Macrobenthic Community Structure in the Fitzroy River Estuary, Queensland.

David R. Currie and Kirsty J. Small
Centre for Environmental Management
CRC Coastal Zone, Estuary and Waterway Management
Faculty of Arts Health Sciences
Central Queensland University

Centre for Environmental MANAGEMENT GLADSTONE

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CRC Task FE1: Ecosystem Health Monitoring

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David R. Currie and Kirsty J. Small
Centre for Environmental Management
CRC Coastal Zone, Estuary and Waterway Management
Faculty of Arts Health Sciences
Central Queensland University
Gladstone Qld 4680

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EXECUTIVE SUMMARY

Macrobenthic community structure in the Fitzroy Estuary was examined from quantitative grab samples collected at 74 depth-stratified stations during 2001. Analysis of variance showed a significant ($p<0.05$) decline in species abundance from the upper to the lower reaches of the estuary, and a pronounced increase in abundance with depth. Much of this change could be attributed to the distribution of the mat-forming mussel *Amygdalum* cf. *glaberrima,* which occurs exclusively in the upper Fitzroy, and in some locations at densities >2000/m^2. Spatial gradients in species richness were less compelling, although marked declines in this parameter were evident from the upper to the lower reaches of the estuary. Two infaunal community groupings, corresponding with stations from the upper and lower reaches of the Fitzroy were also identified in ordinations of species abundance data. Neither ordination grouping displayed strong underlying patterns of changing community structure with depth, however distinct shifts in trophic structure were identified. Infaunal communities in the subtidal were dominated by filter-feeding organisms (~80% of the total species abundance), while those from the intertidal zone were dominated by deposit feeding polychaete worms. A small proportion of the organisms collected during the survey (7 of 49 species) have never been recorded in the contiguous estuarine waters of Port Curtis, and none of these could be confidently matched with archived Australian material. Whether these species represent un-described endemic organisms or exotic introductions remains to be determined, together with the principal factors underpinning the geographical disparity in species representation.

INTRODUCTION

Although it is widely accepted that estuarine ecosystems are highly productive and critical to the maintenance of coastal bird-life and fisheries, very little is known about the invertebrate faunas that inhabit them. Invertebrate organisms play important roles in the diets of many shorebird and fish species, and can profoundly influence the abundance and species composition of these tertiary consumers (Bottom and Jones, 1990; Skagen and Oman, 1996; Stillman *et al*., 2000). Invertebrates also play an integral role in the recycling of nutrients, and conservation of water quality within estuarine systems (Harris, 1999; Peterson and Heck, 1999). Understanding temporal and spatial change in invertebrate community structure, and the factors underpinning them, is therefore essential to the better management of these waterways.

Hutchings (1999) has recently reviewed the knowledge base for macro-invertebrates in Australian estuaries, and has confirmed that most of our taxonomic and ecological understanding stems from only a limited geographical region. Specifically, the review highlights the fact that little quantitative data exists on the biota of estuaries situated outside of the major population centres of southeastern Australia, and particularly the paucity of information on tropical estuaries. In an effort to redress the lack of information on tropical estuarine systems, this study examines the distribution and composition of macrobenthos throughout the saline reach of a large tropical Queensland estuary.

The Fitzroy catchment is the second largest in Australia and covers nearly 150,000 km^2. Natural flows in the Fitzroy are regulated by a barrage located at Rockhampton, 50km from the river mouth. This barrage prevents any tidal movement of saline water into the upstream freshwater reach of the waterway and allows overflow of freshwater into the downstream estuarine reach during flood events. Freshwater inputs to the system are principally derived from heavy summer rainstorms associated with monsoonal depressions. Cyclonic events within north-eastern Australia occur intermittently, and large inter-annual and seasonal variations in flow are apparent (Faithful and Griffiths, 2000). During severe floods, large volumes of sediment may be transported down river, and may have a considerable impact on

bottom dwelling organisms. Effects due to shifts in the boundary of the freshwater/saltwater interface are also likely to be significant during such flood events, as estuarine species become subject to less saline conditions. In 1991, spill-water from a major flood broached the barrage at Rockhampton, and temporarily transformed the normally fully saline waters of the Fitzroy estuary into a brackish waterway (O'Niell *et al*., 1992). Since this event, few significant floods have occurred in the Fitzroy and marine water conditions have largely prevailed in the lower reaches of the estuary.

METHODS

Field sampling

A survey of spatial differences in benthic community structure within the estuarine zone of the Fitzroy River was conducted from 14-16 November 2001. A total of 16 stations were sampled during the survey (Figure 1); thirteen of these stations were located at sites regularly sampled by the EPA for water quality parameters (ie Stations 1-13) and the remainder were placed at new locations close to the Fitzroy Delta (Station 13 – Keppel Bay, Station 14 - Port Alma, and Station 16 – The Narrows).

On each sampling date, co-ordinates marking the start and end points of transects running the width of the Fitzroy River at each sampling station were fixed using a differential GPS. Research staff then profiled variations in depth along each transect using an echo-sounder. This profile data was used as the foundation for a stratified sampling scheme designed to limit depth related variations in community composition. The sampling scheme selected involved the collection of 5x 0.1m^2 van Veen grab samples from each transect. Two of the grabs were collected from the intertidal zone on each river bank, 2 were taken from the 5m depth zone, and one from the deepest location on the transect (Figure 2). This design makes it possible to examine local ecological gradients occurring within a station, but also permits the assessment of longitudinal variations in community structure over the entire length of the Fitzroy estuary.

Sediment sub-samples (70ml) were removed from each grab and snap-frozen for metals analysis. The remaining portion of the grab sample was weighed and visual graded into sediment classes before being sieved on a 1mm mesh screen. All biota retained on the mesh sieve was preserved in 10% formaldehyde solution and later sorted into component species and counted.

While considerable effort was made to ensure that all stations were effectively sampled during the preliminary survey, only 74 of the proposed 80 samples (nb. 5 grabs from 16 stations) were collected. This shortfall was largely due to localised patches of rock on the river bed which prevented the grab from penetrating the substrate. As a consequence no data are available for two replicate grab samples taken at each of stations 1, 12 and 13.

Statistical Analysis

Spatial differences between benthic communities at the 16 benthic sampling stations were examined using Bray-Curtis (B-C) dissimilarity measures (Bray and Curtis 1957). This dissimilarity measure was chosen because it is not affected by joint absences, it gives more weighting to abundant than rare species, and it has consistently performed well in preserving 'ecological distance' in a variety of simulations on different types of data (Field *et al*. 1992, Faith *et al*. 1987). Double square root ($N^{¼}$) transformations were applied to all data before calculating B-C dissimilarity measures. These transformations were made to prevent abundant species from influencing the B-C dissimilarity measures excessively (Clarke and Green 1988, Clarke 1993).

Bray-Curtis dissimilarity measures calculated for the stratified sites resulted in a triangular matrix of inter-site relationships. Fifteen grab samples did not contain any benthic organisms

and were omitted from the matrix as they could not contribute to the dissimilarity measure. Multidimensional scaling (MDS) was therefore used to map 61 inter-station relationships in two-dimensional space. The computer package PRIMER (Clarke and Gorley 2001) was employed for the MDS ordinations in this study, and the final configurations presented were the best solutions (ie. exhibited the lowest 'stress' values, or least distortion) from a minimum of 100 random starts.

