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A Comparison of Fish Assemblages from Seagrass and Unvegetated Areas of a Southern Australian Estuary

R. M. Connolly

Department of Zoology, University of Adelaide, SA 5005, Australia.
Present address: State Water Laboratory, South Australian Department of Engineerring & Water Supply, PMB, Salisbury, SA 5108, Australia.

Abstract

Assemblages of small fish from eelgrass (mainly *Zostera muelleri*) and unvegetated patches in a shallow, marine-dominated estuary were compared over one year as a preliminary step towards finding the consequences of eelgrass loss to small fish. There were more species and more individuals at eelgrass sites than at unvegetated sites at every sampling period. Multivariate analysis (MDS ordination) of assemblages showed distinct grouping of eelgrass and unvegetated sites. The statistical significance of groupings was tested by using an analysis of similarities (ANOSIM) randomization routine. The cryptic syngnathid *Stigmatopora nigra* and juvenile whiting, *Sillaginodes punctata*, the species of greatest economic importance in the estuary, were predominantly over eelgrass, whereas the flounder *Rhombosolea tapirina* was usually caught at unvegetated sites. *Atherinosoma microstoma*, the most abundant species, was more common over eelgrass at two dates but had similar abundances over both habitats at other dates. The limitations of survey work caused by possible associations between the presence of vegetation and environmental factors have been partially offset by interspersion of sites and by measurement of water temperature and salinity. Secondarily to habitat differences, fish assemblages were weakly grouped according to distance of sites from open water.

Introduction

Seagrass meadows in many parts of the world support large numbers of juvenile fish and provide a nursery habitat for many commercially important species (Pollard 1984). Unvegetated areas adjacent to seagrass meadows have different fish assemblages, usually with fewer fish and fewer species (Bell and Pollard 1989). Assemblages associated with seagrass consist mainly of small, inconspicuous species and juveniles of larger species, whereas the fauna of unvegetated areas is characterized by adults of large, mobile fish and species protected by schooling behaviour or camouflage against sediments (Bell and Pollard 1989).

The Barker Inlet–Port River region is a sheltered, marine-dominated estuary comprising extensive intertidal areas with either eelgrass cover (*Zostera* and *Heterozostera*) or no vegetation. The estuary has very high abundances of juveniles of commercially important fish species (Jones 1984) and mainly for this reason has been declared an aquatic reserve.

The estuary is almost surrounded by the city of Adelaide (population more than one million people) and is consequently subjected to many types of pollution, viz. treated sewage, storm water, agricultural and horticultural runoff, spilt oil, thermal effluent, shipping, altered flow regimes and fishing. Further extensive urban development along the foreshore is planned (Anon. 1992*a*). Toxic dinoflagellate blooms (Hallegraeff *et al.* 1988), loss of mangroves (*Avicennia marina* (Forsk.)) to clearing (Talbot 1982), and build-up of the macroalga *Ulva* sp. (Connolly 1986) have all been recorded, but changes in eelgrass cover within the estuary are not documented. Since the installation of Adelaide's main sewage outfall just north of the Barker Inlet/Port River estuary, 600 ha of intertidal eelgrass have been lost adjacent to the outfall (Shepherd *et al.* 1989).

Within the estuary itself, variously sized patches with and without eelgrass occur. Despite the factors contributing to the presence or absence of eelgrass being unknown, it is likely that eelgrass cover has been and will be altered by human activities. The aim of this survey was to

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compare assemblages of small fish from eelgrass and unvegetated areas as a preliminary step to finding the consequences of eelgrass loss to fish communities and in particular to stocks of commercial importance.

Materials and Methods

Site Selection

Unvegetated and eelgrass areas (mostly *Zostera muelleri* Irmisch ex Aschers., occasionally *Heterozostera tasmanica* (Martens ex Aschers.)) of the Barker Inlet–Port River region (138° 30' E, 34° 45' S) were mapped in January 1990 (Fig. 1). Excluding the region south of Inner Beacon (because it is grossly affected by warm-water effluent from a power station; Jones, unpublished data), there were seven eelgrass and eight unvegetated areas. At each of five sampling periods between January 1990 and February 1991, 20 sites were selected for sampling (10 in each habitat). In some sampling periods, the actual number of sites sampled was less than the 20 selected because of the limited time of appropriate tidal height for sampling (see sample sizes in Table 2).

