CHAPTER 2
Pilot Studies

The following two pilot studies contain information obtained in an effort to resolve some sampling doubts and confirm the future research procedure (see also Chapter 3). A third pilot study was also undertaken in association with Part C (chapter 11).

2.1 PILOT STUDY #1
Evaluation of appropriate sieve mesh size for sampling sandy beach macrofauna communities

2.1.1 Introduction

There is, as yet, no accepted standardized definition for the lower limit of the size range of benthic macrofauna. In past work, the fauna has usually been defined in terms of the mesh size used in extraction from the sediment and this in turn has depended on the author and the nature of the study. The mesh size of the sieve for sampling is therefore of critical importance to macrofaunal work; both for the project itself and for potential comparative work. It should thus be determined at an early stage of planning (Eleftheriou & Holme, 1984). For sandy beach studies a mesh size of 0.5mm or 1mm is usually accepted; however, screens as wide as 1.5mm (McLachlan 1977,1990; McLachlan *et al.*, 1979), 3.5mm (McLachlan & Hesp, 1984) and even 4mm (Dye *et al.*, 1981; Wooldridge *et al.*, 1981) have been used.

Some studies have been conducted to investigate the effects of different mesh sizes on macrofauna retained (for example: Jonasson, 1955; Reish, 1959; Driscoll, 1964; Lewis and Stoner, 1981; Nalepa and Robertson, 1981; Bachelet, 1990). Generally it is agreed that the mesh size should depend on the species sought. However, the usual conclusion of these studies is that a smaller mesh size gives a more accurate result - especially where juvenile stages are concerned. In a recent comparison, Bachelet (1990) found that, for subtidal and estuarine intertidal communities, a 1mm mesh had an efficiency of only 20-70%. This is a large potential loss of fauna which could have serious implications for results.

In Australia, James and Fairweather (1996) elected to use a 0.5mm mesh for extracting beach macrofauna, albeit with a smaller sample size and more shallow sample depth than was used here (see also section 2.2).

Alternatively, Cattaneo and Masse (1983) suggested screens of less than 1 mm mesh size should not be used in studies on the structure of benthic communities due to the potential retention of newly settled macrofaunal juveniles. Juveniles typically have a high mortality rate and are thus not a true indication of the overall structure of the community. However, Cattaneo and Masse worked on sheltered, estuarine and muddy marine environments which typically have a much finer sediment and a greater number of animals of small body size than exposed sandy beaches. Sieve requirements for sandy beach work may be very different.

Eleftheriou & Holme (1984) recommend that a 0.5 mm mesh be used for macrofauna extraction;however, they also concede that in the case of a coarse grained environment such as a sandy beach (especially one of reflective nature where gravel and even rocks are often present) this sieve may retain too large a volume of sediment to be workable and so a compromise may have to be made. In this case it is suggested that the final mesh be related to the grade of the deposit and the size of the organisms to be separated.

The aim of this survey was to find the most appropriate mesh size for large scale quantitative sampling for the macrofauna of exposed sandy beaches in eastern Australia.

2.1.2 Materials and methods

During September and October 1993, six beaches representing a range of morphodynamic types were sampled for macrofauna using a corer of 5.15 cm radius (area 83 cm^2) to a depth of 30cm. A range of beaches and different tidal levels were investigated in an attempt to include the different faunal components and abundances relative to the morphodynamic states (refer section 1.1.3 and 1.3.2). The beaches were all located on the mid-north coast of New South Wales and included: Ocean View Beach, Fiddaman's Beach and Hearns Lake Beach (all near Woologoolga; 30°04'S, 153°07'E), Minnie Water Beach (near Grafton; 29°24'S, 152°33'E), Broadwater Beach (at Broadwater; 28°35'S, 153°07'E) and Sharps Beach (near Ballina; 28°31'S, 153°21'E). All these beaches are modally intermediate in morphodynamic state; Ocean View, Fiddamans and Hearns Lake beaches the most reflective at the time of sampling, with Broadwater and Sharps Beach the most dissipative (Short, 1993).

For each study site, nine samples were taken at each of three levels on the beach:

High tide - approximately 1m below the drift line

Low tide - within the low tide swash

Mid tide - in between the above levels

Each sample was sieved three times - once through each of a 0.5mm, 1mm and 2mm mesh - and the fauna recorded in major taxonomic groups. Fauna that will pass through a 0.5mm sieve are usually considered meiofaunal (Hulings & Gray, 1971; Lewis & Stoner, 1981) and are thus excluded from the scope of this study.

Becasue of the low abundance of animals and high occurrence of nil counts for cores (especiall on the more reflective beaches), data for each beach as a whole were pooled. The proportion of fauna retained by the larger meshes relative to that recorded on the 0.5mm sieve was then calculated for faunal groups and total fauna on each beach.

