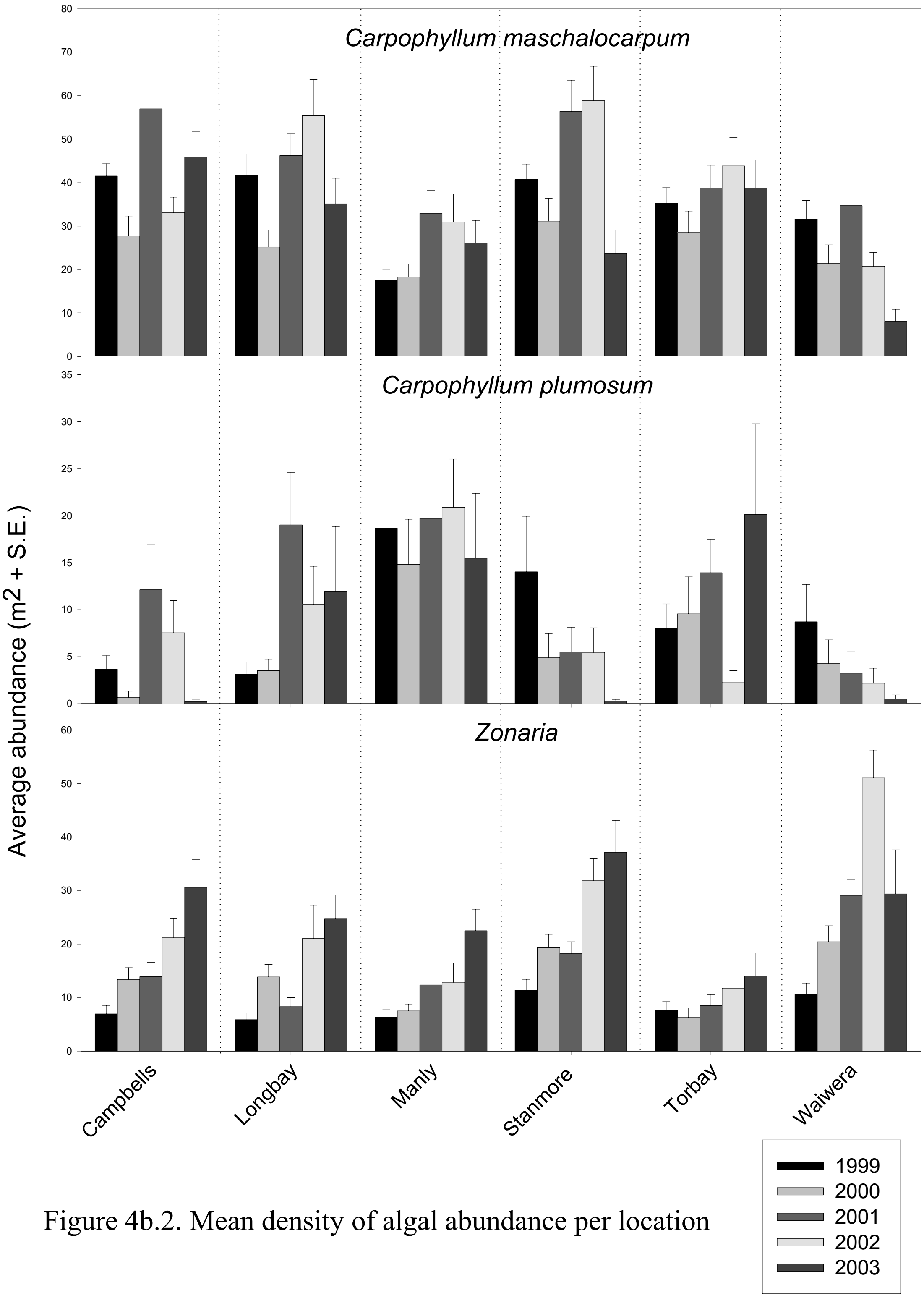


Figure 4b.2. Mean density of algal abundance per location

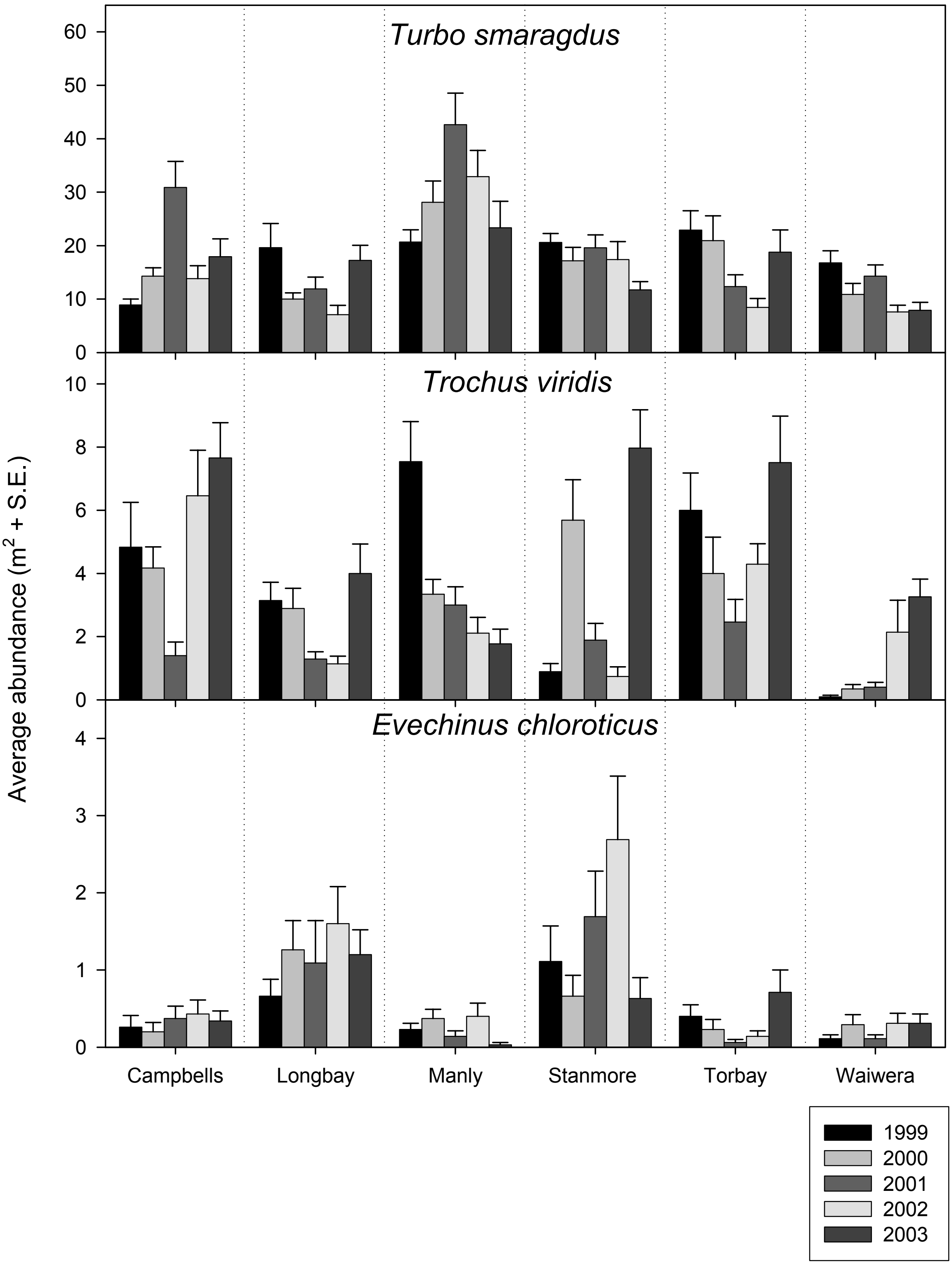
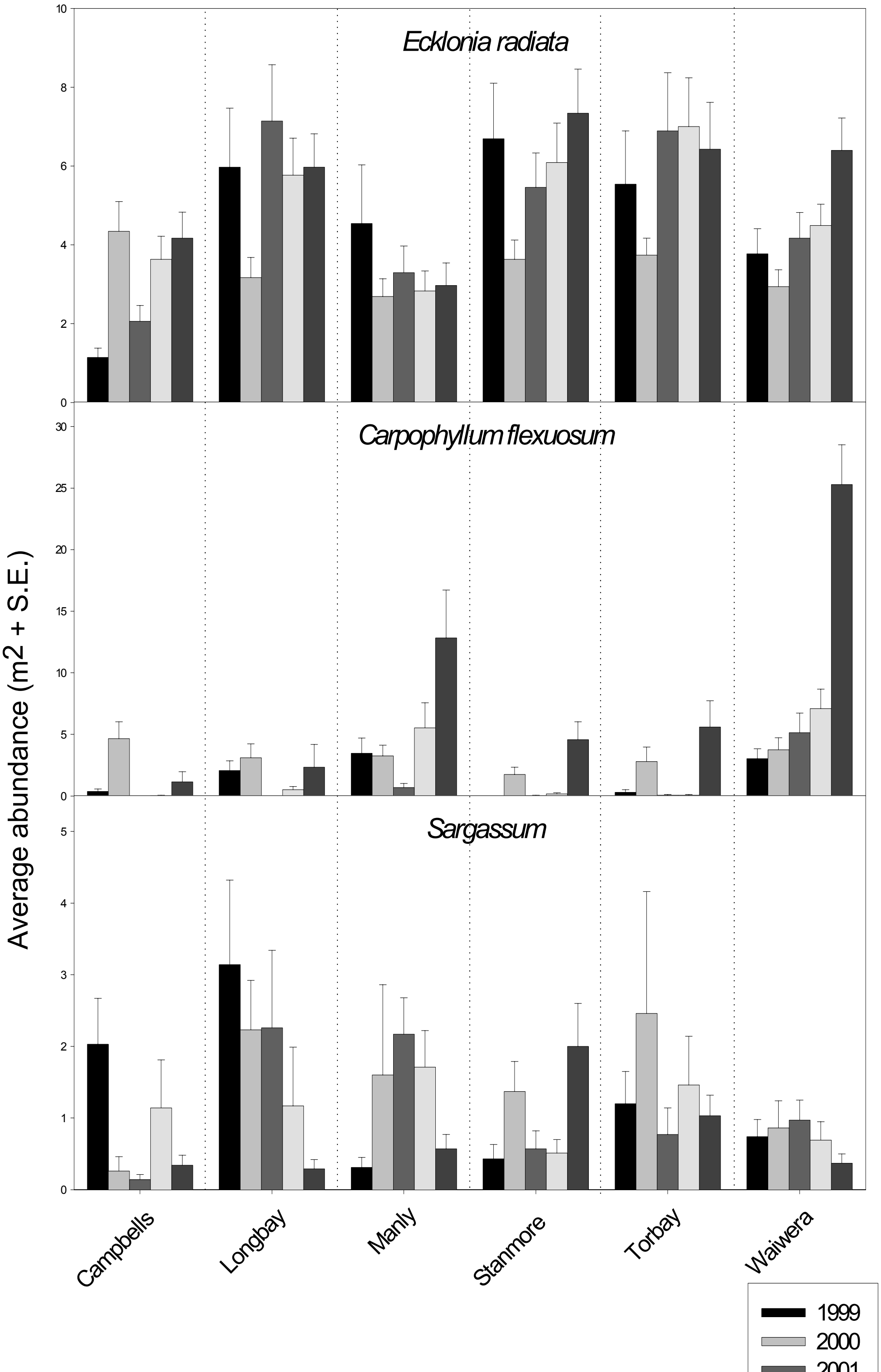


Figure 4b.3. Mean faunal density per location.