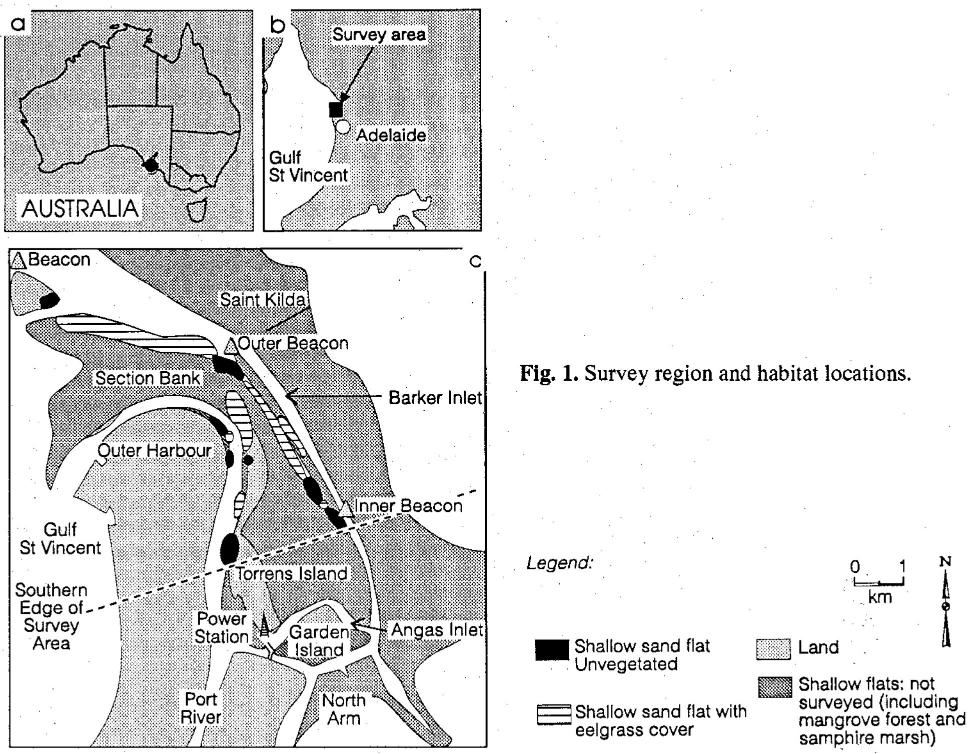

Fig. 1. Survey region and habitat locations.

The spatial distribution of areas of the two habitats was predetermined by the state of the estuary. There was, however, some interspersion of habitats so that the situation of having all or most of one type of habitat at one end of the estuary, for example, was avoided. Within the patches of habitat, choice of sites was random subject to the restrictions that (*1*) each of the designated areas of both habitats received at least one sample and (*2*) within a patch of habitat, no two sampling sites were less than 200 m apart. The order in which sites were sampled was randomized, with the proviso that at least two sites of each habitat were sampled on each day. Where sites were covered with the macroalga *Ulva* sp., sampling was abandoned.

The above-ground biomass was measured at each eelgrass site in January 1990 only. At each site, three squares of 625 cm^2 each were harvested and dried at 60°C for two days. The mean above-ground biomass for all eelgrass sites was 146 g dry weight m^{-2} (s.e. = 20.7, n = 9 sites).

Fish Sampling

Fish were sampled at all sites, using two different sizes of beach seine-nets that were operated sequentially, 30 m apart, pulled perpendicular to and towards the shore for (a pre-measured) 20 m. The small net was 5 m long with a mesh size of 1.4 mm, and the large net was 22 m long with a mesh size of 6 mm. The actual area netted was calculated over 10 pulls to be 84 m^2 (s.e. = 1.19) for the small net and 347 m^2 (s.e. = 7.80) for the large net. All fish were identified and counted, and individuals of *Sillaginodes punctata* (Cuvier & Valenciennes) (King George whiting), representing the most important commercial species, were also measured. Numbers from the two nets were combined because both nets together constitute the sampling unit.

All netting was done at or just after the daytime low tide. All sites could not be sampled on one date because it is important to take all nettings at a similar tidal state. Sampling was therefore spread over four consecutive days chosen for similarity of tides. The actual day on which sites were sampled was randomized, and all samples were treated as temporally equivalent; that is, variation between days within sampling periods was not analysed. In June 1991, the seine nets were used at night to catch *S. punctata* as part of a dietary study, and the numbers of *S. punctata* from those nettings are reported as an indication of diel activity. This sampling was done at or just after low tide over three nights between 2300 and 0100 hours.

Water Temperature and Salinity

Water salinity and especially temperature (given the warm-water discharges in the south of the estuary) could influence fish distributions and could also be associated with the presence of eelgrass. Water temperature was measured at each site at the time of netting, at 30 cm depth in water 60 cm deep. Water samples for salinity analysis were taken at the same time and place. The Practical Salinity Scale of 1978 (PSS 78) is used in this paper.