Statistical analysis was not performed as this pilot study was intended to be purely descriptive. Besides this, low core numbers rendered statistical methods of determining significant retention differences between the meshes not viable (e.g. anova, comparisons of means, etc).

In order to determine the characteristics of the sand sediment, samples were also obtained from each sampling site and level to the same depth as the core. These were each dried and sieved through a graded series of meshes suited to the intervals of the Wentworth scale (Buchanan 1971)(see also chapter 3). From this the average grain size for each site was found and the proportion of sediment not passing through each of the 0.5mm, 1.0mm amd 2.0mm meshes calculated. These proportions allow an objective measure of sieving difficulty for each site and mesh.

2.1.3 Results

The results of the pooled faunal data are summarised in Table 2.1. Comparisons of the fauna retained by the different mesh sizes show that, in all instances, very little macrofauna is lost using a 1mm sieve for sampling as opposed to a 0.5mm sieve. The 1mm mesh retained over 89% of the total fauna in all cases. Conversely, substantial losses occurred upon increasing the mesh size to 2mm. In some instances this mesh retained less than 50% of the fauna found on the 0.5mm mesh (Table 2.1).

Although the numbers of organisms found at the different beaches varied considerably, comparisons of total faunal results for each of the beaches show a similar pattern on a percentage loss basis for each of the mesh sizes (Table 2.1). The main losses using the larger sieves occurred in the polychaete, amphipod and insect groups. Crabs, bivalves, gastropods and isopods were fully retained by all sieves in all cases.

Results of the granulometric analysis revealed each of the beaches to be composed of very well sorted fine sand with a median grain size of 2-3ø[1] (0.25 - 0.125 mm diameter). Large grains were, however, present in most of the samples, especially at the low tide levels, and the proportions of sediment of 1ø (0.5mm), 0ø (1mm) and -1ø (2mm) were used to calculate the percentage of the sediment that could not pass through each of the study meshes. These results are summarized in Table 2.2. Table 2.2 also shows the reflective beaches to harbour greater proportions of large grain sizes than the more dissipative beaches. This was expected as part of their definition.

2.1.4 Discussion

Sampling methods in any benthic study can affect the results and thus play a part in determining conclusions. Logically, a smaller mesh size has been repeatedly shown to give a more accurate result. As outlined in the section 2.1.1, this seems especially evident for environments such as the sea floor, freshwater and estuarine lagoons and lakes and other sheltered habitats. However, exposed sandy beaches have different physical conditions to consider (such as wave climate, tide, sediment characteristics and overall dynamics (McLachlan, 1983a) and the comparisons of fauna retained on different mesh sizes in this study indicate that a mesh of 1mm can be used for effective quantitative sampling of Australian sandy beach macrofauna.

Although a small percentage of the macrofauna is lost using a 1mm sieve, the amount of time involved with working the sample can be considerably less and often this needs to be taken into account when planning a survey. Small mesh sizes (e.g., 0.5mm) make sieving extremely difficult and time consuming on coarse grained beaches. This was the case for the three most reflective sites in this study. Results of granulometric analysis showed that up to 24.8% of the sediment would not pass through a 0.5mm mesh and that this could be substantially reduced by increasing the mesh size to 1mm (thereby making the sieving process less laborious). This is relevant to the limitation by the tide on the time available for work in the intertidal region. Even dissipative beaches can harbour coarse grains as the result of a storm event (Short & Wright 1983), although the effects of small amounts of coarse material on sieving effort is undoubtedly not as severe. In any case, by using a 1mm mesh as opposed to 0.5mm for sandy beach work,

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[1] The phi (Ø) scale is a measurement of sediment size where Ø=-log2 of the particle size in mm. See also chapter 3.3.4.

Table 2.2: Comparisons of sediment proportions unable to pass through 0.5mm, 1mm and 2mm mesh at each study site and tidal level.

		% sediment not able to pass through mesh		
Beach	**Tide level**	**0.5 mm**	**1.0 mm**	**2.0mm**
Ocean View Beach	High Tide	1.2		
	Mid Tide	8.1		
	Low Tide	17.7	8.3	
Fiddaman's Beach	High Tide	1.4		
	Mid Tide	1.4		
	Low Tide	24.8	18.2	5.2
Hearn's Lake Beach	High Tide	0.9		
	Mid Tide	6.6		
	Low Tide	16.4	7.4	
Minnie Water Beach	High Tide	1.3		
	Mid Tide	12	4.3	
	Low Tide	7.2	3.4	
Broadwater Beach	High Tide	1.4		
	Mid Tide	1,2		
	Low Tide	7.2	3.5	
Sharp's Beach	High Tide	1.6		
	Mid Tide	1.3		
	Low Tide	1.5	0.1	

sampling effort is substantially reduced (potentially allowing a greater number of samples to be taken in the time the tide allows) with very little information loss.

