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SEAGRASS BIODIVERSITY ON KANGAROO ISLAND

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Oceans of Blue:
Coast, Estuarine and Marine Monitoring Program

A report prepared for the
Kangaroo Island Natural Resources Management Board

by
Martine Kinloch
Daniel Brock
Hugh Kirkman
Thierry Laperousaz

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Oceans of Blue – Coast, Estuarine and Marine Monitoring Program

Project Officer Contact Details
Martine Kinloch
Coast and Marine Program Manager
Kangaroo Island Natural Resources Management Board
35 Dauncey Street
Kingscote SA 5223

Phone: (08) 8553 4312
Fax: (08) 8553 4399
Email:martine.kinloch@kinrm.com.au

Kangaroo Island Natural Resources Management Board Contact Details
Jeanette Gellard
General Manager
35 Dauncey Street
Kingscote SA 5223

Phone: (08) 8553 4340
Fax: (08) 8553 4399
Email:jeanette.gellard@kinrm.com.au

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Front cover images:

Typical mobile fauna found in seagrass beds *(Andy Schofield)*

Sorting seagrass samples with the help of community volunteers *(Andy Schofield)*

Foreword

This project is a component of the Kangaroo Island Natural Resources Management Board's 'Here to Stay' Investment Strategy. The following Program Outcomes, Actions, Resource Condition Targets and Management Action Targets from the Strategy are relevant to the project.

Program

Oceans of Blue: Managing marine, coastal and estuarine biodiversity on Kangaroo Island

Program outcome

A scientifically rigorous and integrated system of measuring and reporting on the state of marine, coastal and estuarine environments of Kangaroo Island that relates trends in the condition of biodiversity assets to changes in human uses of land and seascapes, provides advice on targeting management action to mitigate anthropogenic impacts where required and empowers the public to respond to threats to natural resource condition and values.

Relevant Resource Condition Targets

8.5.D An enhancement in the condition of natural biodiversity in marine, coastal and estuarine systems through protection and management of key biodiversity assets and areas.

Relevant Management Action Targets

8.5.1 Establish benchmarks and monitoring program for marine and estuarine water quality, terrestrial and marine coastal biodiversity and condition of fisheries stocks.

8.5.2 Establish representative monitoring program for terrestrial and marine coastal biodiversity focusing on areas subject to water contamination and other threatening processes.

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Introduction

Seagrass meadows have long been recognised as biologically and ecologically important marine ecosystems that provide habitat, food and refuge for a wide variety of animals. They are also important breeding and nursery grounds for commercially important species of fish, crustaceans and molluscs (Bell and Pollard 1989; Heck *et al*. 1997; Butler and Jernakoff 2000). Seagrass beds support a greater diversity and abundance of animals than neighbouring unvegetated areas of seabed (Gore *et al.* 1981; Kulczycki *et al*. 1981; Kirkman *et al.* 1991; Jenkins and Wheatley 1998; McDonald 2007); degradation or loss of seagrass meadows can therefore result in significant reductions in the productivity and biodiversity of shallow marine ecosystems.

Seagrass loss is a problem worldwide and in Australia it is estimated that around 45,000 hectares have been lost this century (Sheperd *et al*. 1989; Walker and McComb 1992). In South Australia there has been significant loss of seagrass beds along the Adelaide metropolitan coastline. While natural events such as storms can result in large-scale seagrass loss (Seddon *et al*. 2000), of primary concern to management agencies are the anthropogenic causes of seagrass decline in the vicinity of urbanised coastal areas. Sediment and nutrient inputs from sewage, stormwater, coastal erosion and runoff from agricultural land can lead to a deterioration in water quality in the inshore marine habitats in which seagrass beds commonly occur. Excessive nutrients (eutrophic conditions) have been linked to seagrass loss and degradation as they encourage the growth of epiphytes[1] and drift macroalgae that reduce the amount of light available to seagrass for photosynthesis (Walker and McComb 1992; Cambridge *et al*. 1986).

Extensive seagrass meadows occur in several large embayments around the eastern coastline of Kangaroo Island (Figure 1). There is evidence, based on seagrass mapping and measurements of epiphyte loads, that in some of these bays seagrass meadows are degraded and seagrass habitat has been lost as a result of eutrophication (Cameron and Hart 2002; Bryars *et al.* 2003; Southgate 2005). Particular concern has been expressed for the health of seagrasses in Nepean Bay on the northeast coast of the Island, where the main town of Kingscote is situated (Figure 1). As a result, almost all studies of KI's seagrass meadows have so far focused on the extent and condition of seagrass meadows in Nepean

[1] Epiphytes = algae that grow on seagrass blades. Epiphytes utilise seagrass leaves as a substrate for support, but not as a source of nutrients.

Bay, with only Southgate's recent study also, for the first time, examining seagrass condition in other bays around KI (Southgate 2005).

To date, though, there have been no studies of the faunal assemblages associated with seagrass meadows on Kangaroo Island or what, if any, effect seagrass decline may have on marine biodiversity in these systems. Faunal species as indicators of seagrass health have not been used (Gillanders 2006) but may have potential early-warning properties. For example, degraded seagrass meadows are often characterized by high numbers of grazing and detritivorous[2] invertebrates (Kirkman *et al*. 1991; Jernakoff and Nielsen 1997) associated with excessive epiphyte growth (Cambridge *et al*. 1986). Certainly, given their value as habitat for a diverse range of marine species and susceptibility to impacts from expanding human development, it is important to investigate and inventory seagrass biodiversity in order to develop an understanding of the faunal communities associated with seagrass meadows, benchmark their condition, and thereby aid in the management of these threatened ecosystems.

The aim of this study was, therefore, to fill a significant gap in the baseline biodiversity information of an important underwater environment on KI by characterising the mobile seagrass epifauna[3] of several inshore seagrass meadows around the Island, and to compare faunal assemblages in degraded seagrass environments with those in apparently healthy meadows. A secondary aim was to investigate the potential of finding faunal indicator species for on-going monitoring of seagrass meadows on Kangaroo Island.

