CHAPTER 6
Community structure on tropical Australian beaches

6.1 Introduction

6.1.1 Physical characteristics of tropical Australian beaches

The tropical eastern Australian coastline is bordered by the Great Barrier Reef and small off-shore islands. Consequently, ocean swell is prevented from reaching the mainland coast and wave energy experienced by the beaches here is generally low. Additionally, the central Queensland coast experiences tide ranges of up to 10 metres (Masselink and Short, 1993) (Fig. 6.1). In general, the sands of this region are also fine and siliceous with some localities containing a substantial proportion of shell. In order to study as many tropical beach types as possible, two areas of differing tidal range were selected: Mackay and Yeppoon (see also Fig. 6.2).

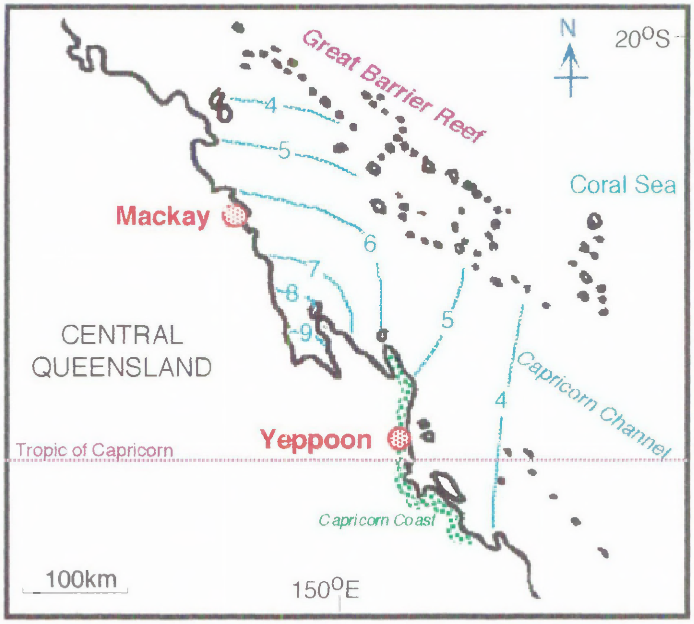


Figure 6.1 : Maximum tidal ranges in metres along the central Queensland coastline
[After Masselink and Short, 1993]

a) Mackay

In the Mackay region the continental shelf is extensive and the Great Barrier Reef is confined largely to the outer sea (Cannon and Goyen, 1992). However, the effects of numerous small mainland islands and their fringing reefs on wave energy has led to the beaches being shaped primarily by the large tidal influence. Surf zones, where they exist in this region, are small and as a result beaches are very level and grade into tidal flats.

b) Yeppoon/Capricorn Coast

This region is south of Mackay, yet beaches here also "feel" the presence of the Great Barrier Reef in terms of its limits on wave energy. However, there is some input to the mainland coast from the offshore wave regime owing to the presence of the Capricorn Channel - a stretch of relatively deep water seaward of the Keppel Islands (Fig. 6.1). Thus, wave action and the presence of a surf-zone are more dominant features of Capricorn Coast beaches than many beaches further north. Combined with the action of large tides, beaches and dunes of the Capricorn Coast are variable and complex with the relatively low lying shore punctuated by prominent headlands. These form a major sediment distribution control. The location of several small tidal inlets in the region may also exert considerable influence on adjacent beach behaviour (Beach Protection Authority, 1979)