Data Analysis

Comparisons between unvegetated and eelgrass areas of total abundances and abundances of the key species are straightforward applications of the Mann–Whitney *U*-test. The number of fish at eelgrass sites in January 1990 was tested for association with the above-ground biomass estimate of each site by using Spearman's rank test. A comparison of assemblages (all species together) from eelgrass and unvegetated sites suggests a multivariate analysis of variance (MANOVA). The assumption of multivariate normality, however, is likely to be grossly violated by the present data, the fish samples being characterized by small numbers with many zeros. A non-parametric analogue with no assumption of normality is the analysis of similarities (ANOSIM), which has the added advantage over MANOVA of being able to detect differences without any assumptions of constant spread (Clarke 1993). ANOSIM compares ranked similarities between and within groups selected *a priori* (here eelgrass and unvegetated habitats) by using a randomization test for significance. At each sampling period, assemblages from the two waterways, (Barker Inlet and Port River) were also compared by using a two-way crossed ANOSIM, with habitat (eelgrass or unvegetated) as the second factor. This analysis determines whether assemblages from the two waterways differ after accounting for habitat differences. All ANOSIM tests involved 5000 simulations with the Primer package from Plymouth Marine Laboratory, England.

Non-metric multidimensional scaling (MDS) is an ordination technique that uses the same matrix of ranked similarities as does ANOSIM; it displays samples in low- (usually two-) dimensional space while retaining as nearly as possible the similarity rankings between samples.

For comparisons of fish assemblages between unvegetated and eelgrass sites, raw counts were transformed by using $x^{0.25}$ to emphasize the distribution of less common species in the analysis. The transformation $x^{0.25}$ gives slightly more emphasis to less common species than does log$x$ in cases such as this, where counts are small (Clarke 1993). The Bray–Curtis similarity coefficient is used throughout as a meaningful and robust measure (Clarke 1993).

Analysis of the similarity matrix used in MDS and ANOSIM has also been used to highlight the species making the largest contribution to between-group differences (Clarke 1993).

The association of environmental variables with patterns in biotic data can be measured by correlating the ranked similarity matrices of the environmental and biotic data (Clarke and Ainsworth 1993). At each sampling period, the association between fish assemblages and the environmental variables of (*1*) water temperature, (*2*) salinity and (*3*) distance to open water were measured by using the weighted Spearman's coefficient recommended by Clarke and Ainsworth (1993). Distance to open water was measured as the shortest distance by sea from sites to gulf waters unprotected by islands or shoals. Distances ranged from 1.0 to 9.1 km.

All comparisons (univariate and multivariate) have been done for each period separately, because the fauna changes over time within both habitats as juveniles of larger species move to deeper water or grow too large to be caught by the nets. An MDS ordination has also been performed on data from all periods combined, and a two-way crossed ANOSIM was used to test differences between periods and habitats.

Results

Number of Species

In all, 36 fish species were caught during the survey. More species were caught at eelgrass sites than at unvegetated sites at all sampling dates (Fig. 2).

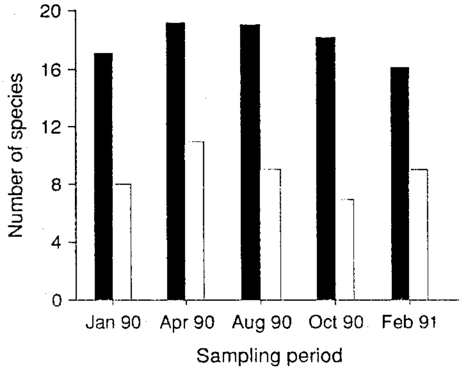

Fig. 2. Total number of fish species caught in eelgrass and unvegetated habitats at each sampling period. Black bars, eelgrass; white bars, unvegetated.

Number of individuals

In all, 13 871 fish were caught, 9866 (71%) from eelgrass sites and 4005 (29%) from unvegetated sites.

The number of individuals caught at eelgrass and unvegetated sites is shown for the 10 most common species from both eelgrass and unvegetated sites in Table 1. Comparisons of catches at eelgrass and unvegetated sites are shown (Fig. 3) as mean number per site (small and large nets combined), separately at each sampling date, for (*a*) total catch (all species), (*b*) *Sillaginodes punctata*, (*c*) *Atherinosoma microstoma* Günther, and (*d*) all species except *A. microstoma* and *Spratelloides robustus* Ogilby. Results of Mann–Whitney *U*-tests for differences between catches from eelgrass and unvegetated sites are listed in Table 2 for all dates.

There were more fish at eelgrass sites than at unvegetated sites at all dates (Fig. 3*a*), and only at August 1990 was the difference not significant (Table 2). In February 1991 the mean numbers of fish at both eelgrass and unvegetated sites were very high because of an extraordinarily large number of *Pelates sexlineatus* (Quoy & Gaimard) (striped perch) at eelgrass sites and *A. microstoma* (hardyheads) at eelgrass and unvegetated sites. The above-ground biomass of eelgrass at eelgrass sites was not correlated with total fish numbers in January 1990 (Spearman's rank test: $P > 0.1$).

Sillaginodes punctata (King George whiting)

The number of *S. punctata* at eelgrass sites was significantly greater than that at unvegetated sites at all dates (Table 2, Fig. 3*b*). Nearly all fish were caught in large nets in the first half of 1990 and 1991 and in small nets in the second half of 1990. This highlights not only the different size selectivities of the two nets used but also, in conjunction with the median lengths of *S. punctata* shown in Table 3, the growth of year classes. *S. punctata* spawns in April (Jones *et al.* 1990), is first caught in the estuary about mid-year, and after another year is too large to be caught by the nets used in this study.