4b.4. Mean density of algal abundance per location

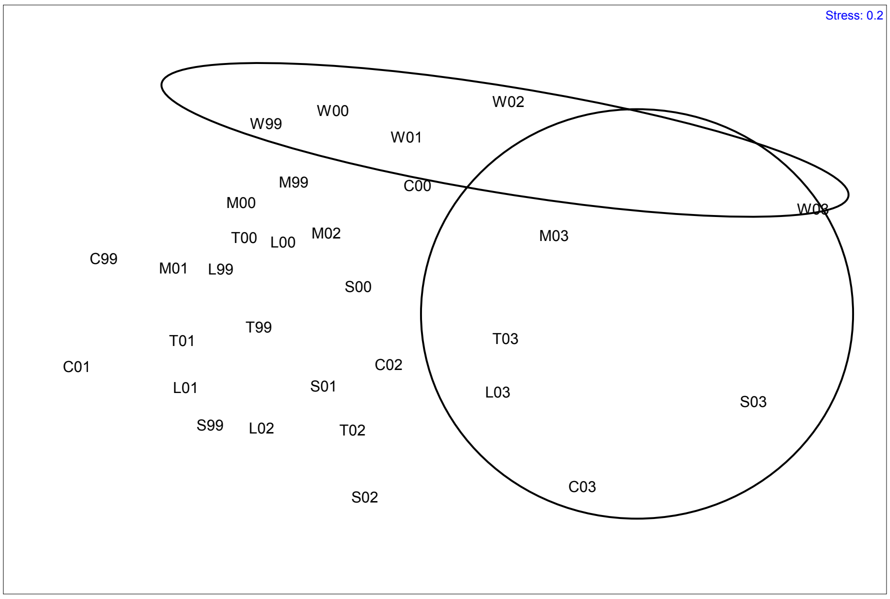


Figure 4b.5. MDS plot of community structure at each combination of site and year.

NB: Not too much importance should be placed on the detail of this plot due to the high stress value (0.2). Data circled are for the site Waiwera and the year 2003, which are emphasised in the text.

The community structure of locations sampled in 2003 also grouped apart from the other survey data to the right of the MDS plot (Fig. 4b.5), indeed pairwise tests showed that 2003 was significantly different to all other years (Table 4b.2). *Carpophyllum plumosum* was the species which contributed most to the majority of the between year dissimilarities, but *Carpophyllum flexuosum* contributed most to the 2003 versus 2002 dissimilarities. The years 1999 and 2002 were also significantly different from each other and 2001 and 2002 were the most similar to each other.

Table 4b.1. Pairwise statistics for ANOSIM analysis on differences between community structure on rocky reefs at different locations and major species contributing to dissimilarity (SIMPER) for all years combined. NS = not significant, bold indicates significant differences, grey \indicates least dissimilar.

	Long Bay	Manly	Stanmore	Torbay	Waiwera
Campbells	R = 0.023 p = 34% NS	**R = 0.252 p = 0.1% C. plumosum**	**R = 0.294 p = 0.1% C. plumosum**	R = 0.001 p 47% NS	**R = 0.518 p = 0.1% C. flexuosum**
Waiwera	**R = 0.344 p = 0.1% C. flexuosum**	**R = 0.454 p = 0.1% C. plumosum**	**R = 0.238 p = 0.1% C. flexuosum**	**R = 0.299 p = 0.1% C. flexuosum**	
Torbay	R = -0.102 p = 97% NS	R = 0.036 p = 23% NS	R = 0.103 p = 5.7% NS		
Stanmore	R = 0.174 p = 1.1% NS	**R = 0.307 p = 0.1% C. plumosum**			
Manly	R = 0.069 p = 11% NS				

Table 4b.2. Pairwise statistics for ANOSIM analysis on differences between community structure on rocky reefs in different years and major species contributing to dissimilarity (SIMPER) for locations combined. NS = not significant, bold indicates significant differences, grey \indicates least dissimilar.

	1999	2000	2001	2002
2003	**R = 0.425 p = 0.1% C. plumosum**	**R = 0.368 p = 0.1% C. plumosum**	**R = 0.459 p = 0.1% C. plumosum**	**R = 0.239 p = 0.1% C. flexuosum**
2002	**R = 0.180 p = 0.4% C. plumosum**	R = 0.092 p = 6.9% NS	R = -0.021 p = 63% NS	
2001	R = 0.048 p = 20% NS	R = 0.062 p = 15% NS		
2000	R = 0.058 p = 19% NS			

4. b. 2. Variations in Key Species

Variations in the 10 key species (the most numerically dominant species, or those deemed ecologically important) are described in detail in sections below (see Table 4b.3 for list of species). Eight of these species showed significant interaction effects between location and years, *C. plumosum* and *Ecklonia radiata* however, showed non-significant interactions between these factors, this indicates the pattern in variability is likely to be consistent. Therefore, further post-hoc tests were applied to identify the variation. Post-hoc comparisons, however, showed no clear pattern with either year or location for either

C. plumosum or *E. radiata.* Highest and lowest values for each significant factor are displayed below (Table 4b.3).

Table 4b.3. 2-factor ANOVA statistics, showing differences between location, year or location x year interaction for each of the 10 key species. The last 2 columns show the highest and lowest factor, or combination of factors where a significant difference was seen.

Species	Locations	Years	Interaction	Location and year or Location x year in which density or % cover was:			
				Highest		Lowest	
Carpophyllum maschalocarpum			*F*=2.50 p<0.001	Stanmore 2002		Waiwera 2003	
Carpophyllum flexuosum			*F*=4.84 p<0.001	Waiwera 2003		Long Bay 2001	
Carpophyllum plumosum	*F*=15.54 p<0.001	*F*=6.07 p<0.001	*F*=1.21 p=0.236 NS	Manly	2001	Waiwera	2000
Sargassum sinclairii			*F*=3.31 p<0.001	Long Bay 1999		Campbells 2001	
Zonaria turneriana			*F*=2.55 p<0.001	Waiwera 2002		Long Bay 1999	
Trochus viridus			*F*=8.18 p<0.001	Stanmore 2003		Waiwera 1999	
Turbo smaragdus			*F*=2.54 p<0.001	Manly 2001		Long Bay 2002	
Ecklonia radiata	*F*=12.10 p<0.001	*F*=6.44 p<0.001	*F*=1.39 p=0.118 NS	Torbay	2003	Campbells	2000
Evechinus chloroticus			*F*=1.68 p=0.031	Stanmore 2002		Manly 2002	
Crustose coralline algae			*F=2.85* p<0.001	Waiwera 1999		Campbells 2001	

Crustose Coralline Algae

The most dominant benthic cover was crustose coralline algae (CCA), which covered, on average per location, between 37 – 66% of the substratum per m^2 (Fig. 4b.1). Coverage of CCA per m^2 ranged from 0 to 95%. On average, the lowest coverage (<40%) of this organism was at Manly and Campbells in 2001 and Torbay in 2003. Stanmore, Manly and Waiwera had the highest coverage (>60%) of CCA in 1999.

Carpophyllum maschalocarpum

Individuals of *Carpophyllum maschalocarpum* ranged between 8-59 on average per m^2 per location (Fig. 4b.2), but between 0-210 per m^2. There were no consistent patterns in *Carpophyllum maschalocarpum* over time or between locations. The highest densities of *Carpophyllum maschalocarpum* were found at

Campbells in 2001, Long Bay in 2002 and Stanmore in 2001 and 2002. The lowest densities were found at Waiwera in 2003.

Turbo smaragdus

Turbo smaragdus was the most dominant gastropod and was found in almost all quadrats, number of individuals ranging on average between 7-43 per m^2 per location (Fig. 4b.3) and between 0-152 per m^2. There were generally higher densities of *Turbo smaragdus* found at Manly than other monitored locations in all years except 1999. The lowest densities were found at Waiwera in the past 2 years (2002-03) and at Long Bay and Torbay in 2002 and Campbells in 1999.

Zonaria turneriana

There was a general increase in densities of *Zonaria turneriana* over the monitored period (1999-2003) with the exception of Waiwera, which decreased in 2003 (Fig. 4b.2). In 1999 there was on average 8 individuals m^{-2} increasing to 26 individuals m^{-2} in 2003. The yearly increase of this alga was not as marked at Torbay as at other locations.

Carpophyllum plumosum

There were very low densities of *Carpophyllum plumosum* at Campbells, Stanmore and Waiwera in 2003 (Fig. 4b.2). Densities of *Carpophyllum plumosum* at Waiwera and Stanmore showed a decrease over the monitoring period (1999-2003). Higher densities than average were seen at Torbay in 2003, Manly in 1999, 2001 and 2002 and at Long Bay in 2001.

Carpophyllum flexuosum

Greater densities of *Carpophyllum flexuosum* were found at Waiwera and Manly in 2003 than had been recorded in previous years (Fig. 4b.4). Indeed, there were increased densities of this alga at most sites (except Campbells Bay and Long bay) in 2003 when compared to previous years. Four of the locations (Campbells, Long Bay, Stanmore and Torbay) had decreased densities of *Carpophyllum flexuosum* in 2001 and 2002 when compared to either previous or subsequent years.

Trochus viridis

There were higher densities of *Trochus viridis* in 2003 than in previous years at all locations except at Manly (Fig. 4b.3). There has been a steady decrease of Trochus over the monitoring time at Manly and a steady increase over time at Waiwera. All other sites (Campbells, Long Bay, Stanmore and Torbay) showed a decrease in *Trochus viridis* in 2001 and/or 2002.

Ecklonia radiata

Densities of *Ecklonia radiata* ranged, on average, between 1-7 per m^{-2} per location (Fig. 4b.4), but up to 40 per m^{-2} were counted. *Ecklonia radiata* showed a reduction in density in 2000 at all sites except Campbells, densities increased subsequently at all sites except Manly. A steady increase of this alga over the past 4 years can be seen at Stanmore and Waiwera.

Sargassum sinclairii

The greatest density of *Sargassum sinclairii* was found at Long Bay in 1999 (Fig. 4b.4). Decreased densities of *Sargassum sinclairii* were seen in 2003 by comparison to 2002 at all sites except Stanmore.

Evechinus chloroticus

The highest densities of *Evechinus chloroticus* in 2002 were seen at Stanmore in 2002 followed by Long Bay in all years, which generally had consistently higher densities when compared to all other sites (Campbells, Manly, Torbay and Waiwera) (Fig. 4b.3). The lowest densities of *Evechinus chloroticus* were found at Manly in 2003 and Torbay in 2001. Densities of *Evechinus chloroticus* ranged between 0-8 per m^2 per location, but up to 19 were found in a m^{-2}.

4. b 3. This monitoring period (2002-2003)

The dominant substrate cover was encrusting red algae (mostly CCA) followed by brown algae, sediment, un-colonised substrate (gravel, bare rock, sand, shell hash) then sponges and other minority groups in decreasing order (see Fig. 4b.6 and 4b.7). The most numerous group of invertebrates (assessed using counts, not % cover) were the Gastropods, followed by the Echinoderms, Opisthobranchs (see Fig 4b.8) and Bivalves (not shown) in decreasing order. Brown algal percent cover was lower in 2003 than in 2002 and substrates, sponges and gastropods were generally higher in 2003 than in 2002. On average there were more Echinoderms at Stanmore than all other locations. Opisthobranchs were found either in very low densities (all sites except Long Bay and Stanmore), or were not found at all. Bivalves (e.g. mussels and oysters) were only found at Stanmore in 2003 in very small densities (not shown).

