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An Analysis of Benthic Marine Invertebrate Communities in Subtidal Seagrass and Sand Habitats in Shark Bay, Western Australia

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Abstract

The fauna of three habitats (*Posidonia* and *Amphibolis* seagrass beds and open sand) on a subtidal sandflat off Monkey Mia, Shark Bay, Western Australia (25° 48′S, 113°43′E), was investigated. The fauna of the seagrass beds was diverse and abundant. *Amphibolis* stations had 115 species, a total density of 332.2 individuals/m^2 and a shellfree, dry biomass of 32.5g/m^2. The corresponding figures for *Posidonia* stations were not significantly different: 97 species, 298.1 individuals/m^2 and 38.0g/m^2. By comparison the sand stations were impoverished: 20 species, 19.3 individuals/m^2, and 4.3g/m^2. There was a substantial overlap of species between the two seagrass habitats but little overlap between the fauna of either seagrass and sand stations. Epifauna and epibiota dominated the seagrass stations. Infauna was relatively rare, but at the same level as in the sand stations, where it was dominant. Reasons for the relative impoverishment of sand stations are discussed.

Introduction

Seagrasses form extensive beds in many estuaries and shallow marine embayments along the Australian coast. In Western Australia large beds are found on the south west coasts as far north as Shark Bay. North of Shark Bay seagrasses still occur but they do not form extensive beds. Seagrasses are an important source of primary production in coastal areas (for review see Hutchings, 1982). Despite their importance as a source of primary production few animals feed directly on seagrasses. Instead breakdown of dead plants into particles and adhering microorganisms are consumed by animals which in turn are preyed upon by carnivores (Fenchel 1977; Kirkman and Reid 1979; Robertson and Mann 1980). The detrital material can be utilized by a variety of animals within the bed itself or can be exported from the system by currents and wave action and utilized elsewhere (Ogden and Zieman 1977).

Seagrass beds are generally rich in fauna (Hutchings 1982), but the composition of the fauna is poorly known. The fauna of Western Australian seagrass beds has

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received little attention. Scott (1981) examined the fish fauna of *Posidonia* beds in detail. Qualitative listings of the fauna of seagrasses in Cockburn Sound have been undertaken but remain unpublished. Seagrass beds are also important habitats for larval stages and juveniles of important fish and crustacean species (Young 1978; Bell et al., 1978).

Shark Bay is the largest marine embayment in Western Australia, with an area of 12,500 km^2. The bay is shallow and consists of eastern and western gulfs. The average depth is approximately 9 m with maximum depths seldom exceeding 37 m (Logan and Cebulski 1970). While only an estimated 10% of the bottom of the bay is covered by seagrasses, the beds are considered to be the most important source of primary production in Shark Bay (Smith and Atkinson 1983). Mangroves occurring in restricted parts of the eastern gulf and phytoplankton are two additional sources of primary production, but their contribution is thought to be relatively small. The seagrass flora of Shark Bay is diverse, with at least 17 species (McComb et al. 1981) out of a world total slightly in excess of 50 (Hutchings 1982). The dominant species are *Amphibolis antarctica* (Lahill) and *Posidonia australis* Hawk f. which form monospecific beds in many parts of the bay. In many areas sand patches of varying size occur among the beds.

The present paper is the first analysis of the fauna of seagrass beds in Shark Bay. Preliminary observations undertaken in March 1982 indicated there are different animal communities in *Amphibolis* and *Posidonia* seagrass beds, and that the faunas of adjacent sand patches are relatively impoverished. This parallels the situation reported in sand and seagrass beds of *Zostera capricorni* Aschers and *Posidonia australis* in the Port Hacking estuary, New South Wales, by Wadley (1981). In addition to the different composition of the fauna in *Amphibolis* and *Posidonia* beds in Shark Bay, biomass of animals seemed to be higher in *Posidonia* beds than in the other habitats. This study sets out to test these observations. The taxonomic problems associated with many of the animal phyla occuring in the seagrass beds of Shark Bay precluded an analysis of the fauna to the species level. Quantitative descriptions in terms of diversity, density and biomass, are given at phylum level for each habitat.