The statistical significance of regional and depth-related differences in infaunal species abundance and richness was further examined using two-way fixed factor analysis of variance (ANOVA). Homogeneity of variance was examined using Cochran's test and heterogeneity removed from species abundance using a Log10(n+1) transformation.

RESULTS

Depth

Depth profiles in the upper reaches of the Fitzroy River (stations 1-9) are symmetrical in cross-section (Figure 3). Typically depth at these stations increases gradually with increasing distance from the river bank and is greatest in the central portion of the waterway (7-10m). Further downstream, profiles become distinctly asymmetric and deep channels up to 22m deep become evident close to the outer banks of large meanders. The width of the river also increases markedly with distance downstream. At 'The Barrage' in Rockhampton the river is approximately 200m wide, at station 9 (which is located about 25km downstream of Rockhampton) the river is more than 650m wide, and at the river mouth (50km downstream from Rockhampton) it is almost 9km in width.

Sediment

Visual classification of sediment samples provides a quick and relatively inexpensive assessment of gross variations in sediment distribution. A schematic summary of sediment distribution within the Fitzroy River system is presented in Figure 4. This summary illustrates that out-with the immediate vicinity of the barrage (which is principally composed of rock and gravel substrates), there is a higher incidence of fine sediment types in the shallow margins of the estuary and a greater incidence of coarser sediment types in the deeper reaches. This distribution pattern is consistent with tidal and freshwater flows being greatest in the deepest reaches of the river and least near the river banks. The qualitative model presented in Figure 4, does not show any distinct longitudinal trends in sediment structure between the upper and lower reaches of the river. It is, however, likely that such trends may be more readily apparent once quantitative assays of frozen sediment sub-samples have been completed.

General species observations

A total of 49 benthic species and 7449 individuals were identified from the 74 grabs processed (Appendix 1). The principal phylogenetic groupings represented included polychaetes (19 species), crustaceans (14 species), molluscs (14 species) echinoderms (1 species) and chordates (1 species). Bivalve molluscs accounted for most of the total abundance (~77%), due largely to the presence of one species (the mussel *Amygdalum* cf *glaberrima*). Polychaetes were much less commonly collected (~17% of total abundance), while crustaceans, chordates and echinoderms were the least abundant taxa (~5%, 0.4 % and 0.03% of total abundance respectively). Filter-feeding animals were the best represented trophic group in the Fitzroy River and accounted for nearly 80% of the total species compliment Other groups were less well represented: deposit feeders (18%), predators (1.5%) and scavengers (0.5%). The filter-feeding organisms (principally mussels) were, however, only dominant in the subtidal zone. In the intertidal they were subordinate to deposit feeding polychaete worms, which accounted for more than 80% of the total abundance.

Macrobenthic community analysis

The species level MDS ordination presented in Figure 5 displays differences in community composition between the 61 grab samples that contained infaunal organisms. In this ordination samples taken from the upper reaches of the Fitzroy estuary (stations 1-9) are enclosed by a light-grey filled area, and those downstream (stations 10-16) by a dark-grey filled area. While some intergrading of grab samples occurs, particularly towards the centre of the ordination, it is readily apparent that stations from the upper and lower regions of the Fitzroy form discrete clusters; grabs taken form the upper Fitzroy form a loose association of points on the left hand side of the plot while those from the lower reaches of the waterway lay towards the right hand side of the plot. Only one grab sample (14C) fails to conform to this polarised model of community structure in the Fitzroy. Grab 14C is located in the centre of the shipping channel at Port Alma and contained only one individual of the predatory polychaete *Marphysa* sp.1. As small abundances of this species are only found elsewhere in grabs taken from the upper Fitzroy, grab 14C plots at the extreme left of the MDS ordination, at a point furthest removed from those grabs sampled in the lower Fitzroy.

While there appears to be a distinct shift in community structure between the upper and lower reaches of the Fitzroy estuary, this change does not occur gradually with increasing distance downstream. If this were the case, station numbers would be arranged in either an ascending or descending order across the ordination. In practice, station locations in the ordination are widely dispersed and do not appear to conform to any geographical order. Similarly, there does not appear to be any obvious pattern of changing community structure with depth. This is confirmed by superimposing different text strings for the three depth strata sampled at each station on the MDS ordination presented in Figure 5. In the resulting plot (Figure 6), grabs taken from the intertidal, 5m depth and >5m depth zones intergrade and do not form any discrete groupings.

Bubble plots of species richness, abundance and diversity superimposed on the MDS ordination presented in Figure 5, provide additional insights into the regional differences in infauna community structure between the upper and lower reaches of the Fitzroy River (Figures 7,8, & 9). In these plots numerals indicate the value of the superimposed variable while circles surrounding them indicate the relative magnitude of the number on a monotonic scale. Figure 7 shows the spatial distribution of total species numbers at each station and replicate grab. From this plot it appears that species richness is generally higher upstream, even though elevated numbers of species are occasionally present in grabs taken downstream (ie 8 species at Station 15A in the Fitzroy delta, Station 16B and Station 16C in the Narrows). A formal test of differences in species numbers between the two regions confirms that species richness is significantly higher in the upper reaches of the river (3.9 species/grab in the upper Fitzroy *vs*. 2.5 species/grab in the lower Fitzroy, ANOVA $p < 0.05$).

The bubble plot of species abundance exhibit a similar decline in values from the upper to the lower reaches of the Fitzroy (Figure 8.). A formal statistical test confirms the significance of this decrease in total species abundance between the upper and lower reaches (167.2 individuals/grab in the upper Fitzroy *vs*. 8.4 individuals/grab in the lower Fitzroy, ANOVA $p < 0.05$). It is readily apparent in Figure 8 that much of regional difference is due to extremely high abundances at a relatively small number of grabs. On closer examination it is evident that most of the difference in abundance between the upper and lower reaches of the Fitzroy is due elevated numbers of the filter-feeding mussel *Amygdalum* cf *glaberrima* (Stations 1, 3, 4, 5, 6 and 8). This mussel forms dense subtidal mats on the sediment surface and was most prevalent in a grab taken next to an abattoir outfall (Station 5C, 2095 individuals/0.1m^2). The mussel was not, however, encountered in any grab samples collected downstream of station 8.

Shannon-Weiner diversity indices are commonly used in benthic ecology to assess the relative richness and evenness of species abundance data. Stations with high Shannon-Weiner

(S-W) diversity generally have a higher number of species however the index may also increase as the proportion of individuals per species becomes more constant. In the plot of S-W diversity from the Fitzroy River (Figure 9) no patterns are readily distinguishable. Despite significantly higher species richness and abundance in the upper reaches of the Fitzroy these variables do not translate to elevated S-W diversity upstream. Mean S-W diversity in the upper Fitzroy (stations 1-9) is relatively higher than the downstream value (0.66 *vs* 0.61) however these measurements do not differ significantly (ANOVA, $p > 0.1$). On closer examination it appears that the exceptionally low value of S-W diversity in the upper Fitzroy is the result of a combination of low species richness and dominance by one species (*Amygdalum* cf *glaberrima*) at small number of subtidal sites (ie 1B, 1C, 3C, 4C, 5C and 6C).