[2] Detritivorous = organisms that use organic waste (detritus) as a food source.
[3] Epifauna = benthic (bottom-dwelling) animals that live on the surface of seagrass. Epifauna may attach themselves to the seagrass blades or range freely over them by crawling or swimming. Snails, shrimps, crabs, seastars and certain fish are epifaunal animals.

Methods

Nine study sites were selected within three major seagrass meadow habitats on Kangaroo Island, all of which are important in terms of areal extent, fisheries value or conservation status (Table 1, Figure 1). Collectively, the three areas also represent a range of environmental and anthropogenic conditions, *viz*:

1. **Nepean Bay (5 sites**) - a shallow, sheltered, eutrophic embayment on the northeast coast of the Island, where seagrass degradation and loss have been documented since 1995 (Edyvane 1997). High epiphyte loads and the presence of extensive drift macroalgae have been linked to elevated levels of nutrients (Bryars *et al*. 2003) entering Nepean Bay through the Cygnet River, the largest watercourse on the Island. The Cygnet River drains 11% of the land area of KI, and the major land use in the catchment is agriculture (Figure 1).

2. **Pelican Lagoon (2 sites**) - a large (~14 km^2), protected, shallow marine lagoon opening via American River into Nepean Bay (Figure 1). Pelican Lagoon has been an Aquatic Reserve since 1975 due to its importance as a sanctuary for juveniles of commercial fish species and is soon to be declared a Marine Park Sanctuary Zone. It has no riverine input but receives diffuse runoff from the surrounding catchment where land uses are agricultural, residential and conservation. The seagrass beds in Pelican Lagoon are considered to be exhibiting signs of poor health, with moderate epiphyte loads (Southgate 2005).

3. **Antechamber Bay (2 sites)** - an open, exposed, oligotrophic[4] bay on the eastern end of Kangaroo Island (Figure 1). The Bay is well-flushed by the strong tidal currents that flow through Backstairs Passage and disperse terrigenous inputs from the Chapman River or surrounding agricultural land use on Dudley Peninsula. Antechamber Bay supports lush, healthy seagrass meadows with very low epiphyte loads (Southgate 2005).

Aerial photography and field surveys were used to select sites that were dominated by species of the genus *Posidonia* or, alternatively, that were representative of the main species of seagrass within the meadow (Table 1). Site selection aimed to minimise patchiness in

[4] Oligotrophic = naturally occurring low levels of nutrients in the water.

seagrass cover and ensure the extent of seagrass beds was sufficient for a 50-metre sampling transect.

Figure 1: Map of seagrass sampling sites.

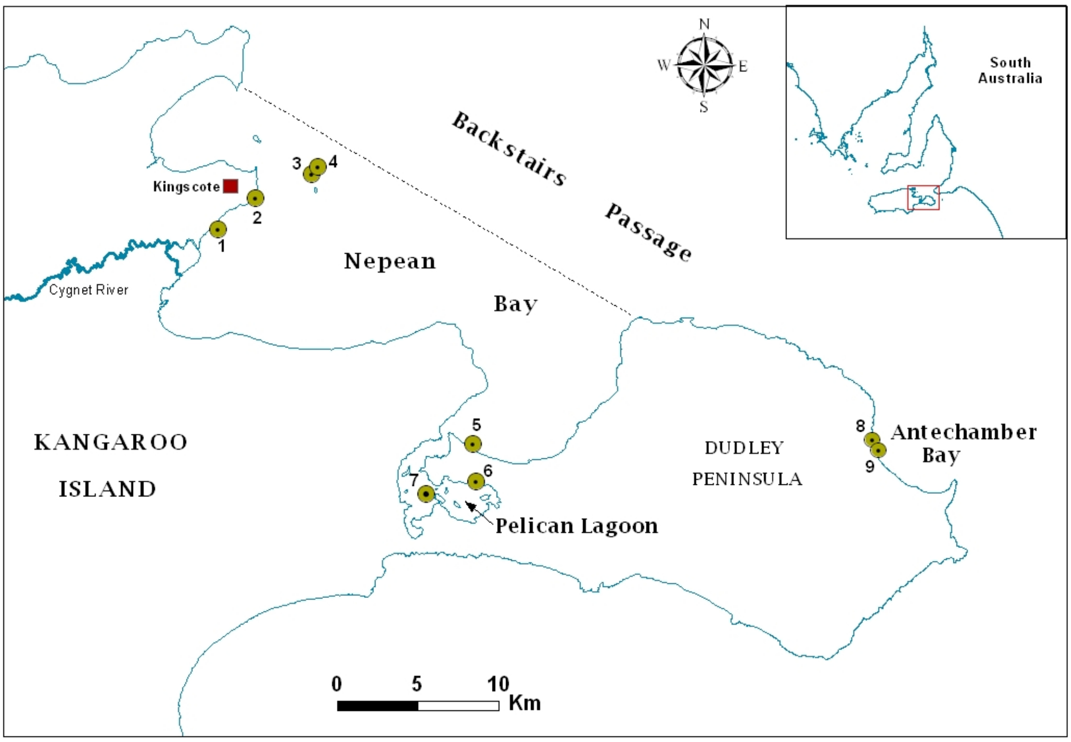


Table 1: Description of seagrass sampling sites.

Location	Site No.	Site	Site Code	Dominant seagrass species	Sub-dominant seagrass species	% cover
Nepean Bay (NB)	1	Brownlow	BL	*Posidonia australis*		79
	2	Kingscote	KGC	*P. sinuosa*		88
	3	Inner Spit	IS	*P. australis*		68
	4	Outer Spit	OS	*P. australis*		70
	5	Island Beach	IB	*P. australis*		100
Pelican Lagoon (PL)	6	PL East	PLE	*Ruppia sp.*	*P. sinuosa*	98
	7	PL West	PLW	*Halophila australis*	*Ruppia sp., P. australis*	100
Antechamber Bay (AB)	8	AB North	ABN	*P. angustifolia*	*P. sinuosa*	73
	9	AB South	ABS	*P. angustifolia*	*P. sinuosa*	87

Mobile seagrass epifauna was captured using a roller beam trawl 1 metre (m) wide, 0.5 m deep and with net panels of mesh size 3 mm and a cod end of mesh size 1 mm (Young 1975). The net was towed three times at each site at approximately 0.04 m/s between two floating buoys set 50 metres apart. Beam trawling took place at night, in depths of 1 - 4 m in Nepean Bay and Pelican Lagoon and 5 - 7 m in Antechamber Bay. Trawl samples were returned to the laboratory, sorted into major taxonomic groups, preserved in 70% ethanol and sent to the South Australian Museum for identification and counting. Summer samples were collected between 11/12/05 and 19/12/05; winter samples were taken between 9/8/06 and 15/8/06.

