CHAPTER 5
Community structure on warm temperate Australian beaches

5.1 Introduction

5.1.1 Physical characteristics of warm temperate Australian beaches

The N.S.W. coast stretches from 28-38°S, placing it outside the tropics but still well north of the cooler climates of the Southern Ocean. The beaches here have features characteristic of those of the temperate middle latitudes where beach sand consists of principally well-weathered quartz grains with variable amounts of shell fragments (Short, 1993). Towards the Queensland border the northern N.S.W coast contains beaches backed by largely infertile Pleistocene coastal dunes. Moving south, towards Coffs Harbour, these grade into more ancient coastal sedimentary rocks that form numerous beach filled bays. This northern N.S.W coastline experiences a highly variable wind/wave climate and a persistent south-easterly swell. The semi-diurnal tides have a mean range of 1.2m and a maximum tide range of 2m. Beaches of this region were investigated for the warm temperate component of this study.

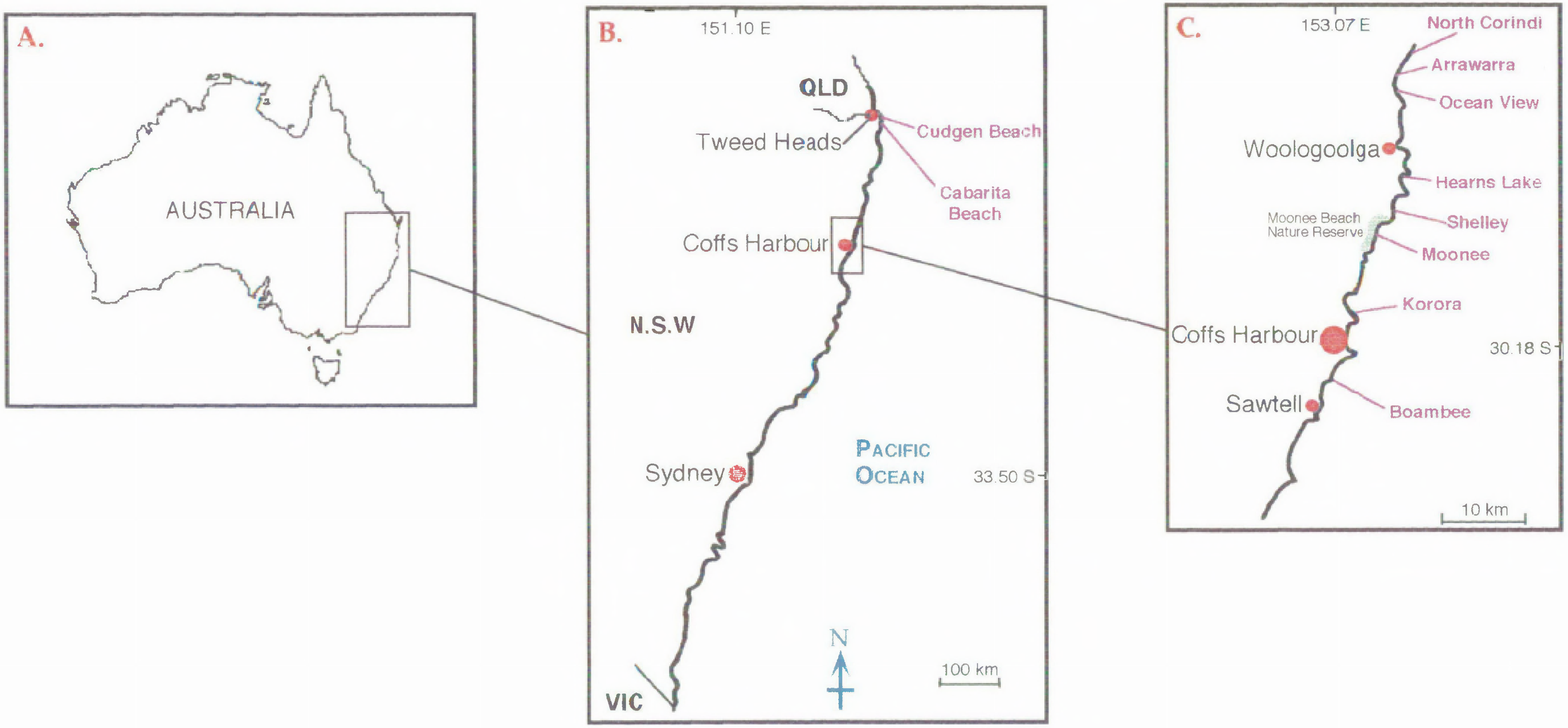
5.1.2 Aim

The primary aim was to investigate trends in species richness, diversity (Simpson's Index), abundance and biomass for a morphodynamic series of beaches (classified and compared according to Ω and BSI) in warm temperate northern N.S.W, Australia.

5.2 Materials and Methods

Ten sandy beaches were selected for exploration in northern N.S.W, Australia - eight of the beaches in the Coffs Harbour region and, in an attempt to include more dissipative representatives, two beaches further north. The beaches are named (in descending latitude): Cudgen, Cabarita, North Corindi, Arrawarra, Ocean View, Hearns Lake, Shelly, Moonee, Korora and Boambee (Fig. 5.1).

Figure 5.1: Location of warm temperate study sites (northern New South Wales)



The above beaches were sampled at low tide each day from 5th-15th January, 1994 according to the method outlined in Chapter 3. Local weather at this time was sunny, calm and clear. Statistical analysis was performed according to section 3.4.

