J. Sains & Teknologi, Desember 2007, Vol. 7 No. 3: 109–118 ISSN 1411-4674

SPATIAL DISTRIBUTION OF EPIFAUNA IN ARTIFICIAL AND NATURAL SEAGRASS (*Zostera capricorni*) BEDS

Khairul Amri

Faculty of Marine Science and Fisheries, Hasanuddin University

ABSTRACT

Declines of seagrass beds are frequently accompanied by fragmentation of larger beds into smaller patches. Manipulative experiment utilizing artificial seagrass units (ASUs) was done to examine the effect of factors related to fragmentation of seagrasses on abundance, diversity and composition of epifauna associated with seagrass. The experiment was conducted at Killarney Vale, Tuggerah Lakes, New South Wales to investigate the effects of distance from the source of colonizers, differences between the edge and middle areas of the patches and differences between artificial and natural seagrass. The results of the experiment showed that the distance from natural seagrass beds was an important factor for amphipods abundances and position within a patch (edge versus middle) was important for tanaids group, but not for other groups. There was no significant difference between artificial and natural seagrass beds in abundance of epifauna indicating that ASUs represent an adequate substitute for natural seagrasses for experimental purposes. In general, the study demonstrated that the effects of various factors related to fragmentation of seagrass beds have different effects on different groups of organisms.

Key words: Artificial seagrass units (ASUs), epifauna, fragmentation

INTRODUCTION

Natural fragmentation and human disturbances of seagrass meadow in shallow coastal waters frequently leads to habitat loss and increased levels of fragmentation (Frost *et al.*, 1999).

One crucial aspect of fragmented habitats that has received considerable attention is the role of habitat edges in influencing both species abundance and ecological process, especially predation (Bell *et al.*, 2001; Tanner, 2003). Edge zone where two habitats meet often contains high diversity of species because of high proportion of the species from both communities inhabit or utilize the area (Chapman and Reiss, 1998; Fox *et al.*, 1997). Thus, the ecological processes associated with edges may differ from those in the middle or interior habitats (Tanner, 2003).

For many years it was considered that edges were areas of high biodiversity and productivity due to the mixing of organisms from two separate habitats (Fox *et al.*, 1997; Tanner, 2003). In small patches, the probability of interception of larvae by the patch edge was increased (Eggleston *et al.*, 1999). However, more recently it has been recognized that edges may also have negative influences on some species due to increased predation risks (Paton, 1994; Peterson *et al.*, 2001; Tanner, 2003).

As the degree of habitat fragmentation increases, the proportion of edge to interior also increases (Bell *et al.*, 2001; Tanner, 2003). Therefore, those species preferring interior habitat can be greatly endangered by increased levels of habitat fragmentation (Fox *et al*, 1997).

This study will examine the hypotheses that (1) there will be greater abundance of epifauna in the edges than in the middle (interior) of the seagrass patches, (2) there will be differences in abundances of epifaunal organisms at different distances from natural seagrass bed.

To test whether ASUs provide an adequate habitat for epifauna, comparison was made on abundances and composition of epifaunal assemblages between artificial and natural seagrasses.

METHODS

Study site

The experiment was carried out at Killarney Vale, Tuggerah Lakes, New South Wales. As previous experiment has demonstrated that abundance of epifauna was significantly higher one month than four days after deployment of ASUs (Amri, 2003), this experiment was run for one month. Artificial seagrass units were deployed on July 10, 2003 and were sampled on August 12, 2003.

Experimental design and sampling

Artificial seagrass units were used to mimic patches of *Zostera capricorni*, the dominant seagrass species found in Tuggerah Lakes (West *et al*., 1989). The ASUs were deployed at two distances: close (0 m or adjacent to natural seagrass beds and far (15 m from natural seagrass beds). At each distance, four replicates of large patches containing 25 units (3.06 m^2) of artificial seagrass were set up. Distance between patches was approximately 5 m.

During sampling, in each patch of artificial seagrass units, two edges and two middle units were sampled using epifaunal sampler. Sampling of natural seagrass bed was also done in four patches. In each patch, two edges and two middle parts were sampled by this device.

