THE ECOLOGY OF POSIDONIA SEAGRASS FISH COMMUNITIES IN COCKBURN SOUND, WESTERN AUSTRALIA

Department of Conservation and Environment
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THE ECOLOGY OF *POSIDONIA* SEAGRASS FISH COMMUNITIES IN COCKBURN SOUND, WESTERN AUSTRALIA

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CONTENTS

PART 1. SPATIAL AND TEMPORAL CHANGES IN COMMUNITY STRUCTURE

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ii ABSTRACT

Seagrass beds in Cockburn Sound (32^{o} 12'S, 115^{o} 42'E), Western Australia, were sampled periodically between 1972 and 1978 using a small beam trawl Forty-one fish species were found associated with the seagrass *Posidonia sinuosa* . Most of these fish species were restricted to the seagrass meadows for at least part of their life cycle. The number of fish species differed between five study sites and the abundance of each species varied seasonally due mainly to the appearance of juveniles. Four seagrass microhabitats based on vertical distribution, and six types of behavioural use by fish among these habitats, were recognized. This partitioning may account for the relatively large number of species inhabiting a superficially uniform environment. Changes in fish species composition were observed between 1972 and 1978. These changes coincided with the degradation of the seagrass habitat and may be interrelated.

CONTENTS
(PART 1)

TABLES

FIGURES

1. INTRODUCTION

Considerable attention has been paid to the biology of the seagrass and associated flora and fauna that occur in shallow marine embayments and estuaries (Kikuchi, 1980; Ogden, 1980). In temperate waters, the dominant predators of the invertebrate fauna associated with seagrass are usually fish. A number of studies have pointed out seasonal patterns of abundance of fish (Hoese and Jones, 1963; Adams, 1976; Koike and Nishiwaki, 1977); residency of fishes in seagrass meadows (Kikuchi and Peres, 1977); day-night changes in behaviour (Bell and Harmelin-Vivien, 1982; Harmelin-Vivien, 1983); and the use of space amongst the blades of the seagrass (Harmelin-Vivien, 1983). Seagrasses are also held to be important breeding grounds for fishes (Kikuchi, 1974; Weinstein and Heck, 1979), but there has been relatively little work done on whether or not juveniles occur in neighbouring areas without seagrass (Koike and Nishiwaki, 1977).

Several studies have been made of the fish assemblages occurring in seagrass meadows from the south-eastern and eastern coasts of Australia (see review by Pollard, 1984). Only Geographe Bay had been sampled previously for seagrass fish in Western Australia (Scott, 1981).

In this study, we describe the seagrass fish fauna of Cockburn Sound and document seasonal patterns of fish abundance, diel changes in fish activity and their use of space within the seagrass beds. Sampling was done in conjunction with a major environmental study in which fish species of all habitats within Cockburn Sound were surveyed using various conventional fishing methods (Dybdahl, 1979).

Seagrasses and their associated fauna are susceptible to pollution (Kikuchi, 1974; Cambridge, 1975), and this is of concern because of the high productivity of these types of shallow water ecosystems (McRoy and MacMillan, 1977). Changes in the area of seagrass beds have been documented (Peres and Picard, 1975; McComb, Cambridge, Kirkman and Kuo, 1981), but only Japanese studies have shown the effect of such changes on the seagrass fish (Kikuchi, 1974). Seagrasses cover large areas of the seabed in Cockburn Sound, Western Australia, but these areas decreased over the 10 years prior to 1979, apparently due to industrial pollution (Cambridge 1975, 1979; Cambridge and McComb, 1984; Silberstein, 1985). In this study, changes in fish species composition within the seagrass meadows between 1972 and 1978 are also examined.

2. METHODS

Cockburn Sound (32°12'S; 115°42'E) has three major habitats: the sandy shoreline, the seagrass meadows, and the central basin (Chittleborough, 1970). The seagrass areas were sampled for fish at five locations(Figure 1). Sampling in the seagrass meadows was restricted to *Posidonia sinuosa* Cambridge and Kuo, the main seagrass species in the Sound, except in some shallow areas where *Posidonia australis* Hook *f* interspersed the main species. Details on the seagrass meadows are given in Cambridge (1979).

At each site, the water depth ranged between 1 and 5 m, but sampling was usually at a depth of about 2 m (the tidal range in Cockburn Sound is less than 1 m). Sampling locations for the other habitats are given in Dybdahl (1979).

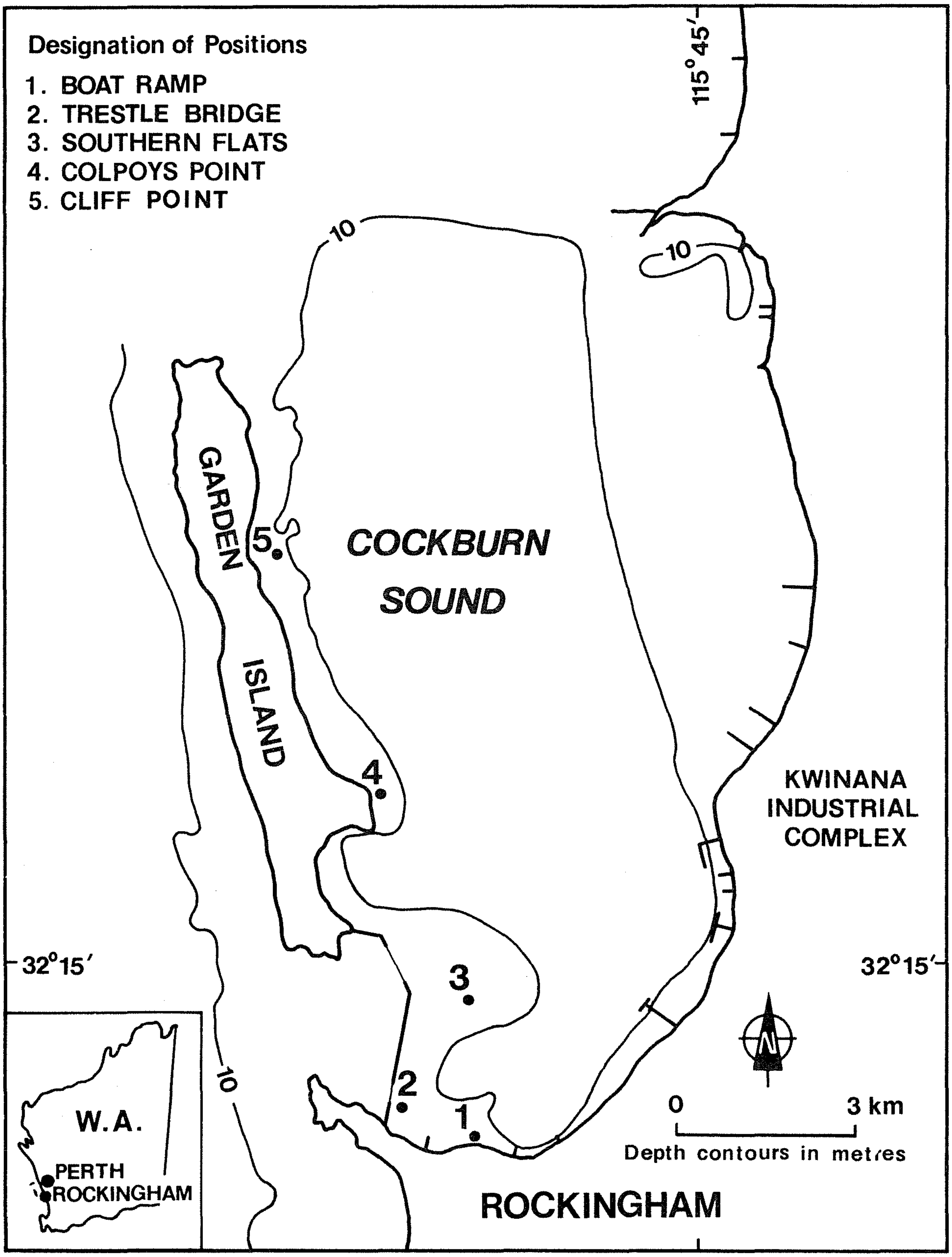

Figure 1. Beam trawl sampling sites within Cockburn Sound.

Most of the sampling in the seagrass was conducted with a small beam trawl (mouth dimensions 1.0 m by 0.4 m, and length 2 m with mesh of 2 mm). The beam trawl caught a wide size-range of individuals including post-larval fish, and was regarded as the most expedient method for sampling within a seagrass meadow. Our observations on other methods, such as seines and otter trawls, found that these nets tended to pass over the top of the seagrass, and only caught larger fish in the upper canopy.

Beam trawl samples were taken in August 1972, December 1975, January, February and May in 1976 at the Boat Ramp site (Figure 1). From January 1978 to January 1979, beam trawl samples were taken approximately every two months from all five sites except in July when inclement weather prevented sampling. Samples were taken during the day, with the exception of diel sampling in September 1978 and January 1979. On each occasion, three tows of approximately one minute in duration with the trawl covering a minimum distance of 50 m were made at each site. Usually two tows were adequate to sample the maximum species number.