Materials and Methods

The area selected for study is an extensive subtidal sandflat offshore from Monkey Mia (25°48′S, 113°43′E). It was selected because there were large, monospecific patches of both of the major seagrass species which occur in Shark Bay interspersed with sand patches; thus all of the three habitats to be examined were represented. Also, since the entire area is subtidal, differences between the three habitats were not masked by varying effects of exposure during low tide.

Sampling transects were run across the sandflat parallel to the shore at Monkey Mia. They were at least 100 m apart and stations on a transect at least 50 m apart.

Sand patches were sampled as they were encountered and the adjacent seagrass was also sampled. When all sand stations had been completed additional transects were made to complete the seagrass stations. In all three habitats samples were made at least 2 m from the edge of the habitat to avoid possible transitional effects at the fringes. A total of 15 samples was made in each habitat. No attempt was made to measure the density of seagrasses in each station, but the beds appeared visually to be uniform.

At each station a circular steel frame 0.1 m^2 in area with a serrated edge was worked into the substrate to a depth of 10 cm. In some seagrass stations, particularly *Amphibolis*, the root network was too densely packed to be penetrated by the frame on its own, and the roots were cut with a diving knife. All seagrasses above the sediment surface were removed by hand and placed in a cloth bag. Sediment was then removed from the frame by an airlift pump made from a 5 cm diameter PVC tube approximately 1.3 m long. The sample was strained through a 1 mm mesh and placed in a labelled cloth bag for sorting on shore. All live animals were removed and preserved in 10% formalin buffered with borax.

Periodic measurements were made of temperature and salinity. Depth was measured at each station when the sample was taken. At the first five stations in each habitat a sediment sample was taken by pushing a PVC tube (with an area of 0.08 m^2) 5 cm into the sediment. The sample was labelled and placed in a plastic bag.

In the laboratory the preserved animal samples were washed in water, sorted to species, counted and retained in 70% alcohol. No attempt was made to identify the species, but representatives of each were deposited in the Western Australian Museum. The remaining specimens were decalcified in 7% hydrochloric acid, washed in water, and dried to constant weight at 60°C. They were weighed to the nearest 1 mg on a Sartorius electronic balance. Corrections were made to biomass figures for individuals used as voucher specimens. Numbers of species, densities, and biomasses were then calculated for each station and means and standard deviations were determined for each habitat type. All biomass figures presented refer to shell-free dry weight.

Sediment samples were placed in diluted hydrogen peroxide at room temperature to remove organic materials and to break down sediment bound together by mucus. Additional hydrogen peroxide was added daily until all reaction ceased. The samples were washed in water and allowed to sit for several days until sediment particles had settled to the bottom. The supernatant was drained off and each sample was dried at 60°C. The sediment was then sieved through meshes of 1000, 500, 250, 125 and 63 μm. Material remaining on each sieve was weighed to the nearest 0.1 g on the Sartorius balance. Weights obtained were converted to ϕ values on the Udder-Wentworth scale, and other sediment characteristics were calculated as shown by Buchanan (1971).

Species diversity, biomass and density of invertebrates recorded at 15 stations in each of the three habitats (two seagrass types and one sand) were analyzed with a balanced, one-factor analysis of variance. To stabilize heterogenous variances, data were transformed to Log_e (x+1) before analysis. Significant differences between habitats were further tested *a posteriori* with a Student-Newman-Keuls (SNK) multiple comparison test (Sokal and Rohlf 1969).

Results

During sampling (May 1982) water temperatures on the sandflat ranged from 18 to 21°C. The stations were at depths of 0.9 to 2.0 m at low tide. Sediment characteristics for the *Amphibolis* and *Posidonia* stations were similar. *Amphibolis* stations consisted of medium sand with a mean grain size of 1.54 ± 0.30 ϕ and a silt content of 15.9 ± 9.1% compared to a mean grain size of 1.68 ± 0.13ϕ and a silt content of 15.0 ± 10.0% respectively for *Posidonia.* Sand stations also had medium sediments, with a mean ϕ value of 1.33 ± 0.10 but the silt content of 1.4 ± 0.4% was much lower (Table 1).