Two-way ANOVA's on location and depth differences

The statistical significance of depth and sampling location on species abundance are summarised in Table 1A. As station, depth and the interaction term (station*depth) are all significant, post-hoc comparisons have been conducted for each main effect (station - Table 1B; depth - Table 1C) and a plot of marginal means constructed to examine the interaction (Figure 10A). Results from two different post-hoc tests have been presented here (Tukeys and SNK) as there is uncertainty concerning the most appropriate significance test in particular circumstances. In both tests, logarithms of station means are arranged by order of magnitude and grouped into homogeneous subsets. The SNK test (Table 1B) indicates that stations principally located in the upper reaches of the Fitzroy (stations 1,2,3,4,5,6,9) have significantly higher Log abundances (1.35 – 2.42 species/0.1m^2) than stations primarily located downstream (0.23 – 1.00 species/0.1m^2; stations 7,8,10,11,12,13,14,15,16). The Tukey test, in comparison, presents a contradictory outcome; it fails to show a significant difference in station abundances along the river as subsets of all homogeneous station means overlap. Multiple comparison tests of depth related differences in abundance are much more consistent. Both the SNK and Tukeys tests confirm that Log abundances are significantly higher in the deepest strata of the river (1.5 species/0.1m^2 at >5m depth, Table 1C). The same tests also indicate that abundances do not differ significantly between the less populated intertidal and 5m depth strata. A profile plot of marginal means (Figure 10A) reveals that the significant interaction term for abundances identified in Table 1A is largely the result of massive and unparalleled declines in species densities between the upper and lower Fitzroy, at >5m depths only.

The effect of depth and sampling location on species richness have been summarised in Table 2A. This table shows that there is a significant difference ($p > 0.05$) in the number of species between stations, but no significant difference in species numbers with depth. Both post-hoc comparison tests conducted on differences in mean species richness between the 16 sampling stations (Table 2B) are unable to discriminate stations into subsets. Rank orders of station means in these tables do, however, suggest that species richness is generally higher in the upper part of the river (stations 1-6) and lower in the downstream reaches (stations 10-12).

Water quality

Observed differences in benthic community structure between stations, were further examined in relation to water quality. The Queensland Environmental Protection Agency (EPA) has collected water quality data at stations 1-13 in the Fitzroy since 1990. Using an automated probe, key parameters measured *in situ* have included temperature, salinity, dissolved oxygen and turbidity. In recent years, daily, depth-stratified measurements at each station have generally been collected once each month. As many invertebrate species have relatively short-life spans (months rather than years), only water quality data from 11 sampling dates in a one year period prior to the benthic survey have been included here (15 Nov 2000, 12 Dec 2000, 17 Jan 2001, 20 Feb 2001, 10 Apr 2001, 22 May 2001, 13 Jun 2001, 3 Jul 2001, 7 Aug 2001, 11 Sep 2001, 20 Nov 2001).

Plots of mean station temperature, salinity, dissolved oxygen content and turbidity are presented in Figure 11 (A-D). Three of these parameters were found to change significantly (ANOVA, $p<0.001$) along the length of the Fitzroy; water salinity and turbidity generally increased with increasing distance downstream, while the concentration of oxygen generally declined. Temperature did not differ significantly between stations when formally tested (ANOVA, $p=0.6609$), however a plot of this variable (Figure 11A) strongly suggests a trend of decreasing temperature with increasing distance downstream.

DISCUSSION

Subtidal macrofaunal communities in the Fitzroy estuary were dominated by the filter-feeding mussel *Amygdalum* cf *glaberrima.* This small mollusc species (<1.5cm length), which forms dense beds on the sediment surface, was solely restricted to upper reaches of the estuary. Several physical, chemical and biological factors might explain this discontinuity, although the relative importance of such factors in the distribution of *Amygdalum* cf *glaberrima* is difficult to assess. Unfavourable salinity regimes, dissolved oxygen contents and temperature are simply a few water chemistry parameters that might preclude the distribution of *Amygdalum* cf *glaberrima* from the lower Fitzroy. The speed of the bottom current and its effect on the particle size of the sediments (both suspended and deposited) are also likely to be major factors in determining the geographical limits of this species in the Fitzroy. It is, however, the availability of suspended particulate food mater in the upper Fitzroy that potentially has the greatest influence on density and distribution of this suspension feeding bivalve. Many filter-feeding bivalves flourish in organically enriched environments (Taylor, 1997), and it is probably quite significant that the highest recorded biomass of this species (118 g wet wt per $0.1m^2$) was obtained from a grab sample taken adjacent to an abattoir outfall on the eastern outskirts of Rockhampton. According to the National Pollutant Inventory Database approximately 120 tonnes of total Nitrogen was discharged into the water column at this location during the 2000/2001 financial year (Environment Australia, 2002). This volume of nitrogen emissions is more than an order of magnitude greater than that discharged from a nearby municipal sewerage works over the same period, and clearly represents a significant point source for organic enrichment within the Fitzroy estuary. It is suggested that stable nitrogen isotope tracers could provide a mechanism for a more exact explanation for the elevated abundances of *Amygdalum* cf *glaberrima* in the upper Fitzroy estuary

Amygdalum cf *glaberrima* was only rarely encountered in the intertidal sediments of the Fitzroy, and it appears as if this species is poorly adapted for life between the tide-marks. Visual assessments of sediments from the intertidal reveal that bedforms comprising the river banks are principally composed of silt and clay fractions. As fine particulate matter only settles in calm water, it is apparent that the near shore waters of the Fitzroy and the intertidal zone in particular, are infrequently subject to strong tidal currents. Under such conditions organic debris readily settles, and the organic content of the intertidal sediments is likely to be markedly elevated. While there is potentially an increased bio-availability of food for infaunal organisms inhabiting the intertidal zone of the Fitzroy, this does not in practice result in elevated species abundances and biomasses in the intertidal. Deposit feeding polychaete worms (*Scoloplos simplex* and *Platynereis* sp.) dominate the intertidal sediments of the Fitzroy estuary, but never attain densities as high as that of the subtidal mussel *Amygdalum* cf *glaberrima*. The trophic implications of this finding are *prima facie* that bottom-feeding fish (ie mussel eating species including catfish) probably benefit most from primary productivity within the estuary, while wading-birds (particularly those species dependant on invertebrates) probably do rather poorly. It should, however, be stressed that this survey has only considered large macrobenthic organisms (>1mm diam.). Standing stock and productivity of smaller meiofaunal organisms (<0.1mm diam.) could well exceed that of the intertidal macrofauna, and therefore promote quite different trophic outcomes.