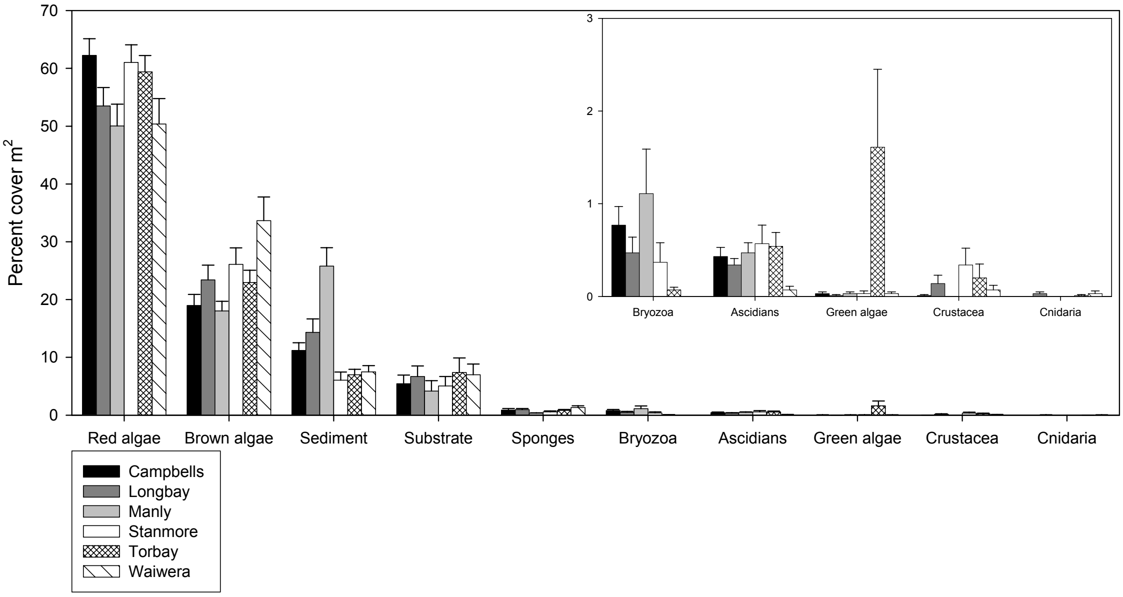


Figure 4b.6 Average percent cover per m^2 of groups of organisms and substrate types found at all sites during the 2002 survey. Inset shows last 5 groups at a smaller scale.

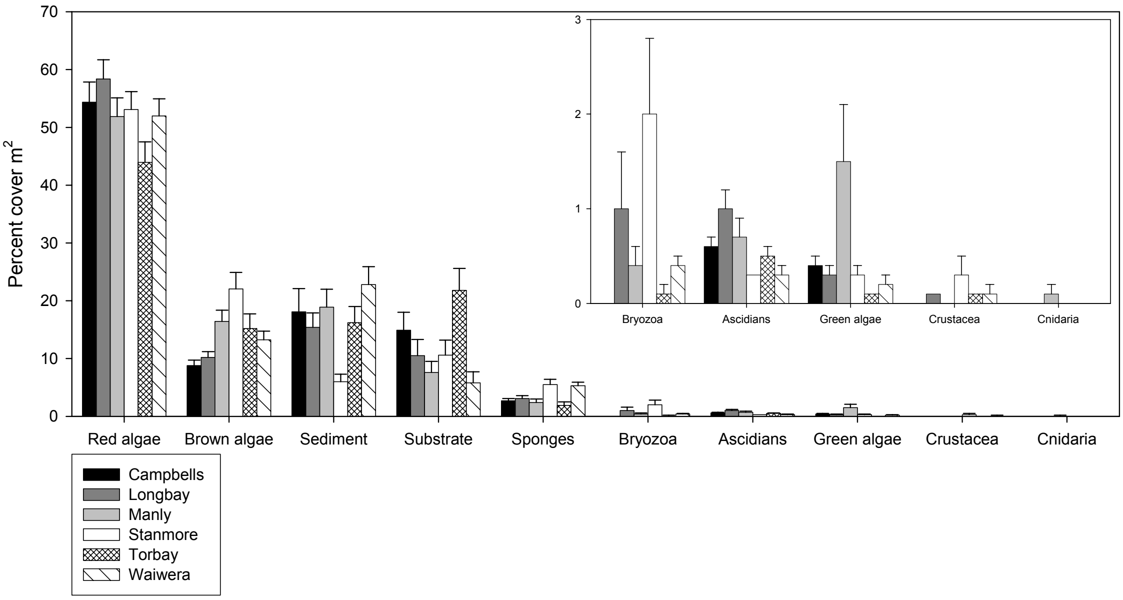


Figure 4b.7 Average percent cover per m^2 of groups of organisms and substrate types found at all sites during the 2003 survey. Inset shows last 5 groups at a smaller scale.

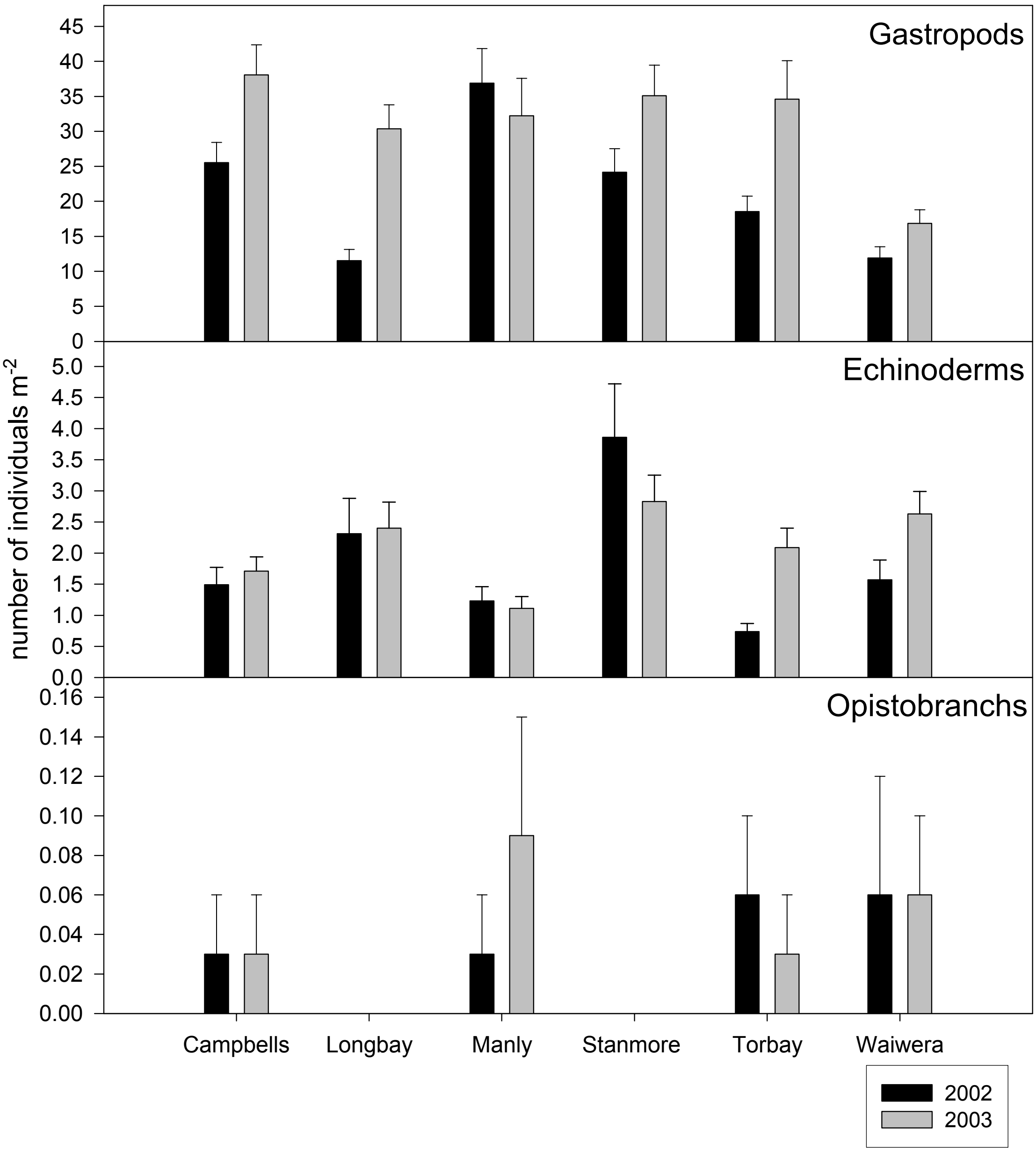


Figure 4b.8. Main groups of invertebrates at all sites for the 2002 and 2003 surveys. Note the changing scale between graphs.

4. b. 4. Size frequency distribution for 2002 and 2003 samplings

Carpophyllum maschalocarpum

Fewer small *Carpophyllum maschalocarpum* plants were found in 2003 compared to the previous year, 2002 (Fig. 4b.9). In both years there was a higher frequency of smaller algal sizes than larger sizes. The ratio of medium to larger individuals in 2002 was very similar to in 2003.

Turbo smaragdus

The mean size of *Turbo smaragdus* was 15-20mm in both years (Fig. 4b.10). Several small individuals (0-5mm size) were recorded in 2002 at Manly. The largest sizes of this gastropod were 30-35 mm and were found in very low densities at Manly and Waiwera in 2003. More 15-20 mm individuals were found in 2003 at Long Bay and Torbay than in 2002, a large number of this size class were also found at Manly in 2002.

Zonaria turneriana

The majority of *Zonaria turneriana* individuals were shorter than 10cm in length in both 2002 and 2003 (Fig. 4b.11). The mean alga size for 2002 was 5-10 cm, and 0-5 cm for 2003. In 2003 there were larger algae (10-20 cm) at Campbells and Stanmore than at the other sites surveyed. Waiwera had the highest density of small algae (below 5 cm) in both years. The largest algae were found at Campbells in 2003 and Waiwera in 2002, but in very small densities.

Carpophyllum plumosum

Manly had a much higher density of the 20-25 mm size of *Carpophyllum plumosum* in both 2002 and 2003 (Fig. 4b.12) compared to all other sites. In 2002 recruitment occurred at Long Bay, Manly, and Stanmore. In 2003 recruitment was also evident at Long Bay, Manly and, to a smaller extent, Torbay. There was a loss of *Carpophyllum plumosum* at Stanmore and Campbells in 2003 compared with the presence of this alga in 2002.

Carpophyllum flexuosum

This year there were greater densities of *Carpophyllum flexuosum* (Fig. 4b.4) and a greater range of sizes present than in 2002 (Fig. 4b.13). There was very little recruitment in 2002, with a few juveniles found at Waiwera. In 2003 however, there was recruitment at most locations except Long Bay, with the greatest recruitment at Waiwera. Much longer algae were seen at Waiwera, (>125 cm long) and at Manly. There were a range of sizes recorded this year at Torbay and Campbells, where only very few algae had been recorded in the previous year (2002).

Trochus viridis

The mean size range for *Trochus viridis* was 10-15 mm in 2002 and 5-10 mm in 2003 (Fig. 4b.14). A few larger individuals (35 – 40 mm)were found in all bays (except Torbay) in either 2002 or 2003.

Ecklonia radiata

Stipe length is presented for size class frequency distributions for *Ecklonia radiata*, as it is more indicative of algal age than total plant length. This alga showed some recent recruitment in 2003 with a number of young plants with, as yet, no stipe (Fig. 4b.15). In 2002 however, there were slightly more in the class size 1-5 cm than in 2003.

Evechinus chloroticus

There was very little recruitment (below 35 mm) of *Evechinus chloroticus* in 2002 or 2003 (Fig. 4b.16). The recruitment that did occur in 2003 was mainly at Campbells and Long Bay, but was also present to a smaller extent at Waiwera and Torbay.

Sargassum sinclairii

There was recruitment of Sargassum sinclairii in 2002, but less recruitment was seen in 2003 (Fig. 4b.17). Recruitment in 2002 occurred predominantly at Long Bay, Manly and Torbay, although some occurred at the remaining locations. The 2002 recruitment did not translate into larger algae in 2003 except perhaps at Torbay. The recruitment that did occur in 2003 was mainly at Stanmore with some at Manly.