The two seagrass types harboured a diverse fauna. At the *Amphibolis* stations a total of 115 species was recorded, with the most diverse groups being crustaceans (39 species), molluscs (26) and polychaetes (24) (Table 2). The mean number of species per station was 17.2. The *Posidonia* stations were not as diverse in total species with 97 but the same three groups were dominant. In *Posidonia* 33 species of crustaceans, 27 molluscs, and 20 polychaetes were recorded. The mean number of species per station in *Posidonia* was 12.8. By comparison sand stations were impoverished with a total of only 20 species, and a mean per station of 1.7. Of the 20 species recorded in sand 12 were molluscs. A one-factor analysis of variance comparing the differences in number of species per station in the three habitats indicated that there was a significant difference between habitats ($P<0.001$; $F=33.86$; $F_1=2$, $F_2=42$). The mean number of species per habitat was significantly highest in *Amphibolis,* second in *Posidonia* and least in sand ($P<0.05$; SNK Test).

A total of 156 species was collected in the *Posidonia* and *Amphibolis* stations, 50 of which were common to both habitats. The overlaps between both seagrass habitats and sand were much lower; seven species of 127 were in common between *Amphibolis* and sand, and eight of 102 between *Posidonia* and sand. Only five species occurred in all three habitats (the molluscs *Cantharus erythrostoma* (Reeve, 1846), *Circe lenticularis* Deshayes, 1853 and *Tapes literata* Linnaeus, 1758, one pagurid crustacean, and one polychaete). Many of the 166 species were collected only once, and thus could have only been collected in one habitat. Species overlaps between habitats were recalculated for all species in which five or more individuals were collected. When only these species were considered the overlap between *Amphibolis* and *Posidonia* stations became even more pronounced with 24 of the 29 species being shared in common. The high degree

of species overlap between *Amphibolis* and *Posidonia* stations indicates that only one community is present. The overlap between sand and seagrass stations was low: four species of 27 for sand – *Amphibolis* and four of 26 for sand – *Posidonia*. The four species (the molluscs *C. erythrostoma* and *T. literata*, one pagurid crustacean and one polychaete) were in fact recorded in all three habitats. The low overlap between sand and seagrass stations demonstrates that a different community is present in the sand.

Data for density showed much the same relationships between habitats as that for species numbers (Table 2). *Amphibolis* stations had the greatest mean density (332.2/m^2), comprised mainly of ascidians (97.3/m^2), crustaceans (86.0/m^2) and polychaetes (52.7/m^2). The mean density in *Posidonia* stations was similar (298.1/m^2). The same three groups were numerically dominant, though in a different order: molluscs (115.3/m^2), crustaceans (76.7/m^2) and ascidians (52.7/m^2). Total mean density in sand was only 19.3/m^2, an order of magnitude lower than in the seagrass habitats. Molluscs (10.0/m^2) and polychaetes (6.0/m^2) were numerically dominant in sand. One-factor analysis of variance showed significant differences in density among the three habitats ($P<0.001$; $F=43.5$; $f_1=2$, $f_2=42$). The mean density of the sand habitat was significantly less ($P<0.05$) than the densities of either the *Amphibolis* or *Posidonia* habitats, which were not significantly different to each other ($P>0.05$; SNK test).

The overall pattern for biomass was also similar to that shown for species numbers and density (Table 2). *Posidonia* stations had the greatest mean dry, shellfree biomass (38.0 g/m^2) which was comprised primarily of molluscs (20.4 g/m^2), ascidians (12.8 g/m^2) and crustaceans (2.9 g/m^2). The mean biomass in *Amphibolis* stations was lower (32.5 g/m^2) and comprised of ascidians (22.4 g/m^2), molluscs (4.7 g/m^2) and crustaceans (3.2 g/m^2). Again sand stations were relatively impoverished. The mean biomass in sand was 4.3 g/m^2, over 99% of which was molluscs. One factor analysis of variance showed that biomass varied significantly between habitats ($P<0.001$; $F=18.15$; $f_1=2$, $f_2=42$). The mean biomass at the sand habitat was significantly less ($P<0.05$) than the biomass at either the *Amphibolis* or *Posidonia* habitats which were not significantly different from each other ($P>0.05$; SNK Test).