A monofilament gill net (40 mm stretch mesh) was also used in the seagrass meadows during the September 1978 sampling at the Cliff Head site to catch adult weed whiting, *Neoodax semifasciatus*, which normally eludes the beam trawl. Other large fish were rare in the seagrass meadows (Dybdahl, 1979) and sampling was not attempted.

Observations on day-night changes in the abundance of seagrass fish species were made at the Cliff Point site (Figure 1) using SCUBA and snorkel along marked transects. A transect of 1200 m^2 was searched during the day in November 1978, and 1000 m^2 was searched during the day and again at night using underwater torches in January 1979. A nearby area was beam trawled during the day and the transect area was trawled at 2200 hours, an hour after completion of the January night-time visual survey.

Additional observations of fish behaviour and spatial use were made on the most common fish species in aquaria (1100 x 400 x 500 mm depth) containing seagrass.

Complementary sampling by seining and trawling was carried out as part of a major three-year study on Cockburn Sound by the Cockburn Sound Study Group. More details on these methods and the nets used can be found in Dybdahl (1979). During this faunal inventory survey, a beach seine and small otter trawl were used to catch fish above the seagrass and on the sandy shoreline. A large otter trawl from the RV 'Flinders' was used to sample the central basin of the Sound. Notwithstanding probable species selectivity, the seine and small trawl captured fish larger than 20 mm, while the large trawl captured fish longer than 30 mm.

All fish from the beam trawl were preserved in 10% formalin-seawater before the standard length was measured to the nearest millimetre. Other fish were measured to the nearest centimetre when caught.

The fish fauna is listed according to the classification and common names given by Hutchins and Thompson (1983). The two unnamed species of clingfish (Aspasminae) were briefly described by Scott (1981) and assigned the same numbered code in this paper.

The species composition of samples from various sites and dates were compared using the Bray-Curtis dissimilarity measure (Clifford and Williams, 1976). The Bray-Curtis measure is calculated as follows:

$$\frac{\Sigma i \ |x_{1i} - x_{2i}|}{\Sigma i \ (x_{1i} + x_{2i})}$$

where x_{1i} and x_{2i} are the proportions of i^{th} species in sample 1 and sample 2, respectively. This gives a measure of the dissimilarity between samples which can be summarized using dendrograms.

3. RESULTS

The beam trawl caught 2506 fish comprising 41 species with 10 species accounting for over 90% of the total abundance. Standard length and abundance data for each fish species are given in Table 1. The cardinal fish, commonly called gobbleguts, *Apogon rueppellii*, was the most common species (59.3% of the total fish caught). Where species lived during their juvenile and adult stages was deduced both from the present study's data and from data on species size and abundance collected by Dybdahl (1979). A summary of this information is also given in Table 1. The following paragraphs, consider seasonal distributions based on size measurements for the most abundant species, *(A rueppellii)* .They also summarize similar data for the other nine most abundant species.

3.1 *APOGON RUEPPELLII*

Juveniles were present in the seagrass from January and remained for at least a year (Table 2a). Some larger individuals were found above the seagrass throughout the whole year (Table 2b), while only adults were caught in the central basin of the Sound (Table 2C). Juveniles were probably present in the basin, but were not caught by the fishing method.

A rueppellii was also observed as adults and juveniles around reefs and artificial structures. In the extensive survey by Dybdahl (1979) it was the second most common species and the most widespread.

3.2 OTHER ABUNDANT SPECIES

Six of the remaining abundant species were associated with seagrass as adults and juveniles. Measurement of their lengths and observations produced the following results: adult males of the pipefish, *Stigmatophora argus*, carried eggs throughout the year and juveniles were caught from October to January; juveniles of the pipefish, *Syngnathus poecilolaemus*, appeared from October to January; juveniles of the weed whiting, *Neoodax semifasciatus*, appeared during September and October; juveniles of *N radiatus* appeared from November to January; juveniles of *N balteatus* appeared in January. The bridled leatherjacket, *Acanthaluteres spilomelanurus*, was also associated with the seagrass beds and juveniles were caught during both January and August.

A different distribution from other species was shown by the spiny-tailed leatherjacket, *Bigener brownii*, which were caught in the seagrass meadow as juveniles, while adults were caught above the seagrass by the beach seine and the small trawl. Adults of *N semifasciatus* were also observed in the upper canopy of the seagrass and were caught by the gill net (N = 20; x ± SE length = 19.4 ± 0.86 cm; range = 17.3 to 21.0 cm).

Juveniles and sub-adults of the devil fish, *Gymnapistes marmoratus*, were present in the seagrass bed but were also found in other habitats (Dybdahl 1979). By using Grant's (1972) data on reproductive size for this species, it appeared that the Cockburn Sound population had few adults and the Sound as a whole acted as a nursery. Finally, the rough leatherjacket, *Scobinichthys granulatus*, was found in similar size ranges in all nets and was also widespread within the Sound.

3.3 DISTRIBUTION WITHIN THE SEAGRASS BEDS

Table 3 summarises the spatial use of seagrass by various fish species. The seagrass was divided into four vertical microhabitats: bottom, middle, top, and above the seagrass canopy. Within these zones, individual species showed different behaviours which were grouped arbitrarily into six broad categories based on feeding position and locomotory pattern.

3.4 DAY-NIGHT COMPARISON

Only nine species caught by the beam trawl, and two observed while diving were common to both the day and night trawls (Table 4). Far more individuals were observed and caught during the day, largely due to an increased capture of resting *A rueppellii*, which is a nocturnally active species. At night, the numerous juveniles of *A rueppellii* were not present on the top of the seagrass or in the water column during visual surveys. These fish may migrate to deeper areas at night (Chrystal, Potter, Loneragan and Holt, 1985).

Stigmatophora argus, *Syngnathus curtirostris*, *S poecilolaemus* and the three *Neoodax* species, however, were diurnally active. They remained within the seagrass canopy at night, and consequently had a greater percentage representation in night samples. *G marmoratus* was the only species for which significantly greater numbers of individuals were caught during trawls made at night than trawls made in daylight ($t = 2.6$, $df = 37$, $p < 0.05$).

3.5 COMPARISON OF FISH ABUNDANCE BETWEEN SAMPLING SITES

A rueppelli was the most abundant species at all sites (Table 5). *G marmoratus* and *S argus* were the next most abundant overall, but not necessarily at each site. Species of lower-ranked abundance differed considerably between sites.

The overall similarity in abundance of species between sites sampled during the period January 1978 to January 1979 is expressed by the dendrogram in Figure 2. The Cliff Point site and, to some extent, the Southern Flats site were most dissimilar from the other three sites. Cliff Point had the greatest number of species which explains a large degree of the difference between this site and the others.