5.3 Results

A total of 38 species was detected on the beaches in this region. These species included representatives of bivalve and gastropod molluscs, polychaete worms, nemertea, crustacea (comprising various isopods, amphipods, decapods, stomatopods and mysids) and insects. A list of the species detected and their presence/absence on the study beaches is presented as Table 5.1. Ghost crab (Family: Ocypodidae) burrows were noted on the high beach and dune area for all beaches although these were not always met in sampling.

Each of the above beaches can be considered exposed according to the rating scheme of McLachlan (1980a). Relative Tide Ranges (RTR) indicate that these beaches are also dominated by wave and swash processes. Calculations of Ω and BSI for each of the ten beaches showed the sites to represent a range of almost reflective to high energy intermediate states (Table 5.2). There are no fully dissipative beaches in N.S.W (Short, 1993). The beaches also showed a range of intertidal gradients.

In relation to the Dimensionless Fall Velocity, Ω, only species number formed a significant regression (t_8=4.81, P<0.001, R^2=74.1%) (Fig. 5.2). There was no significant relationship with Ω for log abundance (t_8=2.25, P=0.054, R^2=38.8%), log biomass (t_8=1.45, P=0.186, R^2=20.7%) or Simpson's Index of diversity (t_8=-0.46, P=0.685, R^2=2.6%) See figures 5.3, 5.4 and 5.5 respectively.

The BSI provided more significant results overall with both species number (t_8=4.50, P<0.001, R^2=71.7%) and log abundance (t_8=2.76, P=0.025, R^2=48.8%) forming significant regressions (Figs 5.6 and 5.7). Log biomass and Simpson's Index of diversity remained not significantly related to beach index (Biomass: t_8=1.45, P=0.185, R^2=20.8%; Simpson's Index: t_8=-0.40, P=0.701 R^2=1.9%)(Figs 5.8 and 5.9).

Residual plots of the species number data regressed against both Ω and BSI for the present beaches proved ambiguous in distinguishing heterogeneity of the variances. Interestingly, and unlike the cool temperate beaches and beaches of past studies, the species number/beach state relationship was improved when the species values were log transformed (as indicated by anti-logged predicted values of the log model - refer chapter 3.4). This occurred for regressions against both Ω and BSI (Figs 5.10 and 5.11).

Table 5.1: Species composition at warm temperate Australian beaches (northern N.S.W.) (Star (*) indicates presence)

	Korora	Nth Corindi	Arra-warra	Shelley	Ocean View	Cabarita	Hearns Lake	Cudgen	Boam-bee	Moonee
MOLLUSCA										
Bivalvia										
Donax deltoides					*	*		*	*	
Donax (tentidonax) veruinus		*		*	*	*	*	*		*
Gastropoda										
Neverita incei				*		*		*		
POLYCHAETA										
Arabella iricolor iricolor		*	*	*		*	*		*	*
Hemipodus australiensis	*	*			*	*	*	*	*	*
Hirsutonuphis mariahursuta						*			*	
Lobochesis longiseta		*		*	*	*				*
Lumbrineris cf. latreilli										*
Nephtys australiensis		*		*	*	*	*		*	*
Nephtys longipes	*		*	*	*			*	*	*
Notomastus cf. torquatus			*	*	*					
Scoploplos (Leodamus) sp.									*	*
Scoploplos normalis			*				*			
Sigalion cf.oviger									*	
Lumbrinereid A									*	
Polychaete A									*	*
NEMERTEA										
Nemertean A					*		*	*	*	
CRUSTACEA										
Isopoda										
Eurylana arcuata						*				
Pseudolana concinna	*	*	*	*	*	*	*	*	*	*
Pseudolana elegans		*						*		*
Amphipoda										
Exoediceroides ?maculosus						*				
Tittakunara katoa						*		*		
Urohaustorius gunni		*		*	*		*	*	*	*
Urohaustorius halei				*	*	*	*	*		*
Urohaustorius metungi							*			*
Zobracho canguro									*	*
Decapoda										
Diogenes custos									*	
Ocypode ceratopthalma										*
Ocypode cordimana	*					*		*	*	*
Mictyrus platycheles		*	*		*		*			
Scopimera inflata		*	*	*			*			
Stomatopoda										
Australosquilla vercoi								*		
Mysidae										
Haplostylis indicus						*			*	
INSECTA										
Diptera larva	*					*			*	
Coleoptera (Staphylinidae) adult			*							
Coleoptera adult						*	*			*
Hymenoptera (Formicidae) adult										*

Table 5.2: Raw data for warm temperate Australian beaches (northern N.S.W.)

Beach	Beach State Index (BSI)	Deans Value (Ω)	Slope of beach face	Number of species	Abundance m^{-1}	Simpsons Index (*D*)	Biomass gm^{-1}	Sediment fall velocity $cm\ s^{-1}$	Av. wave height (cm)	Av. wave period (s)	Maximum Tide Range (m)	Relative Tide range	Exposure rating (McLachlan, 1980a)
Korora	0.701	1.61	0.074	5	315.12	0.388	26.24	0.062	100	10	2	1.60	14
Nth Corindi	0.860	2.50	0.027	10	2766.63	0.237	15.95	0.032	80	10	2	2.00	11
Arrawarra	0.933	3.03	0.041	8	7666.65	0.479	141.95	0.033	100	10	2	1.60	11
Shelley	0.944	3.12	0.035	11	6625.28	0.279	36.45	0.032	100	10	2	1.60	13
Ocean View	1.011	3.71	0.032	12	3075.70	0.301	42.36	0.035	130	10	2	1.23	14
Cabarita	1.025	3.84	0.045	17	22933.90	0.589	243.54	0.039	150	10	2	1.07	13
Hearns Lake	1.068	4.28	0.042	13	4533.31	0.274	16.07	0.035	150	10	2	1.07	13
Cudgen	1.072	4.32	0.042	13	8533.30	0.416	240.70	0.037	160	10	2	1.00	14
Boambee	1.083	4.44	0.022	18	3672.69	0.180	54.65	0.036	160	10	2	1.00	14
Moonee	1.083	4.44	0.029	19	4214.80	0.255	206.45	0.036	160	10	2	1.00	14