At night in June 1991, there were significantly more *S. punctata* individuals per site over eelgrass (mean = 6.8 fish, $n = 9$ sites) than over unvegetated areas (mean = 0.8 fish, $n = 5$ sites) (Mann–Whitney *U*-test of medians: $P = 0.03$)

Median lengths of *S. punctata* from eelgrass and unvegetated sites have been compared for dates on which enough fish were caught at unvegetated sites to permit a reasonable

Table 1. Numbers of individuals of the 10 most common species (all dates combined) in eelgrass and unvegetated habitat

First 10 species are those most common at eelgrass sites. Final four species are those in the 10 most common species at unvegetated sites not included in the first 10 species. Numbers in parentheses are percentages of the total number in each habitat

Species	Eelgrass	Eelgrass rank	Unvegetated	Unvegetated rank
Atherinosoma microstoma (Small-mouthed hardyhead)	4046 (41.0)	1	2333 (58.3)	1
Sillaginodes punctata (King George whiting)	2291 (23.2)	2	87 (2.2)	5
Pelates sexlineatus (Striped perch)	1823 (18.5)	3	10 (0.2)	10
Favonigobius lateralis (Long-finned goby)	559 (5.7)	4	417 (10.4)	3
Aldrichetta forsteri (Yelloweye mullet)	435 (4.4)	5	909 (22.7)	2
Stigmatopora nigra (Wide-bodied pipefish)	166 (1.7)	6	2 (0.0)	14.5
Hyporhamphus melanochir (Sea garfish)	125 (1.3)	7	40 (1.0)	7
Kaupus costatus (Deep-bodied pipefish)	78 (0.8)	8	5 (0.1)	12.5
Haletta semifasciata (Blue weedy whiting)	58 (0.6)	9.5	0	9.5
Heteroclinus perspicillatus (Common weedfish)	58 (0.6)	9.5	0	9.5
Spratelloides robustus (Blue sprat)	3 (0.0)	25.5	100 (2.5)	4
Rhombosolea tapirina (Greenback flounder)	12 (0.1)	15.5	41 (1.0)	6
Sillago schomburgkii (Yellowfin whiting)	12 (0.1)	15.5	27 (0.7)	8
Arripis georgianus (Tommy rough)	2 (0.0)	27.5	12 (0.3)	9
Other species	198 (2.0)		22 (0.5)	
Total	9866		4005	

comparison (Table 3). Even at these dates, sample sizes were much larger at eelgrass sites; however, the variance and degree of skewness and kurtosis were similar across habitats, so the test results can be regarded, cautiously, as meaningful. *S. punctata* individuals were longer in the unvegetated habitat at all dates, significantly so at January 1990 and February 1991.

Atherinosoma microstoma (small-mouthed hardyhead)

A. microstoma was the most abundant species at both eelgrass and unvegetated sites (all dates combined). Only at two dates were significantly more caught in eelgrass, similar numbers having been caught at eelgrass and unvegetated sites on the other three dates (Table 2, Fig. 3*c*).

All species except A. microstoma and Spratelloides robustus

If *A. microstoma*, which is numerically dominant and at some dates does not show a strong pattern of greater abundance over eelgrass, is excluded and the numbers of all other species are combined, then numbers are greater at eelgrass sites than at unvegetated sites at all dates (Table 2, Fig. 3*d*). *S. robustus* (blue sprat) occurred infrequently but was also excluded because it is similar in size and behaviour to *A. microstoma*.