For data analyses, the three beam trawl samples taken at each site in each season were pooled so that the total area swept by the beam trawl was 150 m^2 in each season. Unfortunately, however, only two trawl samples were collected at the Antechamber Bay sites (ABN, ABS) during summer. To estimate the numbers of species that would have been captured in a third sample, the mean percentage contribution to total species diversity added by a third trawl was calculated from the data for all other sites. This percentage was then used to scale up the values recorded for the two trawls at Antechamber Bay in summer to a total species diversity that could be compared with other sites. To compare densities of animals at each site (no. individuals/m^2) the species abundances at the Antechamber Bay sites in summer were divided by 100, not 150 as was the case for the other sites.

Multivariate analysis was used to examine differences in epifaunal assemblages among sites and identify species contributing to these differences. The sites-by-species matrix was transformed by the log (x + 1) transformation then multivariate analysis was undertaken using non-parametric multidimensional scaling (NMDS) (PC-Ord Mather 1976; Kruskal 1964). Sorensen's distance measure was used to calculate the similarity matrix. Thirty runs with real data on six axes were undertaken to select the appropriate dimensionality and starting configuration for the final NMDS. Indicator species analysis (PC-Ord Mather 1976; Kruskal 1964) was used to describe species contribution to different site groupings. Thirty Monte Carlo randomizations were used to determine statistical significance of indicator species ($p<0.05$).

Results

A total of 157 species of mobile epifauna were recorded from seagrass meadows at the nine sites. Teleosts (bony fish) were the dominant group in terms of species number (70 species = 45% of total), while crustaceans were the most abundant taxon, contributing nearly 60% of the total number of animals (Table 2). Decapods (crabs and shrimps) were the most diverse and abundant crustaceans while gastropods (snails) were the most diverse and abundant molluscs (Table 2). A complete inventory of species recorded at each site can be found in Appendix 1.

Table 2: Total species richness and abundance of mobile epifauna at all sites.

Taxon	No. Species	Abundance
Teleosts	**70**	**1,466**
Crustacea	**32**	**15,642**
Decapoda	22	13,631
Isopoda	9	1,497
Mysidacea	1	514
Mollusca	**39**	**9,338**
Gastropoda	33	9,189
Cephalopoda	3	140
Polyplacophora	1	6
Bivalvia	2	3
Echinodermata	**15**	**116**
Echinoidea	4	39
Ophiuroidea	2	32
Asteroidea	5	28
Holothuroidea	4	17
Chelicerata	**1**	**1**
Pycnogonida	1	1
Total	**157**	**26,563**

Overall, when data from summer and winter were pooled, sites in Nepean Bay (IB, IS, OS, BL, KGC) had higher ***species diversity*** (a greater variety of species) than sites in Pelican Lagoon and Antechamber Bay (Table 3). Antechamber Bay South had the lowest species diversity of all nine sites (47 species) and Antechamber Bay North the third lowest. Inner Spit, Brownlow, and Island Beach had the highest diversity, with almost equal numbers of species (Table 3). Sites at Antechamber Bay, especially ABN, had a noticeably lower diversity of molluscs than the other sites (Figure 3a).

There were also significantly higher ***abundances*** of mobile epifauna in Nepean Bay versus Antechamber Bay with a two- to six-fold difference in mobile faunal densities (Table 3). Animal density in Nepean Bay ranged from 8 (OS) to 21 (KGC) individuals/m^2 compared with 3 – 4 individuals/m^2 at Antechamber Bay (Table 3). In a similar pattern to species diversity, Antechamber Bay sites had disproportionately lower densities of molluscs than all other sites (mean density AB 0.17 vs 4.4 individuals/m^2 for all other sites) (Figure 3b).

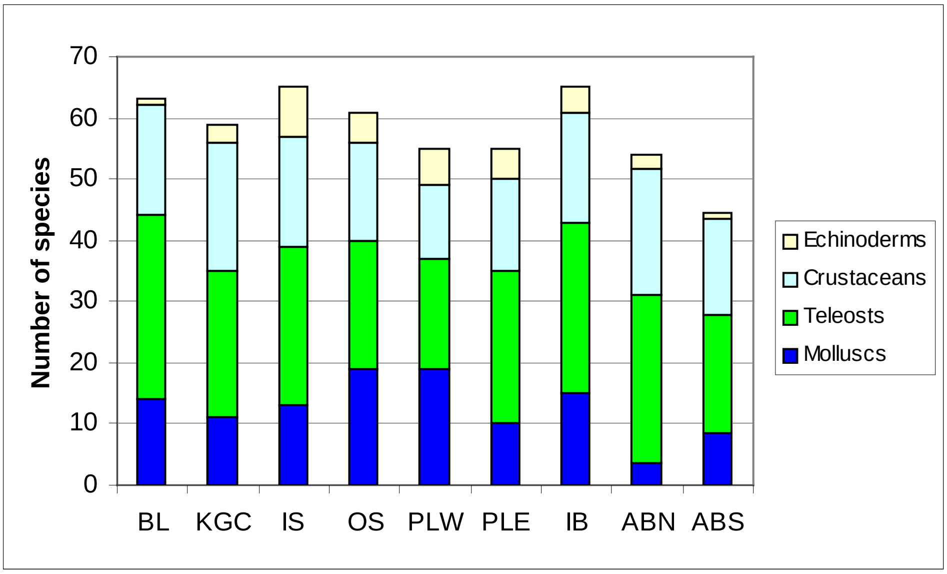
Table 3: Species richness and density of mobile epifauna at each site.