While the identities of several benthic organisms collected in the Fitzroy estuary appear to conform morphologically with native species, not all specimens are readily identifiable. Most infaunal organisms collected in the Fitzroy occurred at very low abundances (90% of species, <1 individual per $0.1m^2$), and because no historical sampling of benthos has been conducted, it is conceivable that some of the organisms encountered during the survey are either endemic to the water body or quite possibly exotic introductions. This latter option is presently receiving considerable international research interest, as the magnitude of impacts caused by introductions on native species become more apparent. Exotic species alter natural interactions in the invaded ecosystem, and when present in high numbers, can compete with and even displace native organisms (Carlton and Geller, 1993). In view of the relatively low abundances of most species collected in the Fitzroy, it is unlikely that any exotics present are having a significant ecological impact. Nevertheless, it is clearly important from a precautionary perspective that the identities of all organisms encountered within the Fitzroy are resolved quickly.

ACKNOWLEDGEMENTS

The contribution of many staff members at Central Queesland University to this project is gratefully acknowledged. In particular we would like to thank Rod Johnson, and Andrew Davis for their assistance with the field work, and Jill Campbell and Karen Boundy for their time and dedication to the laboratory analysis. Thanks are also due the Queensland Environmental Protection Agency for providing us with historical water quality data for the Fitzroy Estuary. We are also indebted to Bob Packet (DNRE) for operational support, and Bob Noble and Alistair Melzer (Coastal CRC) for facilitating this work. This project was funded by the Co-operative Research Centre for Coastal Zone, Estuary and Waterway Management.

REFERENCES

Bottom, D.L. and Jones, K.M. (1990). Species composition, distribution, and invertebrate prey of fish assemblages in the Columbia River Estuary. *Progress in Oceanography*. 25: 243-270.

Bray, J.R. and Curtis, J.T. (1957). An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs.* 27: 325-349.

Carlton, J.T. and Geller, J.B. (1993). Ecological roulette: the global transport of non-indigenous species. *Science* 261, 78-82.

Clarke, K.R. (1993). Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology*. 18: 117-143

Clarke, K.R. and Green, R.H. (1988). Statistical design and analysis for a 'biological effects' study. *Marine Ecology Progress Series*. 46: 213-216.

Clarke, K.R. and Gorley, R.N. (2001). PRIMER v5 user manual / tutorial. PRIMER-E, Plymouth.

Environment Australia (2002). National Pollutant Inventory Database Query. http://www.npi.gov.au.

Faith, D.P., Minchin, P.R., Belbin, L. (1987). Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* 69: 57-68

Field, J.G., Clarke, K.R., Warwick, R.M. (1992). A practical strategy for analysing multispecies distribution patterns. *Marine Ecology Progress Series*. 8: 37-52.

Gray, J.S. (1981). The Ecology of Marine Sediments. Cambridge University Press. 185pp.
Harris G.P. (1999). Comparison of the biogeochemistry of lakes and estuaries: Ecosystem processes, functional groups, hysteresis effects and interactions between macro- and microbiology. *Marine and Freshwater Research*. 50(8): 791-811.

Hutchings, P. (1999). Taxonomy of estuarine invertebrates in Australia. *Australian Journal of Ecology*. 24: 381-394.

O'Neill, J.P., Byron, G.T. and Wright, S.C. (1992). Some physical characteristics and movement of the 1991 Fitzroy River flood plume. In "Workshop on the impacts of flooding" (ed. Brown G.T.). Great Barrier Reef Marine Park Authority Workshop Series 17.

Peterson B.J. and Heck K.L.Jr. (1999). The potential for suspension feeding bivalves to increase seagrass productivity. *Journal of Experimental Marine Biology & Ecology.* 240(1): 37-52

Skagen, S.K. and Oman H.D. (1996). Dietary flexibility of shorebirds in the western hemisphere. *Canadian Field-Naturalist*. 110(3): 419-444.

Stillman, R.A., Caldow R.W.G., Goss-Custard J.D. and Alexander M.J. (2000). Individual variation in intake rate: The relative importance of foraging efficiency and dominance. *Journal of Animal Ecology*. 69(3): 484-493.

Taylor, J.D. (1997). Diversity and structure of tropical Indo-Pacific benthic communities: relation to regimes of nutrient input. In "Marine Biodiversity – Patterns and Processes" (eds. R.F.G. Ormond, J.D. Gage and M.V. Angel). Cambridge University Press, Cambridge.

Figure 1. Satellite map of the Fitzroy Estuary showing the locations of stations sampled for macrobenthos during the period 14-16 November 2001.

Figure 2. Schematic diagram of the macrobenthic sampling design showing the depth-stratified arrangement of five 0.1m^2 van Veen grabs collected at each of 16 transects.

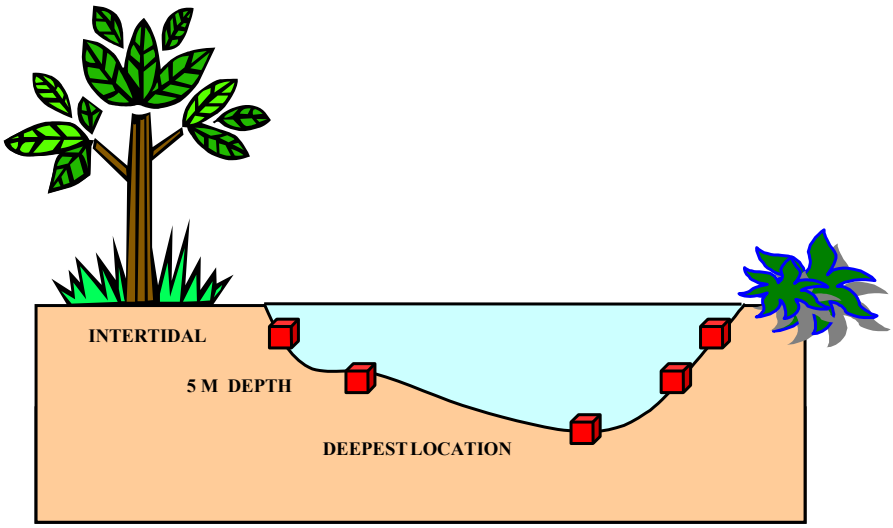


Figure 3. Depth profiles at 16 sampling stations in the Fitzroy Estuary. Note that all depths have been corrected to reflect high above the lowest astronomical tide.

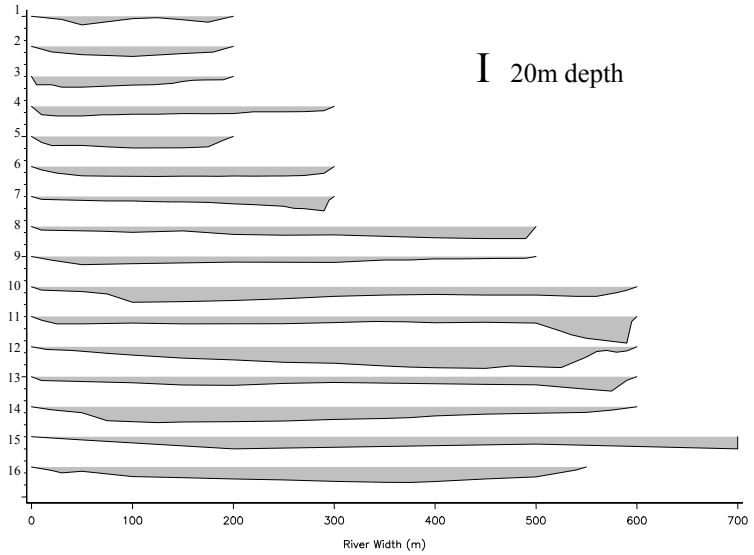


Figure 4. Sediment profile of the Fitzroy Estuary determined from visual classification of sediments collected from 3 depth strata at 16 sampling locations.