Figure 5.2: **Warm temperate Australian beaches: Species number vs Ω**
Showing a significant increase in number of species with dimensionless fall velocity (Ω)

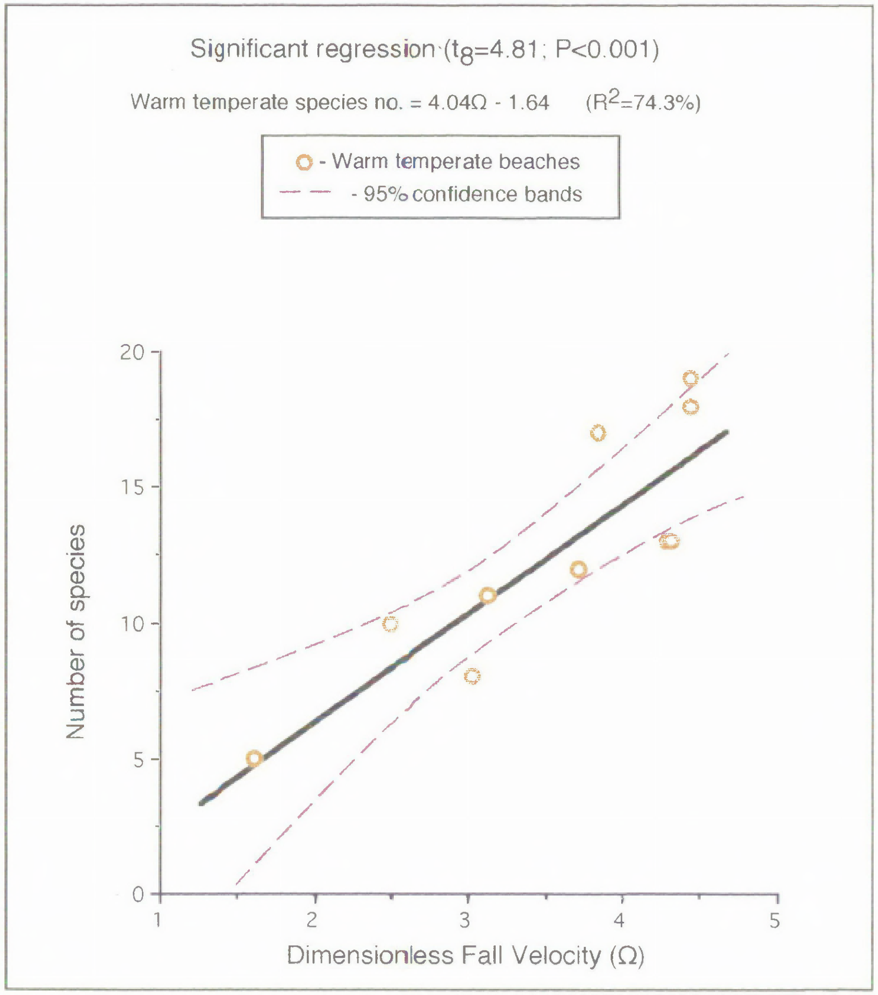


Figure 5.3: **Warm temperate Australian beaches: Abundance vs Ω**
Although a trend of increase is apparent, the total animal abundance data (per metre of beach) show a non-significant relationship with dimensionless fall velocity (Ω)