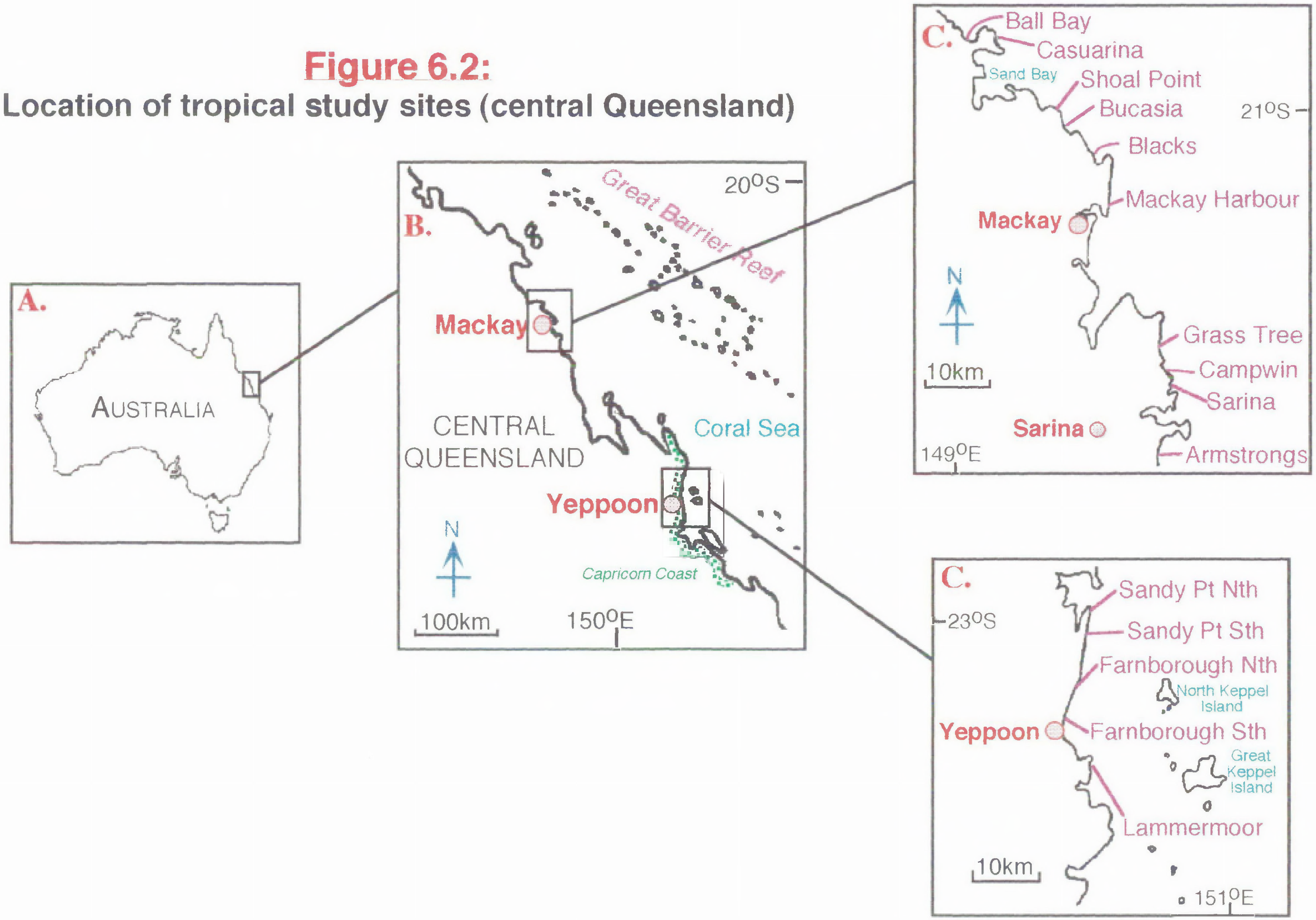
6.1.2 Aim

The aim was to investigate trends in species number, abundance, diversity (Simpson's Index) and biomass for a morphodynamic series of beaches (classified and compared according to Ω and BSI) in tropical Australia.

6.2 Materials and Methods

Ten beaches were selected for study in the Mackay region and five on the Capricorn Coast. Many of the selected beaches had been previously utilised by Masselink (1993) and Masselink and Short (1992) to provide the tidal beach morphodynamics models currently in use - they were thus chosen again for this related biological study. In the Mackay area the beaches included: Mackay Harbour, Blacks Beach, Sarina, Campwin, Grass Tree, Shoal Point, Bucasia, Armstrongs, Ball Bay and Casuarina Beach (Fig. 6.2). Near Yeppoon the beaches were: Lammermoor, Farnborough (North and South) and Sandy Point (North and South). Farnborough and Sandy Point beaches are, in

Figure 6.2:
Location of tropical study sites (central Queensland)



reality, part of a continuous beach/dune system about 20km long. Sandy Point is the northern extreme of this system where the beach widens and merges with a transgressive dune to form a long sandy spit (Fig. 6.2).

Beaches around Mackay were sampled at low tide each day from 10th-18th December, 1994; and at Yeppoon from 19th-21st December, 1994. Local weather during this entire period was hot, still and humid with some cloudy days. Sampling and analysis was conducted according to Chapter 3.

6.3 Results

The tropical beaches sampled in this study contained 69 species - dominated by polychaetes and crustaceans, yet also containing many different molluscs and insects. As the beaches became increasingly tide dominated, additional animal phyla were found: cnidarians (in the form of burrowing anemones) and echinoderms (including specially adapted star-fish, brittle stars, sand dollars and heart urchins)(Table 6.1).

The fifteen beaches studied were all exposed (McLachlan, 1980a) with wave height consistently low during the study at approximately 0.5m (Table 6.2). The sites ranged from low-tide terrace systems with a steep, reflective high tide beach at the low beach state extreme, through low gradient ultra-dissipative to almost tidal flats. Relative Tide Ranges were all >7 indicating the large intertidal dominance of shoaling waves over surf-zone swash.

The dimensionless fall velocity (Ω) showed significant relationships with macrofauna for species number and abundance (Figs 6.3 and 6.4), both parameters increasing with dissipativeness. Biomass values also showed a slight increase with Ω but remained marginally non-significant (Fig. 6.5). Simpson's Index of animal diversity showed no relationship with Ω (Fig. 6.6).

Use of the BSI tightened the beach state association with species number data (Fig. 6.7), however there was no significant regression with either abundance or biomass (Figs 6.8 and 6.9). Thus Ω remains the better association with the latter cases in terms of the significance of both the regression and R^2 values. Simpson's Index of diversity remained unrelated to beach state (Fig. 6.9).

Like the cool and warm temperate provinces, ambiguity of the residual plots (heterogeneity of variances) for species number suggested the testing of a logarithmic model. Like the warm temperate beaches, species number regressions with beach state

Table 6.1: Species composition at tropical Australian beaches (Central Queensland)
(Star (*) indicates presence)

	Lammer -moor	Farnb. South	Mackay Harbour	Blacks	Sandy Pt Sth	Sandy Pt Nth	Farnb. North	Sarina	Camp-win	Grass Tree	Shoal Point	Bucasia	Arm-strongs	Ball Bay	Cassuar -ina
MOLLUSCA															
Bivalvia															
Anisodanta cf. caledonica												*			
Donax brazieri							*								
Donax faba	*		*								*	*			
Donax sp.											*				
Dosinia nedigna													*	*	
Mactra pusilla						*					*				
Paphies elongata	*	*	*	*		*	*	*	*	*	*	*	*	*	*
Strigilla euronia	*	*					*								
Gastropoda															
Conuber conicus								*	*			*			
Neverita incei	*				*		*				*				
POLYCHAETA															
Arenicola bombayensis	*									*	*		*	*	*
Armandia sp #1														*	
Armandia sp #2														*	*
Axiothella sp.		*											*	*	
Barantola lepte													*		
Diopatra dentata													*		
Dispio glabrilamellata								*	*	*	*	*			*
Drilonereis sp.	*		*	*		*		*		*	*				
Glycera sp.	*	*		*	*	*			*	*	*	*	*	*	*
Hemipodus sp.	*	*	*	*	*	*	*	*	*		*	*	*		
Hirsutonuphis mariahursuta		*			*	*		*							
Hirsutonuphis sp.									*					*	
Lobochesis bibranchia	*		*	*	*		*	*				*	*		
Magelona sp.															*
Nepthys longipes	*	*			*	*	*								
Notomastus annulus			*	*	*	*		*		*	*				*
Ophelia multibranchiata		*	*					*							
Orbinia papillosa															*
Scolelepis cf. carunculata	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Scolelepis sp.		*	*	*	*		*		*	*	*	*			
Sigalion cf. oviger		*					*				*		*	*	
OLIGOCHAETA														*	
Oligochaete					*	*						*	*		
NEMERTEA															
Nemertean	*	*	*	*	*	*	*		*	*	*	*		*	*
CRUSTACEA															
Isopoda															
Actaecia pallida			*					*							
Pseudolana concinna	*	*	*		*	*	*	*	*	*	*	*	*	*	
Amphipoda															
Exoediceroides latrans															
Platyschnopis mirablis				*					*					*	*
Quadrivisio sp.								*	*	*			*		
Urohaustorius halei	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Urohaustorius metungi	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Talorchestia quadrimana					*				*		*			*	