The animals collected were divided into the four habitat groupings of infaunal, epifaunal, epibiotic and epibenthic as defined by Hutchings (1982). Epifauna dominated in *Amphibolis* stations, with 63 species, followed by epibiotic species (26) and infaunal species (19) (Table 3). The same pattern occurred in *Posidonia* stations, where there were 55 epifaunal species, 20 infaunal and 19 epibiotic. The dominance of epifaunal species in seagrasses was not as pronounced when compared on a basis of the mean number of species/station. This was particularly true in *Amphibolis*, where the mean number of epifaunal species was 8.6, compared to 6.0 for epibiotic species. In *Posidonia* stations the mean number of epifaunal species was higher, 7.5/station, out of a total of 12.8/station. The

Table 1 Sediment characteristics in three habitats on a subtidal sandflat off Monkey Mia, Shark Bay, Western Australia.

	Size ± 1S.D. (ϕ)	Range (ϕ)	Deviation ± 1S.D. (ϕ)	Range (ϕ)	Mean Skewness ± 1S.D. (ϕ)	Range (ϕ)	Mean % greater than 1.0 mm (W/W)±1S.D.	Range (%)	Mean % <63μ± 1S.D. (W/W)	Range (%)
Amphibolis stations	1.54±0.30	1.05-1.84	1.22±0.30	0.88-1.71	0.27±0.34	0.07-0.79	9.87±3.80	6.34-15.76	15.91±9.08	3.49-27.05
Posidonia stations	1.68±0.13	1.57-1.82	1.21±0.54	0.45-1.65	0.29±0.42	0.05-0.79	5.38±4.24	1.53-10.63	15.00±9.97	8.40-29.25
Sand stations	1.33±0.11	1.22-1.50	0.65±0.15	0.47-0.80	0.17±0.10	0.03-0.28	8.80±5.06	3.12-16.23	1.37±0.43	0.80-1.86

Table 2 Characteristics of the animals collected in three habitats on a subtidal sandflat off Monkey Mia, Shark Bay, Western Australia.

Group	Total Species	Species/Station $\bar{x}$ ± 1S.D.	Species/Station Range	Density (#/m^2) $\bar{x}$ ± 1S.D.	Density (#/m^2) Range	Biomass (g/m^2) $\bar{x}$ ± 1S.D.	Biomass (g/m^2) Range
			AMPHIBOLIS STATIONS				
Molluscs	26	2.7 ± 2.6	0-10	40.0 ± 43.6	10-170	4.7 ± 6.1	0-19.3
Crustaceans	39	5.8 ± 2.5	3-13	86.0 ± 46.0	60-220	3.2 ± 3.2	0.1-11.9
Polychaetes	24	3.1 ± 1.8	1-6	52.7 ± 39.2	10-130	0.6 ± 1.9	0-7.3
Ascidians	1	0.9 ± 0.3	0-1	97.3 ± 91.4	0-440	22.4 ± 25.0	0-79.7
Bryozoans	12	2.9 ± 1.3	1-5	36.9 ± 40.0	10-180	0.2 ± 0.1	0-0.4
Sponges	10	0.7 ± 0.5	0-1	7.3 ± 4.6	0-10	0.6 ± 1.2	0-4.5
Coelenterates	1	0.9 ± 0.2	0-1	9.3 ± 2.6	0-10	0.4 ± 0.5	0-1.5
Echinoderms	1	0.1 ± 0.4	0-1	2.0 ± 5.6	0-20	0.4 ± 1.4	0-1.2
Flatworms	1	0.1 ± 0.3	0-1	0.7 ± 0.3	0-10	0 ± 0	0-0.1
Totals	115	17.2 ± 6.0	8-27	332.2 ± 137.2	120-590	32.5 ± 26.3	8.4-95.9
			POSIDONIA STATIONS				
Molluscs	27	3.7 ± 2.7	0-8	115.3 ± 145.7	0-530	20.4 ± 32.4	0-101.5
Crustaceans	33	4.3 ± 4.4	0-17	76.7 ± 117.2	0-470	2.9 ± 5.5	0-20.0
Polychaetes	20	2.4 ± 2.7	0-8	38.0 ± 43.6	0-140	0.9 ± 1.7	0-5.7
Ascidians	1	0.9 ± 0.4	0-1	52.7 ± 63.0	0-240	12.8 ± 21.2	0-69.2