Laboratory analysis

Collected samples were sieved to retain organisms > 500 µm. Samples were put under running water to separate animals from non-living components such as sand, plant wrack and shell debris.

All animals were stored into labelled jars. To preserve samples, 70 % ethanol was added to the jars.

Organisms were identified to the lowest possible taxa and were enumerated under a stereomicroscope.

Univariate statistical analysis

Three analysis using ANOVA were done to compare effects of edge versus middle, the effect of distance from the source of colonizers (natural seagrass beds) and the differences between natural and artificial seagrasses in the abundance of epifauna.

Multivariate Statistical Analysis

Multivariate techniques (nMDS, ANOSIM and SIMPER) were used to show patterns in the assemblages of taxa at different patches of artificial and natural seagrass beds. Six factor groups were examined in this analysis: Edge-Distance 1, Middle-Distance 1, Edge-Distance 2, Middle-Distance 2, Edge-Natural Bed and Middle-Natural Bed. Due to disproportional influence between common and scarce taxa, fourth root transformations were applied when constructing Bray-Curtis similarity matrices.

RESULTS AND DISCUSSION

General Findings

30820 individuals of epifaunal animals representing 15 taxa have been collected in this experiment. Epifaunal organisms colonizing artificial seagrass units showed much higher abundances compared to the previous experiment in the same location (Amri, 2003) despite the fact that this experiment was done during the coldest months of the year. Higher epifaunal abundances were found in artificial seagrass located far away from natural seagrass bed compared to natural seagrass and artificial patches close to natural bed. Both artificial seagrass habitats represented 75 % of overall organisms collected.

Similar to the previous experiment (Amri, 2003), amphipods and polychaetes were the two faunal groups collected in higher abundances than other groups. This trend agrees with some other previous studies that found that peracarid crustaceans and polychaetes were more abundant than other taxonomic groups in seagrasses and macroalgae (Virnstein and Howard, 1987; Edgar, 1990; Connolly, 1997). Sometimes amphipods occur in extremely high densities amongst seagrass or algae (Conlan, 1994).

Amphipods represented by genera *Ampithoe, Caprellidea, Melita*, *Gammaropsis, Paracalliope, Paracorophium*, and *Paradusa* constituted of 98.07 % in artificial seagrass distance 1, 96.43 % in artificial distance 2 and 96.78 % in natural bed.

Amphipod genera collected in this experiment had uneven distribution. *Gammaropsis* was the most abundant genus (82.21 – 89.95% from all individuals of amphipods). In contrast, genus *Ampithoe* only had one individual found in artificial seagrass adjacent to natural bed.

Patterns of epifaunal abundances

Amphipods were more abundant at distance 2 (figure 1). There was a significant difference between the two distances in abundance of amphipods (table 2). However, there was no significant difference in abundances of amphipods between edge and middle of the patches (table 1).

Figure 1. Mean (+SE; n = 2) abundance of Amphipods sampled from edge and middle parts of artificial and natural seagrass beds, Distance 1 = 0 m or adjacent to natural seagrass bed; Distance 2 = 15 m from natural seagrass bed. 1,2,3,4 are replicate patches. Patches 1 and 2 for middle part at distances 1 and 2 are absent due to the losses of the ASUs during the experiment.

Polychaetes were the second most abundant groups in this experiment. There was no significant difference between edge and middle of the patch and between distances in abundance of polychaetes.

Bivalves and gastropods were found in low abundances. There were no differences in distribution of these groups with respect to edge versus middle and between distances.

Abundances of tanaids were significantly different between edge and middle of the patches, but did not differ between distances. Isopods were also found in low abundances. This group did not show any consistent differences between distances or between middle and edge of the patches.

Among the six taxonomic groups, only tanaids showed a significant difference between edges and middle parts of the seagrass patches. A study by Bell *et al.* (2001) found little evidence that any taxonomic group is sensitive to fragmentation and prefers to utilize edge or middle areas of seagrass patches. However, they found that infaunal polychaete, *Kingbergonuphis simoni* had significantly lower densities at the edge areas of *Halodule* beds. In contrast, Tanner (2003) found that most of crustacean taxa exhibited a clear response to the boundary between sand and seagrass. He found that in most cases, the highest abundances were near the habitat boundary, and declined towards the interior of the seagrass patch.