Continued next page......

Table 6.1: (continued...)

	Lammer -moor	Farnb. South	Mackay Harbour	Blacks Beach	Sandy Pt Sth	Sandy Pt Nth	Farnb. North	Sarina	Camp-win	Grass Tree	Shoal Point	Bucasia	Arm-strongs	Ball Bay	Cassuar -ina
CRUSTACEA (continued...)															
Decapoda															
Albunaea symnista									*	*	*	*		*	
Diogenes ovarus													*		
Diogenes sp.							*				*				
Hymenosonatidae sp.													*		
Macropthalmus setosus													*		
Matuta sp.	*	*	*		*				*					*	*
Ocypode cordimana				*	*	*				*		*			
Mictyrus longicarpus		*					*			*	*			*	*
Scopimera inflata		*		*	*	*	*	*	*	*	*	*	*	*	*
Shrimps and Cumacea															
Botroiidae sp.															*
Callianassa australiensis			*	*			*			*	*	*	*	*	*
Haplostylus sp.			*	*	*	*	*	*	*		*				
Penaeus plebejus														*	*
INSECTA															
Blattodea (Blattaria) - cockroach													*		
Diptera larvae #1 - fly											*			*	*
Diptera larvae #2 - fly						*			*						*
Coleptera adult #1 - beetle	*			*			*	*	*	*		*	*		*
Coleptera adult #2 - beetle				*		*				*					
Coleoptera (Staphylinidae) - beetle	*														
Hemiptera (Gerridae) - water strider	*			*	*	*						*			*
Hymenoptera (Formicidae) - ant															*
CNIDARIA															
Actinaria #1 (burrowing anemone)											*				
Actinaria #2 (burrowing anemone)										*				*	
Actinaria #3 (burrowing anemone)													*		
ECHINODERMATA															
Amphiuridae sp. (brittle star)											*		*		
Australopectin vappa (starfish)											*				
Clypeasteroidea sp. (sand dollar)				*						*	*		*	*	
Spatangoidea sp. (heart urchin)															

Table 6.2: Raw data for tropical Australian beaches (central Queensland)

Beach	Beach State Index (BSI)	Deans Value (Ω)	Slope of beach face	Number of species	Abundance (log) m^{-1}	Simpsons Index (*D*)	Biomass (log) 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)
Lammermoor	1.12	1.98	0.033	19	16969.50	0.55	67.17	0.042	50	6	4.9	7.2	14
Farnb. Sth	1.18	2.31	0.025	18	21840.00	0.21	95.85	0.026	50	6	4.9	7.2	13
Mackay Harb	1.28	2.38	0.027	17	16404.75	0.19	315.61	0.042	50	5	6.0	9.8	13
Blacks	1.28	2.43	0.041	20	12268.00	0.19	14.50	0.041	50	5	6.0	9.8	14
Sandy Pt Sth	1.31	3.20	0.016	20	63270.00	0.24	259.37	0.026	50	6	4.9	7.2	14
Sandy Pt Nth	1.31	3.20	0.018	20	61965.00	0.27	208.87	0.026	50	6	4.9	7.2	14
Farnb. Nth	1.33	3.33	0.018	20	234626.25	0.72	374.56	0.025	50	6	4.9	7.2	14
Sarina	1.36	2.70	0.026	20	22312.50	0.29	100.35	0.037	50	5	6.5	9.8	13
Campwin	1.38	2.85	0.022	21	15840.00	0.18	93.10	0.035	50	5	6.5	9.8	13
Grass Tree	1.45	3.33	0.031	22	9956.25	0.22	90.20	0.030	50	5	6.5	9.8	13
Shoal Point	1.46	3.44	0.005	30	48262.50	0.11	1054.24	0.029	50	5	6.5	9.8	13
Bucasia	1.49	3.70	0.024	21	26400.00	0.18	400.08	0.027	50	5	6.5	9.8	11
Armstrongs	1.49	3.70	0.009	26	16447.20	0.08	1643.28	0.027	50	5	6.5	9.8	11
Ball Bay	1.60	4.76	0.014	26	313470.00	0.92	426.31	0.021	50	5	6.5	9.2	11
Cassuarina	1.62	5.00	0.025	24	274336.50	0.97	183.87	0.020	50	5	6.5	9.8	11

Figure 6.3:

Tropical Australian beaches: Species number vs Ω

Showing a significant increase in number of species with dimensionless fall velovity (Ω)