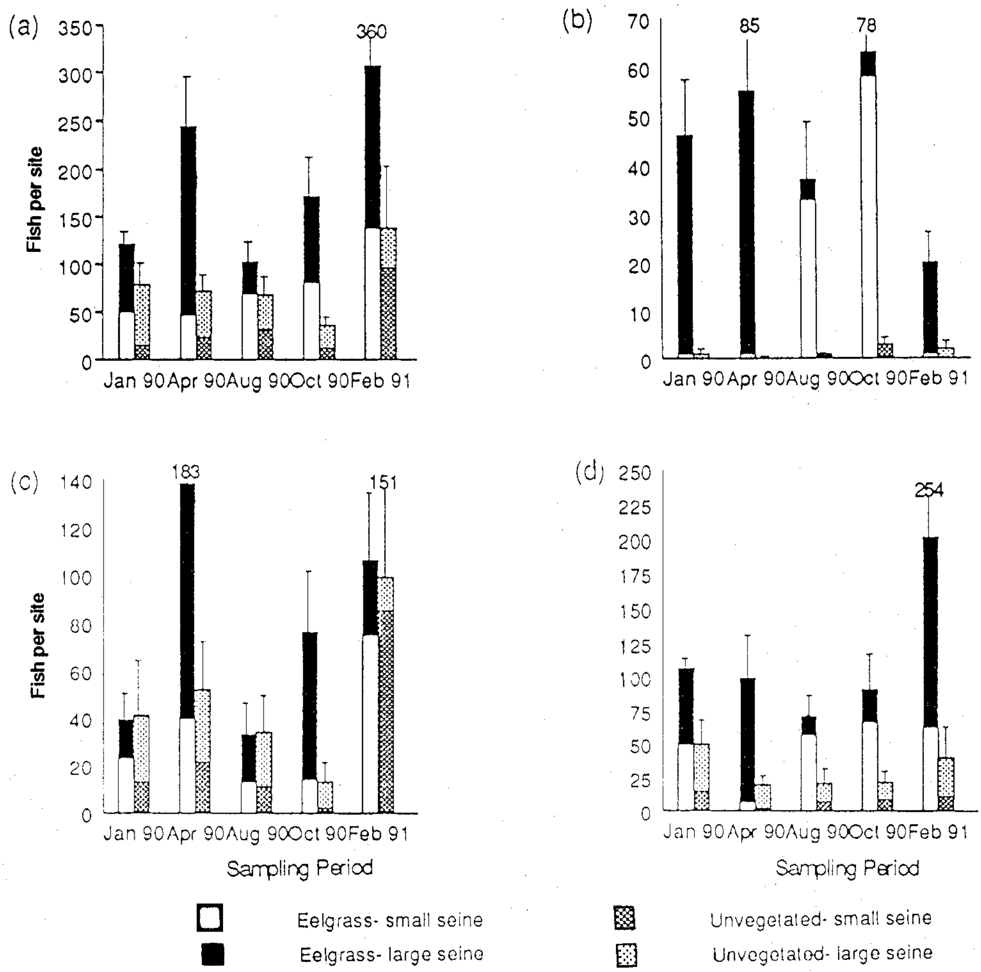

Fig. 3. Mean number of fish per site from eelgrass and unvegetated habitats: (*a*) all species; (*b*) *Sillaginodes punctata*; (*c*) *Atherinosoma microstoma*; (*d*) all species except *A. microstoma* and *Spratelloides robustus*. Lines, standard error (of mean per site, small and large nets combined).

Table 2. Results of Mann–Whitney *U*-tests for differences in abundance between eelgrass and unvegetated sites

Probabilities: significance criterion = 0.05. Non-significant comparisons are marked n.s.

Sampling period	Number of sites (eelgrass : unvegetated)	All species	*Sillaginodes punctata* (King George whiting)	*Atherinosoma microstoma* (Hardyhead)	All species except *A. microstoma, Spratelloides robustus*
January 1990	9:11	0.037	0.001	0.183 n.s.	0.004
April 1990	10:10	0.003	0.001	0.041	0.019
August 1990	8:7	0.298 n.s.	0.001	0.601 n.s.	0.015
October 1990	8:7	0.003	0.008	0.024	0.005
February 1991	10:9	0.050	0.019	0.205 n.s.	0.003

Table 3. Comparisons of median lengths of *Sillaginodes punctata* individuals at eelgrass and unvegetated sites

Mann–Whitney *U*-test probabilities: significance criterion = 0.05. Non-significant comparisons are marked n.s.

Sampling period	Habitat	Number of fish	Median length (mm)	Mann–Whitney *U*-test result
January 1990	Eelgrass	310	80	<0.001
	Unvegetated	13	110	
April 1990	Eelgrass	210	110	Not tested
	Unvegetated	4	130	
August 1990	Eelgrass	202	24.5	Not tested
	Unvegetated	2	25.5	
October 1990	Eelgrass	221	32	0.060$^{n.s.}$
	Unvegetated	19	35	
February 1991	Eelgrass	169	90	0.002
	Unvegetated	19	110	

Stigmatopora nigra Kaup (wide-bodied pipefish)

Over the survey period, 166 individuals of *S. nigra* were caught. Of these, 11 were caught in the large net and can be excluded because this species can swim easily through the mesh of the large net and is caught only when it is entrapped by algal fronds. Of the 155 fish caught in small nets, 153 were over eelgrass and two were over the unvegetated habitat.

Rhombosolea tapirina Günther (greenback flounder)

R. tapirina, of which only juveniles were caught, was found mainly at unvegetated sites. It is effectively caught in both small and large nets, and of the 53 individuals taken over the survey period, 12 (23%) were from eelgrass sites and 41 (77%) were from unvegetated sites.