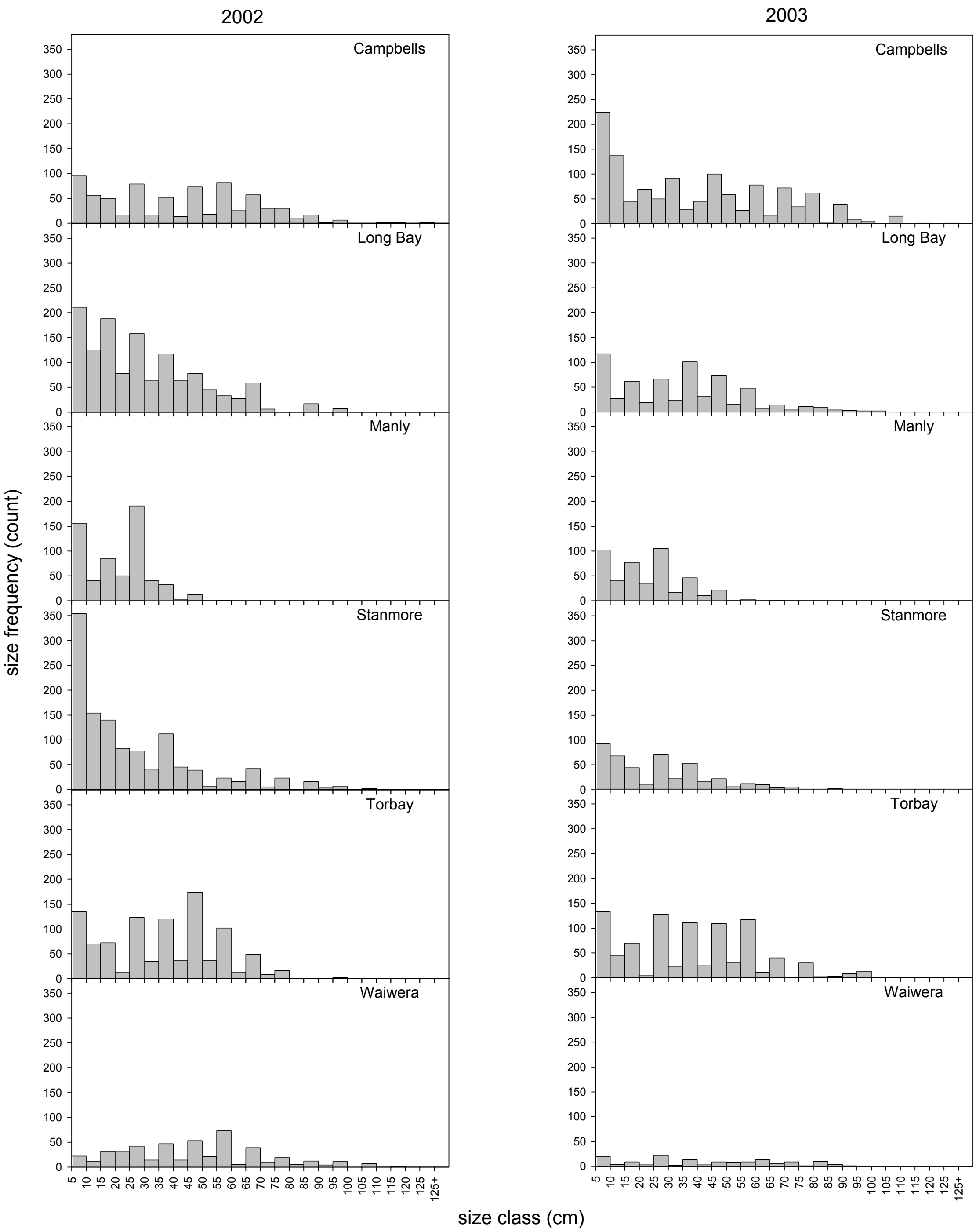


Figure 4b.9. Size frequency distribution of *Carpophyllum maschalocarpum* for 2002 and 2003

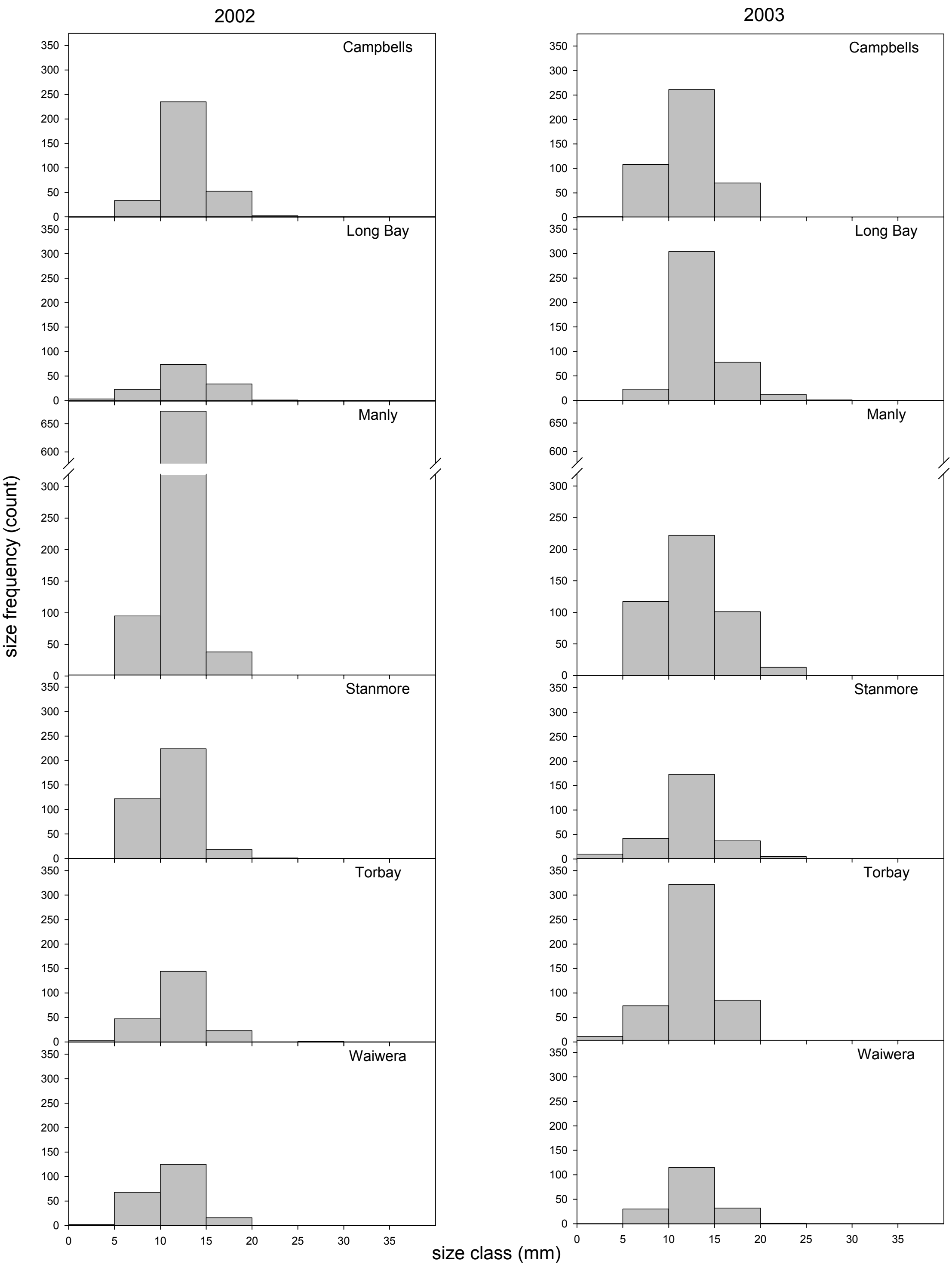


Figure 4b.10. Size frequency distribution of *Turbo smaragdus* for 2002 and 2003

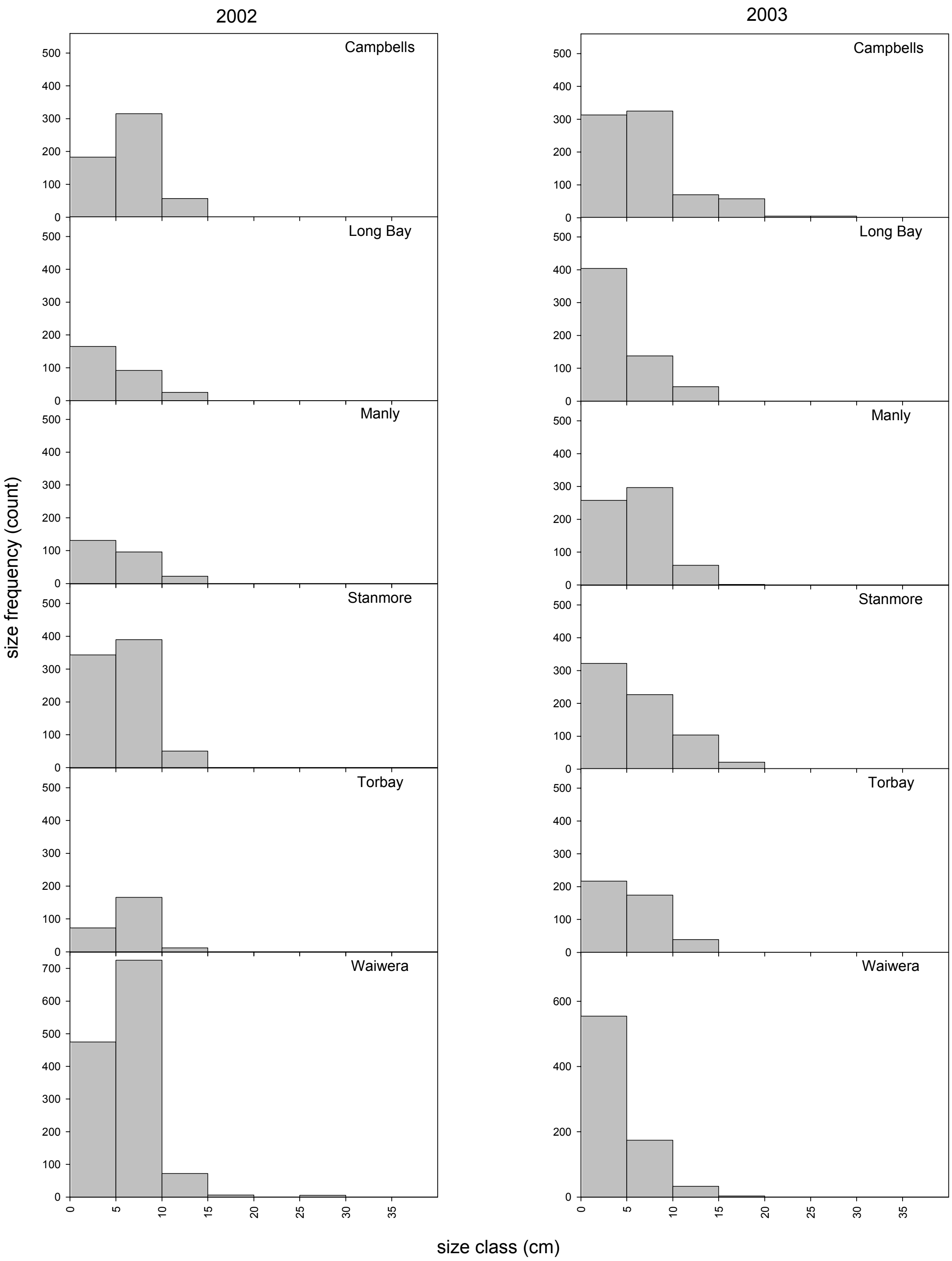


Figure 4b.11. Size frequency distribution of *Zonaria turneriana* for 2002 and 2003