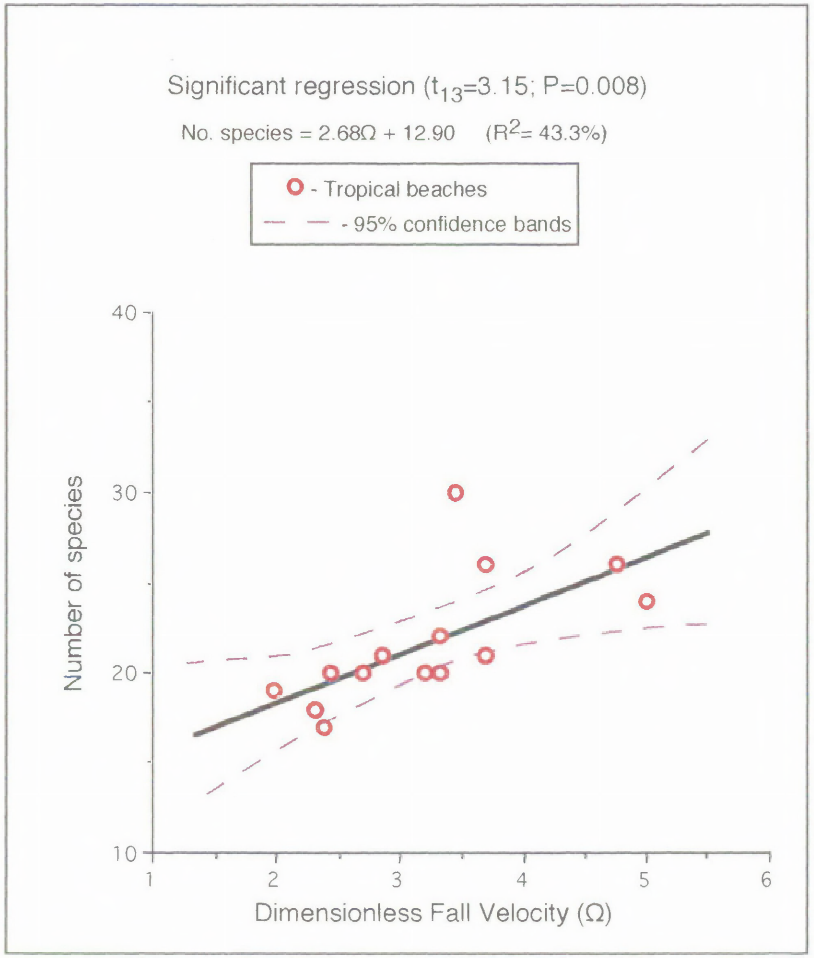


Figure 6.4:

Tropical Australian beaches: Abundance vs Ω

Showing a significant increase in total animal abundance (per metre of beach) with dimensionless fall velocity (Ω)

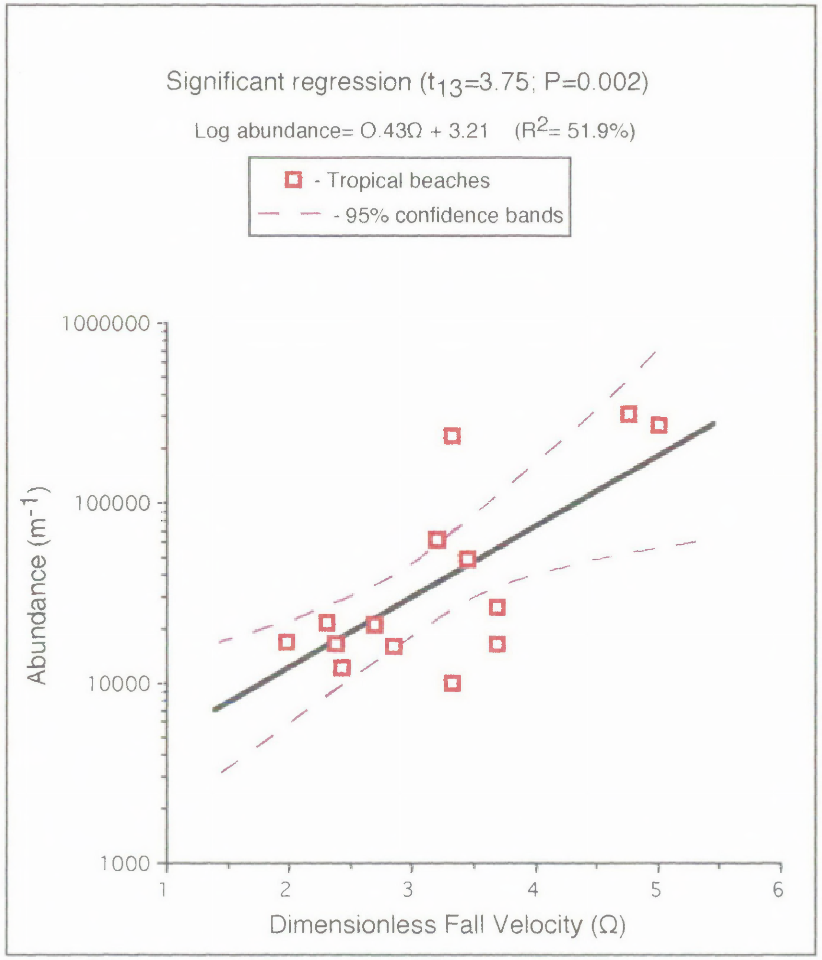


Figure 6.5:

Tropical Australian beaches: Biomass vs Ω

Showing no significant relationship between total biomass (per metre of beach) and dimensionless fall velocity (Ω)