Multivariate Analysis

The differences between eelgrass and unvegetated sites in fish species richness and abundances of several common species suggest differences between fish assemblages of these habitats. Two-dimensional ordination plots show, at every period, strong grouping of eelgrass and unvegetated sites (Fig. 4). Assemblages of the two habitats were significantly different at all periods, as judged by the ANOSIM results (Table 4). Of the species contributing most to differences in assemblages associated with the eelgrass and unvegetated habitats (Table 4),

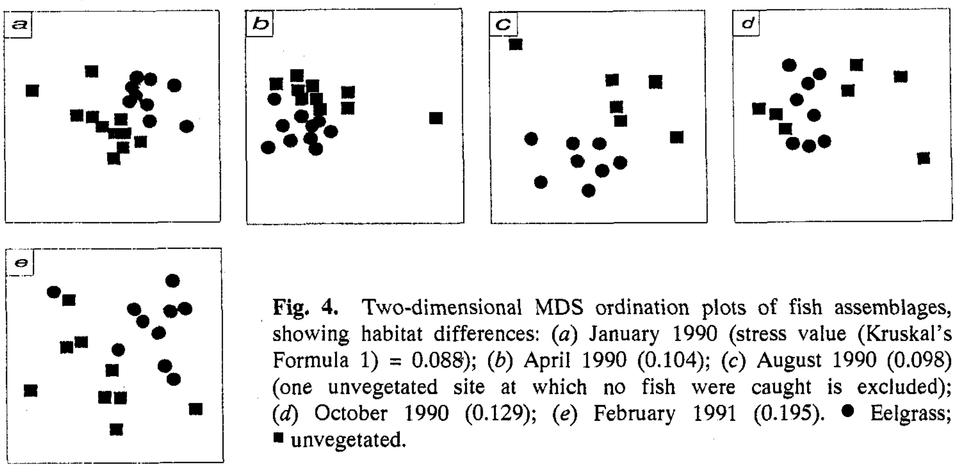

Fig. 4. Two-dimensional MDS ordination plots of fish assemblages, showing habitat differences: (*a*) January 1990 (stress value (Kruskal's Formula 1) = 0.088); (*b*) April 1990 (0.104); (*c*) August 1990 (0.098) (one unvegetated site at which no fish were caught is excluded); (*d*) October 1990 (0.129); (*e*) February 1991 (0.195). ● Eelgrass; ■ unvegetated.

Table 4. Multivariate comparisons of eelgrass and unvegetated assemblages
ANOSIM probabilities: all comparisons are significant at 0.05 level. Contributing species: two main species only. *A.f.*, *Aldrichetta forsteri*; *A.m.*, *Atherinosoma microstoma*; *H.m.*, *Hyporhamphus melanochir*; *P.s.*, *Pelates sexlineatus*; *S.n.*, *Stigmatopora nigra*; *S.p.*, *Sillaginodes punctata*.

Sampling period	Probability from ANOSIM test	Main contributing species
January 1990	<0.001	*S.p.*, *A.m*
April 1990	<0.001	*S.p.*, *H.m*
August 1990	<0.001	*S.n.*, *S.p*
October 1990	0.008	*S.p.*, *A.f*
February 1991	<0.001	*S.p.*, *P.s*

Sillaginodes punctata predominated. No differences were found at any period between assemblages of the two waterways (Barker Inlet and Port River).

Water temperature and salinity did not match the biotic data. At all periods, the distance from sites to open water was the only environmental variable having any importance in matching the patterns in fish assemblages. Nor did any combination of the three environmental variables match the biotic data better than did distance to open water alone. However, even distance to open water was only weakly matched, with correlations between matrices of fish assemblages and distance ranging from 0.10 to 0.34. There is currently no test for significance of these correlations, but the values are low (Clarke and Ainsworth 1993). A simple overlay of distance to open water onto MDS plots of fish assemblages (Fig. 5) reveals that, for all periods except August 1990, one site, with the smallest distance to open water, is far from any other site. In all cases, this site is in the unvegetated patch at the extreme north-western end of the sampling region. In August 1990, no fish were caught at the site in this unvegetated patch and the sample was therefore excluded from the MDS ordination. When the site is included, the correlation between similarity matrices of fish assemblages and distance to open water is 0.21. After exclusion of the site (as in the plots in Figs 4 and 5), the correlation drops to –0.01. This evidence, taken together with the overlays at other periods, suggests that the weak correlation between distance to open water and fish assemblages is due mainly to this one unvegetated patch, which is near open water and has a peculiar fish assemblage, persistent over time. This patch with the greatest exposure to open water is characterized by very low fish catches, always including at least one *Rhombosolea tapirina*. Any importance of distance to open water in determining fish assemblages seems to be in