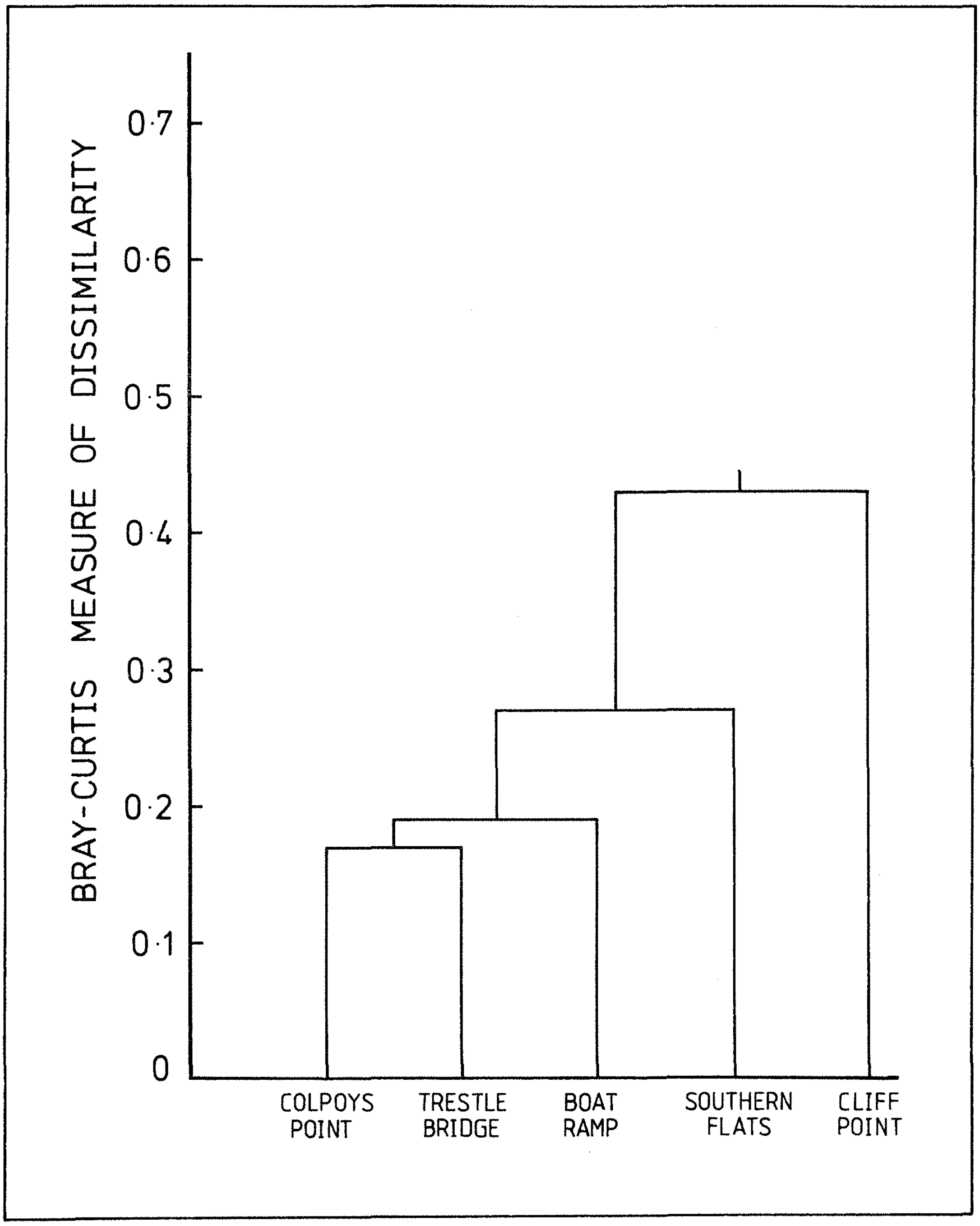

Figure 2. Classification of seagrass sampling sites.

3.6 COMPARISON OF FISH ABUNDANCE BETWEEN SAMPLING DATES

A rueppellii was the most abundant species throughout the year except during October and November when *G marmoratus* dominated the samples (Table 6). The abundance of the other species varied with the recruitment of juveniles. Figure 3 gives the dissimilarity in species abundance between beam trawl samples from different dates; the two January samples were the most similar reflecting the annual recruitment of juveniles at this time. Seasonal differences were also apparent with winter samples being most dissimilar from the summer samples.

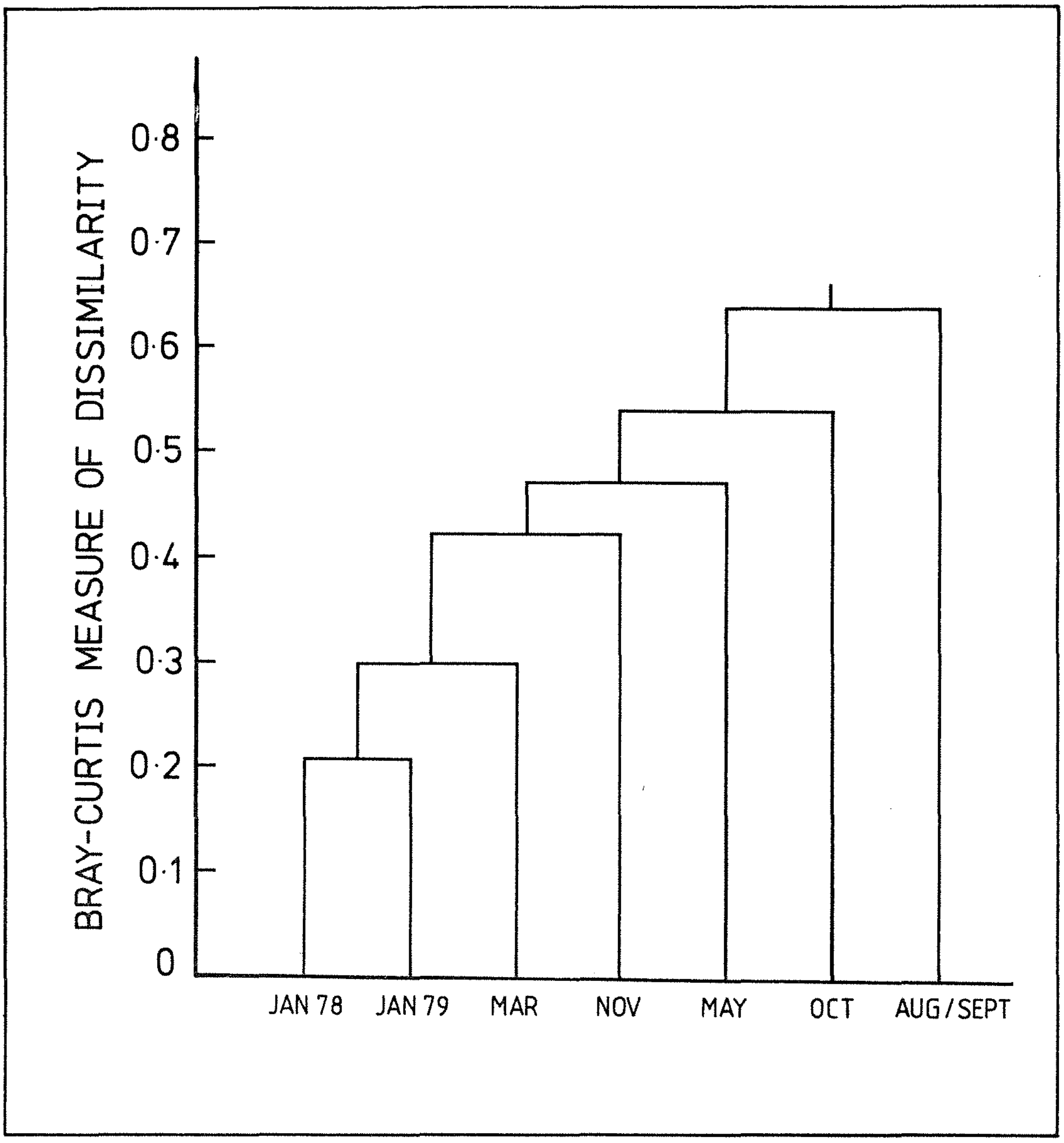

Figure 3. Classification of seagrass sampling dates.

3.7 BETWEEN-YEAR COMPARISONS

The three between-year beam trawl samples at the Boat Ramp site were similar to each other (Bray-Curtis measure based on data in Table 7; 1972-1975/76 = 0.61; 1972-1978 = 0.68; 1975/76 - 1978 = 0.65). However, the dominant species differed between years. For example, the weed whiting, *N balteatus*, formed over half the fish fauna at the Boat Ramp site in 1972, while it ranked sixth during 1975 to 1976 and eighth in the 1978 samples.

4. DISCUSSION

Extensive sampling of seagrass meadows from 1972 to 1979, and sampling of areas without seagrass in 1977 and 1978 (Dybdahl, 1979), has established that:

1. seagrass beds are a nursery for some species but not exclusively a nursery for others;

2. a community of fish exists in the seagrass, and is not found in the surrounding habitats, including the water column microhabitat above the seagrass; and

3. the fish community is spatially and temporally heterogeneous.

The 16 most abundant species found (95% of fish caught) in this study used *Posidonia* meadows as a nursery area. Of these, only the three leather jackets (Monocanthidae) could be regarded as commercial species. Thus the seagrass meadows do not appear to be of direct importance to commercial fish species. This contrasts with the general importance ascribed to several seagrass species, especially *Zostera* spp, as commercial fish nurseries in other parts of the world (Kikuchi, 1980; Pollard, 1984). In Cockburn Sound and Western Australia the seagrass meadows, however, are of considerable indirect importance to commercial fish species, for example, their contribution to the detrital food chain.

The spatial restriction of several fish species to seagrass in this study emphasises the differences observed between temperate and tropical seagrass meadows as outlined by Ogden (1980). Most fish species in tropical seagrass meadows show strong affinities with the nearby coral reefs (Vivien 1973; Ogden and Zieman 1977; Weinstein and Heck 1979). Of the six habitats recognised in Cockburn Sound (Chittleborough, 1970), only two, rock outcrops and artificial structures, were not examined in detail. These are small compared to the area of the other habitats and only a few species such as Brownfield's wrasse, *Halichoeres brownfieldi* and probably the brown-spotted wrasse, *Pseudolabrus parilus*, the parrotfish, *Heteroscarus acroptilus*, and the weed whiting, *Olisthops cyanomelas*, occur as juveniles in seagrass and were seen to be living as adults in areas of rock outcrop or artificial structures.

The types of variation in species composition between sampling sites observed here was also noticed in other seagrass beds studied by Brook (1978), and Weinstein and Heck (1979). The variation in Cockburn Sound may result from differences in standing crop of the seagrass. The Boat Ramp site was the most degraded while the sites near Garden Island were healthier and had a biomass and density of blades most similar to these expected of a healthy seagrass meadow (Cambridge, 1979; Cambridge and McComb, 1984).

Over half the seagrass in Cockburn Sound disappeared during the 10 years before 1979 (Cambridge, 1979). In the remaining seagrass meadows, *A rueppellii* was the most abundant species. Evidence from other fish communities of seagrass in Geographe Bay, Western Australia, (Scott, 1976., 1981), and samples taken in 1972 suggest that *Neoodax* species may be considered as 'typical' and the most abundant species in *Posidonia* beds of south-western Western Australia. Samples taken on 29 April 1975 at the Boat Ramp site were dominated by *N balteatus*. Samples taken on the 11 May 1975 on the Parmelia Banks at the northern edge of Cockburn Sound were dominated by *N radiatus*, while samples from the neighbouring Warnbro Sound taken on the 3 October 1975 were dominated by *N radiatus*. The high abundance of *A rueppellii* in Cockburn Sound in 1978/79 could be considered indicative of basic changes in the seagrass fish fauna since 1972. Such changes in seagrass fish faunas have been well documented by Japanese studies (Kikuchi, 1974).