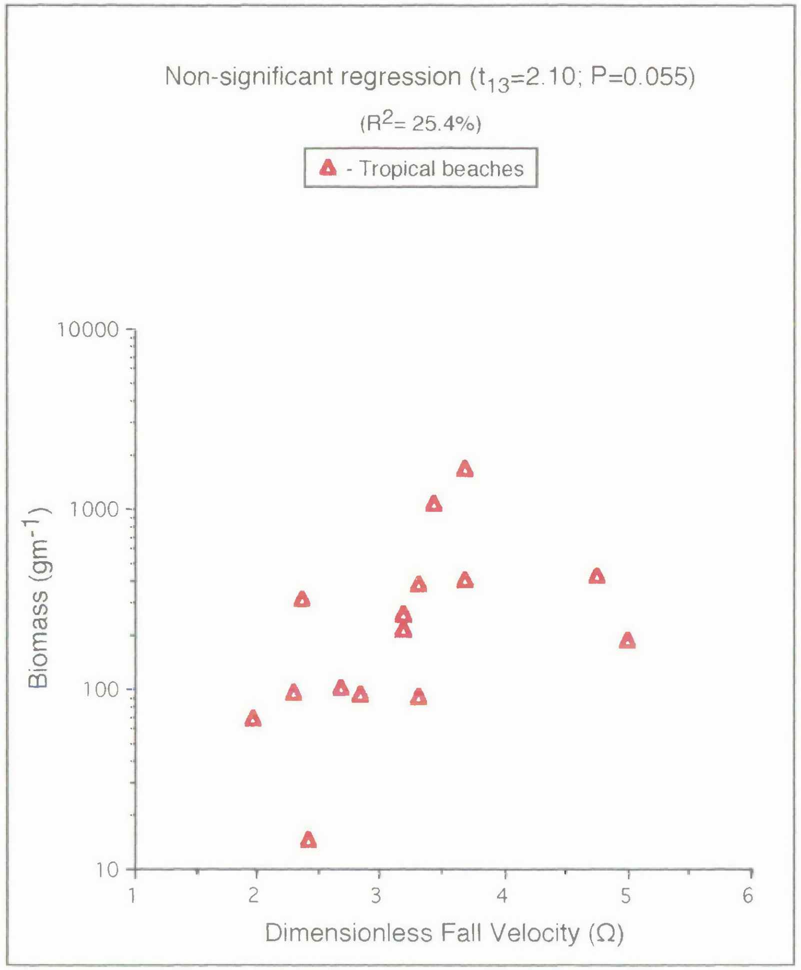


Figure 6.6:

Tropical Australian beaches: Simpson's Index vs Ω

Showing no significant relationship between animal diversity (Simpson's Index) and dimensionless fall velocity (Ω)

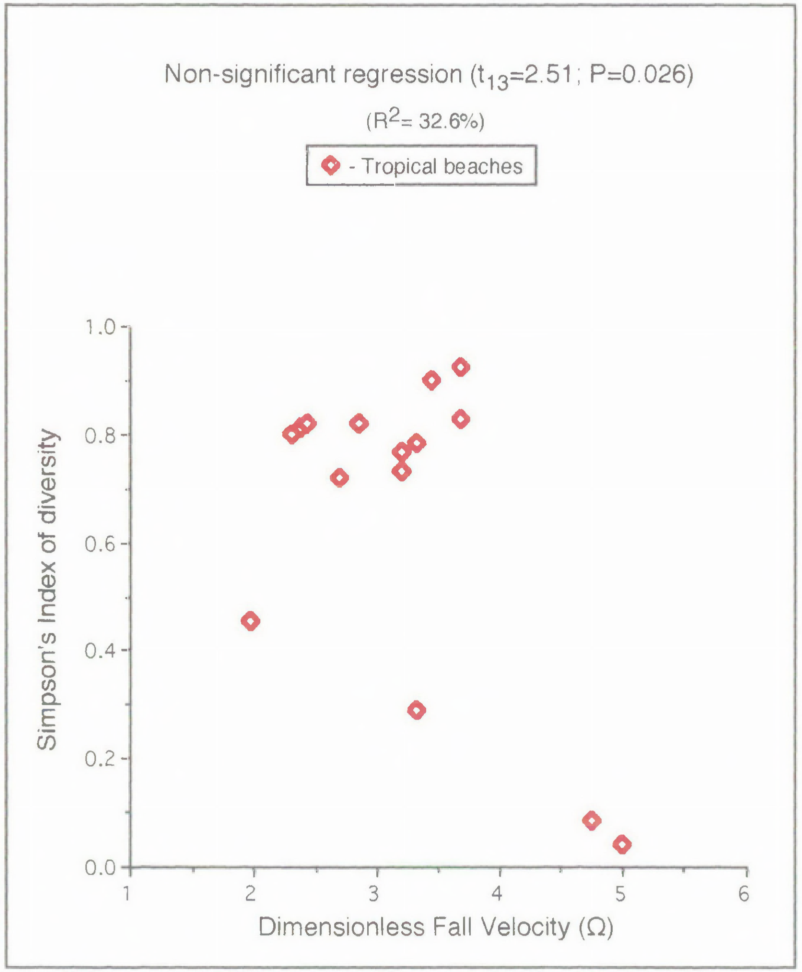


Figure 6.7:

Tropical Australian beaches: Species number vs BSI

Showing a significant increase in number of species with Beach State Index (BSI)