Comparison between abundance of epifaunal at different distances (0 and 15 m) from natural seagrass bed indicated that amphipods were more abundant at a distance 15 m from seagrass bed. Other groups did not show any significant differences. This result was different from the result of the previous experiment in the same location which found that distances were not significant for amphipods but significant for polychaetes and bivalves (Amri, 2003). Virnstein and Curran (1986) found that crustacean abundance increased with distance from vegetation and was significantly greater at both 5 and 15 m than closer to the natural seagrass beds.

Colonization patterns in seagrass beds often reflected the dispersal abilities of the colonizers. Some organisms are actively migrating within and between patches of seagrass and choice of suitable habitats (Virstein and Curran, 1986: Sogard, 1989; Boström and Bonsdorff, 2000). While passive dispersal is driven by the hydrodynamic environment modified by seagrass structures (Boström and Bonsdorff, 2000). Virnstein and Curran (1986) found that most crustacean species exhibited a pattern of increasing abundance with distance from the seagrass bed, while gastropods and hermit crabs that crawl on the sediment surface decreased in abundance with increasing distance. Crustacean species such as amphipods with good swimming ability exercise active choice of substrate in which to hide and forage (Boström and Bonsdorff, 2000; Tanaka and Leite, 2003).

Table 1. Results of analysis of variance (GMAV5) of the abundance of amphipods, polychaetes, bivalves, gastropods, tanaids and isopods. Data were untransformed unless specified. MS = Mean square; *P* = Level of probability; * *P* < 0.05; NS = Not Significant; DF = Degrees of Freedom; C = Cochran's test; EM = Edge vs Middle; Di = Distance; Pa = Patch.

		Amphipods $C = 0.53^{NS}$			**Polychaetes** $C = 0.67^{NS}$			**Bivalves** $C = 0.65^{NS}$		
Sources of Variation	**DF**	**MS**	**F**	***P***	**MS**	**F**	***P***	**MS**	**F**	***P***
EM	1	1207251.56	5.21	0.15^{NS}	76.56	0.06	0.82^{NS}	20.25	0.95	0.43^{NS}
Di	1	503035.56	14.96	0.06^{NS}	115.56	0.31	0.63^{NS}	0.25	0.02	0.90^{NS}
Pa (Di)	2	33634.81	0.26	0.78^{NS}	371.56	0.49	0.63^{NS}	11.25	0.69	0.53^{NS}
EM x Di	1	27972.56	0.12	0.76^{NS}	162.56	0.14	0.75^{NS}	2.25	0.11	0.78^{NS}
EM x Pa (Di)	2	231595.81	1.77	0.23^{NS}	1193.31	1.58	0.26^{NS}	21.25	1.31	0.32^{NS}
Residual	8	130590.81			752.94			16.25		
Total	15									
		Gastropods^{trans} $C = 0.50^{NS}$			**Tanaids** $C = 0.50$			**Isopods** $C = 0.57^{NS}$		
Sources of Variation	**DF**	**MS**	**F**	***P***	**MS**	**F**	***P***	**MS**	**F**	***P***
EM	1	0.48	4.00	0.18^{NS}	60.06	25.97	0.04^{*}	2.25	1.80	0.31^{NS}
Di	1	0.48	4.00	0.18^{NS}	5.06	0.80	0.47^{NS}	0.25	0.20	0.70^{NS}
Pa (Di)	2	0.12	2.00	0.20^{NS}	6.31	0.78	0.49^{NS}	1.25	0.71	0.52^{NS}
EM x Di	1	0.48	4.00	0.18^{NS}	1.56	0.68	0.50^{NS}	0.25	0.20	0.70^{NS}
EM x Pa (Di)	2	0.12	2.00	0.20^{NS}	2.31	0.29	0.76^{NS}	1.25	0.71	0.52^{NS}
Residual	8	0.06			8.06			1.75		
Total	15									

trans = Transformed to Ln (x+1) before analysis

Table 2. Results of analysis of variance (GMAV5) of the abundance of amphipods, polychaetes, bivalves, gastropods, tanaids and isopods. Data were untransformed unless specified. MS = Mean square; *P* = Level of probability; * $P < 0.05$; NS = Not Significant; DF = Degrees of Freedom; C = Cochran's test; Di = Distance; Pa = Patch.