Young and Young (1978) have performed cage experiments in seagrass beds in Florida which showed a high predation pressure upon some species of macrobenthos and probably accounted for the low abundance of these species. They stated this could be one of the mechanisms by which changes in species abundance occurs. A reduction in the seagrass blade density associated with pollution might diminish the food resources of the resident fish species and make them more susceptible to piscivores in the water column. This may account for the observed decrease in abundance of *N balteatus* at the Boat Ramp study site. In contrast, *A rueppellii* seemed less dependent on the seagrass habitat and was found throughout the marine habitats of Cockburn Sound (Dybdahl, 1979) and was thus able to maintain and increase its numbers despite the decrease in seagrass cover.

This study distinguished six types of spatial use of seagrass meadows by the most abundant fish species (Table 3). Two major spatial uses, fish resting on the leaves and fish swimming among and under the leaf canopy, have been designated in previous studies (Kikuchi and Peres, 1977; Thayer and Phillips, 1977). Vivien (1973) recognized an additional category of fish living on (and in) the substrate (sand). The six groupings specified here incorporate the above categories except that no species were found to burrow in the sand. Our additional categories include a division of the vertical distribution and attachment to the seagrass.

Two of the major species, *A rueppellii* and *G marmoratus*, are nocturnal while the other abundant species are diurnal. Further heterogeneity in temporal organization of the community is added by the different times of larval settlement.

Seasonality has been recorded for temperate seagrass fish communities by Hoese and Jones (1963), Adams (1976), Koike and Nishwaki (1977) and Young (1981), but not for tropical seagrass fish examined by Weinstein and Heck (1979).

The authors consider both the spatial and temporal heterogeneity as important factors in fish community organisation. This study showed that the fish in the Cockburn Sound seagrass community generally fed on crustaceans (see Part 2 of this Technical Series) with only a few species having a large overlap in the use of the food resource. The potential for competition for food was minimized further, however, by the variation in species occurrence in time and space.

Further work is required on the interaction of species and measurement of habitat characteristics in Cockburn Sound. Only then could changes in species abundance be linked conclusively with changes in the seagrass habitat.

Table 1. Number and length of each species caught by beam trawl and type of use made of the seagrass

	No of fish	Standard length (mm) Mean	SD	Min	Max	Resident A=Adults J=Juvenile	Transitory A=Adults J=Juvenile	X=Collected only from seagrass
PLOTOSIDAE ... Catfishes								
Cnidoglanis macrocephalus (Valenciennes)	8	77	19.9	54	105		J?	
GOBIESOCIDAE ... Clingfishes								
Aspasminae species 2	10	20	4.5	12	25	A J		X
Aspasminae species 3	1	35					A?	
Cochleoceps spatula (Gunther)	22	37	12.2	19	79	A J		X
SYNGNATHIDAE ... Seahorses and pipefishes								
Campichthys galei (Duncker)	9	48	3.5	43	53	A J		
Hippocampus angustus Gunther	6	30	9.1	18	42	A J		
Stigmatophora argus (Richardson)	143	148	45.2	18	252	A J		
Stigmatophora nigra Kaup	19	91	21.5	62	146	A?J?		
Syngnathus curtirostris Castelnau	17	122	35.8	72	181	A J		
Syngnathus poecilolaemus Peters	136	100	48.2	21	222	A J		
SCORPAENIDAE ... Scorpion fishes								
Gymnapistes marmoratus (Cuvier)	208	54	8.9	16	80	J		
Parascorpaena picta (Cuvier)	1	16					J	
TERAPONIDAE ... Trumpeters								
Pelates sexlineatus (Quoy & Gaimard)	4	70	31.0	46	115		A J	
APOGONIDAE ... Cardinalfishes								
Apogon rueppellii Gunther	1481	24	12.8	5	63	A J		
Siphamia cephalotes (Castelnau)	6	31	4.2	24	35		A?	
SCORPIDIDAE ... Sweeps								
Scorpis georgianus Valenciennes	1	32					J	
ENOPLOSIDAE ... Old Wife								
Enoplosus armatus (Shaw)	1	40					J	

Table 1. Number and length of each species caught by beam trawl and type of use made of the seagrass (contd)

	No of fish	Standard length (mm) Mean	SD	Min	Max	Resident A=Adults J=Juvenile	Transitory A=Adults J=Juvenile	X=Collected only from seagrass
LABRIDAE ... Wrasses								
Pseudolabrus parilus (Richardson)	1	148					J	
Halichoeres brownfieldi (Whitley)	27	42	16.1	25	104	J	A	
ODACIDAE .. Weed whitings								
Neoodax balteatus (Valenciennes)	31	46	24.9	15	113	A J		X
Neoodax radiatus (Quoy & Gaimard)	61	80	30.5	26	160	A J		X
Neoodax semifasciatus (Valenciennes)	94	47	27.6	9	155	A J		X
Olisthops cyanomelas Richardson	1	111					J	
SCARIDAE ... Parrotfishes								
Heteroscarus acroptilus (Richardson)	1	17					J	
MUGILOIDIDAE ... Grubfishes								
Parapercis haackei (Steindachner)	5	51	13.5	43	75		A	
BLENNIDAE ... Blennies								
Omobranchus lineolatus (Kner)	2	43	10.6	35	50		J	
OPHICLINIDAE ... Sand Eels								
Ophiclinus antarcticus Castelnau	10	65	13.9	34	83	A J		
CLINIDAE ... Weedfishes								
Cristaceps australis Valenciennes	4	63	12.3	54	81	A J		
Heteroclinus adelaidae Castelnau	10	47	18.8	12	68	A J		X
CALLIONYMIDAE ... Stinkfishes								
Callionymus sublaevis McCulloch	2	59	7.1	54	64		A	
GOBIIDAE ... Gobies								
Callogobius mucosus (Gunther)	16	50	37.3	22	172	A J		
Nesogobius pulchelus (Castelnau)	12	34	7.6	24	50	A J		

Table 1. Number and length of each species caught by beam trawl and type of use made of the seagrass (contd)

	No of fish	Standard length (mm) Mean	SD	Min	Max	Resident A=Adults J=Juvenile	Transitory A=Adults J=Juvenile	X=Collected only from seagrass
MONACANTHIDAE ... Leatherjackets								
Acanthaluteres spilomelanurus (Quoy & Gaimard)	29	43	22.6	19	82	A J		
Anacanthus barbatus Gray	1	109					J?	
Bigener brownii (Richardson)	48	33	11.6	12	68	J		
Brachaluteres jacksonianus (Quoy & Gaimard)	6	24	8.5	13	37	A J		
Meuschenia freycineti (Quoy & Gaimard)	3	105	55.5	41	139		J	
Monocanthus chinensis (Osbeck)	7	59	20.4	31	93	J		
Penicipelta vittiger (Castelnau)	14	35	14.9	14	59	J		
Scobinichthys granulatus (Shaw)	29	58	15.9	31	103	J		
DIODONTIDAE ... Porcupinefishes								
Atopomycterus nicthemerus (Cuvier)	19	53	14.4	28	72	J		

Table 2. Length frequencies by sampling month for *Apogon rueppellii* caught caught by (a) beam trawl, January 1978 - January 1979; (b) beach seine, May 1977 - June 1978; (c) large otter trawl, June 1977-September 1978. No values are given for months not sampled.

Length (cm)	a. Beam trawl												
	Month												
	J	F	M	A	M	J	J	A	S	O	N	D	J
6.0-6.5	2		0		0				0	1	4		4
5.5-6.0	0		5		0				2	1	6		5
5.0-5.5	8		5		0				0	3	8		21
4.5-5.0	26		0		0				0	3	30		28
4.0-4.5	5		0		1				6	5	71		6
3.5-4.0	0		18		11				8	10	34		1
3.0-3.5	0		42		9				8	1	0		1
2.5-3.0	9		20		1				0	0	0		0
2.0-2.5	141		2		0				0	0	0		56
1.5-2.0	98		1		0				0	0	0		371
1.0-1.5	61		0		0				0	0	0		298
0.5-1.0	2		0		0				0	0	0		11
Total	235		93		22				22	24	153		802

Table 2. Length frequencies by sampling month for *Apogon rueppellii* caught by (a) beam trawl, January 1978-January 1979; (b) beach seine, May 1977 - June 1978; (c) large otter trawl, June 1977 -September 1978. No values are given for months not sampled (contd).