The ability to sample large areas is especially important on sandy beaches where the animals are frequently scattered and often of large body size. Larger or more numerous cores of sand are therfore necessary to cover the species-area curve (Jaramillo *et al.*, 1995). Although devices such as elutriators are useful for extraction of fauna from sediments (such as which might remain on a 0.5mm mesh), the large sample size necessary for sandy beach work renders these impractical, time consuming and undesirable when initial use of a 1mm mesh will reduce labour and also provide worthy results.

However, large percentages of fauna are apparently missed in a sandy beach environment if the screen size is increased to 2mm. In particular, only 43% of the polychaetes retained on a 0.5mm mesh were found on the 2mm mesh for the most dissipative beach in this study at the time of sampling (Sharps Beach). This, along with other large losses for groups and totals, indicates that 2mm is too large a mesh size for an effective quantitative survey. Because both species abundance and diversity are known to increase from reflective to dissipative beaches (McLachlan *et al.*, 1993), it is especially likely that all representatives of a species could be lost on dissipative beaches using a sieve of this mesh size.

The low animal abundance shown in this study is a recurring characteristic of sandy beaches (McLachlan 1983a); however, it should be noted that numbers fluctuate seasonally and the size spectrum of animals could be very different at different times of year. This would very likely affect mesh size comparisons. Seasonal recruiting times are not the same for all benthic macroinvertebrates (Leber 1982) and thus, for a complete analysis of the effects of sieve size on macrofauna retained, this type of study should be repeated at different times of year. As mentioned in section 2.1.1, however, some researchers consider the retention of newly settled macrofaunal juveniles to be undesirable in community analysis as, due to a high mortality rate, they are not a true indication of the community structure .

For studies of specific macrofaunal groups, Table 1 may point to the use of a different mesh size relative to the group in question. For example, 2mm mesh appears to be 100% efficient for collecting crabs, bivalves gastropods and isopods. Nevertheless, for studying a specific species or group, the sieve size employed should be relative to the size spectrum of the animals in question and determined separately according to the purpose of the survey (Eleftheriou & Holme 1984).

The results of this study indicate that the use of a 1mm mesh as opposed to a 0.5mm mesh is feasible for the quantitative sampling of macrofaunal communities for a range of Australian sandy beaches. The use of a 2mm screen results in large losses of small fauna and is thus likely to more adversely affect experimental results and conclusions.

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2.2 Pilot study #2
An indication of macrofaunal variation from within an Australian sandy beach

2.2.1 Introduction

No area of environmental study is immune to the problem of inefficiency and bias in the sampling method and its effect on misinterpretation of results (Green, 1979). Thus it is important to know the limitations of any sampling program (Andrew and Mapstone, 1987). Sandy beaches are among the most variable and dynamic environments on earth and are consequently one of the most difficult settings for which to design an effective biological study. Of particular concern is how to sufficiently sample an invertebrate community which is by nature extremely sparse and patchy (both in species number and total abundance). Living within the sediment, the animal community present on a beach is also obscure. This makes it difficult to initially decide the amount and type of sampling required.

Choice of sample size depends on a number of factors, one of which is the size and shape of the organism being sampled (Green, 1979). Components of sandy beach macrofauna (here defined as those organisms which will be retained on a 1mm mesh) vary greatly in size. They may range from minute amphipods and polychaetes to quite substantial crabs and bivalves which can exceed 5cm in diameter. Where there is some prior knowledge of the spatial arrangement of the animals in question, Andrew and Mapstone (1987) suggest that the smallest sample unit be larger than the spacing among the aggregations. In the case of a beach, however, where the spatial arrangement is unknown and even the presence of certain species difficult to determine before sampling takes place, Andrew and Mapstone (1987) suggest a sampling unit at least one order of magnitude times the size of the largest potential organism. This would imply a sampling unit of greater than 50cm diameter for sandy beach fauna. Green

(1979) suggests a sampling unit of at least 20 times larger than the largest potential organism which would imply a sampling unit of 1 metre in diameter. Clearly, in terms of a core sample, this is manually almost impossible.

Recent studies have compromised by using the largest repeatable sample unit feasible during one low tide with a limited availability of labour. Examples of the most recent community surveys include: Jaramillo *et al.*, (1993) and McLachlan *et al.*, (1993) who used 4 x 0.03m^2 cores at ten levels of the beach; Jaramillo (1994) using 3 x 0.03m^2 at ten levels of the beach; and McLachlan et al (1996) using 3 x 0.1m^2 units at fifteen levels of the beach. For species richness information, the total area needing to be sampled depends on beach type and tidal range. For microtidal beaches it has been shown that a sample area of 3-4m^2 needs to be obtained in order to collect greater than 95% of the species present (Jaramillo *et al.*, 1995). This increases as beaches become ultra-dissipative.