		Amphipods $C = 0.53^{NS}$			**Polychaetes** $C = 0.67^{NS}$			**Bivalves^{trans}** $C = 0.50^{NS}$		
Sources of Variation	**DF**	**MS**	**F**	***P***	**MS**	**F**	***P***	**MS**	**F**	***P***
Di	1	1022121.00	8.50	0.03^{*}	7482.25	2.01	0.21^{NS}	1.54	4.85	0.07^{NS}
Pa (Di)	6	120316.96	0.91	0.53^{NS}	3722.46	3.26	0.06^{NS}	0.32	0.53	0.77^{NS}
Residual	8	132339.38			1142.75			0.60		
Total	15									
		Gastropods^{trans} $C = 0.78^{*}$			**Tanaids^{trans}** $C = 0.48^{NS}$			**Isopods^{trans}** $C = 1.00^{**}$		
Sources of Variation	**DF**	**MS**	**F**	***P***	**MS**	**F**	***P***	**MS**	**F**	***P***
Di	1	0.18	0.35	0.58^{NS}	0.005	0.02	0.91^{NS}	0.03	1.00	0.36^{NS}
Pa (Di)	6	0.50	0.82	0.59^{NS}	0.30	0.62	0.71^{NS}	0.03	1.00	0.49^{NS}
Residual	8	0.62			0.49			0.03		
Total	15									

trans = Transformed to Ln (x+1) before analysis

There were no significant differences in abundances of epifauna between natural seagrasses and ASUs adjacent to them (table 3).

Table 3. Results of analysis of variance (GMAV5) of the abundance of amphipods, polychaetes, bivalves, gastropods, tanaids and isopods. Data were untransformed unless specified. MS = Mean square; *P* = Level of probability; * $P < 0.05$; NS = Not Significant; DF = Degrees of Freedom; C = Cochran's test; NA = Natural vs Artificial; EM = Edge vs Middle; Pa= Patch.

		Amphipods $C = 0.34^{NS}$			**Polychaetes** $C = 0.67^{NS}$			**Bivalves** $C = 0.65^{NS}$		
Sources of Variation	**DF**	**MS**	**F**	***P***	**MS**	**F**	***P***	**MS**	**F**	***P***
NA	1	74256.25	0.66	0.50^{NS}	76.56	0.17	0.72^{NS}	20.25	16.20	0.06^{NS}
EM	1	127806.25	8.35	0.10^{NS}	115.56	0.10	0.78^{NS}	0.25	0.01	0.94^{NS}
Pa (NA)	2	113236.25	3.44	0.08^{NS}	456.31	0.61	0.57^{NS}	1.25	0.08	0.93^{NS}
NA x EM	1	34040.25	2.22	0.27^{NS}	162.56	0.15	0.74^{NS}	2.25	0.07	0.81^{NS}
EM x Pa(NA)	2	15311.25	0.47	0.64^{NS}	1108.56	1.47	0.29^{NS}	31.25	1.92	0.21^{NS}
Residual	8	32895.00			752.94			16.25		
Total	15									
		Gastropods^{trans} $C = 0.50^{NS}$			**Tanaids** $C = 0.50^{NS}$			**Isopods** $C = 0.57^{NS}$		
Sources of Variation	**DF**	**MS**	**F**	***P***	**MS**	**F**	***P***	**MS**	**F**	***P***
NA	1	0.48	4.00	0.18^{NS}	60.06	18.13	0.05^{NS}	2.25	1.80	0.31^{NS}
EM	1	0.48	4.00	0.18^{NS}	5.06	0.95	0.43^{NS}	0.25	0.20	0.70^{NS}
Pa (NA)	2	0.12	2.00	0.20^{NS}	3.31	0.41	0.68^{NS}	1.25	0.71	0.52^{NS}
NA x EM	1	0.48	4.00	0.18^{NS}	1.56	0.29	0.64^{NS}	0.25	0.20	0.70^{NS}
EM x Pa(NA)	2	0.12	2.00	0.20^{NS}	5.31	0.66	0.54^{NS}	1.25	0.71	0.52^{NS}
Residual	8	0.06			8.06			1.75		
Total	15									

trans = Transformed to Ln (x+1) before analysis

Multivariate Analysis

Multivariate analysis of epifaunal assemblages using non-metric multi-dimensional scaling (nMDS) of all taxa in six categories (figure 2) did not show a distinguishable pattern in the structure of epifaunal assemblages.