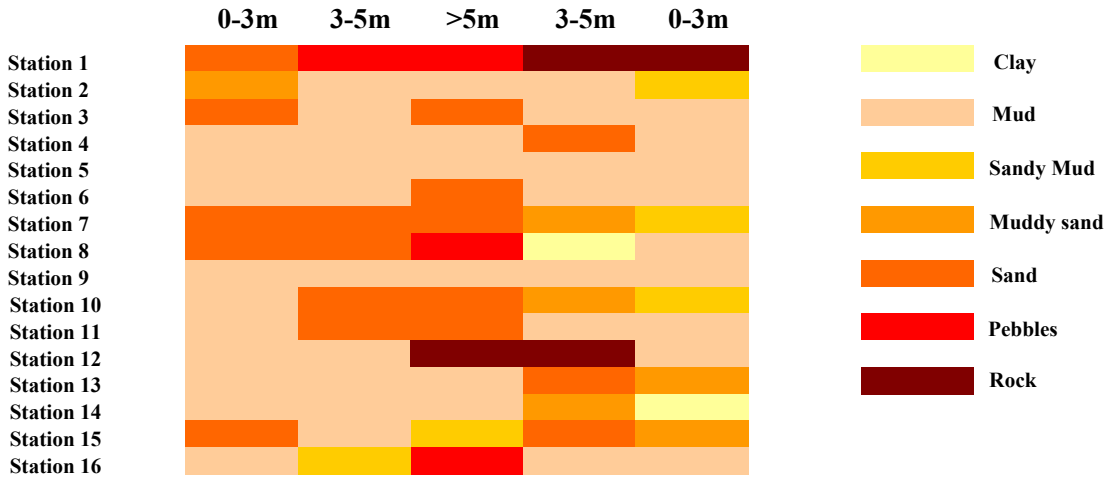


Figure 5. Non-metric MDS ordination of Bray Curtis community dissimilarity measures for Fitzroy River grab samples. Note that numerals denote the location of the sampling station (1-16) and letters indicate the sample depth (A and E =Intertidal, B and D = 5m depth, C = >5m depth).

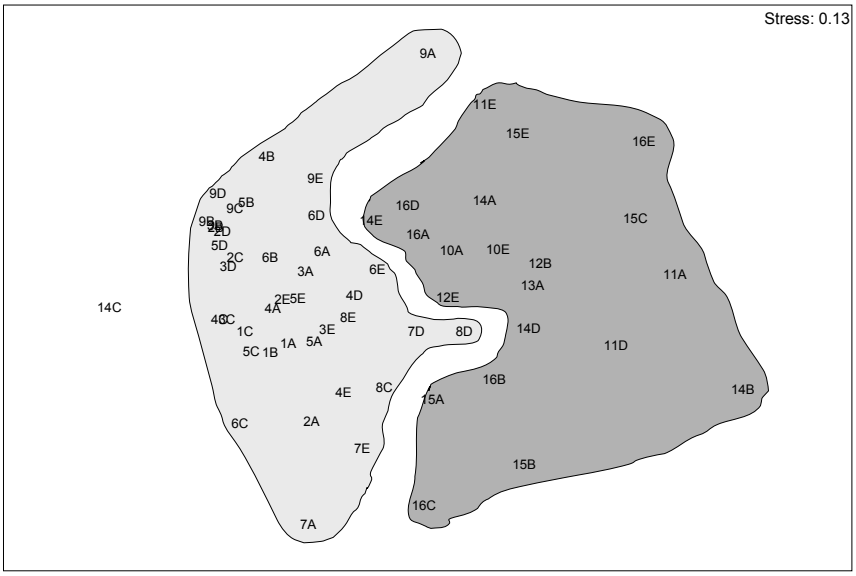


Figure 6. Plot of sampling depth strata (intertidal, 5m depth and >5m depth) superimposed on MDS ordination of grab samples taken from the Fitzroy River.

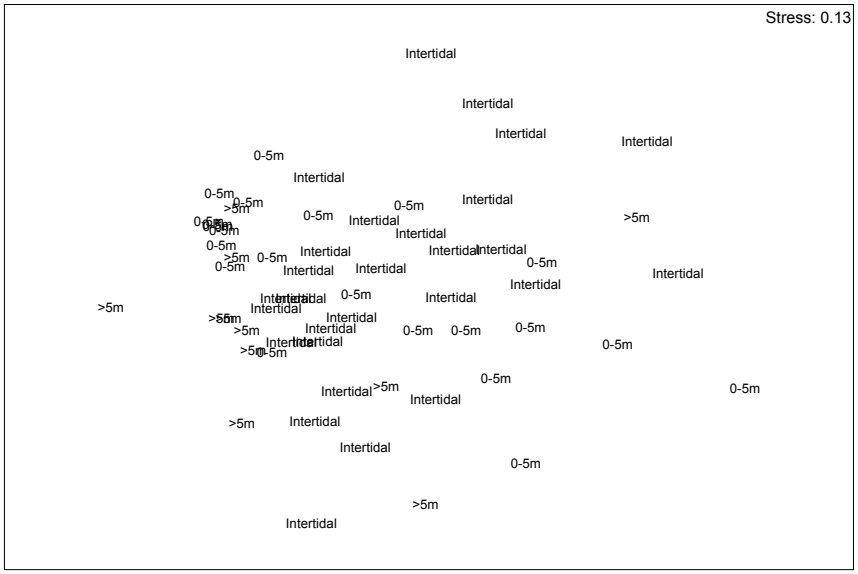


Figure 7. Bubble plot of species richness superimposed on an MDS ordination of benthic grab samples collected from the Fitzroy River. Numerals denote the total number of species in each 0.1m^2 grab sample. Diameters of filled circles also depict total number of species and increase with increased richness. Samples taken from the upper reaches of the Fitzroy River (stations 1-9) are enclosed by a solid line and those from the lower reaches (stations 10-16) by a broken line.