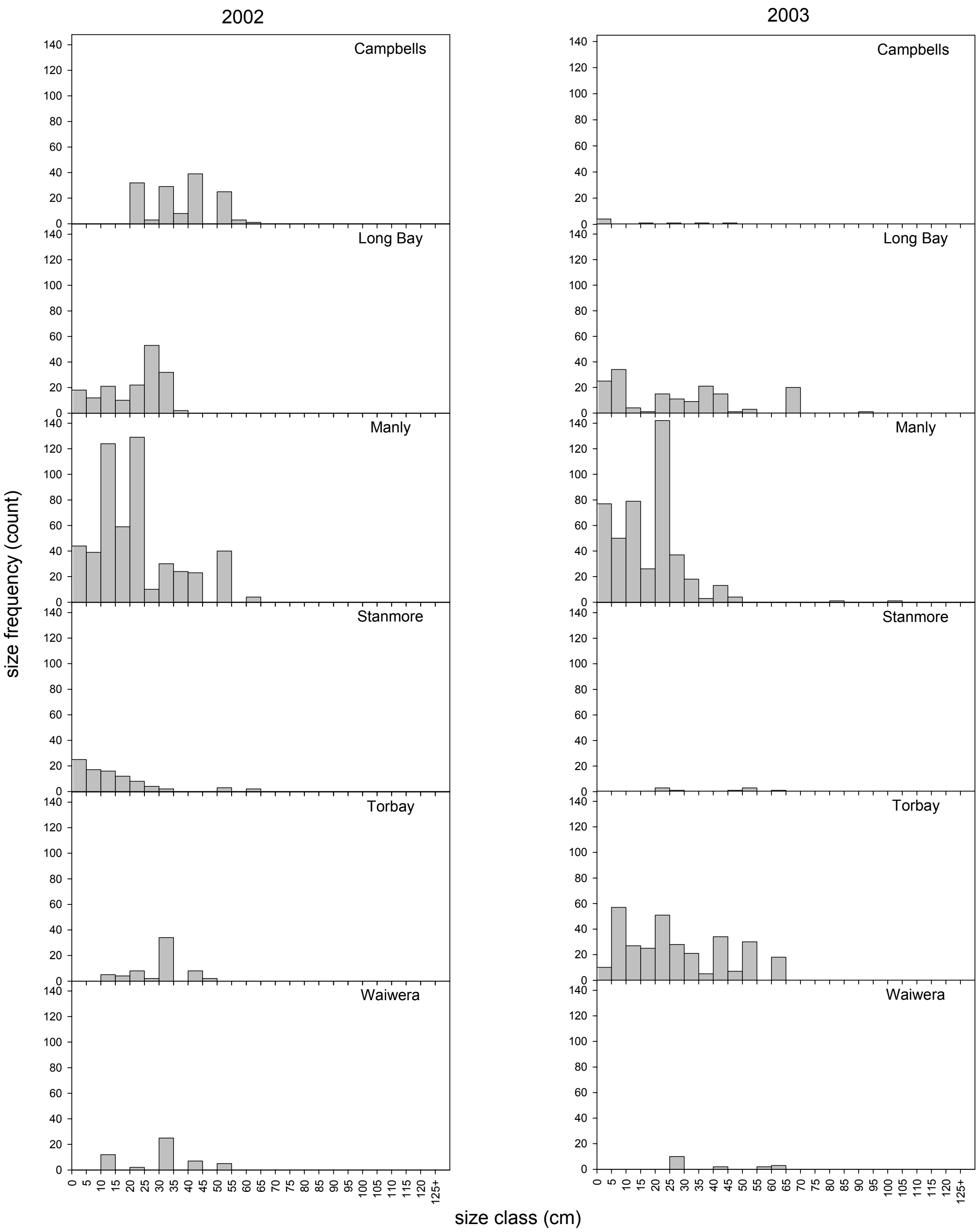


Figure 4b.12. Size frequency distribution of *Carpophyllum plumosum* for 2002 and 2003

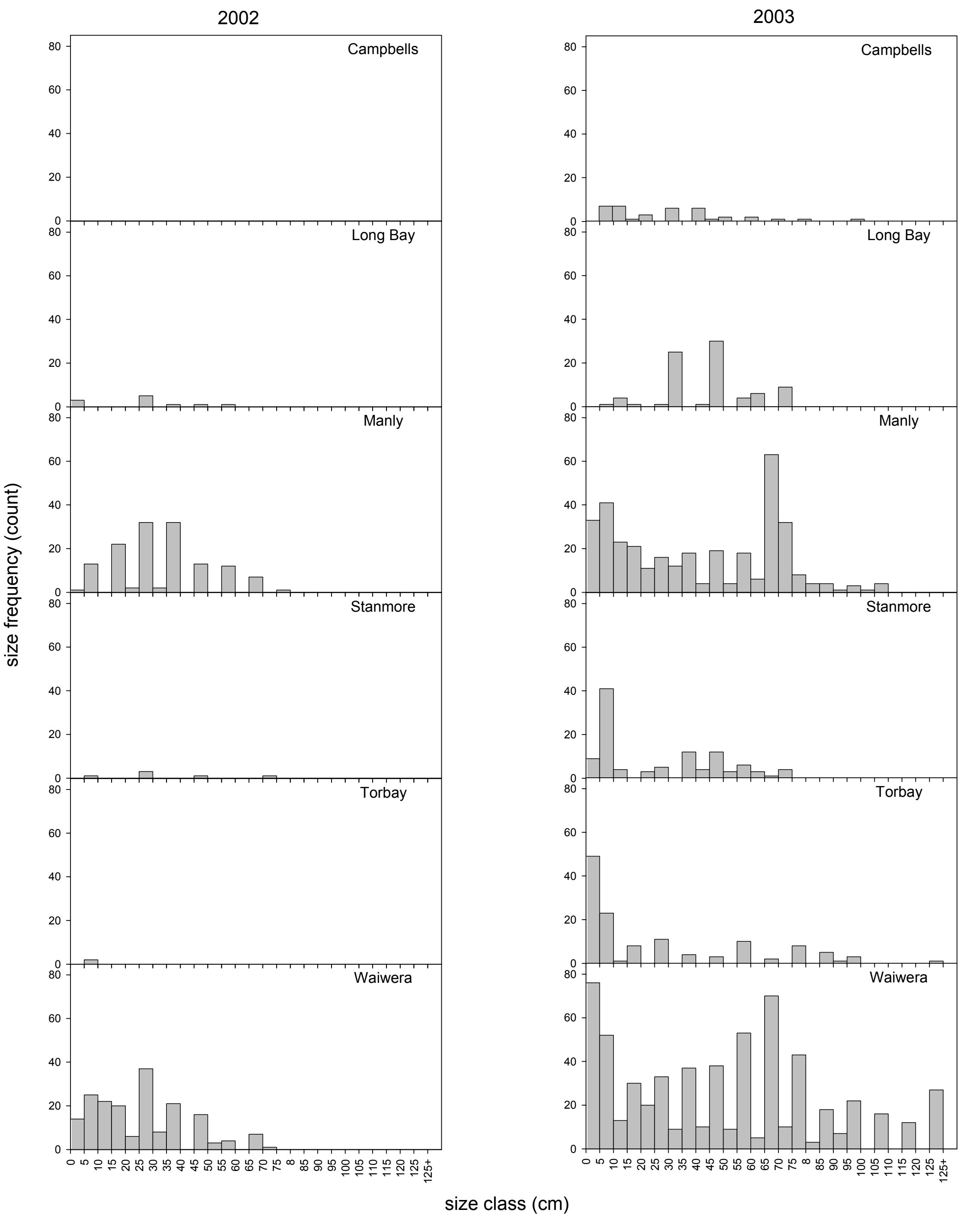


Figure 4b.13. Size frequency distribution of *Carpophyllum flexuosum* for 2002 and 2003