ANOSIM test supported the pattern as shown in the nMDS plot. There were no significant differences for all pairwise comparisons between patches. Their significance levels were ranging between 8.6 – 80.0 %.

SIMPER analysis indicated high similarity among groups. The average similarity was ranged from 71.71 – 80.38 %. The table also showed that two genera of amphipods, *Gammaropsis* and *Paracalliope* consistently had the highest contribution to the average similarity within their groups.

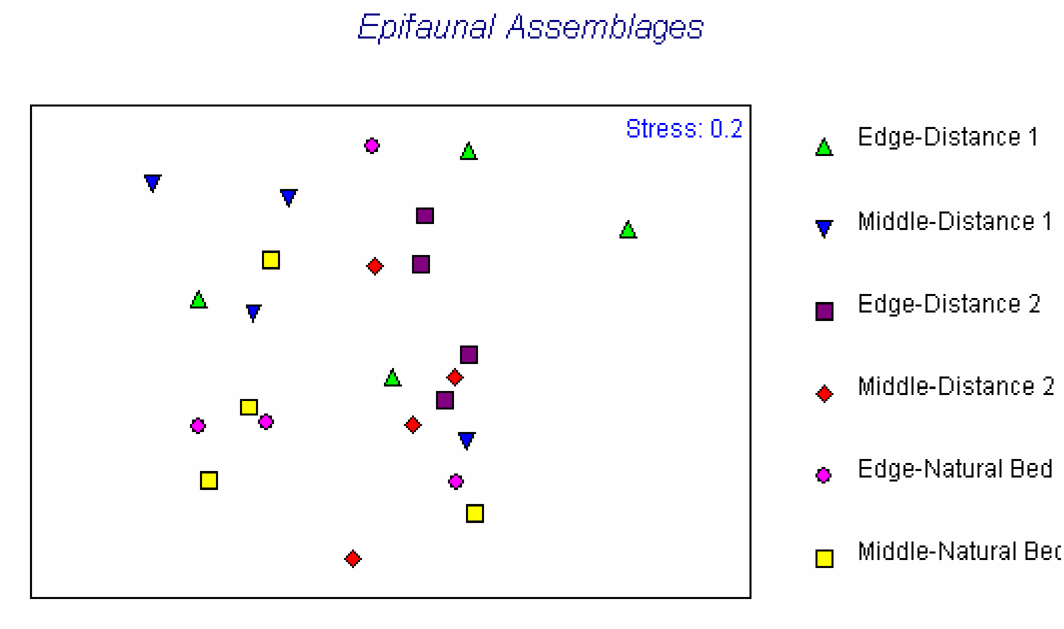

Figure 2. nMDS ordination of epifaunal assemblages. The similarity matrix was calculated by the Bray-Curtis index with a fourth root transformation of data.

Comparisons between natural and artificial seagrass beds did not show significant differences for any epifaunal groups, which is consistent with the results of some other studies. For example, Kenyon *et al.* (1999) found that the postlarvae and juveniles of crustaceans and fish used ASUs in similar way to natural seagrass. Upston and Booth (2003) investigating settlement and density of juvenile fish assemblages in natural and artificial *Zostera capricorni* found a similar result. Bell *et al.* (1985) deployed ASUs for 6 weeks and they found that ASUs were colonized by fewer species than natural *Zostera* beds but there was no significant difference in number of individuals.