Length (cm)	b. Seine													
	Month													
	M	J	J	A	S	O	N	D	J	F	M	A	M	J
8-9	1				0		0	3		6		9		0
7-9	8				2		10	17		58		38		0
6-7	9				2		3	34		80		17		0
5-6	19				2		6	21		12		40		0
4-5	42				2		1	5		10		65		0
3-4	13				2		0	0		103		24		0
2-3	0				1		0	0		81		1		0
Total	93				10		20	79		351		193		0

Length (cm)	c. Otter trawl															
	Month															
	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
8-9	5		11		2		1		1			53		16		7
7-8	193		119		56		27		25			404		78		79
6-7	245		211		42		30		117			317		94		58
5-6	157		277		75		40		14			603		80		75
4-5	99		139		15		5		0			308		49		41
3-4	8		10		0		0		1			15		0		0
Total	708		767		190		103		157			1 700		317		259

Table 3. Spatial use of seagrass beds.

Species	Vertical Distribution in the Seagrass Bed	Behaviour
G marmoratus *P haackei* *O antarcticus* *C australis* *H adelaidae* *C mucosus* *N pulchelus*	Bottom	On the bottom among the root bases or resting among the epiphytes.
H brownfieldi *N balteatus* *N radiatus* *N semifasciatus*	Bottom, middle and top	Juveniles occur in schools among the blades. Adults rest among the epiphytes, often head down, perpendicular to the bottom.
Aspasminae sp 2 Aspasminae sp 3 *C spatula*	Middle	Attached to the blades of seagrass by means of a ventral sucker.
S curtirostris *S poecilolaemus*		Swim horizontally among the seagrass blades.
A spilomelanurus *B brownii* *B jacksonianus* *M chinensis* *P vittiger* *S granulatus*	Middle and top	Between the blades of seagrass. Large specimens may occur above the seagrass.
S argus *S nigra*	Top	Attached, perpendicularly to the bottom, by means of a prehensile tail.
A rueppellii	Top and above	In schools, also above small sand patches in the seagrass bed.
A nicthemerus		Occurs individually, a slow swimmer.

Table 4. Diel percentage abundance of species in the seagrass at Cliff Point on the 9 January 1979, captured by beam trawl and observed during diving.

Species	Trawl		Visual	
	Day	Night	Day	Night
Apasminae species 2	1.1	0	0	0
C spatula	0	4.9	0	0
Hyporhamphus sp	0	0	0	0.5
Pranesus sp	0	0	0	0.5
S argus	2.2	9.8	0	0
S curtirostris	1.4	6.9	0	0
S poecilolaemus	5.8	9.8	0	0
G marmoratus	0.3	2.0	0	0
Platycephalus sp	0	0	0	0.5
P sexlineatus	0	0	2.0	0
A rueppellii	81.3	46.1	97.3	95.2
M strigatus	0	0	0	0.5
E armatus	0	1.0	0.1	1.1
H brownfieldi	0	0	0.3	0
N balteatus	0.6	2.9	0	0
N radiatus	2.8	3.9	0	0
N semifasciatus	2.8	7.8	0.2	0
P haackei	0	1.0	0.05	0
C mucosus	0.6	2.9	0	0
M freycineti	0	1.0	0	0
P vittiger	0.8	0	0.05	0
S granulatus	0.3	0	0	0
A nicthemerus	0	0	0	1.6
No of species	12	13	7	7
Total fish	359	102	2098	187
Sample area (m^2)	50	50	1000	1000

Table 5. Ranking of the 16 most abundant species from the total beam trawl sample and their ranks for each site.

Species	Number of fish	% Abundance	Abundance rank: All Sites	Boat Ramp	Tressel Bridge	Southern Flats	Colpoys Point	Cliff Point
A rueppellii	1481	59.1	1	1	1	1	1	1
G marmoratus	208	8.3	2	2	4	2	5	3
S argus	143	5.7	3	5	3	3	3	2
S poecilolaemus	136	5.4	4	4	2	4	2	10
N semifasciatus	94	3.8	5	3		8	6	8
N radiatus	61	2.4	6			5	4	5
B brownii	48	1.9	7			6		4
N balteatus	31	1.2	8	6				14
A spilomelanurus	29	1.2	9					11
S granulatus	29	1.2	10			7	9	12
H brownfieldi	27	1.1	11					7
C spatula	22	0.9	12			9		9
S nigra	19	0.8	13					6
A nicthemerus	19	0.8	14					13
S curtirostris	17	0.7	15				7	15
C mucosus	16	0.6	16					
Percentage abundance*			95.0	90.4	91.2	91.2	90.1	91.6

* Percentage of the most abundant species of the total number of fish caught at each site.

Table 6. Ranking of the 16 most abundant species on each beam trawl sampling date. Abundance rankings greater than 10 are not given.

Species	Abundance rank						
	Jan 78	May	Aug-Sept	Oct	Nov	Dec	Jan 79
A rueppellii	1	1	1	3	2	1	1
G marmoratus	3	2		1	1	2	5
S argus	7	3	2	2	3	5	3
S poecilolaemus	2	4	4		8	4	2
N semifasciatus	4					3	4
N radiatus	6		5	5		7	6
B brownii					5		
N balteatus	5	7					
A spilomelanurus	9			10	6	8	
S granulatus		6					
H brownfieldi				7		6	
C spatula				8			
S nigra				6			
A nicthemerus			7	9	9		
S curtirostris							
C mucosus		9			7		

Table 7. Percentage abundance of species caught by beam trawl at the Boat Ramp study site for August 1972, August 1978 and average grouped samples taken on the 11 December 1975, 19 January 1976, 13 February 1976 and 16 May 1976.

Species	Percentage abundance		
	August 1972	1975 to 1976	August 1978
Aspasminae sp 2	0	0.5	0
C spatula	0	1.1	0
C galei	0	0	2.0
H angustus	0	1.1	0
S argus	0.5	2.6	6.1
S curtirostris	0.3	1.6	2.0
S poecilolaemus	0.5	0.8	2.0
G marmoratus	11.5	3.9	51.0
P haackei	0	0.2	0
P sexlineatus	0.3	0.6	6.1
A rueppellii	11.7	52.3	16.3
S cephalotes	0.3	0.7	0
H brownfieldi	0	0	4.1
N balteatus	58.3	7.5	2.0
N radiatus	1.8	2.8	4.1
N semifasciatus	0	3.0	0
O antarcticus	0.5	1.3	0
C australis	0	0.8	0
H adelaidae	2.9	3.2	0
C mucosus	1.0	0	0
N pulchelus	3.1	4.2	0
A spilomelanurus	2.3	0.6	0
B brownii	3.1	4.0	4.1
B jacksonianus	0.8	4.7	0
M chinensis	0	1.5	0
S granulatus	0.8	0.7	0
A nicthemerus	0.3	0.2	0
P jenynsii	0	0.1	0
No of species	18	25	11
Total fish	384	857	49

5. BIBLIOGRAPHY

Adams, S M (1976), 'Feeding ecology of eelgrass fish communities', Transactions of the American Fisheries Society **105**, 514-519.

Bell, J D and Harmelin-Vivien, M L (1982), 'Fish fauna of French mediterranean *Posidonia oceanica* seagrass meadows. I. Community structure', Tethys **10**, 337-347.

Brook, I M (1978), 'Comparative macrofaunal abundance in turtlegrass *(Thalassia testudinum)* communities in South Florida characterized by high blade denisty', Bulletin of Marine Science **28**, 212-217.

Cambridge, M L (1975), 'Seagrasses of south-western Australia with special reference to the ecology of *Posidonia australis* Hook *f* in a polluted environment', Aquatic Botany 1, 149-161.

Cambridge, M L (1979), Cockburn Sound Study: technical report on seagrass, Western Australian Department of Conservation and Environment, Report No 7.

Cambridge, M L and McComb, A J (1984), 'The loss of seagrasses in Cockburn Sound, Western Australia, I. The time course and magnitude of seagrass decline in relation to industrial development', Aquatic Botany **20**, 229-243.

Chittleborough, R G (1970), Conservation of Cockburn Sound (Western Australia). A case study, Australian Conservation Foundation, Special Publication No 5.

Chrystal, P J, Potter, I C, Loneragan, N R and Holt, C P (1985), 'Age structure, growth rates, movement patterns and feeding in an estuarine population of the cardinalfish *Apogon rueppellii*,' Marine Biology **85**, 185-197.

Clifford, H T and Williams, W T (1976), 'Similarity measures', in W T Williams, Pattern analysis in agricultural science, Elsevier Scientific Publishing Company of Amsterdam, 37-46.

Dybdahl, R E (1979), Cockburn Sound Study: technical report on fish productivity, Western Australian Department of Conservation and Environment, Report No 4.

Grant, C J (1972), The biology of the soldier fish, *Gymnapistes marmoratus* (Pisces: Scorpaenidae)', Australian Journal of Marine and Freshwater Research **23**, 151-163.

Harmelin-Vivien, M L (1983), 'Etude comparative de l'ichtyofaune des herbiers de phanerogames marines en milieux tropical et tempere', Terre et la Vie **38**, 179-210.

Hoese, H D and Jones, R S (1963), 'Seasonality of larger animals in a Texas turtle grass community', Publications of the Institute of Marine Science University of Texas **9**, 37-47.

Hutchins, B and Thompson, M (1983), The marine and estuarine fishes of south-western Australia, Western Australian Museum, Perth, 103 pp.