Sampling depth for macrofauna is also important. Macrofauna has, at times, been found to a depth of up to 60cm in the sediment (McLachlan and Bate, 1983). However, because ninety-five percent of beach macrofauna is generally accepted to exsist in the top 20-30cm of the sand (Bally, 1983; McLachlan pers comm), intertidal beach studies have usually sampled to a depth of 10-25 cm This study slightly extends the depth of sampling to 35cm in order to locate as many species as possible.

But what of the actual sampling design? Existence of patchiness in soft sediment benthos has been recognised for a long time yet the results of many studies are often confounded due to a lack of proper spatial replication within the sampling design (Morrisey *et al.*, 1992). This is most likely the case for the afore-mentioned sandy beach community studies as they have based their descriptions and comparisons on a single transect. The samples (ie. transects) from each treatment (ie. beach) are not replicated and thus the treatments are compared with what is probably an inappropriate error term. This is known as "pseudo-replication" (Hurlbert, 1984). In these beach studies, pseudo-replication is a result of the measurements made being smaller than the space relevant to the hypothesis being tested (i.e. the results from one transect at one point on a beach are being used to form conclusions for the whole beach).

Given that a 0.1m^2 sample unit is of acceptable dimensions, the aim of the present study is to determine if significant variation exists between replicated transects within and between different sites on a beach. Large significant variations between transects at one beach, particularly within a small site area, would indicate that a large potential exsists for confounding of results to occur when comparing two or more beaches that have been sampled using only one transect. This means that treatment differences detected when comparing many beaches may not be real but simply a result of natural variation within the system.

One of the trade-offs of using large sampling units is that fewer samples can be taken per unit time. Small samples are often preferred by researchers as larger numbers of samples can then be collected; this allowing greater experimental precision. Precision refers to the degree of concordance among a number of measurements for the same population (Sokal and Rohlf, 1981). It is a characteristic of the sampling procedure rather than a reflection of the qualities of the actual community under analysis (Andrew and Mapstone, 1987). Precision analysis allows the calculation of the number of sample units required in order to achieve a particular rigour. For example, Haynes and Quinn (1995) calculated that five replicate $0.38m^2$ samples provided a good estimate of species and abundance at a given height of the beach, with a standard error less than 20% of the mean. From the data obtained in this study, a second aim is to determine how many $0.1m^2$ sample units would be required at a given tidal level in order to attain a data precision of 0.2.

The results of this pilot study will be used as information for the directions of the larger body of this thesis. Following, this is to be related to works of Jaramillo and McLachlan as part of an effort to compare ecological beach studies across the globe.

2.2.2 Materials and methods

During spring tide on May 28th, 1994 a series of macrofaunal samples were taken from Arrawarra beach in northern N.S.W., Australia (approximately 30°0'S, 151°06'E). Arrawarra beach is a 3.2km beach running in a north/south direction. The beach/surf zone is usually in the form of a double bar system with the bars merging towards the southern end to form a wide, low gradient attached bar cut by occasional rips (terminology follows that of Short, 1993). This beach was chosen for the present study as it was known to be an intermediate form in terms of beach morphodynamics. Thus it is closer to being a 'general' representative for all beaches than would be a beach type at the extreme end of the morphodynamic scale. The sampling site for this study was positioned at the southern end of the beach in an area with no apparent rip activity at the time.

In order to try to detect variability within and between study sites and transects, a stratified nested sampling design was employed. First, three separate sampling sites were chosen on what appeared to be a reasonably homogeneous section of the beach in physical terms. These sites were approximately 250m apart. At each of these sites three replicate transects were sampled using 3 x $0.1m^2$ sampling units at each level. For this number of replicates, however, sampling ten levels of the beach during one low tide was unworkable and so the number of levels was reduced to four. These levels were equally spaced (21m apart), from the high tide area, defined as the most recent drift line, to the low tide swash. The levels were labelled A to D, respectively. So, for each transect, of which there were three at each of three sites, 3 x $0.1m^2$ sample units were taken at each of the four tidal levels. This is with the exception of level C where fading light and rising tide allowed only two samples to be taken from each transect . All samples were taken to a depth of 35cm.

Each sample was sieved on site through a 1mm mesh. This has previously been shown to have an adequate retention efficiency for sandy beach macrofauna community work (see section 2.1). The fauna were preserved in ~5% buffered formalin in seawater and number of species and abundances later identified and counted.

Results were analysed for significant differences in species number and total abundance between sites and transects using a nested analysis of variance (SPSS software package, 1988). Means and standard errors were plotted as bar charts for each transect at each site and level.