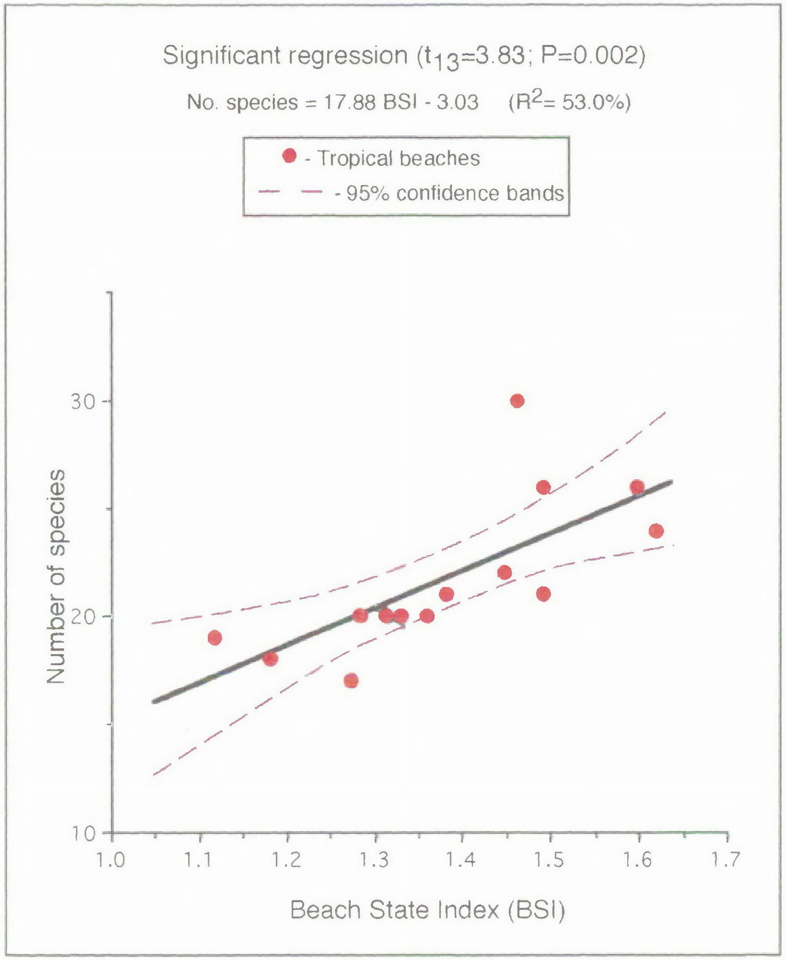


Figure 6.8:

Tropical Australian beaches: Abundance vs BSI

Showing no relationship between total animal abundance (per metre of beach) and Beach State Index (BSI)

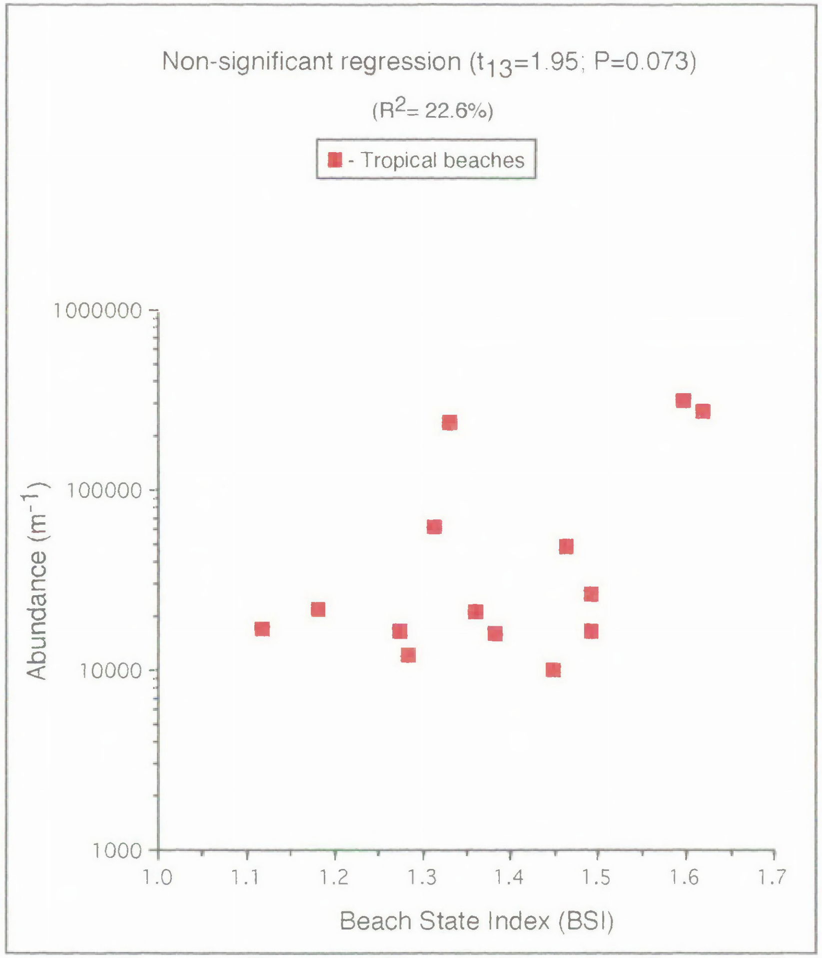


Figure 6.9:

Tropical Australian beaches: Biomass vs BSI

Although a trend of increase is apparent, the total animal biomass data (per metre beach) show no significant relationship with Beach State Index (BSI)

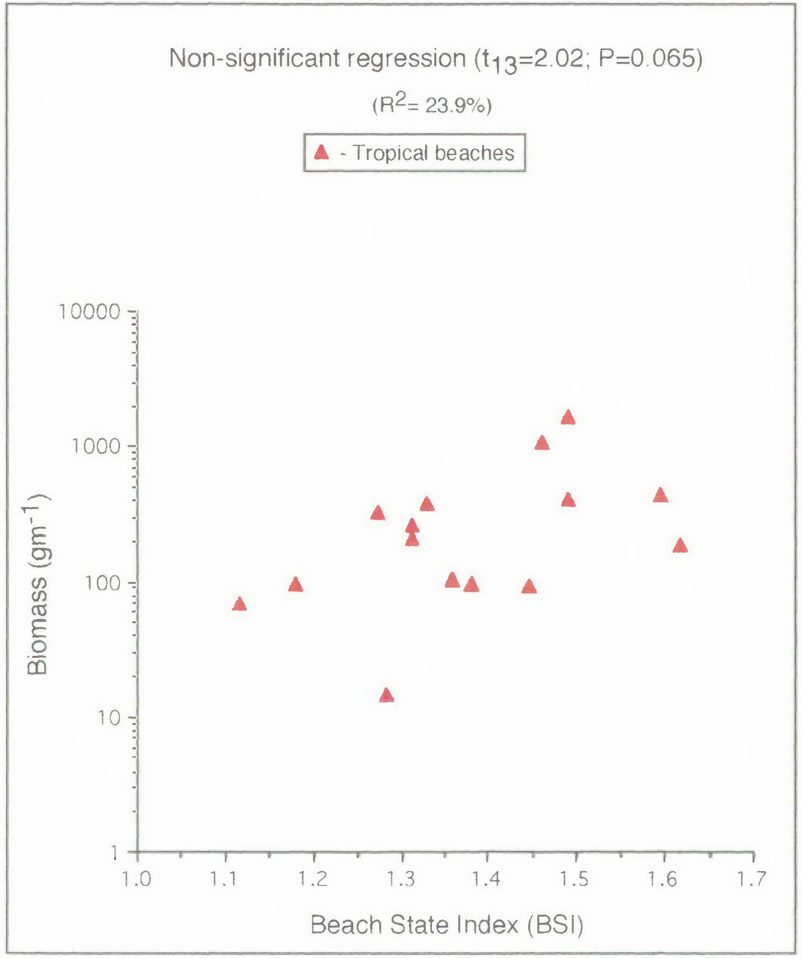


Figure 6.10:

Tropical Australian beaches: Simpson's Index vs BSI

Showing no significant relationship between animal diversity (Simpson's Index) and Beach State Index (BSI)

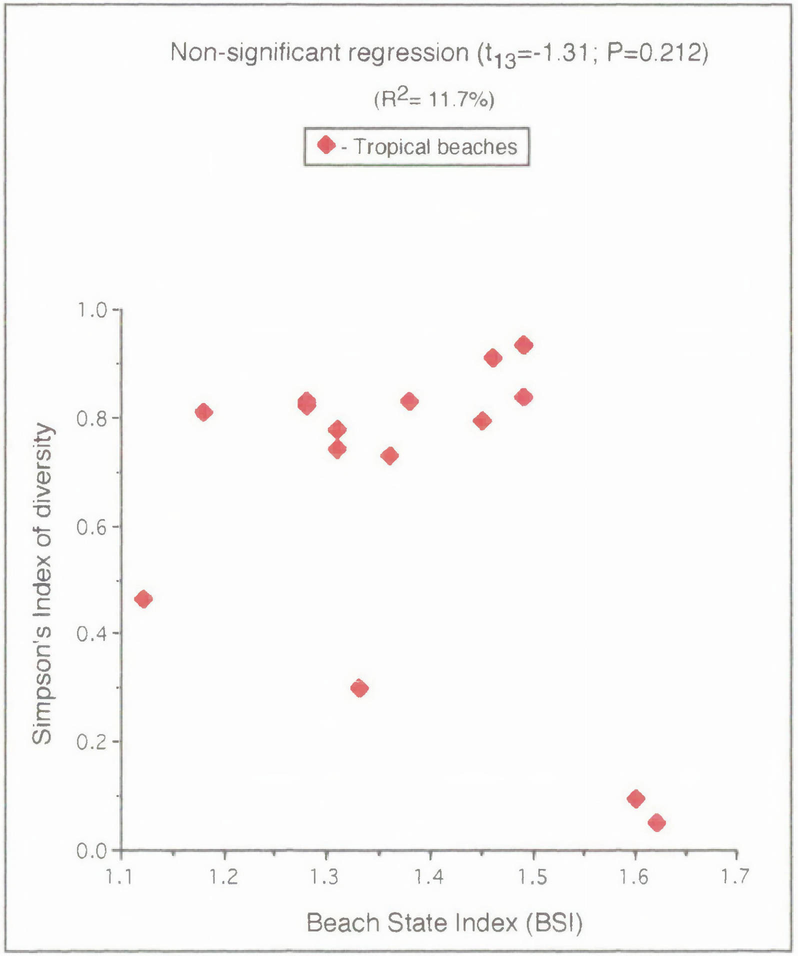


Figure 6.11:

Tropical Australian beaches: Log species number vs Ω

Showing a significant logarithmic increase in species number with dimensionless fall velocity (Ω) and an improved relationship over the linear model of Fig 6.3

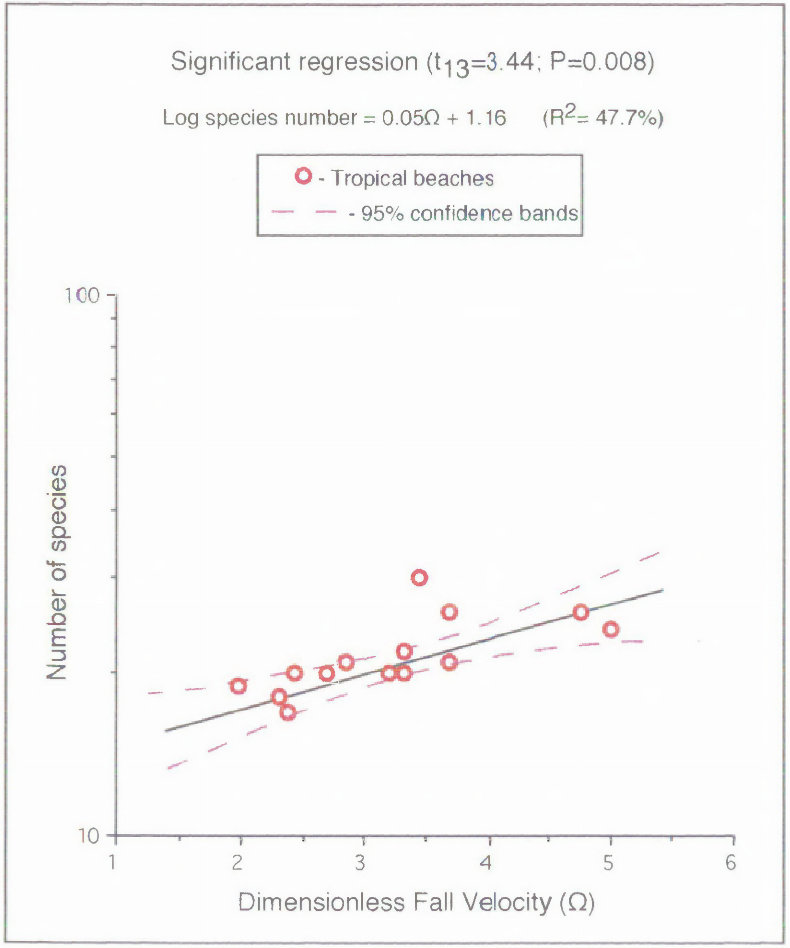
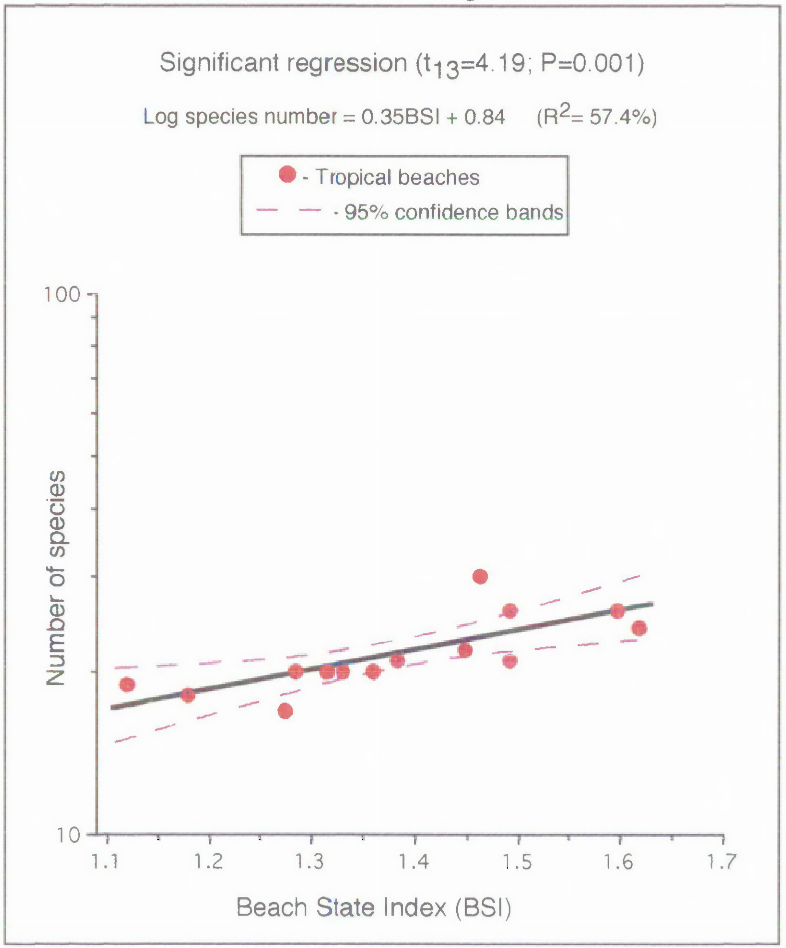