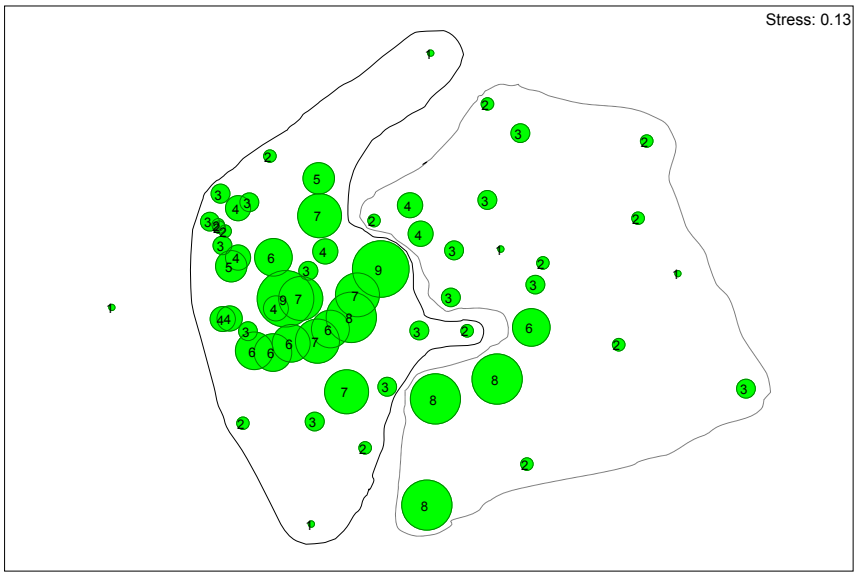


Figure 8. Bubble plot of species abundance superimposed on an MDS ordination of benthic grab samples collected from the Fitzroy River. Numerals denote total abundance in each 0.1m^2 grab sample. Diameters of filled circles also depict total abundance and increase with increased abundance. Samples taken from the upper reaches of the Fitzroy River (stations 1-9) are enclosed by a solid line, and those from the lower reaches (stations 10-16) by a broken line.

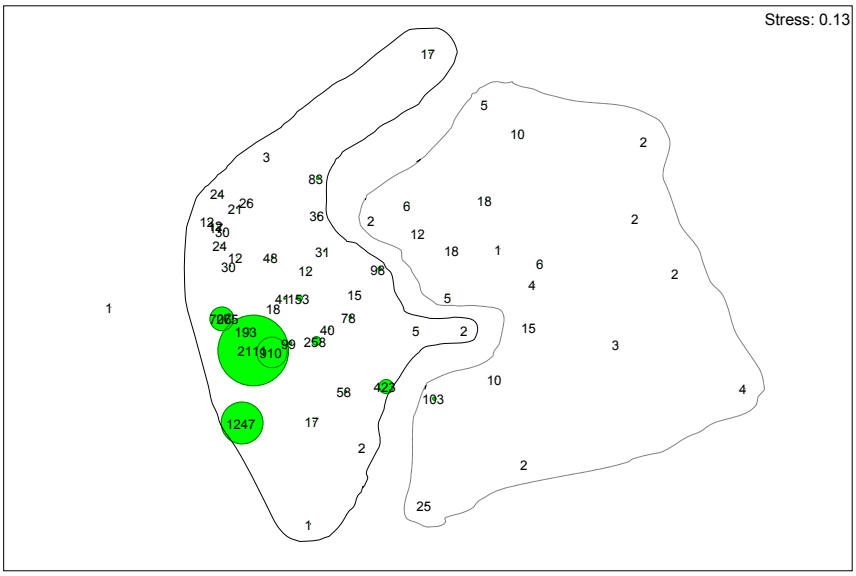


Figure 9. Bubble plot of Shannon-Weiner species diversity superimposed on an MDS ordination of benthic grab samples collected from the Fitzroy River. Numerals denote diversity value in each $0.1m^2$ grab sample. Diameters of filled circles also depict diversity and increase with increased diversity. Samples taken from the upper reaches of the Fitzroy River (stations 1-9) are enclosed by a solid line and those from the lower reaches (stations 10-16) by a broken line.

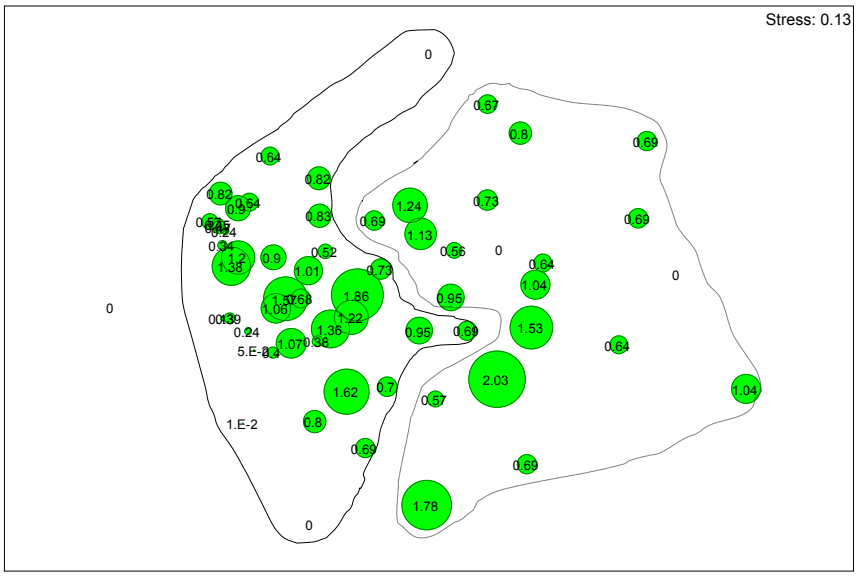
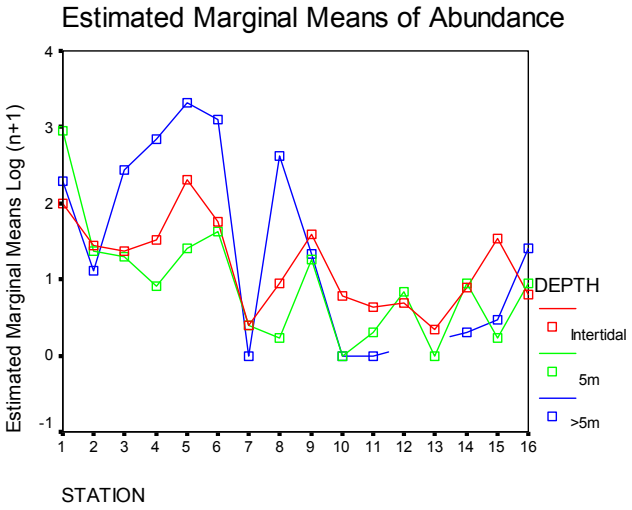


Figure 10. Plots of Fitzroy River infauna (A) Log 10(n+1) abundance, and (B) total species richness at 16 sampling stations and three depth strata (intertidal, 5m, >5m).