Site	No. Species	Density (no. individuals per m^2)
Antechamber Bay North	56	4.06
Antechamber Bay South	47	2.50
Brownlow (Nepean Bay)	64	12.79
Island Beach (Nepean Bay)	63	12.39
Inner Spit (Nepean Bay)	65	12.35
Kingscote (Nepean Bay)	59	20.62
Outer Spit (Nepean Bay)	61	7.62
Pelican Lagoon East	56	7.03
Pelican Lagoon West	54	10.27

There were no statistically significant seasonal differences in total species diversity or abundance between summer and winter (paired t-test, $p<0.01$ for both diversity and density), although there was a slight trend towards fewer species in winter than summer (seven out of nine sites, Figure 4a). There were, however, seasonal differences in species composition, with always less than 50% of species in common between seasons at all sites (Table 5). The seasonal faunal communities overlapped the most at sites in Nepean Bay, where species in common between summer and winter ranged from 36% at Kingscote to 48% at Brownlow (Table 5). Sites in Pelican Lagoon and Antechamber Bay had more distinct seasonal communities with species in common ranging from only 19% at Pelican Lagoon East to 26% at Antechamber Bay South (Table 5). Overall, for all sites combined, the second sampling event in winter contributed an additional 44 species to the inventory of those found in summer.

Figure 3: Comparison of a) species richness and b) species abundance by taxonomic group.

a)



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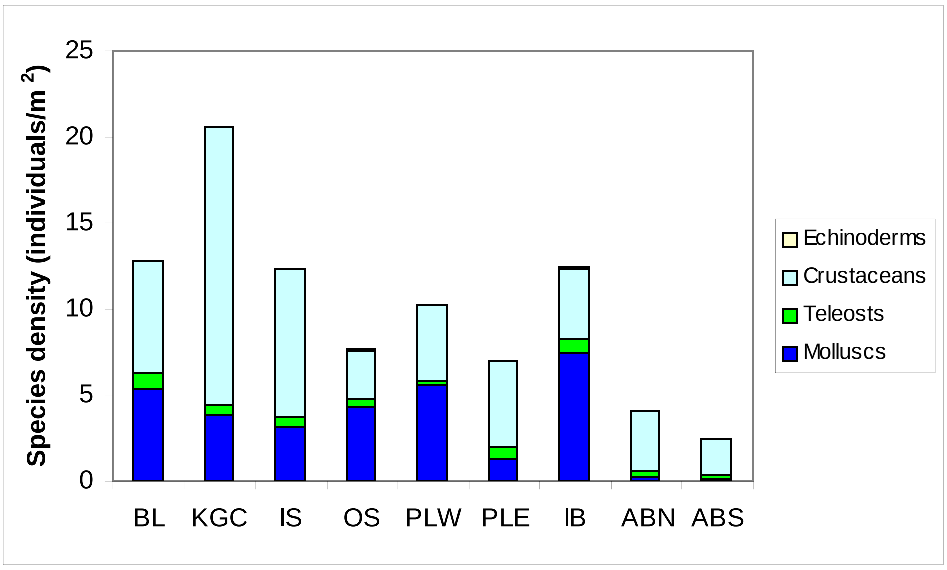
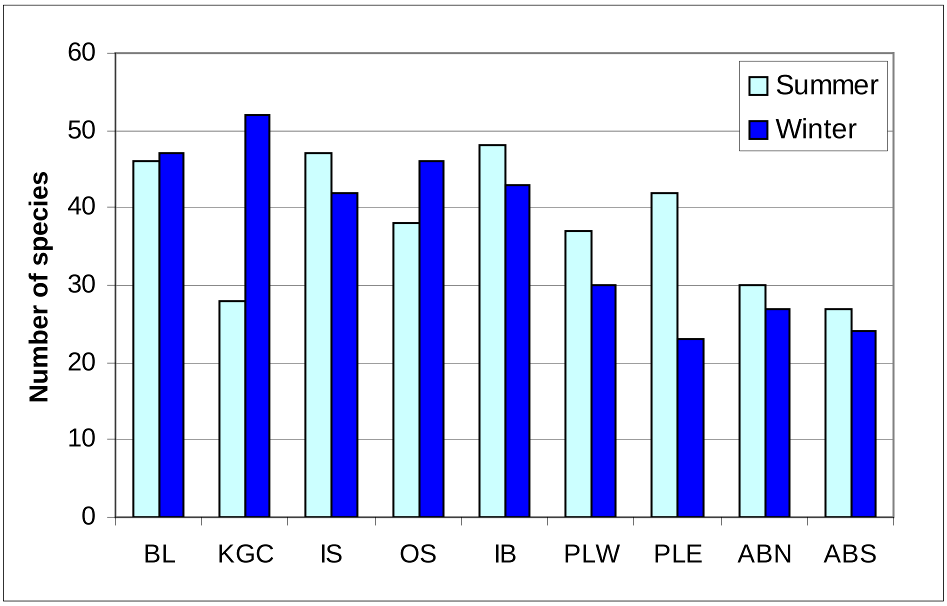


Figure 4: Seasonal comparison of a) species richness and b) species abundance by site.

a)



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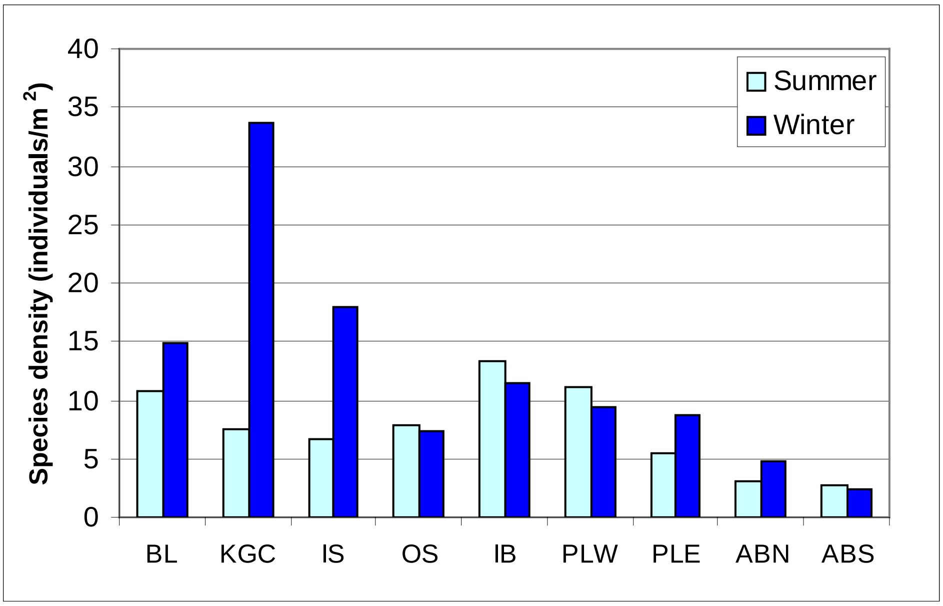