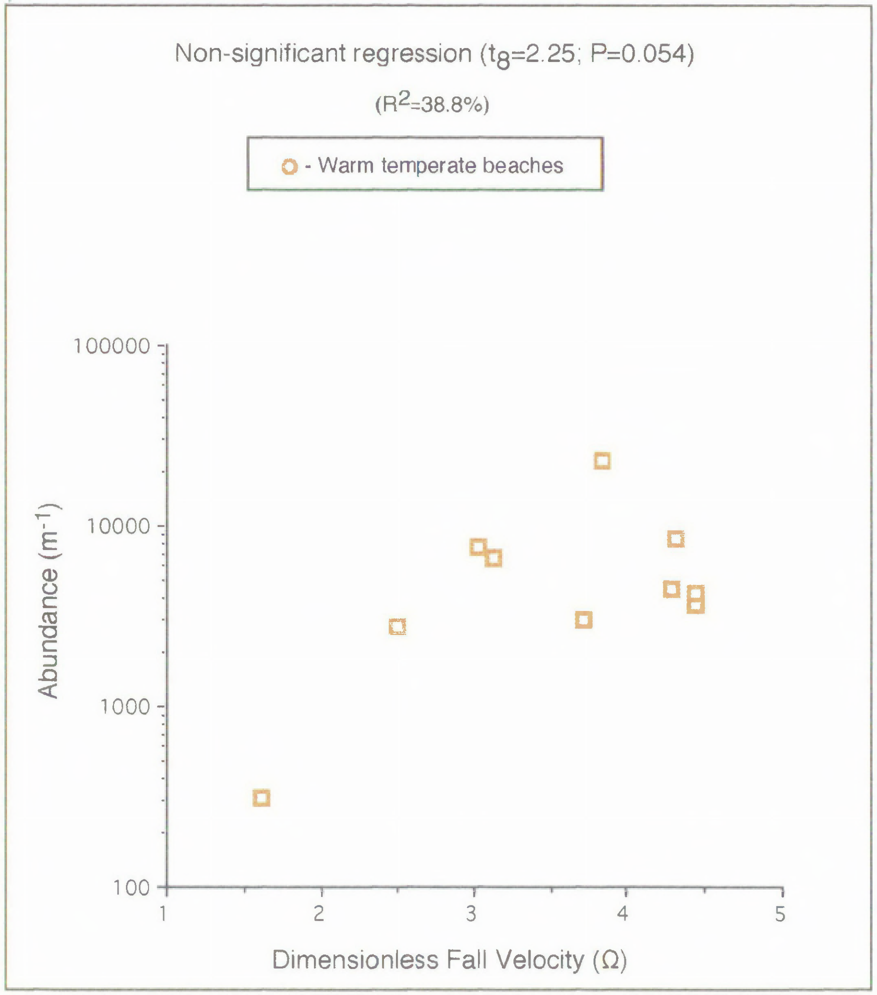


Figure 5.4: Warm temperate Australian beaches: Biomass vs Ω
Showing no significant relationship between total biomass (per metre beach) and dimensionless fall velocity (Ω)

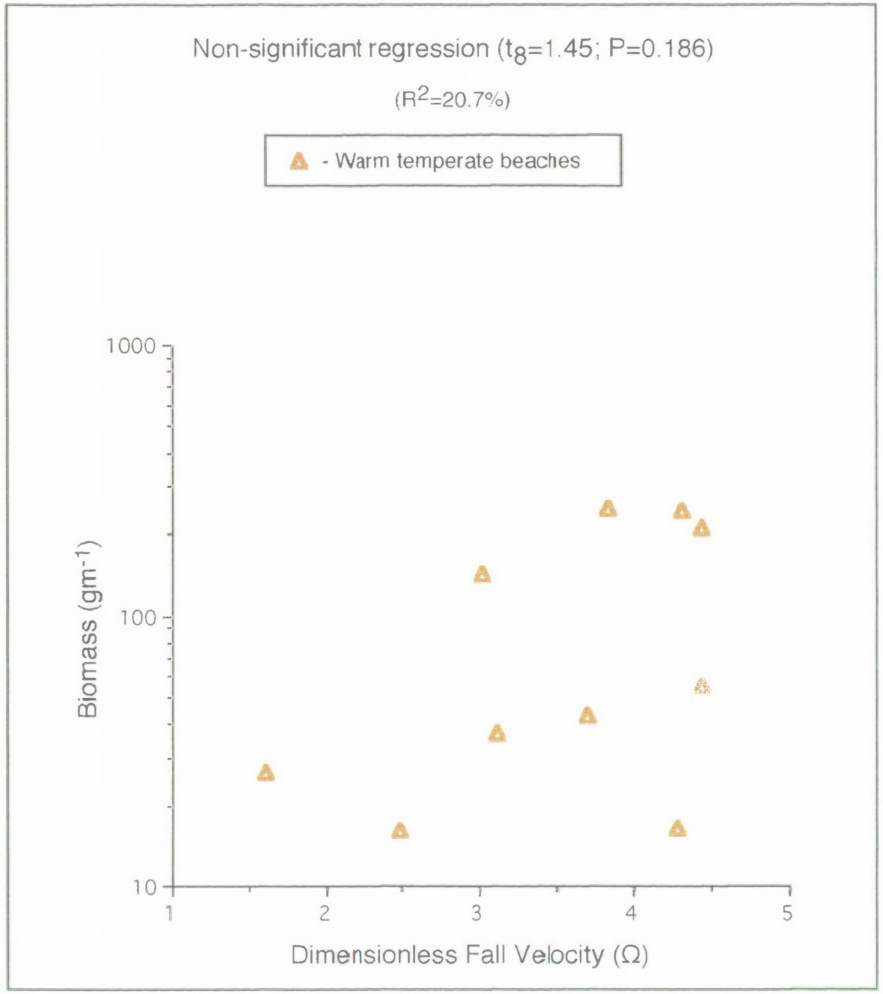


Figure 5.5: Warm temperate Australian beaches: Simpson's Index vs Ω
Showing no significant relationship between animal diversity (Simpson's Index) and dimensionless fall velocity (Ω)