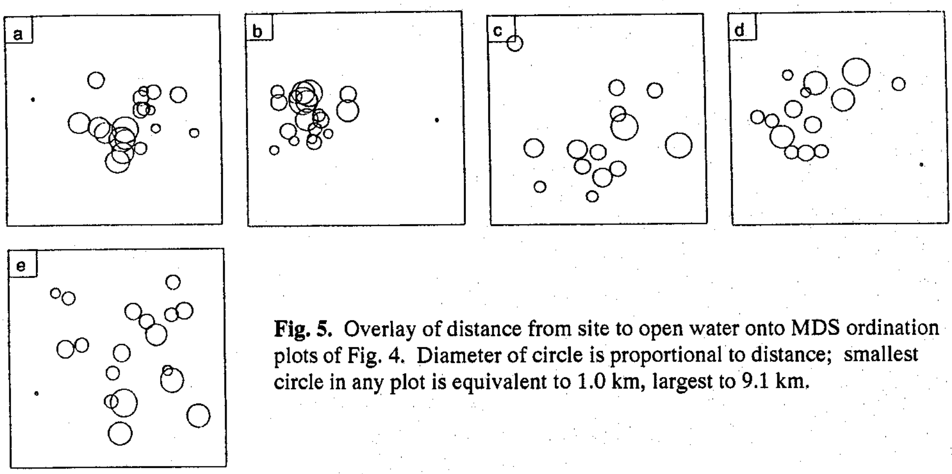

Fig. 5. Overlay of distance from site to open water onto MDS ordination plots of Fig. 4. Diameter of circle is proportional to distance; smallest circle in any plot is equivalent to 1.0 km, largest to 9.1 km.

separating the patch most exposed to open water from other areas rather than in causing a gradual change along the length of the estuary.

When all periods are combined, the distinction between eelgrass and unvegetated sites remains the overwhelming difference (Fig. 6). After differences between habitats are accounted for, sampling periods are, however, also different (two-way ANOSIM, factor 'period', $P < 0.001$). Differences over time are due either to the sporadic occurrence of large numbers of one or two species or to fluctuations in the number of individuals of species present in the estuary at all periods. The relative position of sites over time is different within the two habitats (Fig. 6). Within the unvegetated habitat, periods are quite evenly spaced. Within the eelgrass habitat, January 1990, April 1990 and February 1991 are separated from August 1990 and October 1990. This is mainly the result of large catches of *Pelates sexlineatus* at the first three dates listed.

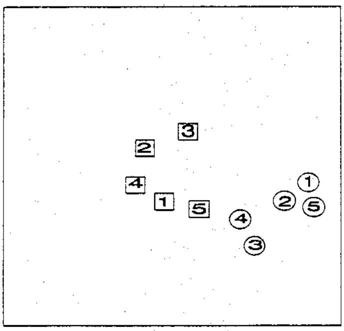

Fig. 6. Two-dimensional MDS ordination plot of fish assemblages over all periods combined. Stress = 0.197. Sites of a given habitat (eelgrass or unvegetated) at a given period have been combined and plotted at their centroid. Periods are indicated by numbers: 1, January 1990; 2, April 1990; 3, August 1990; 4, October 1990; 5, February 1991.

Water Temperature and Salinity

Water temperatures and salinities differed among dates, with both showing marked seasonality. Mean temperatures and salinities were, however, very similar at eelgrass and unvegetated sites (Table 5). No significant differences were found in either temperature or salinity between the two habitats, according to Mann–Whitney *U*-tests.

Table 5. Water temperatures and salinities at eelgrass and unvegetated sites at each sampling period

Temperature measured in degrees Celsius. Salinity measured according to the Practical Salinity Scale of 1978 (PSS 78). Numbers are means, with standard errors in parentheses

Sampling period	Habitat	Temperature	Salinity
January 1990	Eelgrass	22.7 (0.46)	38.5 (0.22)
	Unvegetated	22.8 (0.44)	38.3 (0.37)
April 1990	Eelgrass	21.9 (0.39)	38.1 (0.15)
	Unvegetated	22.8 (0.40)	38.3 (0.18)
August 1990	Eelgrass	15.2 (0.61)	35.3 (0.18)
	Unvegetated	14.6 (0.86)	35.3 (0.14)
October 1990	Eelgrass	19.1 (0.80)	36.1 (0.31)
	Unvegetated	18.5 (0.63)	36.5 (0.19)
February 1991	Eelgrass	27.7 (0.40)	37.8 (0.16)
	Unvegetated	27.4 (0.23)	38.0 (0.17)

Discussion

The fish assemblages of eelgrass and unvegetated areas were distinctly different, and these differences persisted over time. Differences between habitats were as found in comparisons by other researchers (Bell and Pollard 1989 and references therein). The eelgrass habitat was typified by the syngnathid *Stigmatopora nigra*, a small species with cryptic habit, and juveniles of *Sillaginodes punctata*, whereas *Rhombosolea tapirina*, a flounder with extreme modifications for camouflage against a sand or mud background, was found mostly in unvegetated areas. *Atherinosoma microstoma* is a small species that schools, and it might have been expected to be mostly over unvegetated habitat. However, this fish feeds near the surface of the water, at least during the day, and has little to do with the sediment, vegetated or not; this may explain why large numbers of this species were caught over both habitats.