Using data obtained for all sample units across a given level, the number of samples required for a precision of 0.2 at each level was calculated according to the formula:

$$n = \frac{s^2}{D^2x^2} \quad (5)$$

where: n = number of samples required
s^2 = variance (s = standard deviation)
D = desired precision (in this case D = 0.2)
x = mean

2.2.3 Results

Statistical comparisons within and between sites yielded only two significant results. Both were significant differences between sites. No significant differences were detected between transects within sites. Between sites, significant differences occurred only in abundance of individuals at level A ($F=15.07$; df =2,6; $P=0.005$) and level D (F=

19.48; df = 2,6; P = 0.002). Although other results were non-significant, it should be noted that low overall numbers rendered the power of the statistical test low (in all cases other than the two significant results, power was 0.4 or less as calculated by the statistical package).

Means and standard errors calculated for species number, total abundance and abundance of the most common species at each transect, level and site are shown in Fig. 2.1a-c. These results show that the standard errors of the mean in each transect are, on the whole, extremely large - often equal to or approaching the actual sample mean. Large standard errors indicate large amounts of variation within the sample (transect level) and this is especially pronounced in the lower levels of the shore.

The results of the precision analysis are summarised in Table 2.3. These results show that adequate precision using 3 x 0.1m^2 samples is only accomplished for number of species at Level A. Here only 1.54 samples are required for a precision of 0.2. Precision appears generally much more difficult to obtain for abundance data; with 102 samples required to precisely sample total abundance and 312 samples required in order to adequately sample the most common species at the lowest level of the beach.

Table 2.3: Number of samples required at each level to give a precision of 0.2 for number of species, total abundance and abundance of the most common species.

		Level A	Level B	Level C	Level D
Samples required for D = 0.2	No. of species	1.54	8.22	17.08	17.31
	Total Abundance	5.63	9.13	26.13	101.02
	Abundance of most common species	5.66	14.71	120.58	311.27

2.2.4 Discussion

Although the statistical analysis showed no significant differences between sites and transects in all but two cases, the power of the anova was generally low. This means that there is a large chance of a Type II error (ie. a large chance that the null hypothesis stating that there is no significant difference between sites and transects has been

Figure 2.1a: Number of species at transects, sites and levels (means and standard errors).
Showing large standard errors of the means, which indicate large amounts of variation within the sample.