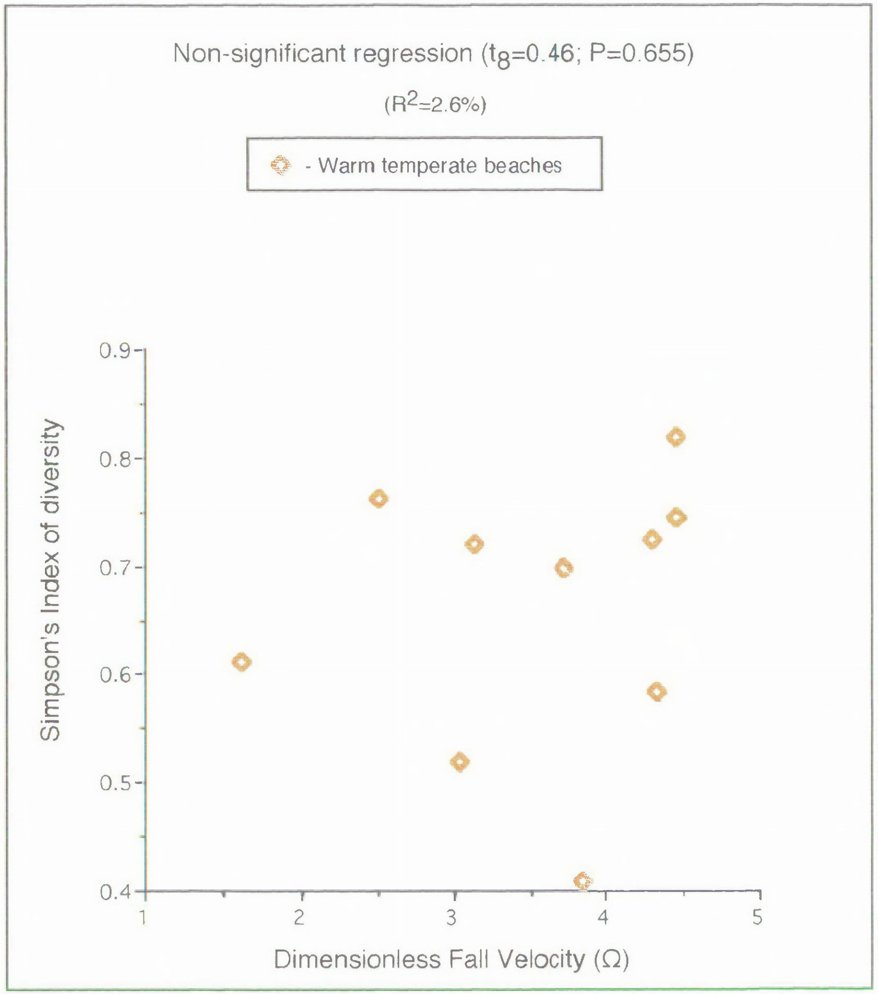


Figure 5.6: Warm temperate Australian beaches: Species number vs BSI
Showing a significant increase in number of species with Beach State Index (BSI)

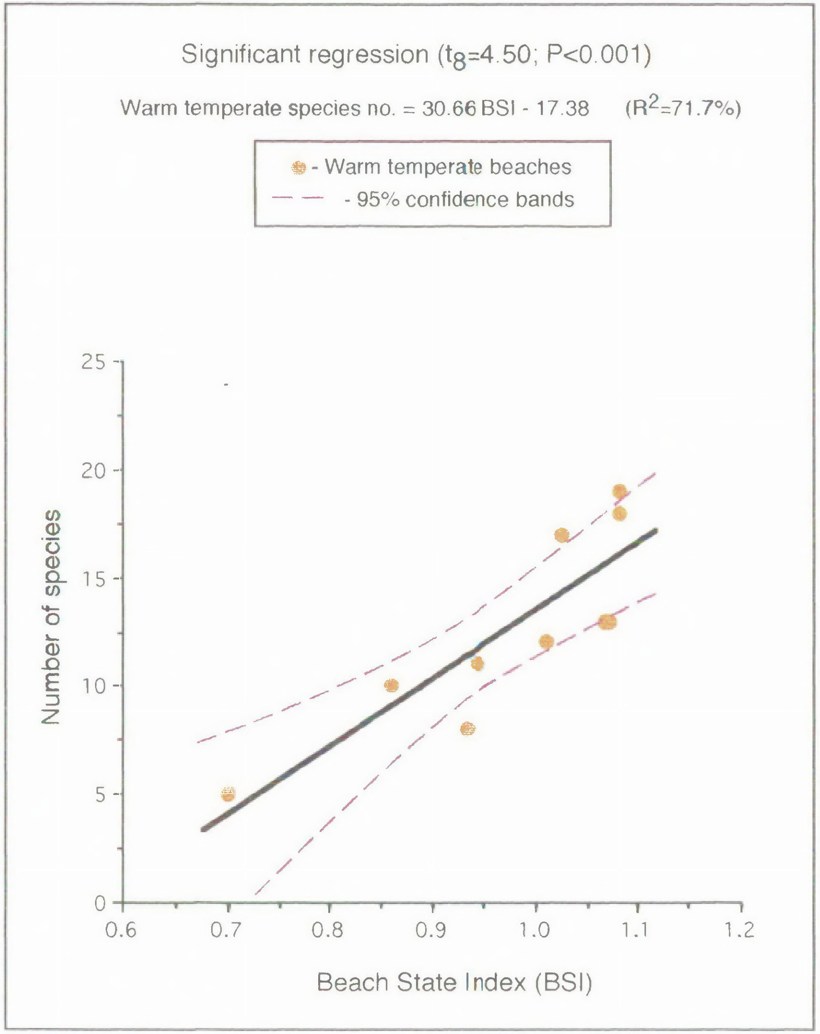


Figure 5.7: Warm temperate Australian beaches: Abundance vs BSI
Showing a significant increase in total animal abundance (per metre of beach) with Beach State Index (BSI)