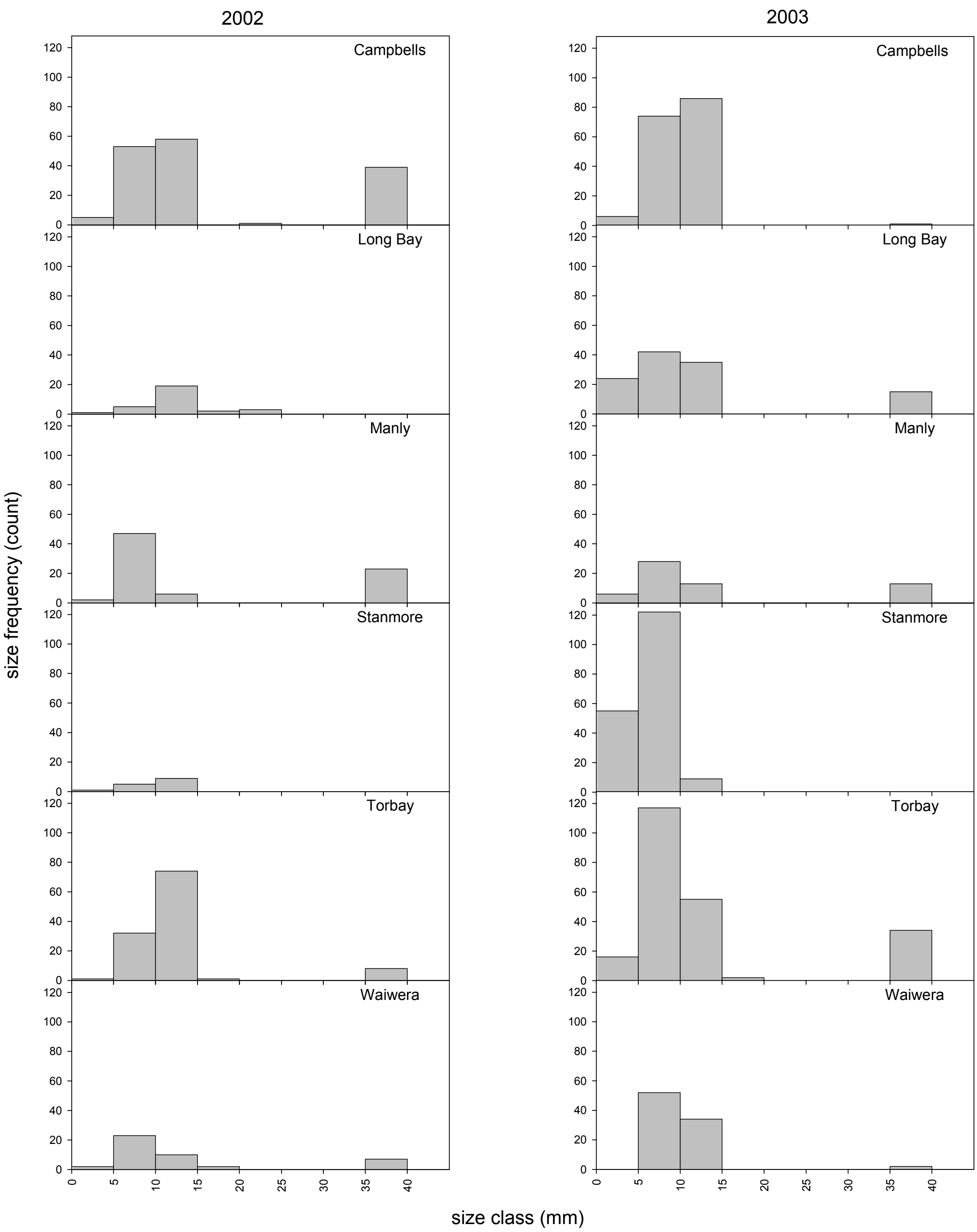


Figure 4b.14. Size frequency distribution of *Trochus viridus* for 2002 and 2003

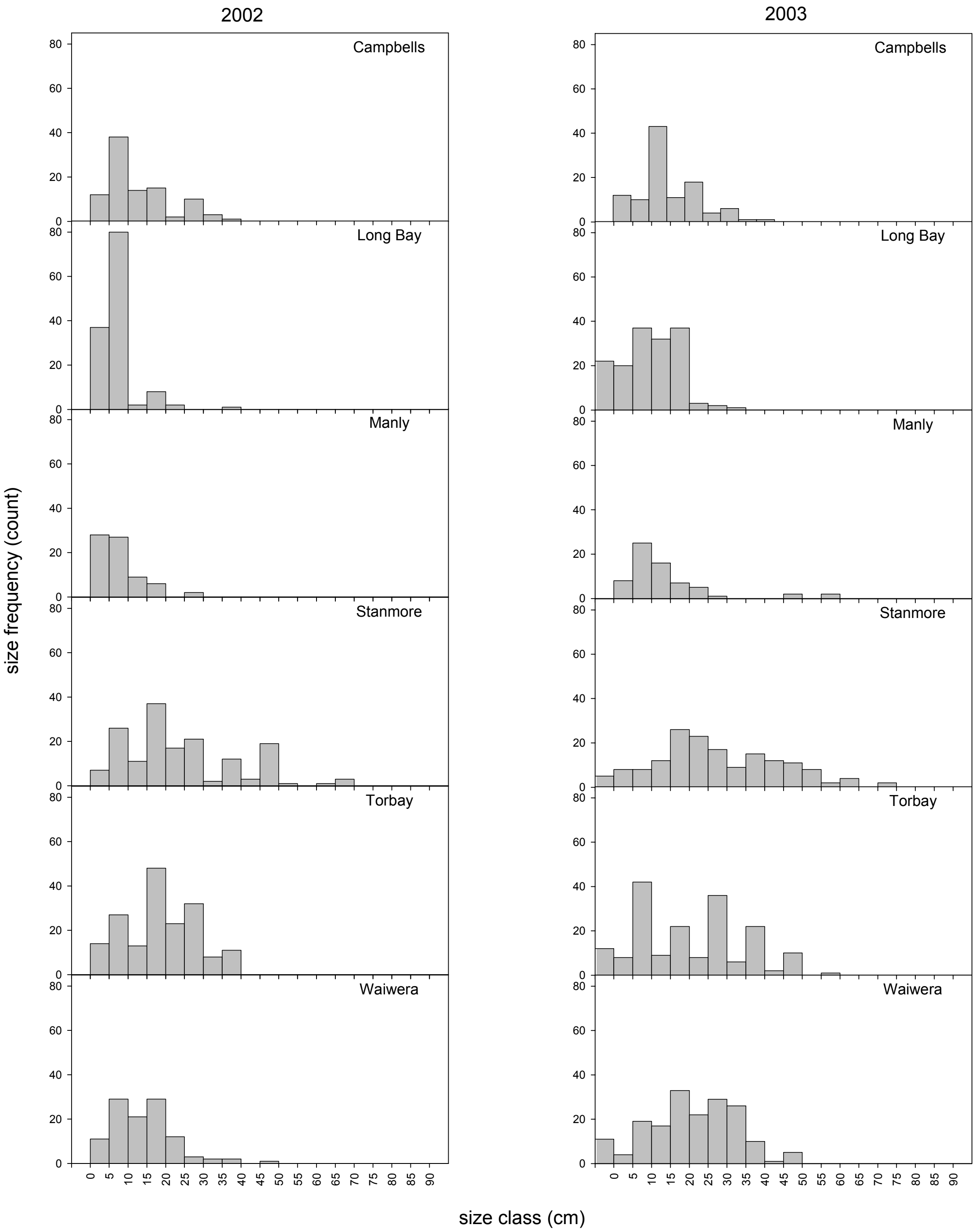


Figure 4b.15. Size frequency distribution of *Ecklonia radiata* (stipe length) for 2002 and 2003

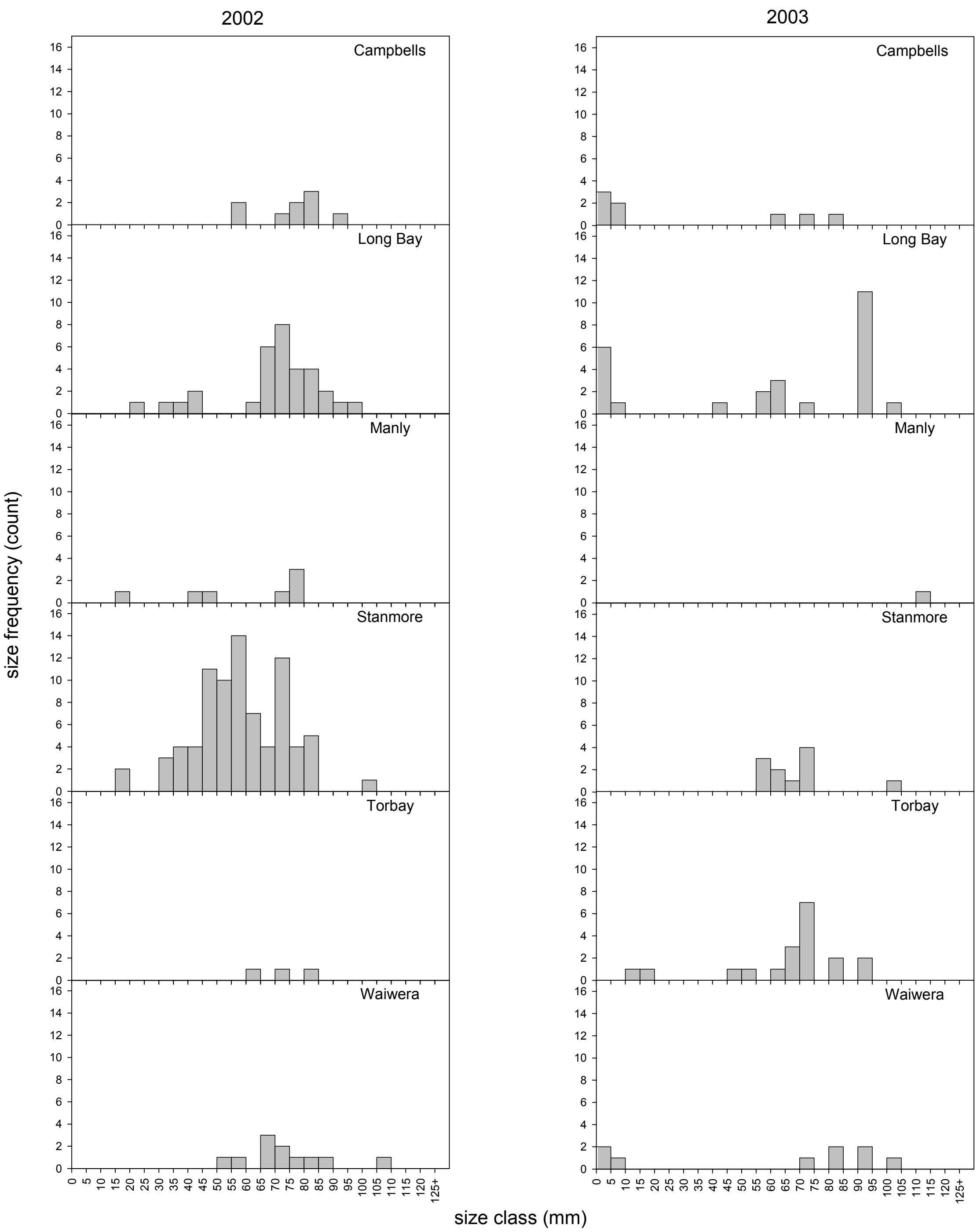


Figure 4b.16. Size frequency distribution of *Evechinus chloroticus* for 2002 and 2003

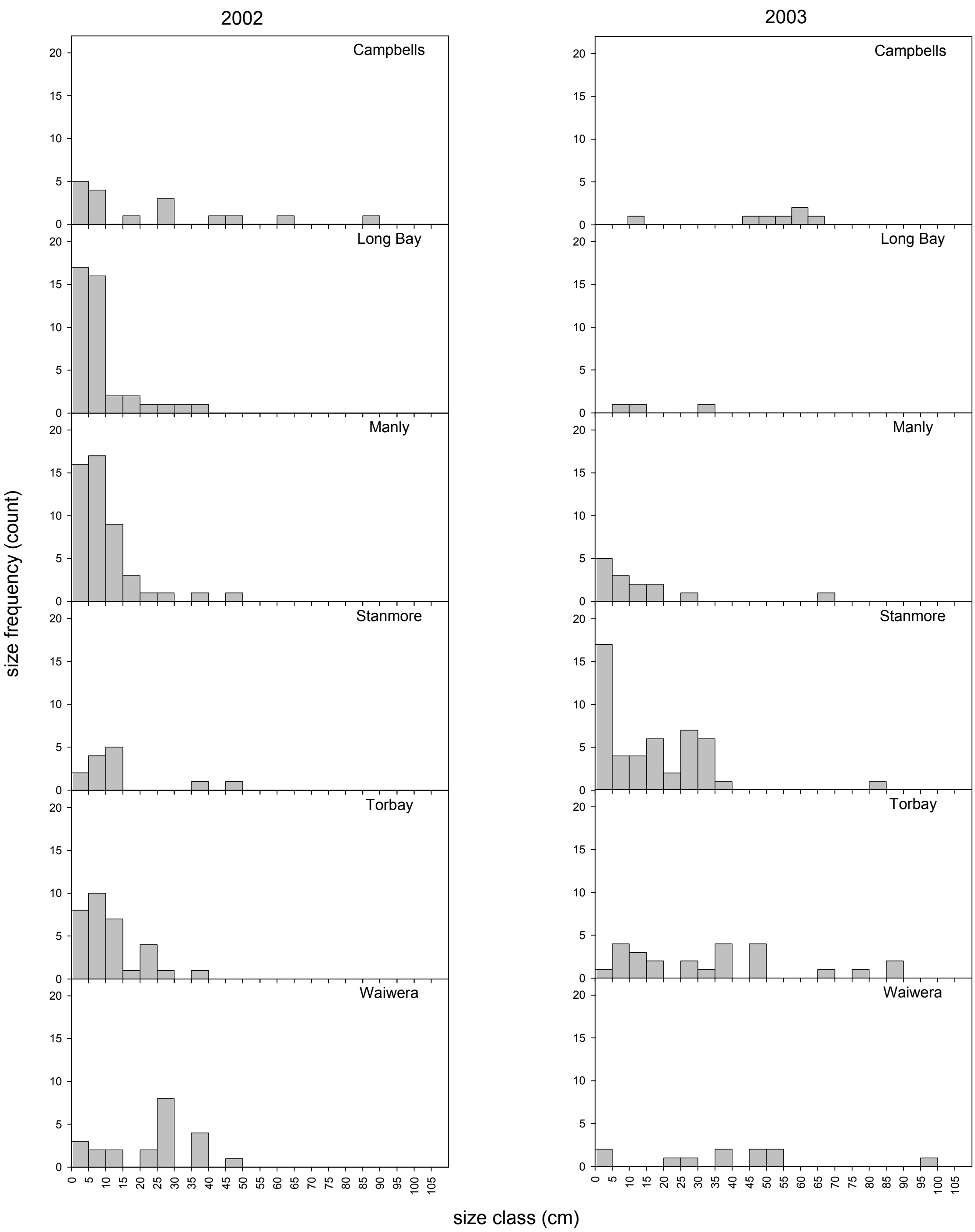


Figure 4b.17. Size frequency distribution of *Sargassum sinclairii* for 2002 and 2003

4. b. 5. Sedimentation

Due to the uneven replication and sometimes sparse monthly data, averages per site per year are presented. Average monthly sedimentation rates for the most recent monitoring period ranged between 0.005 g/day/cm^2 at Stanmore in Nov 2002 to 0.762 g/day/cm^2 at Long Bay in Jan 2003 (not shown). Over the whole monitoring period Long Bay in Jan 2003 (as above) showed the highest sedimentation and the lowest sedimentation was 0.004 g/day/cm^2 at Stanmore in Jan 2000. Average sedimentation per year in the region would approximate to 478 kg/m^2/yr ♦.

On average, sedimentation was highest at Campbells and Long Bay, and lowest at Stanmore over the whole monitoring period (Fig. 4b.18). There were significant differences between locations (F=7.62, p<0.001). Sedimentation over time was not significantly variable (F=0.38, p=0.767), nor was there a significant interaction between location and years (F=1.40, p=0.162). This indicates that the variation between locations was consistent over time. Campbells (the location with the highest sedimentation rate) showed significantly more sedimentation than the 4 locations with the lowest sedimentation rates (Table 4b. SR). Long Bay (the location with the 2nd highest sedimentation rate) showed significantly more sedimentation than the 3 locations with the lowest sedimentation rates. Stanmore (the location with the lowest sedimentation rate) showed significantly less sedimentation than the 3 locations with the highest sedimentation rates.

Table 4b. SR. Differences in sedimentation rate between locations for all years combined. NS = not significant, bold indicates significant differences, grey indicates least dissimilar. Number in brackets after location denotes rank order of sedimentation rate; 1 = highest rate. Chisq= Chi-squared.