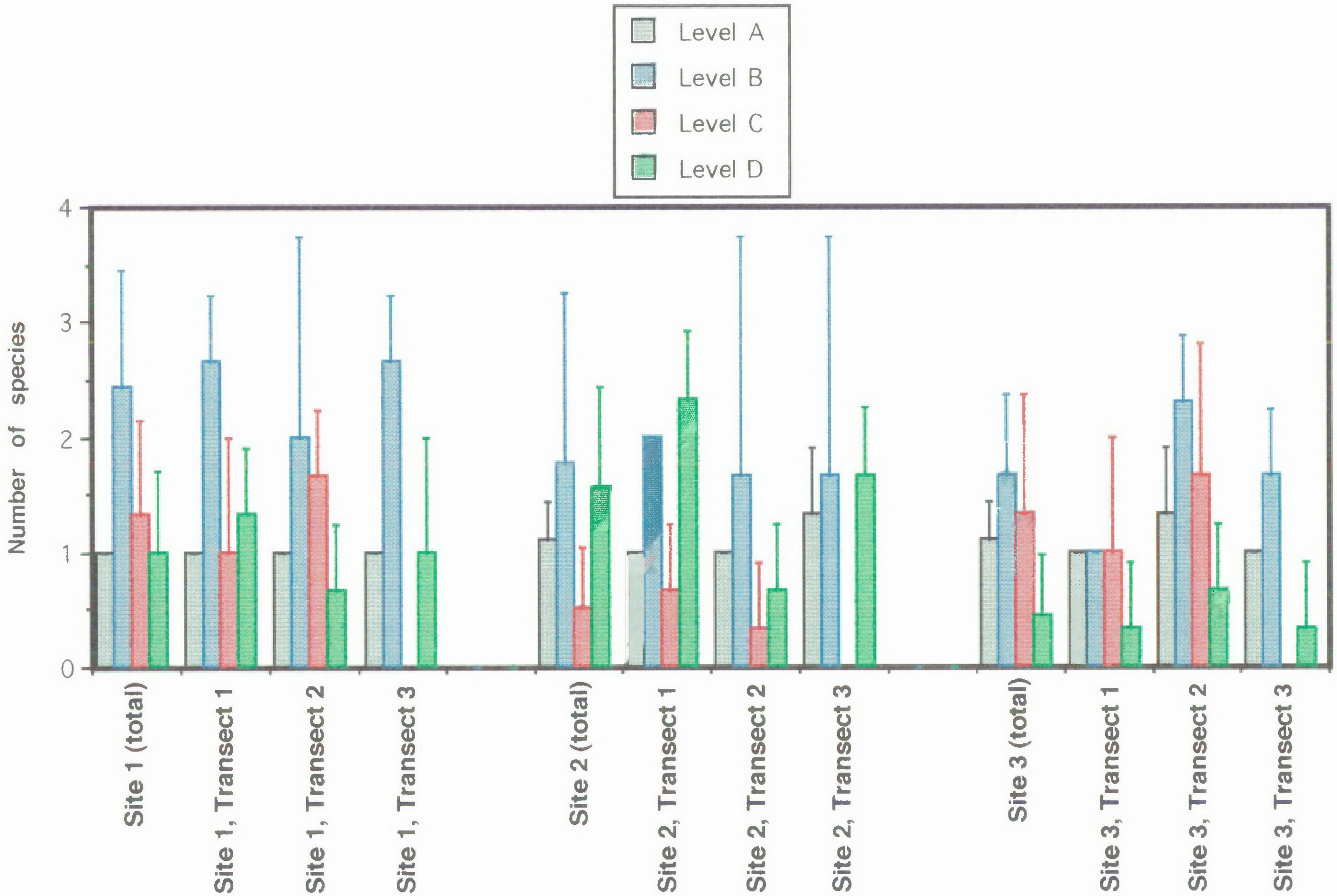


Figure 2.1b: Abundance at transects, sites and levels (means and standard errors)
Showing large standard errors of the means, which indicate large amounts of variation within the sample.