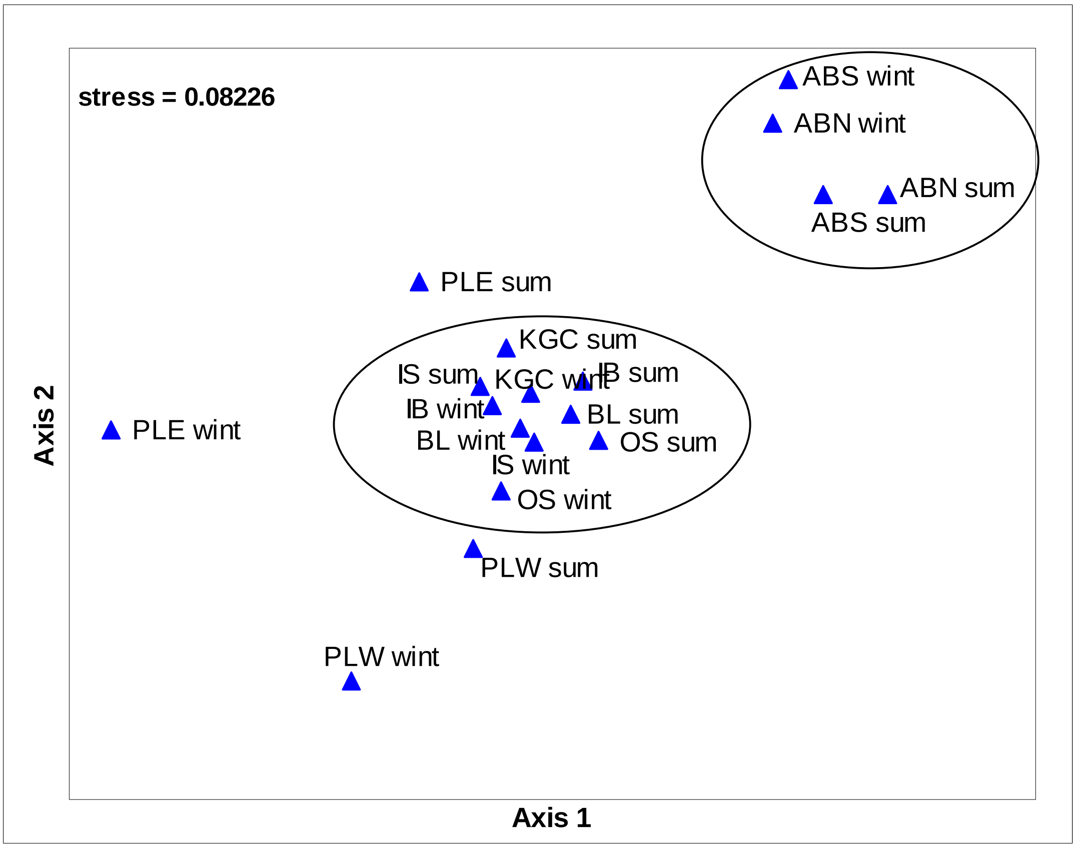
Table 5: Comparison of species composition between seasons.

Site	No. Species		% Species in common
	Summer	Winter	
Brownlow	51	44	48
Kingscote	28	52	36
Inner Spit	48	41	37
Outer Spit	39	46	37
Island Beach	38	30	42
PL West	42	22	26
PL East	49	42	19
AB North	37	26	31
AB South	31	24	27

The multivariate ordination of species assemblages showed two main groups (Figure 5), with the two sites from Antechamber Bay forming one group and the five sites from Nepean Bay forming another, indicating that mobile seagrass epifaunal communities are different in these two bays. Characteristic, or indicator, species for Antechamber Bay were the shrimps *Latreutes compressus* and *Hyppolyte australiensis* and the clingfishes *Cochleoceps viridis* and *Parvicrepis parvipinnis* (Table 6). Indicator species for Nepean Bay included the bridled leatherjacket *Acanthaluteres spilomelanurus*, the spotted pipefish *Stigmatopora argus* and the gastropods *Sassia sexcostata* and *Mitrella lincolnensis* (Table 6).

The major difference between Antechamber Bay and Nepean Bay assemblages was the remarkably low diversity (Figure 3a) and abundance (Figure 3b) of gastropod molluscs (snails) at Antechamber Bay. There were only eight species of snail found at Antechamber Bay, of which one species (*Thalotia conica)* made up 90% of the total number of individuals. This compares with 28 species of gastropod molluscs for sites in Nepean Bay. Common species of snails such as *Mitrella lincolnensis*, *Diala lauta*, species of the genus *Cantharidus* and *Phasianella* that numbered in their hundreds or thousands at Nepean Bay were either absent or represented by one individual at sites in Antechamber Bay.

Figure 5: NMDS ordination plot of seasonal faunal assemblages at nine seagrass sites on KI.



Pelican Lagoon (PL) showed large variations in both species composition and abundance between sites and seasons (Figure 5). For example, at PL West in summer over 1000 individuals of the shrimp *Macrobrachium sp.* were recorded, while the same species was absent in winter. At PL East, five of the six most abundant species in summer were either absent or present only in extremely low numbers in winter. Similar differences occurred when comparing the two sites in Pelican Lagoon in the same season. Pelican Lagoon also had the highest number of unique species per site with an average of 16, compared with eight unique species per site in Nepean Bay and five in Antechamber Bay. These factors combined resulted in the lack of any obvious clustering of the Pelican Lagoon samples in the ordination (Figure 5).