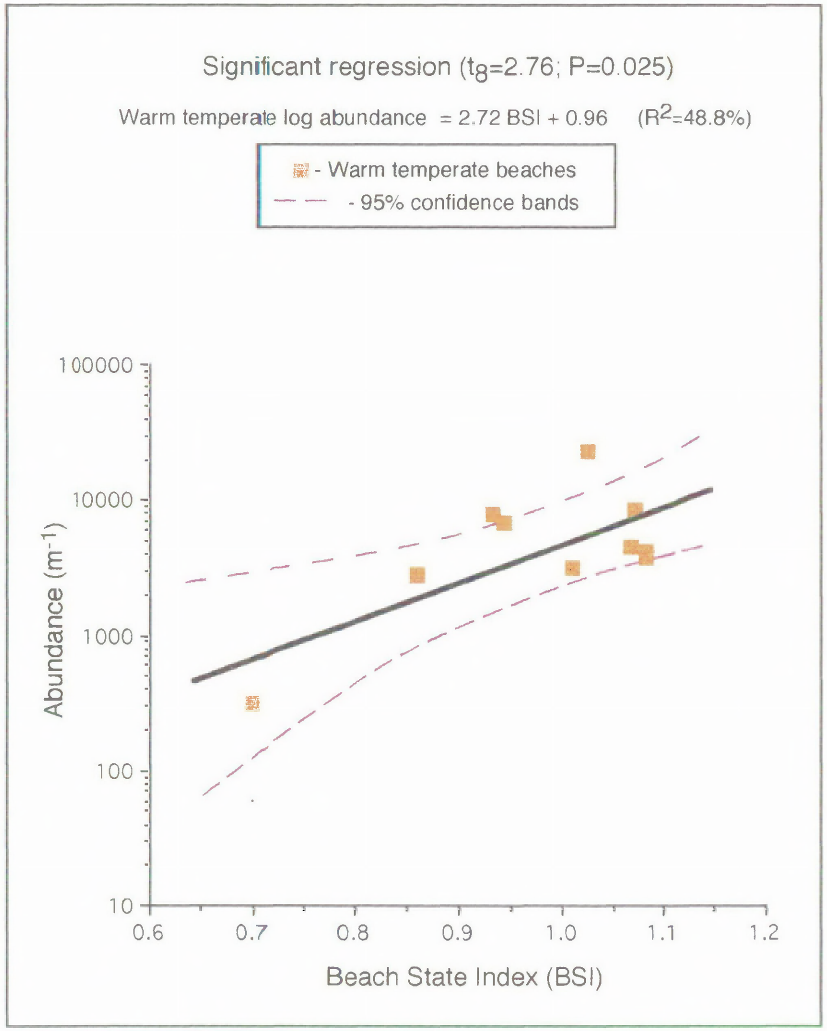


Figure 5.8: Warm temperate Australian beaches: Biomass vs BSI
Showing no significant relationship between total biomass (per metre beach) and Beach State Index (BSI)

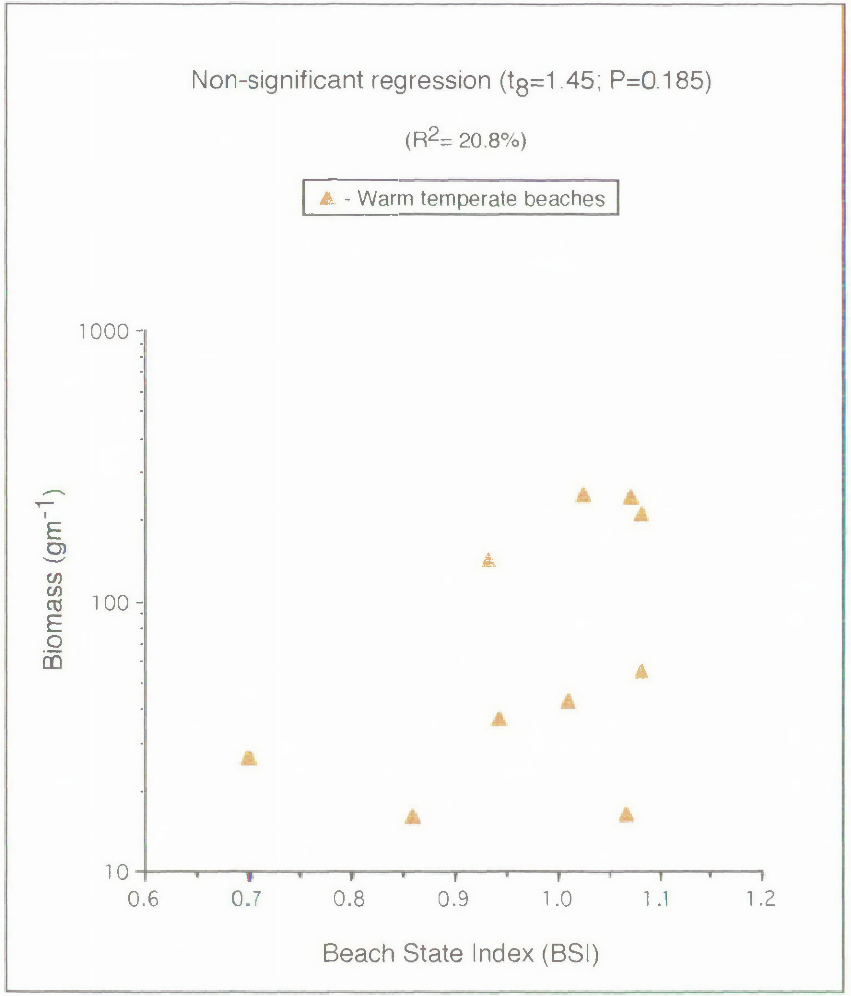


Figure 5.9: Warm temperate Australian beaches: Simpson's Index vs BSI
Showing no significant relationship between animal diversity (Simpson's Index) and Beach State Index (BSI)