Table 2 (continued)

Bryozoans	7	0.8 ± 1.2	0-4	8.0 ± 12.1	0-40	0.3 ± 0.7	0-2.1
Sponges	7	0.5 ± 0.8	0-11	6.0 ± 6.3	0-20	0.4 ± 1.5	0-5.0
Coelenterates	1	0.1 ± 0.3	0-1	0.7 ± 2.6	0-10	0 ± 0.1	0-0.6
Echinoderms	1	0.1 ± 0.3	0-1	0.7 ± 2.6	0-10	0.3 ± 1.3	0-5.0
Totals	97	12.8 ± 10.0	1-38	298.1 ± 286.0	10-1,020	38.0 ± 42.2	0.6-132.7
				SAND STATIONS			
Molluscs	12	1.0 ± 1.1	0-4	10.0 ± 10.7	0-40	4.3 ± 6.5	0-21.1
Crustaceans	1	0.1 ± 0.4	0-1	1.3 ± 3.5	0-10	0 ± 0	0-0
Polychaetes	4	0.4 ± 0.6	0-2	6.0 ± 9.9	0-30	0 ± 0.1	0-0.2
Bryozoans	3	0.2 ± 0.8	0-3	2.0 ± 7.7	0-30	0 ± 0	0-0.1
Totals	20	1.7 ± 1.8	0-6	19.3 ± 18.7	0-60	4.3 ± 6.5	0-21.2

Table 3 Microhabitats inhabited by animals in three habitats on a subtidal sandflat off Monkey Mia, Shark Bay, Western Australia.

Group	Total Species	Species/Station $\bar{x}$ ± 1S.D.	Range	Density (#/m^2) $\bar{x}$ ± 1S.D.	Range	Biomass (g/m^2) $\bar{x}$ ± 1S.D.	Range
				AMPHIBOLIS STATIONS			
Infauna	19	2.0 ± 1.5	0-4	26.8 ± 28.2	0-110	2.5 ± 4.3	0-14.7
Epifauna	63	8.6 ± 5.0	1-14	141.7 ± 79.8	10-210	6.1 ± 7.4	0-2.8
Epibiotia	26	6.0 ± 2.0	3-10	158.0 ± 94.3	80-250	23.7 ± 25.2	0.1-6.8
Epibenthos	7	0.6 ± 0.8	0-2	6.0 ± 8.3	0-20	0.2 ± 0.3	0-0.1
Totals	115	17.2 ± 6.0	8-27	332.2 ± 137.2	120-590	32.5 ± 26.3	8.4-95.9
				POSIDONIA STATIONS			
Infauna	20	2.7 ± 2.2	0-8	49.3 ± 61.8	0-210	14.2 ± 26.4	0-94.2
Epifauna	55	7.5 ± 6.4	0-24	173.5 ± 220.5	0-650	10.4 ± 18.4	0-59.6
Epibiotia	19	2.5 ± 2.4	0-9	73.3 ± 85.4	0-350	13.4 ± 21.0	0-69.3
Epibenthos	3	0.1 ± 0.5	0-2	2.0 ± 8.0	0-30	0 ± 0.1	0-0.3
Totals	97	12.8 ± 10.0	1-38	298.1 ± 286.0	10-1,020	38.0 ± 42.2	0.6-132.7
				SAND STATIONS			
Infauna	12	0.9 ± 1.1	0-4	11.3 ± 14.1	0-40	4.0 ± 6.7	0-21.1
Epifauna	5	0.6 ± 0.9	0-2	6.0 ± 9.1	0-20	0.3 ± 1.0	0-3.4
Epibiotia	3	0.2 ± 0.8	0-3	2.0 ± 7.5	0-30	0 ± 0	0-0.1
Totals	20	1.7 ± 1.8	0-6	19.3 ± 18.7	0-60	4.3 ± 6.2	0-21.2

sand stations were dominated by 12 infaunal species which had a mean of 0.9 of a total of 1.7/station.