	Long Bay (2)	Manly (5)	Stanmore (6)	Torbay (3)	Waiwera (4)
Campbells (1)	Chisq = 1.34 p = 0.247 NS	Chisq = 16.55 **p < 0.0001**	Chisq = 19.08 **p < 0.0001**	Chisq = 7.13 **p = 0.008**	Chisq = 8.46 **p = 0.004**
Waiwera (4)	Chisq = 3.92 **p = 0.048**	Chisq = 0.03 p = 0.866 NS	Chisq = 1.63 p = 0.202 NS	Chisq = 0.63 p = 0.429 NS	
Torbay (3)	Chisq = 2.16 p = 0.141 NS	Chisq = 2.23 p = 0.136 NS	Chisq = 4.99 **p = 0.026**		
Stanmore (6)	Chisq = 11.7 **p = 0.0006**	Chisq = 0.87 p = 0.352 NS			
Manly	Chisq = 8.42 **p = 0.004**				

♦ amended sept 04

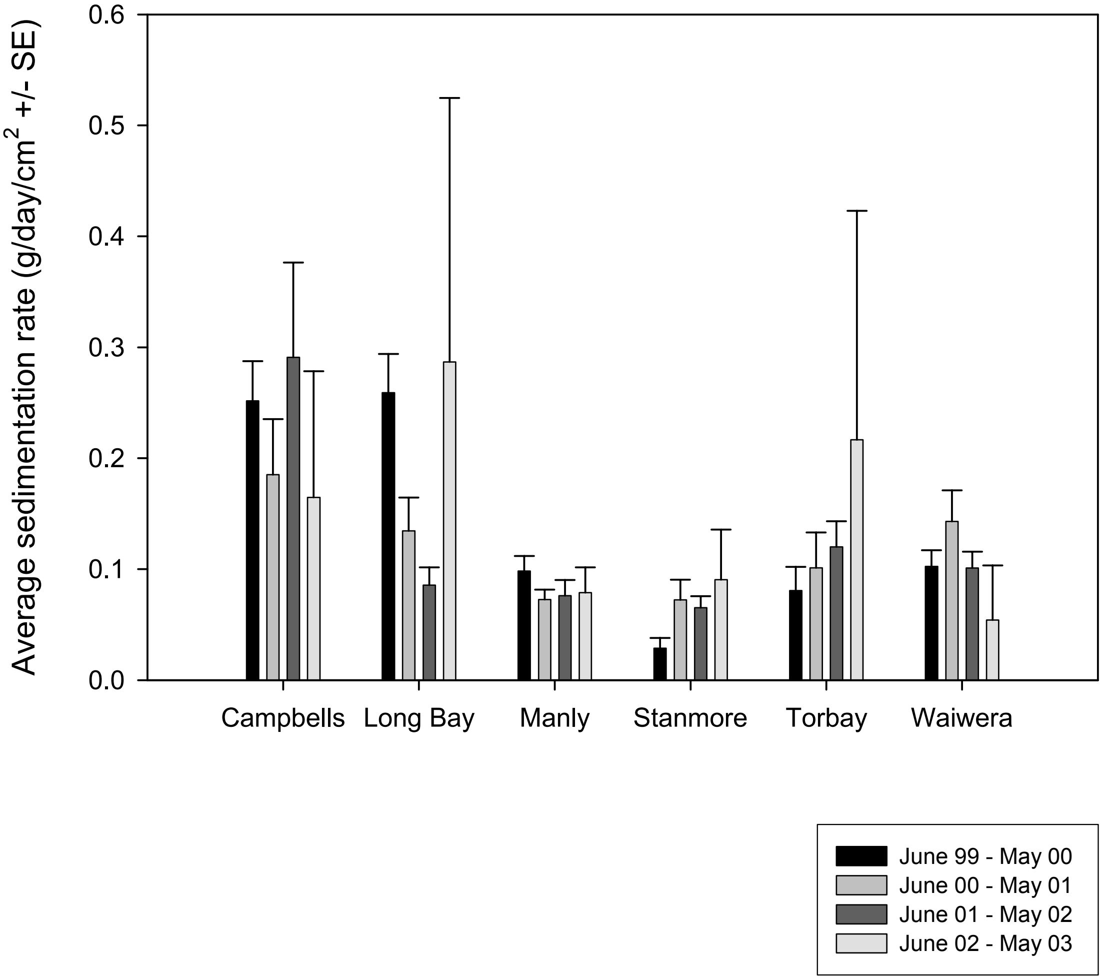


Figure 4b.18. Average sedimentation rate over entire monitoring period (1999-2003)

Sediment was sieved into fractions to assess the proportion (<63µm) that would most likely have originated from terrestrial sources. On average, the fine sediment proportion of sediment trapped ranged from 8 to 82 %. There was a significant interaction effect between year and location (interaction location*years F=2.45, p=0.006), indicating variability was inconsistent. Pairwise comparisons showed that the last year had significantly (p<0.011) more fine sedimentation (<63 µm sediment) than the first year at all locations. Indeed, a general trend of increasing proportion of this fraction is apparent over time (Fig. 4b.19).

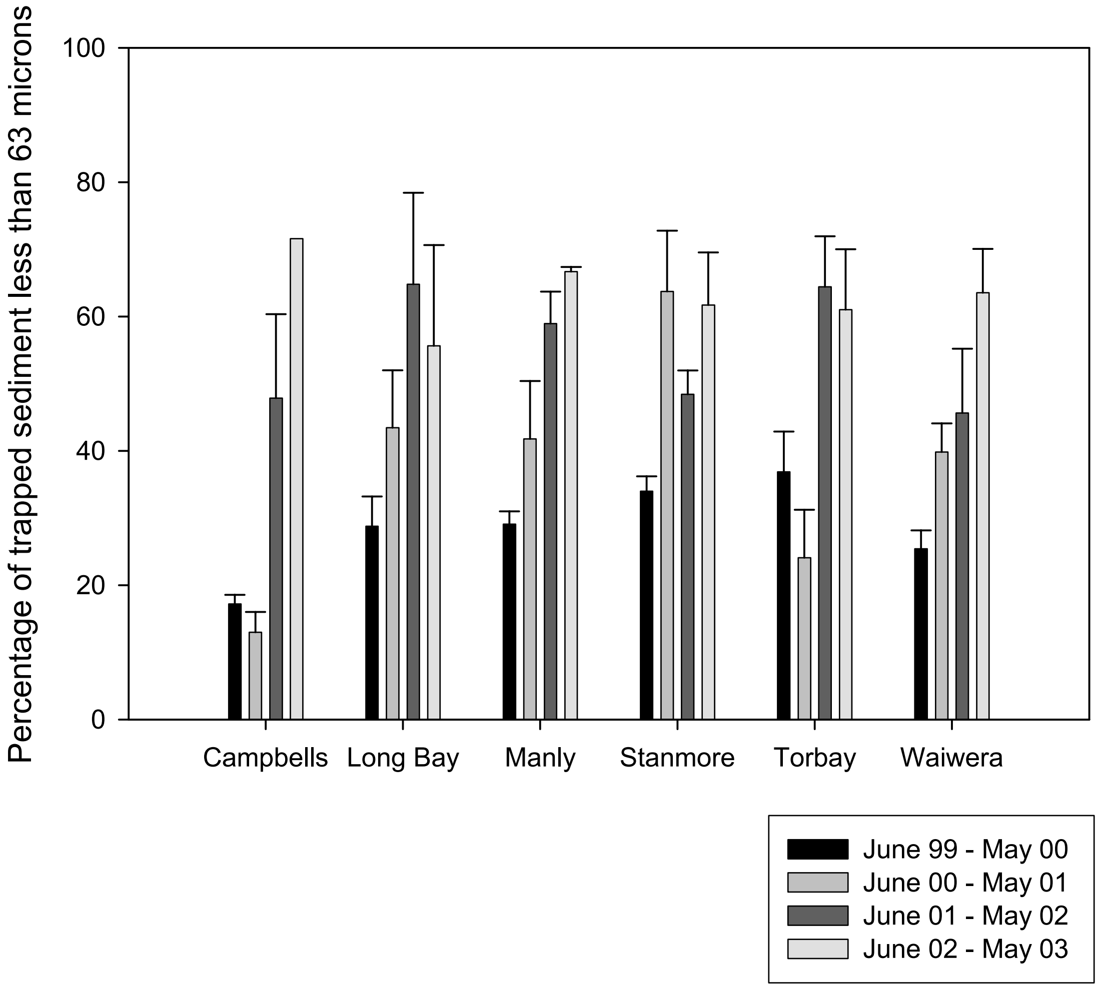


Figure 4b.19. Average percentage of trapped sediment that was less than 63µm grain size over the whole monitoring period (1999-2003). Note that for Campbells Bay in the June 02 – May 03 sampling period, n = 1 thus the absence of an error bar.

5. Discussion

5. a. Intertidal Soft Sediments

There were significant differences in macrofaunal communities between beaches, between tidal zones (mid and low shore zones) and between sampling months. However the significant differences in macrofaunal communities between sampling months (September 2002 and March 2003) only occurred when each beach was analysed separately, and showed no difference when data from all beaches were combined. Therefore, no regional difference was seen between the macrofaunal communities over the sampling period indicating that there were different communities at each beach. The differences between tidal zones was not as strong as the difference between times and beaches.

On Long Bay beach the most abundant organism, the small polychaete *Hesionidae* sp., had the largest contribution to the community differences between zones and times. On Mairangi Bay beach the two dominant species, *Hesionidae* sp. and the cumacean *C. lemurnum*, had the biggest contribution to the community differences between zones and times. On Torbay beach the most abundant species, *C. lemurnum* and *Paphies* sp., had the largest contribution to the community differences between zones and times. On Browns Bay beaches the most dominant species, *Waitangi* sp. and *Paphies* sp. made the largest contribution to the community differences between zones and times. Differences between beaches were mainly due to the same species that charcterised beaches as above, but excluding *C. lemurnum* and including nematodes.

The least variable beaches in terms of community structure were Mairangi Bay at both sampling times and Torbay in March 2003 (SIMPER values over 45%). The beaches with the most variable community structure were Browns bay in both months and Torbay in September 2002 (SIMPER values below 28%).

Long Bay beach was analysed to a greater extent than the other four beaches, due to its potential to be impacted by sedimentation. Long Bay beach showed both along-shore spatial and vertical zonal difference in macrofaunal communities. There was a difference between transects along the beach which meant that the northern and the southern halves of the beach could be considered biologically different. These spatial differences on Long Bay beach were mainly due to differences in 2 of the most abundant species, *Hesionidae* sp. and the amphipod *Waitangi* sp..

The sampling methodology used during the first half of this report period used a 1mm sieve size until March 2002 inclusive. Therefore direct comparisons of this year's data (which used a 0.5mm mesh size) with the previous years data is not possible. As a result, one of the main species contributing to differences in this year's analysis was the small polychaete *Hesionidae* sp. that had not been detected using the previous methodology. However some general comparisons may be tentatively made. Last year's report recorded many more pipis at Torbay than the other beaches, which is consistent with this years findings. Species densities were highest at Browns Bay and lowest at Mairangi Bay this year, a pattern that was consistent with last years survey. There was no detectable seasonal variation over all these beaches in this or last year.

Data analysed from 2 cores was compared with to those analysed from 3 cores, with no discernable difference. Therefore it is recommended that 2 cores taken at each site is sufficient for the level of analysis required.

5. b. Subtidal Rocky Reefs

Community structure of subtidal benthic species demonstrated significant variation over time and between locations within the region. 2003 was significantly different than all other years, with *Carpophyllum plumosum* being the main species contributing to this difference. Waiwera was significantly different from all other locations, due, in part, to high densities of *C. flexuosum* at this location. The locations with the most similar community structure were Long Bay and Torbay and the most similar years were 2001 and 2002. More species were recorded in the past 2 years (55) than previously (39-45).

Long Bay reefs, within the reserve, were not significantly different in community structure than the other locations in the region, with the exception of Waiwera. Consequently, any changes of community structure in the reserve, perhaps due to the potential influence of sedimentation, should be detectable.

The three species (*Carpophyllum maschalocarpum* and *Zonaria turneriana, Evechinus chloroticus*) which have been suggested as the most likely to be affected by sedimentation (Walker, 1999) varied to different degrees over the monitoring period. *Evechinus chloroticus* showed no significant variation over time. Sedimentation rate also did not vary significantly over time, which suggests that *Evechinus chloroticus* may be an ideal candidate as an indicator of sedimentation. This initiative is being pursued as part Jarrod Walkers doctoral studies through the University of Auckland. *Carpophyllum maschalocarpum* showed both increases and decreases over the monitoring period. *Zonaria turneriana* showed a general trend of increasing density since 1999.