Some studies showed that abundance and diversity of epifauna increase with abundance and morphological complexity of seagrass (Mukai *et al.*, 1999; Atrill *et al.*, 2000). Seagrass increases habitat complexity and provides living space and shelter for a greater variety of animal species and greater abundances of individuals than the adjacent unvegetated habitats (Mattila *et al.*, 1999; Parker *et al.*, 2001). More complex habitat may offer greater protection from predators (Jenkins *et al.*, 1997). It is likely that changes in habitat complexity will affect predation rates. In particular, predation rates were dramatically enhanced along the edge in seagrass (Smith, 2001). Potential predators might find it easier to locate and catch prey over an unvegetated habitat (Peterson *et al.*, 2001).

Higher abundance of epifauna colonising artificial seagrass units placed in unvegetated substrate supported the nearest refuge hypothesis where mobile fauna must look for refuge when visual contact with predators occurred. (Virstein and Curran, 1986; Bologna and Heck, 1999). Therefore, ASUs in unvegetated areas become the islands of refuge in inhospitable habitat and may accumulate individuals (Bologna and Heck, 1999). Besides reducing predation pressure, seagrass structure may also act as shelter from extreme environmental fluctuations during low tide periods (Lee *et al.*, 2001). The availability of structures providing refuge may strongly affect survival, distribution and abundance of small benthic crustaceans (Beck, 1995; Herrnkind *et al.*, 1997).

All of these results demonstrate that ASUs represent an adequate habitat and a good experimental tool for studying factors influencing distribution and abundance of epifauna.

CONCLUSION

The study found that amphipods were significantly more abundant in artificial seagrass habitats deployed far away than closer to natural beds. This finding supported the importance of seagrass structures as refuge from predation pressures. However, amphipods did not show preference between edge and middle parts of seagrass habitats. Only tanaids showed differences in this factor.

The results of this study also demonstrated that artificial seagrass could be used as a proxy of natural seagrass to facilitate experiments on epifaunal assemblages.

ACKNOWLEDGEMENT

I would like to thank Dr. Maria Schreider, Dr. Anna Redden and Dr William Gladstone for their contributions in this project. Thanks also addressed to Rohani Ambo Rappe for helping in ASUs preparation, field works and laboratory analyses. This project was funded by Australian Agency for International Development (AusAID) and the University of Newcastle, Australia.

REFERENCES

Amri, K. 2003. Effects of distance, patch size and time on the assemblages of macrofauna colonizing artificial seagrass. Torani, 13 (5): 240-247.

Attrill, M.J., J,A. Strong, and A.A. Rowden. 2000. Are macroinvertebrate communities influenced by seagrass structural complexity? Ecography,23:114-121.

Beck, M.W., 1995. Size-specific shelter limitation in stone crabs: a test of the demographic bottleneck hypothesis. Ecology, 76: 968-980.

Bell, S.S., R.A. Brooks, B.D. Robbins, M.S. Fonseca, and M.O. Hall. 2001. Faunal response to fragmentation in seagrass habitats: implication for seagrass conservation. Biol. Conservation, 100: 115-123.

Bologna, P.A.X. and K.L. Heck Jr. 1999. Macrofaunal associations with seagrass epiphytes; Relative importance of trophic and structural characteristics. J. of Exp. Mar. Biol. and Ecol. 242: 21-39.

Boström, C. and E. Bonsdorff. 2000. Zoobenthic community establishment and habitat complexity – the importance of seagrass shoot-density, morphology and physical disturbance for faunal recruitment. Mar. Ecol. Prog. Series, 205: 123-138.

Chapman, J.L. and M.J. Reiss. 1998. Ecology, Second Edition. Cambridge University Press, Cambridge, United Kingdom.

Conlan, K.E. 1994. Amphipod crustaceans and environmental disturbance: a review. J. of Natural History, 28: 519-554.

Eggleston, D.B., W.E. Elis, L.L. Etherington, C.P. Dahlgren, and M.H. Posey. 1999. Organism responses to habitat fragmentation and diversity: Habitat colonization by estuarine macrofauna. J. of Exp. Mar. Biol. and Ecol., 236: 107-132.

Fox, B.J., J.E. Taylor, M.D. Fox, and C. Williams. 1997. Vegetation changes across edges of rainforest remnants. Biol. Conservation, 82: 1-13.