Kikuchi, T (1974),'Japanese contributions on consumer ecology in eelgrass *(Zostera marina* L) beds, with special reference to trophic relationships and resources in inshore fisheries', Aquaculture 4, 145-160.

Kikuchi, T (1980), 'Faunal relationships in temperate seagrass beds' in R C Phillips and C P McRoy, Handbook of seagrass biology: an ecosystem persepective Garland STPM Press, New York, 153-172.

Kikuchi, T and Peres, J M (1977), 'Consumer ecology of seagrass beds', C P McRoy and C Helfferich, Seagrass ecosystems: a scientific perspective M Dekker, New York, 147-193.

Koike, K and Nishiwaki, S (1977), 'Seasonal change of fish fauna in the *Zostera* zone in Shimoda Bay and Nabeta Cove, the Izu Peninsula', Japanese Journal of Ichthyology **24**, 182-192.

Livingston, R J (1982), 'Trophic organization of fishes in a coastal seagrass system', Marine Ecology Progress Series **7**, 1-12.

McComb, A J, Cambridge, M L, Kirkman, H and Kuo, J (1981), 'The biology of Australian seagrasses, in J S Pate and A J McComb, The biology Australian plants, University of Western Australia Press, Nedlands, Western Australia, 258-293.

McRoy, C P and MacMillan, C (1977), 'Production ecology and physiology of seagrasses, in C P McRoy and C Helfferich, Seagrass ecosystems: a scientific perspective, M Dekker, New York, 53-88.

Ogden, J C (1980), 'Faunal relationships in Caribbean seagrass beds', in R C Phillips and C P McRoy, Handbook of seagrass biology: an ecosystem perspective, Garland STMP Press, New York, 173-198.

Ogden, J C and Zieman, J C (1977), 'Ecological aspects of coral reef-seagrass bed contacts in the Caribbean. Proceedings Third International Coral Reef Symposium, University of Miami, 377-382.

Peres, J M and Picard, J (1975), 'Causes de la rarefaction et de la disparition des herbiers de *Posidonia oceanica* sur les cotes Francaises de la Mediterranee', Aquatic Botany 1, 133-139.

Pollard, D A (1984), 'A review of ecological studies on seagrass - fish communities, with particular reference to recent studies in Australia', Aquatic Botany **18**, 3-42.

Robertson, A I and Howard, R K (1978), 'Diel trophic interactions between vertically-migrating zooplankton and their fish predators in an eelgrass community', Marine Biology **48**, 207-213.

Scott, J K (1976), 'A review of the fish genus *Neoodax* (Odacidae) of Western Australia with description of a closely allied new genus and species', Records of the Western Australian Museum **4**, 349-373.

Scott, J K (1981), 'The seagrass fish fauna of Geographe Bay, Western Australia', Journal of the Royal Society of Western Australia **63**, 97-102.

Silberstein, K (1985), The effects of epiphytes on seagrasses in Cockburn Sound, Western Australian Department of Conservation and Environment, Bulletin No 135.

Thayer, G W and Phillips, R C (1977), 'Importance of eelgrass beds in Puget Sound', Marine Fisheries Review **39**, 18-22.

Vivien, M L (1973), 'Ichthyofaune des herbiers de phanerogames marines du Grand Recif de Tulear (Madagascar) 1, Les peuplements et leur distribution ecologique', Tethys **5**, 425-436.

Weinstein, M P and Heck, K L (1979), 'Ichthyofauna of seagrass meadows along the Caribbean coast of Panama and in the Gulf of Mexico: Composition, structure and community ecology', Marine Biology **50**, 97-107.

Young, P C (1981), 'Temporal changes in the vagile epibenthic fauna of two seagrass meadows *(Zostera capricorni* and *Posidonia australis)* ', Marine Ecology Progress Series **5**, 91-102.

Young, D K and Young, M W (1978), 'Regulation of species densities of seagrass-associated macrobenthos; evidence from field experiments in the Indian River estuary, Florida', Journal of Marine Research **36**, 569-593.

PART 2. FEEDING HABITS

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ii ABSTRACT

Diets were examined of the 11 most abundant fish species from the seagrass meadows *(Posidonia* spp) of Cockburn Sound (32^{0}12'S, 115^{0}42'E), Western Australia. Crustacea were the major food items. The pipefish, *Stigmatophora argus* and *S nigra*, specialized on two different copepods andexhibited little dietary overlap with the other species. Other pipefish, *Syngnathus curtirostris* and *S poecilolaemus* had similar diets to that of the weed whiting, *Neoodax radiatus* . The devil fish, *Gymnapistes marmoratus*, and the cardinalfish, *Apogon rueppellii*, the weed whitings, *Neoodax balteatus* and *N Semifasciatus* and leatherjackets, *Acanthaluteres spilomelanurus* and *Scobinichthys granulatus* showed a range of degrees of overlap in diet with other species (from 0.53 to 0.18 on a similarity value scale ranging from zero to one, with one representing identical diets). Most values were in the lower end of the range, ie little similarity. Differences in feeding morphology and behaviour are suggested as mechanisms which enable division of the food resource.

CONTENTS
(PART 2)

TABLES

1. INTRODUCTION

Seagrass meadows are widespread, shallow coastal ecosystems of high productivity containing considerable diversity of food for fish in the form of epiphytes and epifauna (Kikuchi, 1980; Ogden, 1980). The majority of studies on the feeding habits of seagrass fish communities are from the northern hemisphere in meadows of *Zostera* species (Carr and Adams, 1973; Adams, 1976; Kikuchi, 1966, 1974), and from meadows of *Posidonia oceanica* (Bell and Harmelin-Vivien, 1983) and beds of *Thalassia testudinum* (Brook, 1977).

In the southern hemisphere, Robertson (1980) examined the feeding habits of a community of fish species from south-eastern Australia. These fish inhabited a meadow containing the seagrasses *Zostera* and *Heterozostera*, and exhibited little dietary overlap. Middleton, Bell, Burchmore, Pollard and Pease (1984) compared the diets of juveniles of three dominant species with economic importance, from two sites; one of *Posidonia australis*, the other of *Zostera capricorni*. They found no similarity in the diets of these species between the two sites.

Posidonia is one of the major seagrass genera in southern Australia, and while some work has described fish inhabiting *Posidonia* beds (see review by Pollard, 1984), little is known of the ecology of the resident species. This paper compares the feeding habits of the most abundant species of fish from the *Posidonia* seagrass meadows, in Cockburn Sound, Western Australia.

2. METHODS

Fish were collected mainly from beds of *Posidonia sinuosa* Cambridge and Kuo, which is the main seagrass species in Cockburn Sound (32°12'S; 115°42'E) (Cambridge, 1979). These beds also surrounded small patches of *P australis* Hook *f* which may have been included in the sampling area. The seagrasses stood about a metre in height and were found in water depths less than 6 m around the edge of Cockburn Sound.

Most fish were caught by a small beam trawl (mouth 1.0 m by 0.4 m and length 2 m with mesh of 2 mm) except large weed whiting, *Neoodax semifasciatus*, which, due to their ability to escape the trawl, were caught by gill nets(35 mm stretch mesh size). Fish were collected between 1000 hrs and 1200 hrs during August and September 1978. These months were chosen because the influx of juveniles was at a minimum (see Part 1 of this Technical Series). Only abundant species, accounting for over 90% of fish taken to September in the survey reported in Scott, Dybdahl and Wood (see Part 1 of this Technical Series) were examined for stomach contents.

The fish fauna is listed according to the classification and common names used by Hutchins and Thompson (1983).

The species examined in this study were: the pipefish, *Stigmatophora argus* (Richardson); *Stigmatophora nigra* Kaup; *Syngnathus curtirostris* (Castelnau); *Syngnathus poecilolaemus* Peters; the devil fish, *Gymnapistes marmoratus* (Cuvier); the cardinalfish, *Apogon rueppellii* Gunther; the weed whitings, *Neoodax balteatus* (Valenciennes); *Neoodax radiatus* (Quoy & Gaimard); *Neoodax semifasciatus* (Valenciennes); the leatherjackets, *Acanthaluteres spilomelanurus* (Quoy & Gaimard); and *Scobinichthys granulatus* (Shaw).

Based on the lengths in Table 1 and data in Scott *et al*, (see Part 1 of this Technical Series), only the *G marmoratus* sample consisted entirely of juvenile fish. The leatherjackets, *N balteatus*, and *A rueppellii* samples included both adults and juveniles while the remaining species were adults.

The fish were preserved in 10% formalin-seawater immediately on capture. The standard length of the fish was measured to the nearest millimetre and the gut removed after soaking in water. The stomach contents were examined in all species except the pipefish. The latter group had the entire contents of the tub-like gut examined. Food items were placed in broad taxonomic categories. Identification of food fragments was aided by collections of invertebrates made while collecting the fish.

The contents of each gut was scored by the volumetric method of Windell and Bowen (1978) and expressed as a percentage of the contents volume. The overall value of each food item for each species is the mean of the individual percentage scores.

Stomachs were sampled until the plot of cumulative food item diversity (H) (Pielou, 1974) against the cumulative stomachs reached a plateau.