Sargassum sp, CCA and algal turf, all present in the region, are taxa which may also be sensitive to sedimentation (Ford et al 2002 and refs therein). Their presence suggests there is still possibly "something to lose" if sedimentation were to increase. CCA showed large variability in areal coverage over time (e.g. over all locations the highest coverage was in 1999 and the lowest coverage was in 2001 at a single location, Manly). *Sargassum sinclairii* showed no significant variation over time and therefore any changes in this species due to potential sedimentation should be detected. Algal turf (*Corallina officianalis*, in this region) had very low and quite variable densities (on average ranging from 0-10% cover).

Crustose coralline algae, the most dominant benthic feature in terms of areal coverage, showed large variations in percentage cover over time, especially at Manly. *Carpophyllum flexuosum* showed a range of sizes recorded this year at Torbay and Campbells, with no or very few algae recorded in the previous year (2002). *Carpophyllum flexuosum* can grow up to some 80 cm per year (Cole et el., 2001), therefore this change may be due to colonisation between the 2002 and 2003 monitoring surveys at these locations. There were *Trochus viridis* individuals below the size class 15 mm and above the size class 35 mm but none between these size ranges, which may indicate a lack of recruitment during a past period.

In the previous report (Walker et al. 2001), an increase was seen in the densities of dominant algae (*Carpophyllum maschalocarpum* and *C. plumosum*) and dominant gastropod (*Turbo smaragdus*) over a 3-year monitoring period (1999-2001). This pattern did not, however, continue in the subsequent two years.

Total trapped sedimentation over the past 2 years was on average 0.119g/cm^2/ day or 434 kg/m^2/yr ♠ for the region. Over all years sampled (September 1999 - May 2003) sedimentation was on average 0.131g/cm^2/ day, equivalent to 478 kg/m^2/yr ♣ for the region. No increase in sedimentation has therefore been seen in the past 2 years of monitoring. Stanmore had the lowest sedimentation rate and both Campbells and Long Bay had the highest sedimentation rates over all monitored years. A significant interaction effect was seen between years and location for the less than 63 µm sediment fraction (most likely to be from terrestrial origin). Pairwise comparisons showed that the last year had significantly more fine sedimentation (<63 µm sediment) than the first year. In between these times a general trend of increasing proportion of this fraction has occurred.

In the previous report (Walker et al. 2001) Campbells bay was reported to have a high sedimentation rate, of which a low proportion (compared with other locations) was less than 63 µm grain size. The most recent sampling, however, showed a sedimentation rate consistent with the previous report, but a higher proportion this sediment was in the less than 63 µm fraction.

♠ amended sep 04

♣ amended sep 04

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7. Appendices

Appendix A. Global Positioning Systems (GPS) coordinates of the top of transects for Intertidal Sites

Beach	Transect	Latitude	Longitude
Torbay	1	36°42.08'S	174°45.08'E
Torbay	1a	36°42.16'S	174°45.13'E
Torbay	2	36°42.10'S	174°45.07'E
Torbay	3	36°42.11'S	174°45.06'E
Torbay	3a	36°42.21'S	174°45.10'E
Torbay	4	36°42.13'S	174°45.05'E
Long Bay	1	36°40.51	174°44.56
Long Bay	1a		
Long Bay	2	36°40.55	174°44.57'E
Long Bay	2a		
Long Bay	3	36°41.01	174°44.60'E
Long Bay	4	36°41.05'S	174°45.01'E
Long Bay	4a		
Long Bay	5	36°41.09'S	174°45.03'E
Long Bay	5a		
Long Bay	6	36°41.14'S	174°45.06'E
Browns	1	36°42.43'S	174°45.00'E
Browns	1a		
Browns	2	36°42.47'S	174°44.59'E
Browns	3	36°42.53'S	174°44.58'E
Browns	3a		
Browns	4	36°42.59'S	174°44.59'E
Mairangi	1	36°44.16'S	174°45.21'E
Mairangi	1a	36°44.28'S	174°45.35'E
Mairangi	2	36°44.17'S	174°45.22'E
Mairangi	3	36°44.18'S	174°45.22'E
Mairangi	3a	36°44.32'S	174°45.38'E
Mairangi	4	36°44.20'S	174°45.24'E

Appendix B. GPS Positions of Subtidal Sites

Site	Area	Latitude	Longitude
W1	Waiwera	36° 32.24'S	174°43.06'E
W2	Waiwera	36°32.61'S	174°43.25'E
W3	Waiwera	36°33.06'S	174°42.70'E
W4	Waiwera	36°33.31'S	174°42.67'E
W5	Waiwera	36°33.67'S	174°42.67'E
S1	Stanmore	36°37.04'S	174°44.43'E
S2	Stanmore	36°37.06'S	174°44.58'E
S3	Stanmore	36°36.27'S	174°46.11'E
S4	Stanmore	36°36.23'S	174°46.23'E
S5	Stanmore	36°36.11'S	174°46.55'E
M1	Manly	36°38.44'S	174°44.44'E
M2	Manly	36°38.31'S	174°45.29'E
M3	Manly	36°38.13'S	174°45.59'E
M4	Manly	36°38.03'S	174°46.10'E
M5	Manly	36°37.49'S	174°46.19'E
L1	Long Bay	36°39.53'S	174°44.57'E
L2	Long Bay	36°40.16'S	174°44.54'E
L3	Long Bay	36°40.34'S	174°44.58'E
L4	Long Bay	36°41.21'S	174°45.17'E
L5	Long Bay	36°41.22'S	174°45.24'E
T1	Torbay	36°41.92'S	174°45.60'E
T2	Torbay	36°42.12'S	174°45.55'E
T3	Torbay	36°42.50'S	174°45.25'E
T4	Torbay	36°42.70'S	174°45.30'E
T5	Torbay	36°43.12'S	174°45.08'E
C1	Campbells	36°43.88'S	174°45.45'E
C2	Campbells	36°44.12'S	174°45.42'E
C3	Campbells	36°44.36'S	174°45.63'E
C4	Campbells	36°44.87'S	174°45.96'E
C5	Campbells	36°45.00'S	174°45.95'E

Appendix C. Species list for Intertidal Sites

Species	Group	Species	Group
Amphiod featureless	Amphipod	Ostracod	Ostracod
Amphipod A	Amphipod	*Agalophamus* sp	Polychaete
Amphipod B	Amphipod	*Aonides* sp.	Polychaete
Amphipod C	Amphipod	Aphroditidae	Polychaete
Amphipod fantail	Amphipod	Aricidea	Polychaete
Amphipod Featureless	Amphipod	*Capitella* sp.	Polychaete
Amphipod Horse	Amphipod	Capitellid other	Polychaete
Amphipod No eye	Amphipod	Exogonid	Polychaete
Amphipod X	Amphipod	*Glycera lamellipoda*	Polychaete
Big claw	Amphipod	Glycerid A	Polychaete
Cyclops Amphipod	Amphipod	Glycerid other	Polychaete
Ericthonius pugnax	Amphipod	Glycerid triger stripe	Polychaete
Horse	Amphipod	*Hesionidae* sp.	Polychaete
Paracorophium sp.	Amphipod	*Macroclymenella* sp.	Polychaete
Parakalliope sp.	Amphipod	*Magelona dakini*	Polychaete
Paridotea ungulata	Amphipod	*Minuspio* sp.	Polychaete
Phoxocephalid sp.	Amphipod	Nereid/Nicon	Polychaete
Tanaid	Amphipod	*Notomastus* sp.	Polychaete
Waitangi sp.	Amphipod	*Orbinia papulosa*	Polychaete
Waitangi B	Amphipod	Orbinid other	Polychaete
Waitangi like	Amphipod	Parionis	Polychaete
Elminius modestus	Barnacle	Pectinaridae	Polychaete
Austrovenus stuchburyi	Bivalve	Polydora complex	Polychaete
Bivalve A	Bivalve	Prionospio	Polychaete
Bivalve C	Bivalve	Sabellid	Polychaete
Macomona lilliana	Bivalve	Scolelepis	Polychaete
Nucula sp.	Bivalve	*Scoloplos cylindifer*	Polychaete
Paphies australis	Bivalve	Spionid "shovel nose"	Polychaete
Paphies sp.	Bivalve	Spionid other	Polychaete
Paphies subtriangulata	Bivalve	Spionid X	Polychaete
Unknown bivalve	Bivalve	Spionid Y	Polychaete
Coelomate worm	Coelomate worm	Spionid Z	Polychaete

Calanoid	Copepod	Spoinid fat head	Polychaete
Crab Zoea	Crustacean	Syllid	Polychaete
Halicarcinus sp.	Crustacean	Thin head	Polychaete
Helice crassa	Crustacean	Unknown Polychaete	Polychaete
Hermit crab	Crustacean	Mysid shrimp	Mysidacea
Colorustylus lemurum	Cumacean	Ophuiroid	Echinoderm
Sand dollar	Echinoderm	Sipunculid	Sipunculid
Cominella adspersa	Gastropod	Soletellina	Bivalve
General	Isopod	Trichoptera sp.	Insect
Nematode	Nematode	Unknown Gastropod	Gastropod
Nemertean	Nemertean	Unknown limpet	Polyplacophora
Oligochaete	Oligochaete		

Appendix D. Species and Substrate list for Subtidal Sites

* indicates species found in previous monitoring (prior to 2002)

Species	Group	Species	Group
Encrusting ascidian	Ascidians	Gastropod (unknown)	Gastropod
Solitary ascidians	Ascidians	Haustrum haustorium	Gastropod
Crassostrea gigas	Bivalves	*Maoricolpus roseus*	Gastropod
Carpophyllum flexuosum	Brown algae	*Micrelenchus* sp	Gastropod
Carpophyllum maschalocarpum	Brown algae	Penion sulcatus	Gastropod
Carpophyllum plumosum	Brown algae	**Scutus breviculus*	Gastropod
Colpomenia sinuosa	Brown algae	*Sypharochiton pelliserpentis*	Gastropod
Cystophora sp	Brown algae	*Thais orbita*	Gastropod
**Dictyota* sp	Brown algae	*Trochus viridus*	Gastropod
Ecklonia radiata	Brown algae	*Turbo smaragdus*	Gastropod
**Glossophora kunthii*	Brown algae	green turfing algae	Green algae
**Halopteris* sp	Brown algae	*Bursatella leachii*	Opisthobranch
Hormosira banksii	Brown algae	*Ceratosoma amoena*	Opisthobranch
Ralfsia sp.	Brown algae	*Dendrodois citrina*	Opisthobranch
Sargassum sinclairii	Brown algae	**Microcosmus kura*	Opisthobranch
Xiphophora chondrophylla	Brown algae	Nudibranch (other)	Opisthobranch
Zonaria turneriana	Brown algae	Opisthobranch	Opisthobranch
Bryozoan	Bryozoa	*Polymastia* sp.	Other
Anemone	Cnidaria	*Platyhelminth	Platyhelminth
Hydroids	Cnidaria	*Chaetopterus* sp	Polychaete
*Phlyctenactis tuberculosa	Cnidaria	*Spirorbis* sp.	Polychaete
Barnacles	Crustacea	Coralline Turfing Algae	Red algae
Coscinasterias muricata	Echinoderm	Crustose coralline algae	Red algae
Evechinus chloroticus	Echinoderm	**Laurencia* sp	Red algae
Patiriella regularis	Echinoderm	*Melanthaillia absicca	Red algae
Stegnaster inflatus	Echinoderm	**Osmundaria colensoi*	Red algae
Stichopus mollis	Echinoderm	**Plocamium angustum*	Red algae
Buccinulum sp	Gastropod	*Pterocladia lucida*	Red algae
Cantharidus purpureus	Gastropod	Red foliose algae	Red algae
**Cellana* sp	Gastropod	*Ancorina* sp.	Sponges
Charonia spp.	Gastropod	Cliona celata	Sponges
Cominella adspersa	Gastropod	sponges	Sponges
Cominella virgata	Gastropod	Tethya aurantium	Sponges
Cookia sulcata	Gastropod	*Tethya ingalli*	Sponges
Cryptoconchus porosus	Gastropod		

Substrates	
Bare rock	Substrate
Gravel	Substrate
Sand	Substrate
Shell	Substrate
Sediment	Substrate