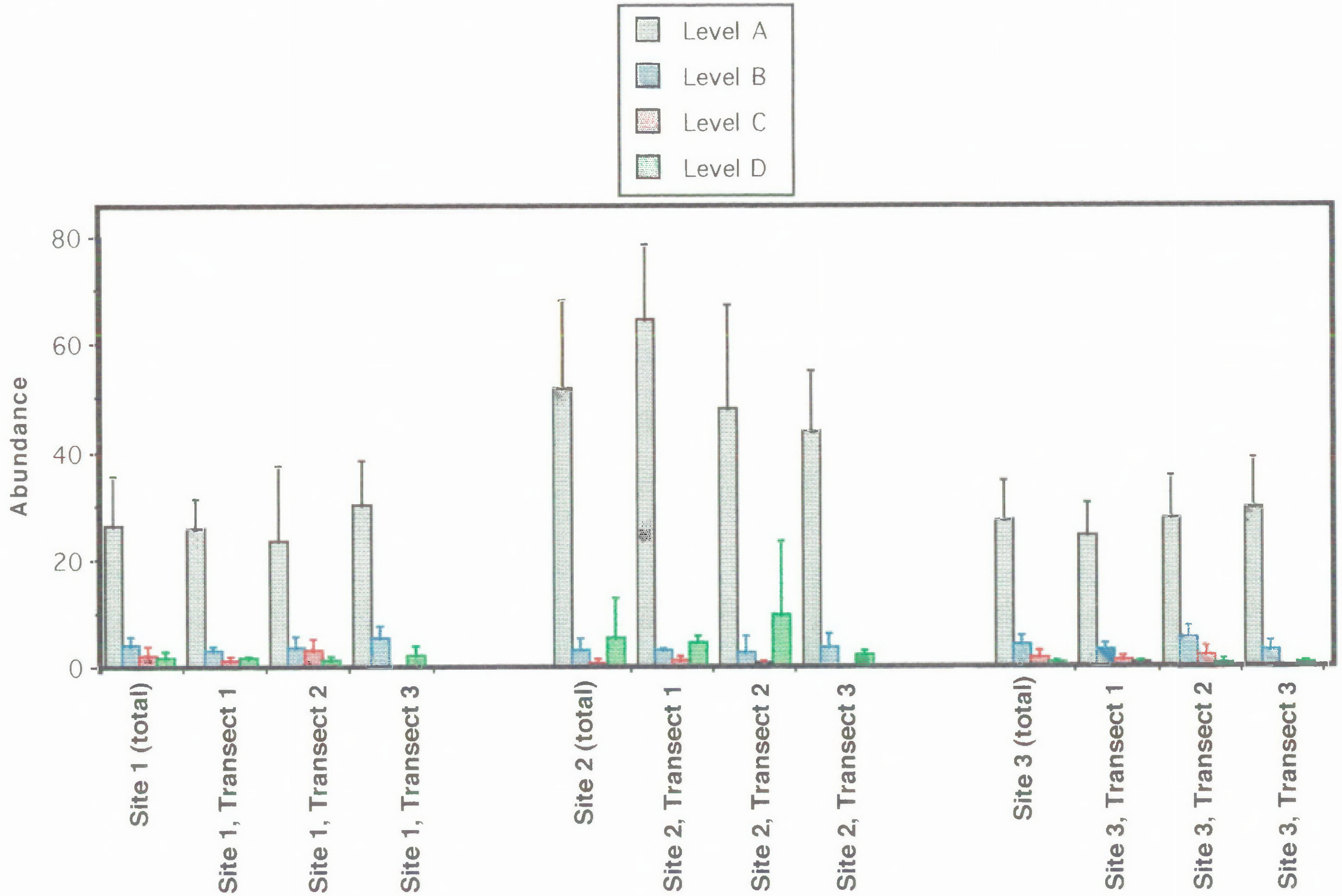
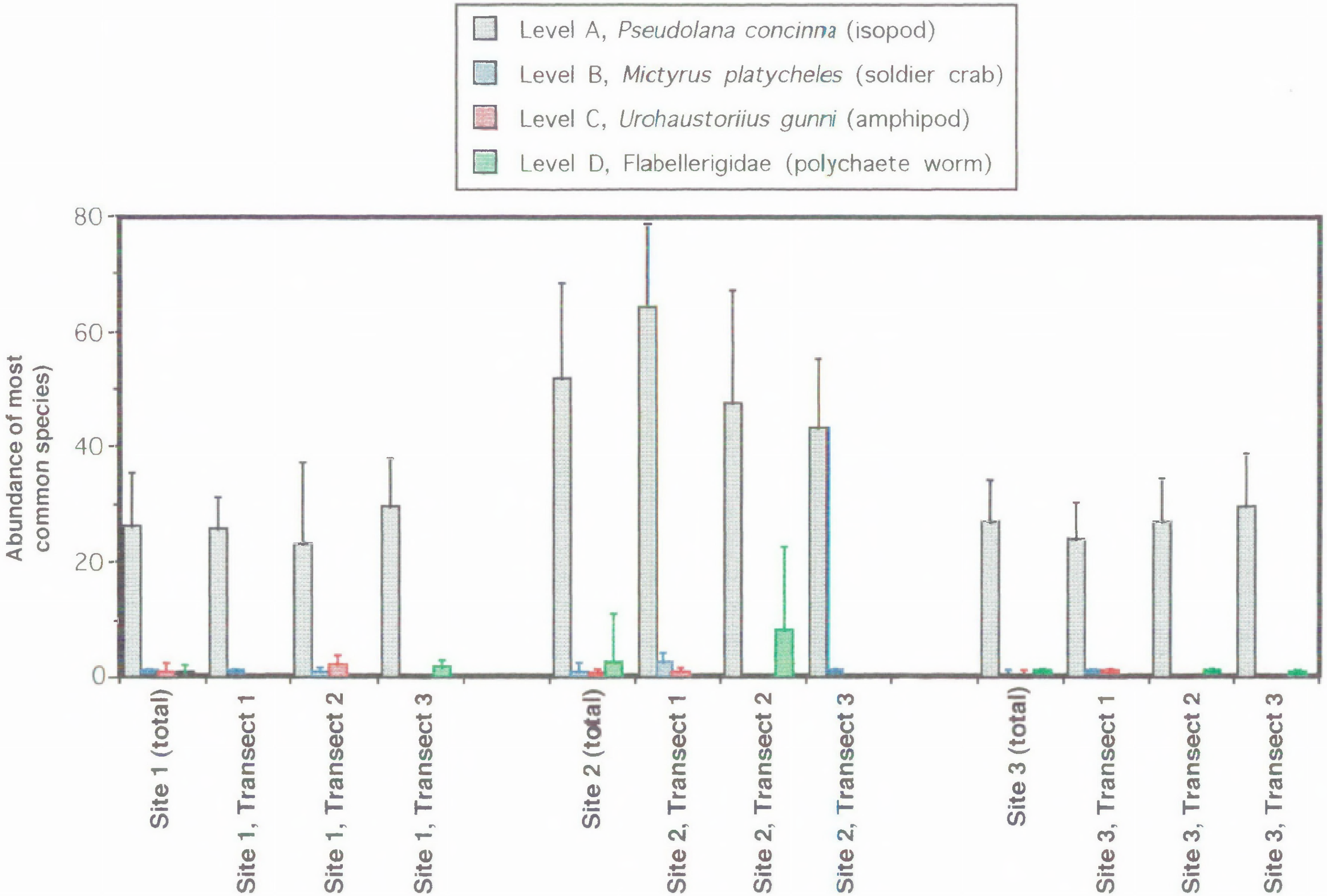


Figure 2.1c: Abundance of most common species at transects, sites and levels (means and standard errors)
Showing large standard errors of the means, which indicates large amounts of variation within the sample.



accepted when in reality it is false). Standard errors of the means are thus possibly a better indication of variability in this case.