Crustaceans, especially shrimps, (*e.g. Macrobrachium sp.* and *Chlorotecella spinicaudus*) were the most common cosmopolitan taxon, being found at seven or more sites (Table 7). Common molluscs included: the trochid shell *Thalotia conica*, the dove shell *Diala lauta* and the southern pygmy squid *Idiosepius notoides*. Common fish species included: the scorpion fish *Gymnapistes marmoratus* (which was present in high numbers except at Antechamber Bay where it was absent), several species of weedy whiting, of which the Little Weed Whiting, *Neoodax balteatus*, was the most abundant, leatherjackets, and pipefish, of which *Vanacampus poecilolaemus* was the most common (Table 7). Clingfish of the genus *Cochleops* were found at all sites but *Cochleops viridis* was found only in Antechamber Bay while *Cochleops spatula* was found everywhere except Antechamber Bay.

Table 6: Indicator species of the main site groupings identified in the NMDS ordination.

Antechamber Bay	Nepean Bay
Cochleoceps viridis	*Acanthaluteres spilomelanurus*
Dumea latipes	*Amblychilepas omicron*
Heteroclinus macrophthalmus	*Cerceis acuticaudata*
Hyppolyte australiensis	*Chlorotecella spinicaudus*
Latreutes compressus	*Cochleoceps spatula*
Parvicrepis parvipinnis	*Diala lauta*
Processa australiensis	*Mitrella lincolnensis*
Thalotia conica	*Phasianella ventricosa*
	Platycerceis hyalina
	Sassia sexcostata
	Stigmatopora argus

Table 7: Cosmopolitan seagrass species (found at seven or more sites)

Species	Common Name
Teleosts	
Acanthaluteres spilomelanurus	bridled leatherjacket
Vanacampus poecilolaemus	pipefish
Gymnapistes marmoratus	scorpion fish
Cristiceps australis	southern crested weedfish
Haletta semifasciata	blue weed whiting
Heteroclinus sp. Type 1	weedfish
Neoodax balteatus	little weed whiting
Crustaceans (shrimps)	
Latreutes compressus	shrimp
Notomysis australiensis	shrimp
Macrobrachium sp.	shrimp
Periclimenes aesopius	commensal shrimp
Philocheras intermedius	shrimp
Processa gracilis	long wristed shrimp
Rhynchocinetes sp.	hinge beak shrimp
Alpheus edwardsii	pistol shrimp
Chlorotecella spinicaudus	shrimp
Crustaceans (isopods)	
Cerceis acuticaudata	sea lice
Crabyzos longicaudatus	sea centipede
Crustaceans (crabs)	
Nectocarcinus integrifrons	red swimmer crab
Litocheira bispinosa	crab
Molluscs (gastropods)	
Cantharidus bellulus	kelp shell
Clanculus dunkeri	
Diala lauta	dove shell
Mitrella lincolnensis	
Thalotia conica	top shell
Molluscs (cephalopods)	
Idiosepius notoides	southern pygmy squid

Discussion

Seagrass meadows on Kangaroo Island support a diverse and abundant range of mobile epifauna with over 157 species of fish and invertebrates (70 and 87 species respectively) recorded in this study. While it is difficult to compare results with other studies because of differences in sampling design and field methods, it appears that KI seagrass meadows have relatively high species diversity compared with other temperate seagrass ecosystems. For example, in a comparative study from Spencer Gulf in South Australia, McDonald (2007) found similar numbers of fish species as this study (85 vs 70), however, McDonald sampled twice the area per trawl and conducted over 400 trawls compared with the 54 trawls undertaken in this study. In another comparable study in Western Australia, Kirkman (1991) recorded a total of 75 species of mobile epifauna (both fish and invertebrates) from beam trawl samples taken in *Posidonia* beds. Two studies of temperate seagrass fish communities sampled using a seine net (Velensini *et al*. 2004; Jenkins *et al*. 1998) recorded 67 and 28 species of fish respectively.

The relatively high diversity of mobile epifauna found in seagrass meadows in this study may be related to the oceanograpic complexity of the region. Kangaroo Island is situated at the confluence of two major oceanic currents: the warm Leeuwin current originating in tropical Western Australia flowing in from the west and from the south-east the cold Flinders current flowing north from Tasmania. The mergin and mixing of these two water masses, each transporting its own distinct planktonic and pelagic biota, adds to the diversity of South Australian marine species, and in particular to the marine biodiversity of Kangaroo Island.

Despite this relatively high biodiversity, most of the species found in this study are typical of the types of animals found in seagrass meadows elsewhere in southern Australia (Kirkman 1991, McDonald 2007). Seagass assemblages are dominated by small shrimps (decapods), slaters (amphipods), sea lice (isopods) and snails, crabs, syngnathid fish (pipefish and seahorses), weedy whitings, scorpionfish and clingfish, plus the odd seastar, polychaete worm and sea cucumber. No new species were discovered here that have not been found elsewhere in South Australia.

The main finding of this study was that the mobile seagrass epifaunal communities of Antechamber Bay were distinctly different from those found in Nepean Bay or Pelican Lagoon. Species diversity was higher and species abundances (density of individuals) far greater in the apparently degraded meadows of Nepean Bay than in the pristine environment of Antechamber Bay, where diversity and abundance were lowest. The main reason for this was the strikingly depauperate community of gastropod molluscs at Antechamber Bay compared with Nepean Bay or Pelican Lagoon. Thus, while the species richness and abundance of both fish and crustaceans were similar among all sites, Antechamber Bay had fewer species, and between 10-20 times lower abundances, of gastropod molluscs (snails) than sites in Nepean Bay. These results are similar to the study by Kirkman (1991) who found much higher numbers of gastropod molluscs in eutrophic *Posidonia* seagrass beds at Albany in Western Australia when compared with oligotrophic ones. He suggested that, as many of these molluscs were grazing species, the increased amount of epiphytic growth stimulated by high nutrient levels provided a food source that supported higher numbers of grazing gastropod molluscs compared with the oligotrophic seagrass beds which were characterized by low epiphye growth. The only abundant grazing mollusc at Antechamber Bay was *Thalotia conica*. By contrast, high numbers of grazing molluscs were present in Nepean Bay that were either completely absent or present as only one or two individuals in Antechamber Bay (*e.g*. *Mitrella lincolnensis*, *Diala lauta*, *Clanculus dunkeri* and species from the genus *Cantharidus*). As in Kirkman's study (*op. cit*.) therefore, the observed higher diversity and abundance of grazing molluscs in Nepean Bay may be being supported by the abundant food source provided by the high biomass of seagrass epiphytes. While epiphyte levels were not measured in this study, Southgate (2005) and Bryars *et al*. (2003) recorded high epiphyte loads in Western Cove (Nepean Bay). Southgate (2005), using a scale of 1- 5 (5 being the highest), found that the average rating of epiphytes in Western Cove was more than twice that of Antechamber Bay (3 vs 1.2).