Similarity in the diet between species pairs was calculated using the formula:

$$Cxy = 1 - 1/2\ (\Sigma|Px_i - Py_i|)$$

where Px_i and Py_i are the proportions of the i^{th} food item used by the x^{th} and y^{th} species respectively. The similarity values range from zero to one, with one representing identical diets. In Hurlburt's (1978) review of overlap indices, he cautioned that the above formula gives a measure of similarity but cannot be interpreted as measuring niche overlap or competition between species because the availability of each food resource is not known.

The feeding behaviour of the species used for gut analysis was observed at the study location by diving with SCUBA or snorkel during both day and night. Further observations were made on these species in aquaria (1100 x 400 x 500 mm depth) containing seagrass.

3. RESULTS

3.1 SIMILARITY OF DIET

Some 97% of the 167 fish examined had food in the stomach (Table 1), with 25 food items recognized. The mean (± standard deviation) of the number of food items consumed was 7.9 (± 4.2) and ranged from two for both *Stigmatophora* species to 15 for *Neoodax balteatus*. In general, the fish fed on crustaceans, particularly gammaridean amphipods.

The degree of similarity of food use ranged from 0.00 to 0.80, with most values in the lower end of the range, ie little similarity (Table 2). *S nigra* was at the bottom of the range with no similarity value greater than 0.01. *S argus* also had a very low overlap of diet with other species. Of the 55 possible interactions, 34 (62%) recorded values of less than 0.25. These low values were taken as indicative of low feeding pattern similarity. A further 16 interactions had values between 0.25 and

0.50. Only 5 (9%) had values greater than 0.50. Of these, two were less than 0.55, while a value of 0.75 was recorded between the diets of the pipefish, *S curtirostris* and *S poecilolaemus*. Values of 0.80 were recorded between the diets of these two species and that of the weed whiting, *N radiatus*.

3.2 DIFFERENCES IN FEEDING MORPHOLOGY

Within families, the weed whitings showed the greatest differences in anatomical size with roughly an incremental doubling in length between the adults of the three species (Table 1). Therefore, despite their similar overall shape and teeth structures (Scott, 1976), the mouth dimensions are different and may indicate differing prey sizes. This could account for some of the dissimilarities between their diets.

The snouts of the four pipefish species were dissected but no teeth or odontoid processes were found (Dawson and Fritzsche, 1975). *Syngnathus curtirostris* and *S poecilolaemus* were of similar size (Table 1, t = 0.19, df = 24, p = 0.50). However, the two species differed in the lengths of their snouts *(S curtirostris*, length ± SD = 5.2 ± 0.80; *S poeciloaemus*, length ± SD = 14.3 ± 2.24; t = 11.49; df =16, p<0.001). The other two pipefish species differed considerably in size, *Stigmatophora argus* being almost twice the size of *S nigra*.

The mouth structures vary among the remaining species. Of the two leather-jackets, *A spilomelanurus* has truncated teeth (Hutchins, 1977) which are a smaller size than the pointed teeth of *S granulatus*. A *rueppellii* and *A rueppellii* and *G marmoratus* have very different mouths and dentitions from each other, and from the other species.

3.3 FEEDING BEHAVIOUR

Two feeding strategies were shown by the pipefish. *Stigmatophora argus* and *S nigra* attached to the seagrass blades by means of a prehensile tail and fed in a position perpendicular to the bottom. *Syngnathus poecilolaemus* and *S curtirostris* remained unattached and fed as they swam horizontally through the canopy. The *Syngnathus* species were diurnal and observations of their behaviour suggested that the longer snouted *S poecilolaemus* foraged foraged deeper in the layer of epiphytes attached to the seagrass.

Both the leatherjackets were primarily browsers, removing epiphytes from the seagrass; but they also ate mobile food such as amphipods. In aquaria, these species were diurnal, as were the leatherjackets studied by Bell, Burchmore and Pollard (1978). The majority of cardinalfish are reported to be nocturnal feeders and cease feeding just before spawning and when carrying young (Suyehiro, 1942; Hobson, 1974; Allen, 1975). In our study, both males and females of *A rueppellii* collected during the day contained food. Chrystal, Potter, Loneragan and Holt (1985) also reported *A rueppellii* feeding during the day.

G marmoratus is also thought to be a nocturnal feeder (Grant, 1972,) but stomach samples collected during the day in this study contained relatively undigested food. Other workers have found that feeding among the scorpionfish need not be restricted to the night-time (Hobson, 1974; Bell *et al* 1978), and that there may well be an undefined activity pattern (Harmelin-Vivien and Bouchon, 1976).

4. DISCUSSION

Of the 11 most abundant fish species occuring in the seagrass of Cockburn Sound, two pipefish species showed specialized feeding on copepods. The remaining species were generalists, with most feeding mainly on epibenthic crustaceans (particularly gammaridean amphipods). In extensive studies, Kikuchi (1966, 1974) found that most fish in Japanese eelgrass beds were generalists feeding on crustacea. In other northern hemisphere studies on seagrass fish communities, Carr and Adams (1973) found that many species were specialist feeders only at certain sizes in their ontogeny, Adams (1976) found one specialist feeder while Brook (1977) found none.

While most of the fish from the seagrass of Cockburn Sound fed on a large number of food categories, dietary overlap was very low among all but three species. Part of the small similarity in diet arose from the fish eating different proportions of the nine categories of crustacea. Robertson (1980) found little overlap among the diets of fish in his study of an intertidal area of seagrass; but contrary to the present study, these fish ranged over a number of habitats, including some non-vegetated areas. Species examined by Middleton *et al,* (1984) showed substantial changes in diet which were related to movement of fish from one species of seagrass to another. Brook (1977) also found that few of the fish in his study were resident in the seagrass and consequently foraged over a large area.

Fish species of the different habitats within Cockburn Sound were studied during 1977-78 (Dybdahl, 1979). From this, it can be deduced that most fish in the present study were restricted to the seagrass beds at the life stages that they were caught; hence they were dependent on food found among the seagrass blades. Kikuchi (1974) also suggests that resident species are restricted to feeding on organisms found in seagrass beds.

The seagrass beds contain a very diverse range of epiphytic algae (Cambridge, 1979). These algae, and the decomposing layer at the base of seagrass meadows, may encourage the diversity of invertebrates found in the beds (Kikuchi, 1980). The variety of microhabitats and food types, coupled with differing feeding morphology and feeding behaviour among species, provides a likely explanation for the diversity of fish species found in seagrasses, such as *Posidonia* spp. Pollard (1984), ascribed the combination of adequate shelter for small fish from predators and the abundant food source as the basis for the importance of the seagrass habitat as 'fish nurseries' in many parts of the world.

Fish are important consumers of seagrass in the tropics, but not generally in temperate waters (Ogden, 1980). In south-eastern Australia, Bell *et al* (1978) and Conacher, Lanzing and Larkum (1979) report the extensive consumption of seagrass by species of monocanthid fish. The ingestion of small amounts of seagrass occurred in about a quarter of the fish examined in this study. However, this may have been the result of accidental inclusions while eating other food items. Similar results to these for a summer sampling period were found by Scott (1981) in a survey of some seagrass fish from Geographe Bay in Western Australia.

As the sampling in this study was confined to one period of the year, and the difficult task of determining the abundances of the various food resources in the *Posidonia* habitat was not attempted, further discussion of the role of food in structuring this community is limited. The importance of crustacea to the diets of these species is recognized, but it is possible that crustacea were simply seasonally superabundant and several fish species may have converged on this food resource in a facultative manner. Thus different degrees of diet similarity would be expected at other times. This study, however, does provide an initial examination of the feeding habits of fish from *Posidonia* beds in Cockburn Sound, an important shallow marine ecosystem in Western Australia.

Table 1: Mean percentage volume of food items and, in parenthesis, the percentage of fish containing the food item. Blank spaces indicate food item was not found to be eaten.

	S argus	*S nigra*	*S curtirostris*	*S poecilolaemus*	*G marmoratus*	*A rueppellii*	*N balteatus*	*N radiatus*	*N semifasciatus*	*A spilomelanurus*	*S granulatus*
Mean ± S E of length (cm)	18.4± 3.23	10.7± 4.21	15.6± 0.85	14.2± 7.25	5.9± 0.37	5.3± 1.08	6.7± 1.57	12.6± 4.30	19.4± 0.86	8.1± 0.24	5.7± 2.76
Range of length (cm)	14.2- 21.6	8.3- 14.5	14.4- 16.8	10.0- 19.3	5.0- 6.9	4.0- 7.3	4.8- 10.4	9.4- 17.3	17.3- 21.0	7.2- 9.9	4.0- 10.1
Sample size*	16	10	11	14	10	10	40	16	20	10	10
Empty stomachs	1	0	0	1	0	0	2	0	0	0	1
Algae				0.4 (8)	2.5 (20)	1.0 (10)	7.5 (68)	2.4 (31)	2.5 (40)	3.0 (20)	
Seagrass			3.2 (9)				5.1 (58)		3.3 (65)	0.5 (10)	16.7 (22)
Foraminifera		0.5 (10)	0.5 (9)	0.4 (8)			5.3 (47)		1.2 (45)	20.0 (80)	7.9 (78)
Anthrozoan						2.0 (10)					1.1 (11)
Porifera											4.4 (33)
Bryozoan							1.3 (14)				3.3 (44)
Polychaeta					7.0 (20)		1.6 (8)	2.4 (19)	19.1 (65)	2.0 (30)	

*Number of stomachs examined.