As stated in the Results section, the standard errors for each transect are, overall, very large. This suggests a copious amount of variation in the data pertinent to the means. The largest standard errors appear in the results for the lower half of the shore (Levels C and D) where patchiness seems particularly pronounced. These results indicate that the effects of pseudo-replication would be especially prominent in the comparative analysis of beach communities using only one transect per beach. This is because any spatial variation between that of the spacing of samples and the spacing of locations will be compounded into the variation among locations in the statistical comparison of locations (Morrisey et al, 1992). Results for individual species (in this case the most common species at each level) showed even greater disparity indicating that particular care should be taken when planning studies of discrete populations on the sandy shore.

Three $0.1m^2$ samples proved adequate for sampling with a precision greater than or equal to 0.2 only for the number of species present at Level A. In terms of the community, this appears to be the most homogeneous level of the beach with one species, the isopod *Pseudolana concinna*, overwhelmingly dominant. Even so, the number of $0.1m^2$ samples required for accurate quantitative population work increases to six - twice the samples taken in past work using a similar sample unit size. Six $0.1m^2$ samples across shore might be achievable for beach community sampling but only at the expense of the number of tidal levels investigated. It is the author's experience that to sample more than 30 units during a single low tide (using four workers on average) would require unusually agreeable beach conditions in terms of inherently fine sediment characteristics as well as weather.

At the lower level of the shore, 18 samples are required in order to be confident of species number data. This might be feasible if only interested in the low tide level and with provision of adequate labour to take the samples during actual low tide time. However, to repeat this at more than one level (as for a total intertidal community survey) would be logistically extremely difficult. The 102 samples required at this level for precise abundance information is clearly impracticable. For individual species abundance, in the best case (ie. most common species) the scenario worsens to impossible - though core size may possibly be substantially reduced depending on the species in question.

What are the implications of these results in reference to past large scale beach ecology work? It seems that confidence in the results as true reflections of the community should be minimal. Yet, despite the within site variation and inherent errors, similar trends are being consistently demonstrated. This suggests that, despite the sampling method being theoretically inadequate, it seems to be enough to reveal at least some general tendencies in community patterns among different beach types.

In an area with an environmental gradient such as the intertidal beach, stratified sampling is necessary in order to reduce the among replicate sample unit error variations in organism abundance. This is due to density variation with tide level (Green, 1979). For beach communities, ten levels has been suggested as the minimum number of strata to ensure sampling occurs more than once in a given tidal "zone" (Group Discussion, Sandy Beaches '94 - An International Symposium On Sandy Beaches, Valdivia, Chile, 1994). It should be pointed out that sandy beach "zonation" is problematic and there is yet to be consensus in the literature as to whether 2, 3, 4 or more ubiquitous macrofaunal zones exist, if at all (see Part C, chapters 10-12).

In any case, if ten levels are to be regarded as a standard minimum down shore, this compromises the number of samples that can be realistically taken along a shore. It thus appears that, in order to ensure adequate replication in one direction, replication in another is jeopardised. The situation appears especially unfortunate when pilot results, such as those presented here, indicate that precision along shore is in effect logistically unobtainable.

Does this mean that any attempt at large scale sandy beach ecological fieldwork should be abandoned? Where the question of pseudo-replication arises, Hurlbert (1984) propounds that "when gross effects of a treatment are anticipated, or when only a rough estimate is required, or when the cost of replication is very great, experiments involving unreplicated treatments may be the only or best option". This does not mean that the study will be devoid of useful information. What is important is that the researcher realises the limits of the study and the consequent qualifications to conclusions that can be drawn.

For sandy beach ecology, especially for studies limited by labour and cost (such as the present thesis), one transect of 3 x 0.1m^2 samples at ten levels may be all that is possible when attempting large scale comparisons between beaches. This is especially problematical when attempting to study tidal flat environments which seem to require an even larger total sample area in order to detect all species (Jaramillo *et al.*,1995). In another attempt to manage sampling effort, James and Fairweather (1996) have argued to omit replicate transects within beach sites as their results suggest that these are a less significant source of variation than the sites themselves. However, although improvements in the sampling design are not simple with limited resources, communication of results from beach ecological research can be improved by:

a) Specifically stating that the transect is to represent a small section of beach and the characteristics applying to that limited area. Morphological features of sandy beaches often change markedly alongshore and these changes would be reflected in the fauna present. Consequently, both the physical and biological data obtained from one transect could not be said to ubiquitously apply to the whole beach.

b) Indicating the range of possible results by the inclusion of error bars (or at least some indication of confidence). This type of information is far more useful in environmental ecology than simply stating a mean with no evidence as to how compact the individual data points might be.

As mentioned previously, this study forms a pilot for the following large scale comparative study of Australian beach macrofaunal communities. On the basis of the results presented here, this study will proceed with a sampling design based on that of the McLachlan/Jaramillo group, as replicated transects or even an increase in precision of a single transect does not seem technically possible. Although this does have the advantage of ease of comparison with past data, inherent errors will be indicated wherever possible and applicable, and conclusions will be based on broad trends.