Figure 6.12:

Tropical Australian beaches: Log species number vs BSI

Showing a significant logarithmic increase in species number with Beach State Index (BSI) and an improved relationship over the linear model of Fig 6.7



were strengthened by log transformation of the data - log species number plotted against BSI providing the best fit within the tropical region (Figs 6.9 and 6.10).

6.4 Discussion

The tropical beaches of this study collectively contained nearly twice the number of species as their temperate neighbours, yet species number and abundance continued to increase with beach type in a similar manner. However, unlike the temperate regions, species number is best connected with BSI values rather than Ω (log-transformed or untransformed values). This is most likely related to the tidal differences between the beaches studied within the present region (unlike Ω, tidal range is incorporated into the BSI formula). Like the warm temperate beaches, the best model for species number in the tropical region was log transformed values regressed against BSI; the species counts for the beaches in the area appearing to increase at a growing rate with dissipativeness of the beach system

Abundance in the tropics, however, was most significantly correlated with Ω. This could indicate that tidal differences in the area affect animal populations less than wave and sediment regime. Because the wave height at the time of sampling was equal across all the beaches, growth in macrofaunal community abundance must be closely related to the decrease in sediment size and beach slope otherwise associated with ascending Ω values. This trend for faunal abundances has also been mathematically demonstrated for beaches in south-central Chile by Jaramillo and McLachlan (1993).

Using either index, increase in species and abundance with beach state again suggests the action of swash exclusion on the macrofauna across the beach types. As expressed by high Relative Tide Range values, tide has taken over as the primary force moving water across the intertidal zone on the tropical beaches studied. This water action is much less turbulent than that which is predominantly generated by waves; thus more and more animals can survive the intertidal climate. This is illustrated within the present beaches by the additional residence of slower animals such as echinoderms and anemones in the area of highest tidal range (around Mackay, Table 6.1). Also indicative of the more benign beach swash climate within the macro-tidal region is the intertidal occupancy by animals which construct more permanent burrows. Examples of these include the lug-worm (*Arenicola bombayensis*), yabby or ghost shrimp (*Callianassa australiensis*), eastern king prawn (*Penaeus plebejus*), mole crab (*Albunaea symnista*) and a cumacean (Botroiidae sp.).

Like beaches in the warm temperate region, biomass values for the tropical beaches were not significantly correlated with either beach index. This indicates that biomass is not essentially controlled by the present combinations of physical parameters, with only around 25% of the variation in the biomass data accounted for by Ω or BSI. Wave energy as a single parameter has been postulated as the primary physical limitation on biomass (McLachlan, 1990; refer also chapter 5); however, wave height in the area studied was continually low. The fact that wave action was consistently small across the tropical beaches may have resulted in a less sensitive response of macrofaunal biomass to the morphodynamic indexes making the relationship non-significant. Differences in sediment size (and therefore the potential retention of nutrients distributed by the large tides) may thus hold greater influence over animal weight in terms of physical factors on such beaches.

Like the beaches of the temperate regions, Simspon's index of diversity was unrelated to beach morphodynamic state. This may be a real result, or a consequence of the limited discriminatory power of the index due to compounding of species number and abundance variation. So, although species number shows a significant increase with dissipativeness of the beach in the tropical region, there is no corresponding trend in dominance diversity.

It is interesting to note that the coefficients of determination were low overall within the tropical province, perhaps hinting at the interplay of non-physical factors. Because biological interactions are more likely to occur in species rich communities (Krebs, 1985), competition and predation may be accountable for the higher variation in the data points. In chapter 7, trends in macrofaunal community composition with beach morphodynamic state are statistically compared across the cool temperate, warm temperate and tropical regions.