The relationships in density were somewhat different (Table 3). Epibiotic species (158.0/m^2) and epifaunal species (141.4/m^2) were codominant in *Amphibolis,* together comprising 90% of the total. However in *Posidonia* epifaunal species were more dense (173.5/m^2) and epibiotic species were relatively less important (73.3/m^2). Together the two comprised almost 83% of the total density. Sand stations were dominated by infaunal species (11.3/m^2), which were 59% of the total density.

In biomass terms *Amphibolis* stations were dominated by epibiotic species, which had a total biomass of 23.7 g/m^2 out of a total of 32.5 g/m^2 (Table 3). In *Posidonia* the biomass was more evenly split: 14.2 g/m^2 for infaunal species; 13.4 g/m^2 for epibiotics; and 10.4 g/m^2 for epifauna. Sand stations were dominated by infaunal species, with 4.0 g/m^2 or 92% of the total. In summary both seagrass habitats were dominated by epifaunal and epibiotic species, with the dominant type varying between habitat depending on whether the number of species, mean species/station, density or biomass was being considered. In contrast, infaunal species dominated in all of these categories in the sand stations.

Discussion

Hutchings (1982) has pointed out that no single type of sampling programme can be effective in a habitat as structurally diverse as a seagrass bed. Epibenthic species were low in density and biomass in both seagrass types and none was collected in the sand samples. Young (1978) has shown that prawns are an important component of seagrass beds in Queensland, and Shark Bay is a major prawn fishery (Penn and Stalker 1979). Epibenthic fish species are also important in seagrasses (Scott 1981). Neither of these groups was adequately sampled during the present study, which was more concerned with benthic species. Another limitation of the present study is that samples were made only in one season. No inferences on seasonality of the fauna, which can be considerable in seagrass beds (Hutchings and Recher 1974; Heck 1977; 1978), can be made.

The present results are consistent with other studies of seagrass beds which have shown that sand is relatively impoverished in comparison with the seagrass areas. Reasons for the relative paucity of fauna in sand are not fully understood, but Hutchings (1982) has summarized the recent literature. Two major theories have emerged. Firstly, the seagrasses stabilize the substrate, reducing disruptions from physical effects such as wave action and from biological effects such as predation by large animals moving over the sand. Secondly, seagrasses increase habitat complexity and surface area, allowing a greater number of species to colonize the area. The second theory is more likely. The presence of seagrasses provides a habitat for epibiotic species which is absent in sand. Mobile epibenthic

species are also given more protection as are the epifaunal species on the sediment surface. All of these increases in species would be due to increased habitat complexity. The stabilization of sediments by seagrasses, however, is offset by the dense mat of roots and rhizomes which makes the sediment largely impenetrable to many burrowing species. Infaunal species were only a small component of the fauna in both seagrasses in terms of number of species and density, and were important in terms of biomass only in *Posidonia* stations.

Related to the diversity of the fauna was the large number of species which were recorded only once or at most a few times. Of the 166 species collected in this study only 29 were represented by five or more individuals. Similar results have been obtained in other studies. Working in New South Wales *Posidonia* beds Collett *et al.* (1984) found that 211 of 363 species collected, or 54.5%, were restricted to one site. A total of 102 species (26.9%) was recorded as single individuals. Collett *et al.* (1984) concluded that there is no characteristic *Posidonia* fauna, a finding confirmed in Shark Bay, where there was a considerable overlap in fauna between *Posidonia* and *Amphibolis* stations.

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