Changes in fish assemblages over the duration of the study were due to seasonal fluctuations in abundances of several species. The common fish of the estuary are either permanent or temporary residents (see definitions in Bell and Pollard 1989). Species that are small as adults, such as *A. microstoma*, *Favonigobius lateralis*, *Stigmatopora nigra* and *Kaupus costatus*, are permanent residents. Seasonal fluctuations in abundances of these species result from short-term (often annual) recruitment and mortality. The temporary residents are larger species that recruit seasonally and move elsewhere later. *S. punctata*, for example, spawns offshore, and its planktonic larvae settle to a benthic existence in the estuary from June to August. This fish moves out of the estuary to deeper waters after two to three years (Jones *et al.* 1990). The size of fish caught over time reflects the growth of these fish. In this study, the largest size of *S. punctata* captured was 140 mm (about 1 year old) in April 1990. Failure to catch larger fish in this study can be attributed to the smallness of the two nets rather than to the departure of larger *S. punctata* to deeper waters.

Different parts of an estuary can have different fish assemblages regardless of vegetation (Bell and Pollard 1989), which could lead to spurious associations of faunas with vegetation types. Fortunately, thorough interspersion of the two habitats was possible in this survey, limiting the likelihood that the different assemblages were simply a result of different locations. Differences in fish assemblages between eelgrass and unvegetated habitat can also depend on how far unvegetated sites are from eelgrass (Ferrell and Bell 1991). The differences shown in the present study are clear even though the distance of unvegetated sites from eelgrass varied widely. Distance to open water explained some of the pattern in assemblages, especially the distinctive assemblage of the most exposed patch. Because this patch was unvegetated, the comparison of habitats was influenced by the peculiarity of the assemblage there. However, the difference between eelgrass and unvegetated sites evident in the ordination plots was consistent across the estuary as a whole at all periods. No difference was detected between fish assemblages of the two waterways (Barker Inlet and Port River). This is despite Port River being a major shipping lane and having been modified by dredging, wharf-building and reclamation of its shores. The fauna of Port River may not have been greatly affected by human activities because eelgrass, which is a relatively fast-growing colonizing plant, has persisted. The similarities of the fauna of the two waterways could also be taken to imply that both waterways have been affected by human activities.

In any comparison of fauna from different habitats, demonstrated differences between habitats are potentially attributable to differences in the effectiveness of the method of capture. In the present study, for example, fish in unvegetated areas, or perhaps certain sizes of fish in unvegetated areas, may have been more easily able to avoid capture. The best evidence that demonstrated differences in faunal abundances between habitats are not due simply to different capture efficiencies would be a similar result using another method of capture. Comparisons of fish from eelgrass and unvegetated habitat in the Barker Inlet region using a buoyant pop net, a method of ensnaring fish over a 25 m^2 area (Connolly 1994), showed the same pattern of greater abundance over eelgrass for *Sillaginodes punctata* and all species combined (Connolly, in press). The comparison using a pop net was done only at one time of year and used unvegetated patches smaller than those in the present survey, but nevertheless provides some evidence that differences in fish abundances described here are not simply a sampling artefact.

Eelgrass presence was not associated with water temperature or salinity, so these factors are unlikely to be the cause of the different fish assemblages. Even secondarily to habitat differences, temperature and salinity were not associated with any faunal differences. This may simply be a result of the extent of the survey region, which included only relatively open and well mixed waters. Temperatures in this study were similar to those measured by Jones (unpublished data) outside the region influenced by hot water effluent entering the southern part of the estuary, and the comparison presented here should be considered representative only of the areas north of the southern limit to sampling shown in Fig. 1.

This comparison of habitats is a necessary step in confirming that eelgrass in the Barker Inlet–Port River estuary is important as habitat for small fish and in particular for juveniles of commercially important species. Absence of eelgrass may be correlated with one or more other factors, not measured in this study, that cause the fish distributions reported here; experimental manipulation of eelgrass densities can distinguish between absence of eelgrass and other factors. The importance of eelgrass probably lies either in the protection from predators (larger fish) that it offers or in the greater abundance of associated food (mostly small invertebrates). Either or both of these factors may not be directly causal but may be the ultimate cause of evolution of habitat selection shown by fish in these shallow areas (Bell and Westoby 1986). Manipulative experiments have been done in the estuary to clarify the role of eelgrass as habitat for small fish (Connolly, in press).

Of most significance to fisheries management, especially in Gulf St Vincent, is the close association of *Sillaginodes punctata* with eelgrass. *S. punctata* accounts for nearly half the value of inshore scalefish landings in South Australia (Anon. 1992*b*). Robertson (1977) found that small *S. punctata* in Western Port, Victoria, used unvegetated areas at some times of the year; there is no evidence of that in the Barker Inlet–Port River region, at least during the day. For some species, distributions at night are very different from those during the day (Robertson 1980; Bell and Pollard 1989), but apart from data for June 1991 this study does not address that possibility. Sampling in June 1991 showed that *S. punctata* was over eelgrass more than unvegetated patches at night also. The greater median length of *S. punctata* at unvegetated sites at several times of the year raises the possibility of size-selective mortality at one or more times of year. Many alternative explanations exist, however, and this presents a line for further investigation.

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