Excessive epiphyte growth caused by eutrophic conditions resulting from terrestrial nutrient inputs (river discharges and diffuse runoff) has been linked to the decline and loss of seagrass meadows. Unfortunately, the causal mechanisms are complex and still poorly understood. Epiphyte growth on seagrass blades is a natural phenomenon and high epiphyte loads cannot necessarily be interpreted as evidence of degraded seagrass condition. Indeed, a review of seagrass indicators by Wood and Lavery (2000) demonstrated that epiphyte load was not a good indicator of seagrass health for Western Australian seagrass communities. One factor that may influence epiphytic growth is water movement. Nepean Bay is a sheltered environment with low current velocities (Oceanique Perspectives 2000) and therefore may be naturally a more eutrophic system than Antechamber Bay, which experiences far greater water movement from the strong tidal currents flowing through Backstairs Passage that flush and disperse nutrients, resulting in lower epiphyte growth.

While comparisons across a gradient of eutrophication in seagrass beds have shown progressive impoverishment in the abundance and diversity of their associated faunal communities (Cardoso *et al.* 2002), what is not known is whether there is an initial increase in species diversity and abundance preceding a final, degraded state of low diversity, as happens in many ecosystems when first disturbed (*i.e.* Intermediate Disturbance Hypothesis, Connell 1978; Kirkman 1985). If this were the case, it could explain the much higher species diversity and abundances found in Nepean Bay. In other words, the more structurally complex (including drift macroalgae, algal turf and epiphytes) and nutrient-enriched environment of Nepean Bay provides more niche environements for animals to inhabitat plus an increased food supply that can support a higher biomass of predators.

It is possible therefore that increases in abundance, and in particular in grazing mollusc numbers, may be an early indication of eutrophication that can potentially lead to a decline in seagrass cover. Unfortunately, the early successional changes in seagrass fauna associated with increasing eutrophication are poorly documented, as major seagrass degradation has generally already occurred before it is detected (Cardaso *et al*. 2004). In many cases, such as in this study, we have no record of community assemblages prior to anthropogenic inputs to the system. However, indicators of such changes could aid in the early detection of declining seagrass health and are important to identify because, once seagrass is lost, recovery can take many years, if it occurs at all (Kendrick *et al*. 2002).

This study also found that seagrass faunal communities differed between seasons and that Pelican Lagoon and Antechamber Bay had far more distinct summer and winter faunal assemblages than sites in Nepean Bay. However, given the absence of clear trends in seasonal species occurrences and the fact that only one sampling event was used to characterise each season, it is difficult to conclude that there are consistent seasonal patterns in seagrass faunal abundances as opposed to naturally high temporal variability in community composition. McDonald (2007), who sampled seagrass faunal communities monthly over a 12-month period, found high spatio-temporal variability in species composition and abundance with no clear seasonal patterns. He concluded that other factors, such as larval supply, patch size and habitat fragmentation were more important in influencing seagrass faunal assemblages than systematic seasonal effects. A more comprehensive and continuous sampling program is required to describe seasonal patterns, if any, in mobile epifaunal diversity and abundance in seagrass meadows on Kangaroo Island.

It is important to note that the relative abundances of mobile fauna, especially fish, can be affected by sampling bias. Guest *et al*. (2003) showed that seine nets were generally more effective at sampling fish than beam trawls as fast swimmers, or fish that position themselves above the seagrass canopy (*e.g. Sillaginoides punctata* (Connolly 1994a)), can more easily escape from the beam trawl. However, other fish species that live near the bottom or amongst the seagrass such as clingfish (*Cristiceps spp.*) and the odacid *Neodax balteus* were found to be inefficiently sampled by seine nets (Jenkins and Sutherland 1997). This study appears to support this premise as the catch rates of Gobiidae and Clinidae in our study were higher relative to free-swimming species such as *S. punctata* than a study conducted in Port Phillip Bay using a seine net, which had very low catch rates of these two families (Jenkins and Wheatley 1998). Therefore, the abundances of some species in this study may be under- or over-represented in the samples compared with their true relative abundances *in situ*.

Conclusions and Recommendations

This study provides a preliminary benchmark of the biodiversity of mobile epifaunal communities in seagrass meadows on Kangaroo Island. These meadows, comprised mainly of species of the genus *Posidonia*, support a high diversity of mobile epifauna, with 70 species of fish and 87 species of invertebrates recorded in this study. This study concluded, however, that there were distinct differences in faunal diversity and abundance between the eutrophic embayments of Nepean Bay and Pelican Lagoon and the oligotrophic environment of Antechamber Bay.

In a recent review of seagrass and eutrophication, Burkholder *et al.* (in press) stated that reliable biomarkers that act as early indicators of nutrient over-enrichment are essential for the protection of seagrass meadows. They concluded that more research into understanding the dynamics of seagrass ecosystems is necessary to identify such biomarkers, but highlighted herbivore interactions as one area that is potentially worthy of further investigation. Both Nepean Bay and Pelican Lagoon had a richer and more abundant suite of herbivorous (grazing) gastropod species than Antechamber Bay. The implications of these differences are that the prevalence of grazing gastropods may be linked to artificially high nutrient inputs from anthropogenic causes in Western Cove (*e.g.* agricultural runoff carried by the Cygnet River). Thus, further investigations of their abundance and distribution in relation to epiphyte load and seagrass cover is warranted in pursuit of biomarkers capable of early detection of declining seagrass health.