Table 1: The mean percentage volume of food items and, in parenthesis, the percentage of fish containing the food item. Blank spaces indicate food item was not found to be eaten. (contd)

	S argus	*S nigra*	*S curtirostris*	*S poecilolaemus*	*G marmoratus*	*A rueppellii*	*N balteatus*	*N radiatus*	*N semifasciatus*	*A spilomelanurus*	*S granulatus*
Gastropoda											
Bivalvia			1.8 (9)				8.7 (26)		3.2 (50)		5.6 (33)
Mussel spat							1.1 (5)	2.2 (25)			
Copepoda 1*	85.0 (93)						10.9 (45)				
Copepoda 2*		99.5 (100)									
Gammarida 1*	15.0 (40)		74.6 (100)	91.9 (92)	7.0 (30)	14.5 (40)	10.9 (50)	79.3 (100)	27.4 (80)	10.5 (60)	25.6 (67)
Gammarida 2*			11.4 (36)								
Caprellida					27.0 (70)	22.5 (40)					
Isopoda			0.9 (9)		19.0 (60)	58.8 (80)	4.7 (13)	0.6 (6)	1.5 (25)	4.0 (20)	11.1 (22)
Cirripeda							22.4 (50)				
Decapoda					22.0 (70)		5.7 (13)	8.3 (25)	7.5 (20)	1.5 (10)	
Brachiura							3.3 (18)		0.3 (5)		3.3 (11)

* Codes signifying different types of copepods and gammaridean amphipods.

Table 1: The mean percentage volume of food items and, in parenthesis, the percentage of fish containing the food item. Blank spaces indicate food item was not found to be eaten. (contd)

	S argus	*S nigra*	*S curtirostris*	*S poecilolaemus*	*G marmoratus*	*A rueppellii*	*N balteatus*	*N radiatus*	*N semifasciatus*	*A spilomelanurus*	*S granulatus*
Pycnogonida								0.3 (6)			
Tunicates										30.5 (80)	17.2 (56)
Eggs							1.1 (13)				4.4 (22)
Calarious fragments			3.2 (36)								
Sand				7.3 (8)					2.0 (20)		
Unidentified material			4.6 (18)		15.5 (90)	2.5 (40)		4.6 (44)	28.0 (100)	27.0 (70)	13.0 (78)

Table 2: The degree of similarity in food use.

	S nigra	*S curtirostris*	*S poecilolaemus*	*G marmoratus*	*A rueppellii*	*N balteatus*	*N radiatus*	*N semifasciatus*	*A spilomelanurus*	*S granulatus*
S argus	0.00	0.15	0.15	0.07	0.15	0.22	0.15	0.15	0.11	0.15
S nigra		0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
S curtirostris			0.75	0.13	0.18	0.17	0.80	0.38	0.17	0.37
S poecilolaemus				0.07	0.15	0.12	0.80	0.30	0.11	0.26
G marmoratus					0.52	0.22	0.25	0.41	0.33	0.31
A rueppellii						0.22	0.19	0.24	0.18	0.30
N balteatus							0.22	0.34	0.26	0.39
N radiatus								0.45	0.22	0.31
N semifasciatus									0.47	0.49
A spilomelanurus										0.53

5. BIBLIOGRAPHY

Adams, S M (1976), 'Feeding ecology of eelgrass fish communities', Transations of the American Fisheries Society **105**, 514-519.

Allen, G R (1975), 'The biology and taxonomy of the cardinalfish, *Sphaeramia orbicularis* (Pisces; Apogonidae)', Journal of the Royal Society of Western Australia **58**, 86-92.

Bell, J D, Burchmore, J J, and Pollard, D A (1978), 'Feeding ecology of three sympatric species of leatherjackets (Pisces: Monacanthidae) from a *Posidonia* seagrass habitat in New South Wales', Australian Journal of Marine and Freshwater Research **29**, 631-643.

Bell, J D and Harmelin-Vivien, M L (1983), 'Fish fauna of French mediterranean *Posidonia oceanica* seagrass meadows, 2. Feeding habits', Tethys **11**, 1-14.

Brook, I M (1977), 'Trophic relationships in a seagrass community *(Thalassia testudinum)*, in Card Sound, Florida. Fish diets in relation to macrobenthic and cryptic faunal abundance. Transactions of the American Fisheries Society **106**, 219-229.

Cambridge, M L (1979), Cockburn Sound Study: technical report on seagrass, Western Australian Department of Conservation and Environment, Report No 7.

Carr, W E S, and Adams, C A (1973), 'Food habits of juvenile marine fishes occupying seagrass beds in the estuarine zone near Crystal River, Florida', Transactions of the American Fisheries Society **102**, 511-540.

Chrystal, P J, Potter, I C, Loneragan, N R and Holt, C P (1985), 'Age structure, growth rates, movement patterns and feeding in an estuarine population of the cardinalfish *Apogon rueppellii*', Marine Biology **85**, 185-197.

Conacher, M J, Lanzing, W J and Larkum, A W (1979), 'Ecology of Botany Bay, II. Aspects of the feeding ecology of the fanbellied leatherjacket *Monacanthus chinensis* in *Posidonia australis* seagrass beds in Quibray Bay, Botany Bay, NSW', Australian Journal of Marine and Freshwater Research **30**, 387-400.

Dawson, C E, and Fritzsche, R A (1975), 'Odontoid processes in pipefish jaws', Nature, **257**, 390.

Dybdahl, R E (1979), Cockburn Sound Study: technical report on fish productivity, Western Australian Department of Conservation and Environment, Report No 4.

Grant, C J (1972), 'The biology of the soldier fish, *Gymnapistes marmoratus* (Pisces: Scorpaenidae)', Australian Journal Marine and Freshwater Research **23**, 151-163.

Harmelin-Vivien, M L, and Bouchon, C (1976), 'Feeding behavior of some carnivorous fishes (Serranidiae and Scorpaenidae) from Tulear (Madagascar)', Marine Biology **37**, 329-340.

Hobson, E S (1974), 'Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii', Fisheries Bulletin **72**, 915-1031.

Hurlbert, S H (1978), 'The measurement of niche overlap and some relatives', Ecology **59**, 67-77.

Hutchins, J B (1977), 'Descriptions of three new genera and eight new species of monacanthid fishes from Australia', Records of the Western Australian Museum **5**, 3-58.

Hutchins, B and Thompson, M (1983), The marine and estuarine fishes of south-western Australia, Western Australian Museum, Perth, 103 pp.

Kikuchi, T (1966), 'An ecological study on animal communities of the *Zostera marina* belt in Tomioka Bay, Amakusa, Kyushu', Publications from the Amakusa Marine Biological Laboratory Kyushu University, **1**, 1-106.

Kikuchi, T (1974), 'Japanese contributions on consumer ecology in eelgrass *(Zostera marina L)* beds, with special reference to trophic relationships and resources in inshore fisheries', Aquaculture **4**, 145-160.

Kikuchi, T (1980), 'Faunal relationships in temperate seagrass beds, in R C Phillips and C P McRoy, Handbook of seagrass biology: an ecosystem perspective', Garland STPM Press, New York, 153-172.

Middleton, M J, Bell, J D, Burchmore, J J, Pollard, D A and Pease, B C (1984), 'Structural differences in the fish communities of *Zostera capricorni* and *Posidonia australis* seagrass meadows in Botany Bay, New South Wales', Aquatic Botany **18**, 89-109.

Odgen, J C (1980), 'Faunal relationships in Caribbean seagrass beds, in R C Phillips and C P McRoy, Handbook of seagrass biology: an ecosystem perspective, Garland STPM Press, New York, 173-198.

Pielou, E C (1974), Population and Community Ecology Principles and Methods, Gordon and Breach Science Publication, New York, 424 pp.

Pollard, D A (1984), 'A review of ecological studies on seagrass - fish communities, with particular reference to recent studies in Australia', Aquatic Botany **18**, 3-42.

Robertston, A I (1980), 'The structure and organization of an eelgrass fish fauna', Oecologia **47**, 76-82.

Scott, J K (1976), 'A review of the fish genus *Neoodax* (Odacidae) of Western Australia with description of a closely allied new genus and species', Records of the Western Australian Museum **4**, 349-373.

Scott, J K (1981), 'The seagrass fish fauna of Geographe Bay, Western Australia,' Journal of the Royal Society of Western Australia 63, 97-102.

Suyehiro, Y (1942), 'A study on the digestive system and feeding habits of fish', Japanese Journal of Zoology **10**, 1-303.

Windell, J T, and Bowen, S H (1978), 'Methods for study of fish diets based on analysis of stomach contents' in T Bagenal, Methods for assessment of fish production in fresh waters. Blackwell Scientific Publications, Oxford, 219-226.