(A)



(B)

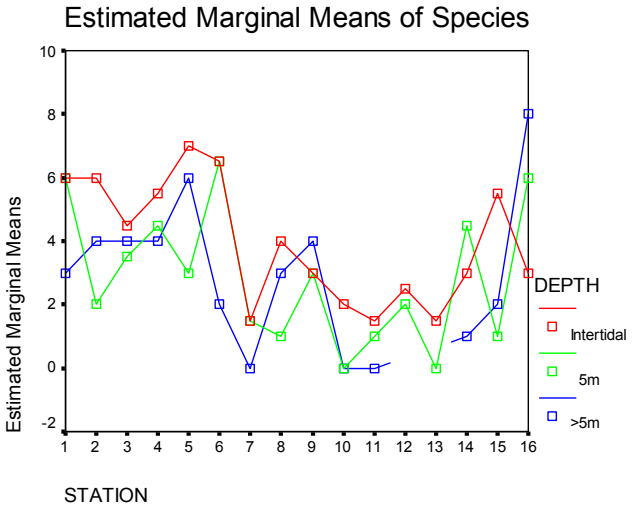
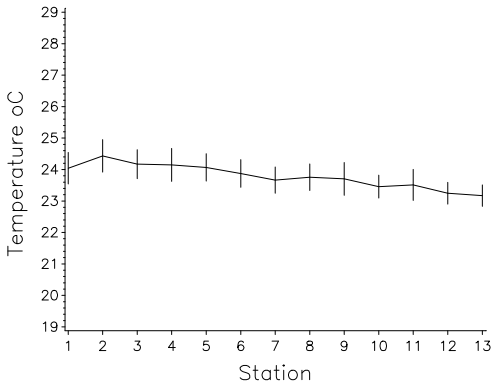
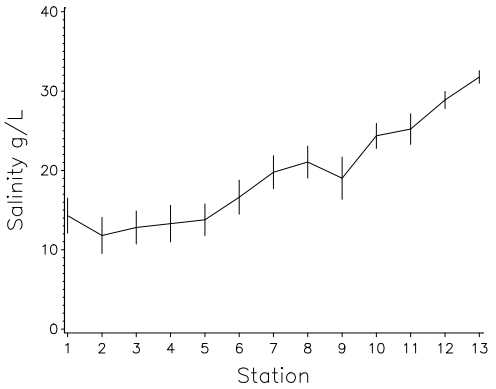


Figure 11. Plots of (A) temperature, (B) salinity, (C) dissolved oxygen and (D) turbidity at 13 sampling stations on the Fitzroy estuary. Means and associated standard errors are derived from 11 samplings between 11 November 2000 and 20 November 2001.

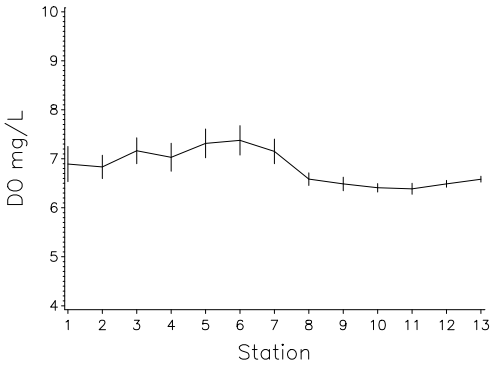
A



B



C



D

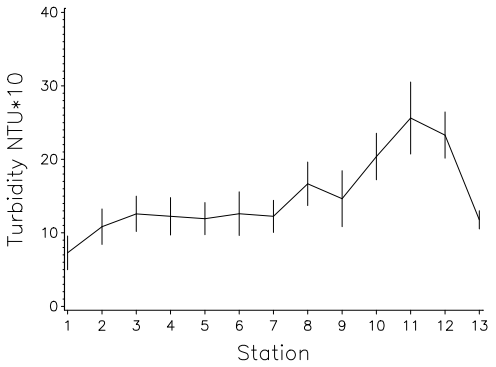


Table 1A. Results of two-way ANOVA on differences in species abundance in benthic grab samples taken from three depth strata (intertidal, 5m and >5m) at 16 sampling stations in the Fitzroy River.

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Observed Power* [a]
Corrected Model	45.476 [b]	45	1.011	5.140	0.000	1.000
Intercept	87.963	1	87.963	447.420	0.000	1.000
STATION	33.115	15	2.208	11.229	0.000	1.000
DEPTH	2.613	2	1.307	6.646	0.004	0.881
STATION * DEPTH	12.584	28	0.449	2.286	0.016	0.960
Error	5.505	28	0.197			
Total	143.934	74				
Corrected Total	50.981	73				

a Computed using alpha = .05

b R Squared = .892 (Adjusted R Squared = .718)

Table 1B. Results of post-hoc multiple comparison tests (SNK and Tukeys) for differences in the mean species abundance between the 16 sampling stations. Means presented here are based on Log10 (abundance+1) and homogeneous groups are displayed as separate subsets. The error term is Mean Square (Error) = 0.197

Test	Station	N	Subset 1	Subset 2	Subset 3	Subset 4	Subset 5
Student-Newman-Keuls [a,b,c]	13	3	0.2330				
	7	5	0.3113				
	10	5	0.3160				
	11	5	0.3715				
	12	3	0.7418	0.7418			
	14	5	0.8007	0.8007			
	15	5	0.8025	0.8025			
	16	5	0.9785	0.9785			
	8	5	1.0004	1.0004			
	2	5		1.3478	1.3478		
	9	5		1.4068	1.4068		
	4	5		1.5410	1.5410		
	3	5		1.5546	1.5546		
	6	5			1.9711	1.9711	
	5	5			2.1510	2.1510	
	1	3				2.4158	
	Sig.		0.2392	0.1817	0.1069	0.3085	
Tukey HSD [a,b,c]	13	3	0.2330				
	7	5	0.3113	0.3113			
	10	5	0.3160	0.3160			
	11	5	0.3715	0.3715			
	12	3	0.7418	0.7418	0.7418		
	14	5	0.8007	0.8007	0.8007		
	15	5	0.8025	0.8025	0.8025		
	16	5	0.9785	0.9785	0.9785	0.9785	
	8	5	1.0004	1.0004	1.0004	1.0004	
	2	5	1.3478	1.3478	1.3478	1.3478	1.3478
	9	5		1.4068	1.4068	1.4068	1.4068
	4	5			1.5410	1.5410	1.5410
	3	5			1.5546	1.5546	1.5546
	6	5				1.9711	1.9711
	5	5					2.1510
	1	3					2.4158
	Sig.		0.0501	0.0580	0.3595	0.1214	0.0712

a Uses harmonic mean sample size = 4.444

b As group sizes are unequal the harmonic mean of the group sizes is used.

c Alpha = .05

Table 1C. Results of post-hoc multiple comparison tests (SNK and Tukeys) for differences in the mean species abundance between the 3 depth strata (intertidal, 5m and >5m). . Means presented here are based on Log10 (abundance+1) and homogeneous groups are displayed as separate subsets. The error term is Mean Square (Error) = 0.197.

Test	Depth	N	Subset 1	Subset 2
Student-Newman-Keuls [a,b,c]	5m	29	0.886	
	Intertidal	31	1.160	
	>5m	14		1.520
	Sig.		0.051	1.000
Tukey HSD [a,b,c]	5m	29	0.886	
	Intertidal	31	1.160	
	>5m	14		1.520
	Sig.		0.121	1.000

a Uses harmonic mean sample size = 21.712
b As group sizes are unequal the harmonic mean of the group sizes is used.
c Alpha = .05

Table 2A. Results of two-way ANOVA on differences in species richness in benthic grab samples taken from three depth strata (intertidal, 5m and >5m) at 16 sampling stations in the Fitzroy River.