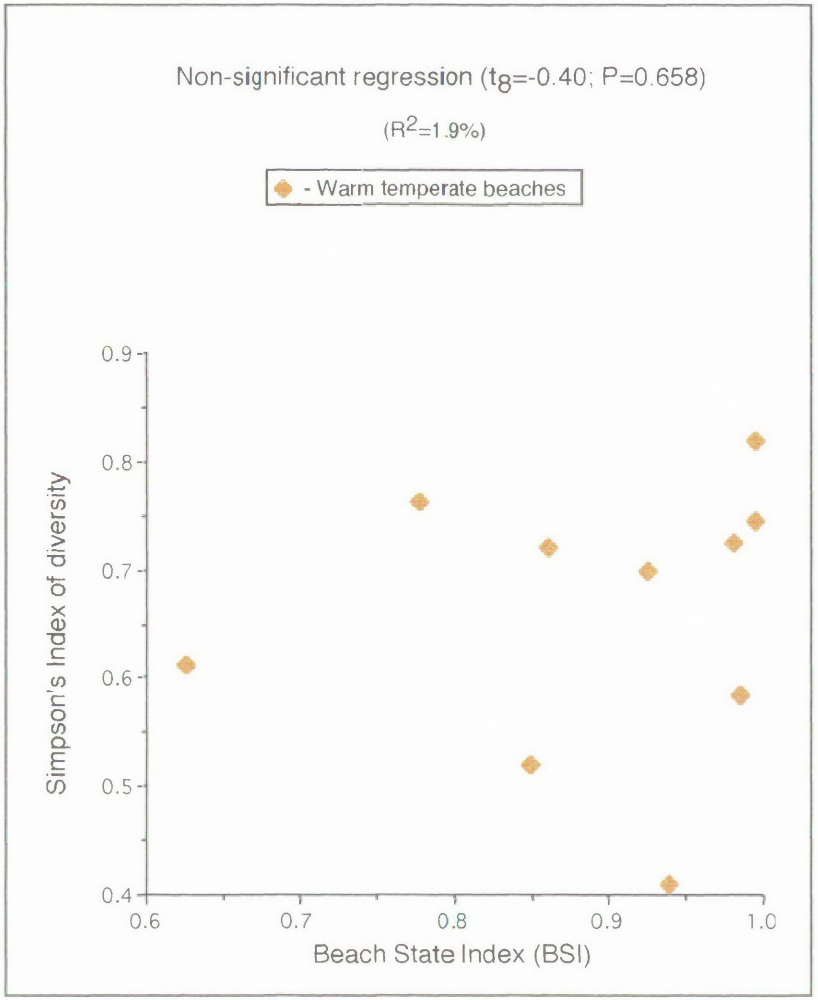


Figure 5.10:
Warm temperate Australian beaches: Log species number vs Ω
Showing a significant logarithmic increase in species number with dimensionless fall velocity (Ω) and an improved data fit over the linear model

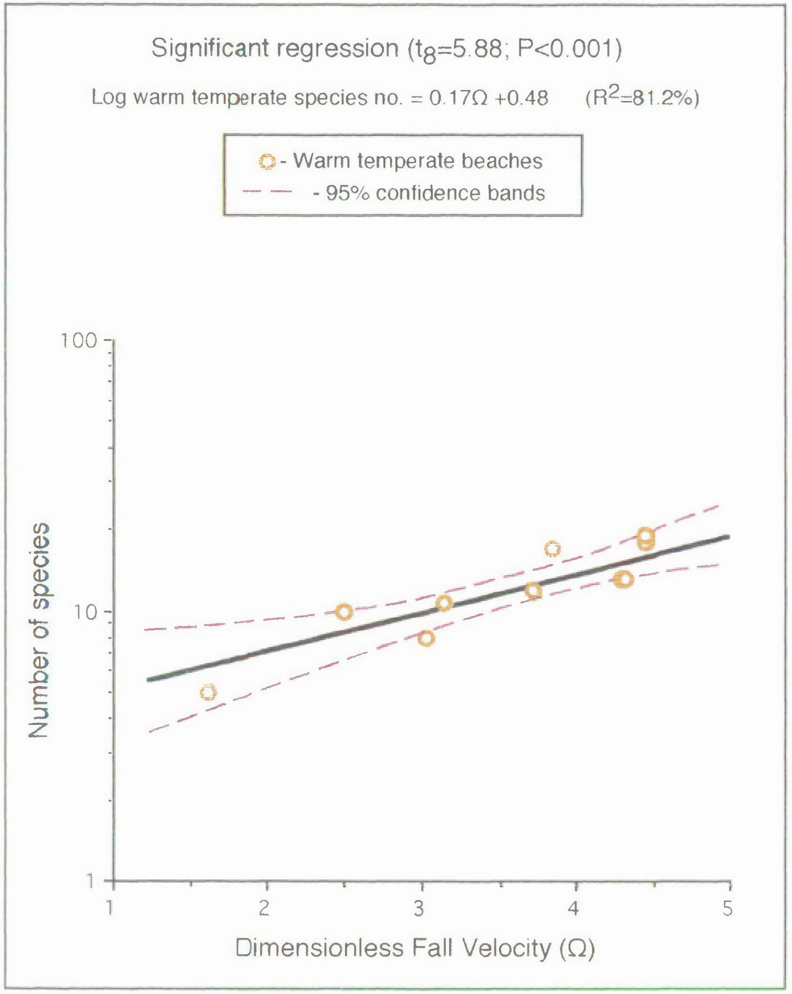
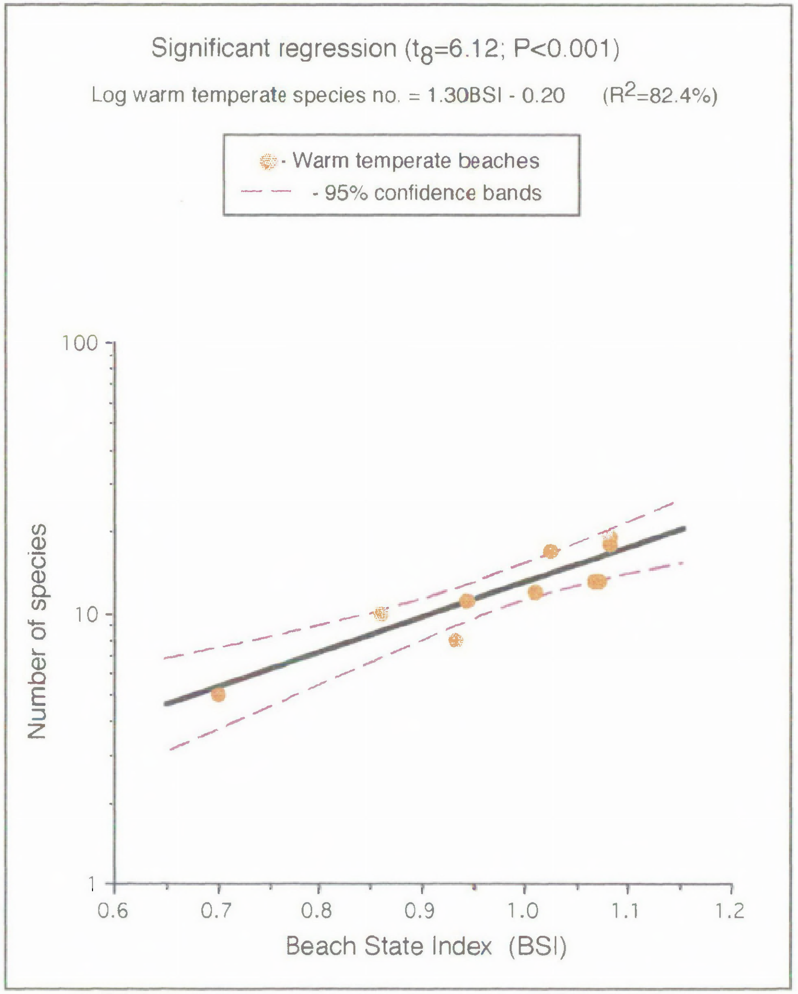