Frost, M.T., A.A.Rowden, and M.J. Atrill. 1999. Effect of habitat fragmentation on the macroinvertebrate infaunal communities associated with the seagrass *Zostera marina* L. Aquatic Conservation, 9: 255-263.

Jenkins, G.P., H.M.A. May, M.J. Wheatley, and M.G. Halloway. 1997. Comparison of fish assemblages associated with seagrass and adjacent unvegetated habitats of Port Phillip Bay and Corner Inlet, Victoria, Australia, with emphasis on commercial species. Estuarine, Coastal and Shelf Science, 44: 569-588.

Kenyon, R.A., M.D.E. Haywood, D.S. Heales, N.R. Loneragan, R.C. Pendrey, and D.J. Vance. 1999. Abundance of fish and crustacean postlarvae on portable artificial seagrass units: daily sampling provides quantitative estimates of the settlement of new recruits. J. of Exp. Mar. Biol. and Ecol., 232: 197-216.

Lee, S.Y., C.W. Fong, and R.S.S. Wu. 2001. The effects of seagrass (*Zostera japonica*) canopy structure on associated fauna: a study using artificial seagrass units and sampling of natural beds. J. of Exp. Mar. Biol. and Ecol., 259: 107-132.

Mattila, J., G. Chaplin, M.R. Eilers, K.L. Heck Jr, J.P. O'Neal, and

J.F. Valentine. 1999. Spatial and diurnal distribution of invertebrate and fish fauna of a Zostera marina bed and nearby unvegetated sediments in Damariscotta River, Maine (USA). J. of Sea Res. 41: 321-332.

Mukai, H., T. Suzuki, and S. Nojima. 1999. Morphological implications of seagrass substratum for mobile epifauna community, Rottnest, Western Australia. *In*: The Seagrass Flora and Fauna of Rottnest Island, Western Australia (eds. D.I. Walker and F.E. Wells). Western Australian Museum, Perth.

Parker, J.D., J.E. Duffy, and R.J. Orth. 2001. Plant species diversity and composition: experimental effects on marine epifaunal assemblages. Mar. Ecol. Prog. Series, 224: 55-67.

Paton, P.C. 1994. The effect of edge on avian nest success – how strong is the evidence. Conservation Biology, 8: 17-26.

Peterson, B.J., K.R. Thompson, J.H. Cowan Jr, and K.L. Heck Jr. 2001. Comparison of predation pressure in temperate and subtropical seagrass habitat based on chronographic tethering. Mar. Ecol. Prog. Series, 224: 77-85.

Smith, M.J. 2001. The role of habitat edges in determining predation rates in seagrass beds. http://www.sardi.sa.gov.au/pages/aquatics/enviro_eco/ habitat_modification.htm. (Accessed: 17 September 2003)

Tanaka, M.O. and F.P.P. Leite. 2003. Spatial scaling in the distribution of macrofauna associated with *Sargassum stenophyllum* (Mertens) Martius : analyses of faunal groups, gammarid life habits, and assemblages structure. J. of Exp. Mar. Biol. and Ecol., 293: 1-22.

Tanner, J.E. 2003. Patch shape and orientation in influences on seagrass epifauna are mediated by dispersal abilities. Oikos, 100: 517-524.

Upston, J. and D.J. Booth. 2003. Settlement and density of juvenile fish assemblages in natural, *Zostera capricorni* (Zosteraceae) and artificial seagrass beds. Env. Biol. of Fishes, 66: 91-97.

Virnstein, R.W. and M.C. Curran. 1986. Colonization of artificial seagrass versus time and distance from source. Mar. Ecol. Prog. Series, 29: 279-288.

Virnstein, R.W. and R.K. Howard. 1987. Motile epifauna of marine macrophytes in the Indian River Lagoon, Florida. I. Comparisons among three species of seagrass from adjacent beds. Bull. of Mar. Sci., 41: 1-12.

West, A.J., A.W.D. Larkum, and R.J. King. 1989. Regional studies – Seagrass of South Eastern Australia. *In*: Biology of Seagrasses. A Treatise on the Biology of Seagrass with Special Reference to the Australian Region (eds. A.W.D. Larkum, A.J. McComb, and S.A. Shepherd). Elsevier, Amsterdam.