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Observed Power* [a]
Corrected Model	314.959[b]	45	6.999	1.356	0.198	0.814
Intercept	627.614	1	627.614	121.614	0.000	1.000
STATION	188.526	15	12.568	2.435	0.020	0.916
DEPTH	22.933	2	11.466	2.222	0.127	0.415
STATION * DEPTH	101.566	28	3.627	0.703	0.822	0.397
Error	144.500	28	5.161			
Total	1264.000	74				
Corrected Total	459.459	73				

a Computed using alpha = .05

b R Squared = .686 (Adjusted R Squared = .180)

Table 2B. Results of post-hoc multiple comparison tests (SNK and Tukeys) for differences in the mean species richness between the 16 sampling stations. Homogeneous means are grouped here in the same subset. The error term is Mean Square (Error) = 5.161.

Test	Station	N	Subset 1
Student-Newman-Keuls	10	5	0.800
	11	5	1.000
	13	3	1.000
	7	5	1.200
	12	3	2.333
	8	5	2.600
	15	5	3.000
	9	5	3.200
	14	5	3.200
	2	5	4.000
	3	5	4.000
	4	5	4.800
	1	3	5.000
	5	5	5.200
	16	5	5.200
	6	5	5.600
	Sig.		0.175
Tukey HSD	10	5	0.800
	11	5	1.000
	13	3	1.000
	7	5	1.200
	12	3	2.333
	8	5	2.600
	15	5	3.000
	9	5	3.200
	14	5	3.200
	2	5	4.000
	3	5	4.000
	4	5	4.800
	1	3	5.000
	5	5	5.200
	16	5	5.200
	6	5	5.600
	Sig.		0.175

a Uses harmonic mean sample size = 4.444

b As group sizes are unequal the harmonic mean of the group sizes is used.

c Alpha = .05

APPENDIX 1. Summary table of macrofaunal species abundances in 74 grab samples taken from the Fitzroy River during November 2001

Phylum	Class	Family	Species name	Trophic Level																																			Station																																						
					1A	1B	1C	2A	2B	2C	2D	2E	3A	3B	3C	3D	3E	4A	4B	4C	4D	4E	5A	5B	5C	5D	5E	6A	6B	6C	6D	6E	7A	7B	7C	7D	7E	8A	8B	8C	8D	8E	9A	9B	9C	9D	9E	10A	10B	10C	10D	10E	11A	11B	11C	11D	11E	12A	12B	12E	13A	13D	13E	14A	14B	14C	14D	14E	15A	15B	15C	15D	15E	16A	16B	16C	16D	16E
Annelida	Polychaetea	Amphraetidae	*Isolda pulchella*	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Capitellidae	*Notomastus* sp. 1	Deposit	1	4	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Annelida	Polychaetea	Capitellidae	*Notomastus* sp. 2	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0
Annelida	Polychaetea	Eunicidae	*Marphysa* sp. 1	Predator	0	2	0	0	0	0	0	1	0	0	3	0	0	3	0	7	0	0	2	0	7	1	3	2	1	0	1	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Glyceridae	*Glycera* sp.	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	2	1	1	0	0	4	0	0	1	1	2	0	0	0	0	6	0	0	1	0
Annelida	Polychaetea	Goniaididae	*Goniada* sp.	Predator	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0
Annelida	Polychaetea	Lumbrineridae	*Lumbrineris* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	3	0	0
Annelida	Polychaetea	Magelonidae	*Magelona* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Nephtyidae	*Nephtys* sp.	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Neriedidae	*Platynereis* sp.	Deposit	56	30	1	12	0	0	0	9	2	0	0	0	1	3	0	0	0	15	4	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Neriedidae	*Tylonereis* sp.	Deposit	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4	10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Onuphidae	*Diopatra dentata*	Scavenger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	4	0	1	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0
Annelida	Polychaetea	Ophelidae	*Ophelina* sp	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	17	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Annelida	Polychaetea	Orbiniidae	*Scoloplos simplex*	Deposit	28	47	10	0	14	6	28	19	4	10	23	11	17	11	1	8	3	0	238	5	5	22	127	27	35	0	2	82	0	0	0	0	0	0	0	0	0	2	0	10	14	6	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Annelida	Polychaetea	Polynoidae	*Harmothoe* sp.	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Annelida	Polychaetea	Polynoidae	*Malmgrenia* sp.	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Annelida	Polychaetea	Sigalionidae	*Sthenolepis* sp.	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	3	0
Annelida	Polychaetea	Spionidae	*Prionspio* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1	0	0	0	0
Annelida	Polychaetea	Sternaspidae	*Sternaspis scutata*	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Chordata	Osteichthyes	Trypauchenidae	*Trypauchen microcephalus*	Predator	0	0	0	0	3	3	2	1	0	2	0	5	0	0	0	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Crustacea	Malacostraca	Apseudidae	*Apseudes* sp.	Deposit	0	0	0	3	0	0	0	6	6	0	0	0	0	0	0	0	0	0	1	0	0	0	8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Cirolanidae	*Cirolana* sp.	Scavenger	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Corophidae	F. Corophidae sp. 1	Deposit	0	1	0	0	0	0	0	2	0	0	0	0	2	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Liljeborgiidae	*Liljeborgia* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Crustacea	Malacostraca	Ocypodidae	*Macrophthalmus* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	16	2	0	0	0	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Ocypodidae	*Macrophthalmus* sp. 2	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Ocypodidae	*Paracleistostoma mcneilli*	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Palaemonidae	*Periclimenes (P.) nr obscurus*	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Panaeidae	F. Panaeidae sp. 1	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Paranthuridae	F. Paranthuridae	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Portunidae	*Portunus pelagicus*	Scavenger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Malacostraca	Sphaeromidae	*Exosphaeroma sp.*	Scavenger	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	3	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacea	Maxillipoda	Balanidae	*Balanus amphitrite*	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	0	0	0	0	0	0	0	0	0
Crustacea	Thalassinidae	Callianassidae	*Upogebia* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Echinodermata	Ophiuroidea	Ophiotrichidae	Ophiothrix martensi	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Mollusca	Bivalvia	Arcidae	*Babatia* sp.	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Mollusca	Bivalvia	Donacidae	F. Donacidae	Suspension	0	0	0	0	0	1	0	0	0	0	2	10	0	0	0	0	1	0	0	20	0	0	1	0	8	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Mollusca	Bivalvia	Lucinidae	*Anodontia omissa*	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Mollusca	Bivalvia	Mytilidae	*Amygdalum glaberrima*	Suspension	12	826	182	0	0	2	0	1	0	0	247	3	0	0	0	690	3	1	0	0	2095	0	1	0	0	1246	1	0	0	0	0	3	1	0	0	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Nuculandiae	*Nuculana (Nuculana) darwini*	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	7	0	1	0	0	1
Mollusca	Bivalvia	Nuculandiae	*Nuculana* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	16	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Psammobiidae	*Soletellina* sp.	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Mollusca	Bivalvia	Semelidae	*Theora* sp.	Deposit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Mollusca	Bivalvia	Solecurtidae	*Azorinus* sp.	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Mollusca	Bivalvia	Veneridae	*Gafrarium transversarium*	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Mollusca	Bivalvia	Veneridae	*Placamen sidneyense*	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Mollusca	Bivalvia	Veneridae	*Venerupis (Venerupis) obesa*	Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Mollusca	Gastropoda	Nassariidae	*Bedeva padaei*	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Mollusca	Gastropoda	Nassariidae	*Nassarius burchardi*	Predator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0