Figure 5.11:
Warm temperate Australian beaches: Log species number vs BSI
Showing a significant logarithmic increase in species number with Beach State Index (BSI) and an improved data fit over the linear model.



Log transformed species number values regressed against BSI show the highest coefficient of determination (R^2=82.4%) and thus, contrary to untransformed species numbers, BSI seems to produce the best predictions of macrofaunal species number overall for the beaches studied.

5.4 Discussion

Like the beaches of South Australia, the fit of the data using BSI as opposed to Ω decreased slightly for species number (untransformed) across the range of beach types studied. This is indicated by a small fall in R^2 values (Figs 5.2 and 5.6). However, the use of the BSI increased the fit of the abundance regression to make it significantly different form zero (Figs 5.3 and 5.7). This suggests that tidal effects (which are not incorporated into Ω) may influence animal abundance and that tidal range should be included when plotting beach morphodynamics versus macrofauna on even a small geographic scale.

Improved data fit means improved predictability of the composition of the macrofaunal community over the range of beaches. Along with demonstrating trends, this is a major consideration in this research. It may be that one index is superior at estimating species number and another for abundance in this area. This information is useful for the appropriate design of environmental impact surveys where biodiversity is often a major concern. This is further explored in chapter 7.

Like the cool temperate beaches, the results from the warm temperate area support that more dissipative beaches inhabit richer fauna. However, unlike past data, log transformation of species number improved the strength of the relationship and its predictions with both beach indexes (compare Figs 5.10 and 5.11 with 5.2 and 5.6). In both cases the significance of the regressions was enhanced over those of untransformed species number data. Thus, warm temperate Australian macrofaunal species appear to grow logarithmically in number with increasing dissipativeness of the beach system (ie. there is a large rate of increase towards higher values of Ω or BSI). The best fit for species number overall was log transformed species number plotted against BSI - which implies that tidal range (as a combined effect with other physical beach parameters) may also influence species number/beach state relationships within this particular region. Logarithmic increase in species number has not been reported in other work and may be a distinctive characteristic of beaches in northern N.S.W.

Unlike beaches of the cool temperate region, biomass results were more scattered in northern N.S.W., with the regression of log biomass not significant using either Ω or BSI as an index. This may be due to a greater influence of nutrient availability as opposed to control purely by physical factors. McLachlan (1990) showed biomass to correlate better with the simple parameter of wave energy (as compared to combinations of physical characteristics). Wave energy plays a large role in generating nutrients in the surf zone and flushing dissolved and particulate organics through the sand habitat. This, as a major food source for beach dwellers, may influence the biomass of the macrofauna, especially filter feeding organisms.

The South Australian beaches of the previous chapter experience persistently high ocean swells and high surf scaling parameters. This may have more consisently regulated nutrients through the beach system and eliminated some of the biomass variability otherwise potentially caused by limits of food resources. With this type of variability reduced, the cool temperate beaches showed a significant relationship between biomass and beach state. It is thus possible that the insignificance of the biomass regression for the warm temperate area is a result of the more variable wind/wave climate and associated nutrient input. However, it may also be that the insignificance of the biomass results for this region is an artefact of the small range of beach morphodynamic states ultimately available for sampling.

Like the beaches of the cool temperate area, Simpson's index of diversity showed no relationship with beach state for the warm temperate beaches. So, although species richness and abundance significantly increase with dissipativeness of the beach system, there is no corresponding trend in diversity (in terms of proportions of the animals present). Whether the community is composed of equal abundances of species or a mix of dominant and rare animals is clearly unrelated to the factors incorporated into the Ω and BSI formulae. Alternatively, variation compounded into the diversity index obscures any trends.

Again, despite the spatial variation within the beach system, significant trends in species number and abundance with the morphodynamic state of the sample transect have been found for beaches of warm temperate northern N.S.W, Australia.