Healthy seagrass meadows occuring around Kangaroo Island's coastline are critical in providing essential ecosystem functions, habitat for a diverse range of fauna (including commercially important species) and stabilisation of the seafloor. Given that recent studies have indicated a decline in seagrass health in certain areas around Kangaroo Island, and the still poorly understood dynamics of seagrass ecology, it is recommended that assessment of seagrass faunal biodiversity be continued and that the processes that affect the diversity and abundance of this fauna be investigated.

References

Bell, J. D., Pollard, D. A. (1989). *Ecology of fish assemblages and fisheries associated with seagrasses*. In: Larkum, A. W. D., McComb, A. J., Shepherd, S. (Eds), Biology of Seagrasses: A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region. Elsevier, Amsterdam, *pp*. 565-609.

Bryars, S., Neverauskas, V., Brown, P., Gilliland, J., Gray, L. and Halliday, L. (2003). Degraded seagrass meadows and evidence of eutrophication in Western Cove, Kangaroo Island. Fish Habitat Program, Primary Industries and Resources South Australia, Adelaide. 25 *pp*.

Burkholder, J. M., Tomasko, D. A. and Touchette, B. W. (in press). Seagrass and eutrophication. *Journal of Experimental Marine Biology and Ecology*.

Cambridge, M. L., Chiffings, A. W., Brittain, C., Moore, L., and McComb, A. J. (1986). The loss of seagrass in Cockburn Sound, Western Australia. II. Possible causes of seagrass decline. *Aquatic Botany*, **24**: 269-285.

Cameron, J. and Hart, D. (2002). *Seagrass mapping of Western Cove using multi-temporal satellite imagery: Western Cove, Kangaroo Island, South Australia*. Department of Environment and Heritage, Image Data Section, environmental and Geographic Information Division. Adelaide. 20 *pp.*

Cardoso, P. G., Lillebo, A. I., Pardal, M. A., Ferreira, S. M., and Marques, J. C. (2002). The effect of different primary producers on *Hydrobia ulvae* populations dynamics: a case study in a temperate intertidal estuary. *Journal of Experimental Marine Biology and Ecology* **277**(2): 173-195.

Cardoso, P. G., Pardal, M. A., Lillebo, A. I., Ferreira, S. M., Raffaelli, D. and Marques, J. C. (2004). Dynamic changes in seagrass assemblages under eutrophication and implications for recovery. *Journal of Experimental Marine Biology and Ecology* **302**: 233-248.

Connell, J.H. (1978). Diversity in tropical rain forests and coral reefs. *Science* **199**: 1302–1310.

Connolly, R. M. (1994a). A comparison of fish assemblages from seagrass and unvegetated areas of southern Australian estuary. *Australian Journal of Marine and Freshwater Research* **45**: 1033-1044.

Edyvane, K.S. (1997) *Seagrass Loss in Nepean Bay: the Need for Integrated Catchment Management*. SARDI Aquatic Sciences, Adelaide. 39 *pp*.

Gillanders, B. (2007). *Seagrasses, fish and fisheries*. In: Larkum, A.W.D., Orth, R.J. and Duarte, C.M. (Eds), Seagrasses: Biology, Ecology and Conservation. Springer, The Netherlands. *pp*. 503–536.

Gore, R. H., Gallaher, E. E., Scotto, L. E. and Wilson, K. A. (1981). Studies on decapod crustacea from the Indian River region of Florida. X1. Community composition, structure, biomass and species-area relationships of seagrass and drift algae-associated macrocrustaceans. *Estuarine, Coast and Shelf Science* **12**: 485–508.

Guest, M. A., Connolly, R. M. and Loneragan, N. R. (2003). Seine nets and beam trawls compared by day and night for sampling fish and crustaceans in shallow seagrass habitat. *Fisheries Research* **64**: 185-196.

Heck Jr. K. L., Hays, G., Orth, R. J. (2003). Critical evaluation of the nursery role hypothesis for seagrass meadows. *Marine Ecology Progress Series* **253**: 123–136.

Jenkins, G. P. and Sutherland, C. R. (1997). The influence of habitat structure on nearshore fish assemblages in a southern Australian embayment: Colonisation and turnover rate of fishes associated with artificial macrophyte beds of varying physical structure. *Journal of Experimental Marine Biology and Ecology* **218**: 103-125.

Jenkins, G.P. and Wheatley, M.J. (1998). The influence of habitat structure on nearshore fish assemblages in a southern Australian embayment: Comparison of shallow seagrass, reef-algal and unvegetated sand habitats, with emphasis on their importance to recruitment. *Journal of Experimental Marine Biology and Ecology* **221**: 147-172.

Jernakoff, P. and Nielsen, J. (1997). The relative importance of amphipod and gastropod grazers in *Posidonia sinuosa* meadows. *Aquatic Botany* **56**: 183–202.

Kirkman, H. (1985). Community structure in seagrasses in southern Western Australia. *Aquatic Botany* **21**:363–375.

Kirkman, H., Humphries, P. and Manning, C. (1991). *The epibenthic fauna of seagrass beds and bare sand in Princess Royal Harbour and King George Sound, Albany, south-western Australia.* In: The Marine Flora and Fauna of Albany, Western Australia Vol. 2, Wells, F.E., Walker, D.I., Kirkman, H. and Lethbridge, R. (Eds). Western Australian Museum, *pp*. 553-563.

Kruskal, J. B. (1964). Mulitdimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. *Psychometrika* **29**:1-27.

Kulczycki, G. R., Virnstein, R. W. and Nelson, W. G. (1981). The relationship between fish abundance and algal biomass in a seagrass-drift algae community. *Estuarine, Coast and Shelf Science* **12**: 341-347.

Mather, P. M. (1976). *Computational methods of multivariate analysis in physical geography*. J. Wiley & Sons, London. 532 *pp.*

McDonald, B. 2007[C1]. *The influence of seagrass habitat architecture and integrity on associated faunal assemblages*. PHD thesis, University of Adelaide, submitted August 2007.

Oceanique Perspectives (2000). Report on water circulation and dispersion in Nepean Bay Kangaroo Island. Report prepared for the Marine Habitat Program, Primary Industries and Resources South Australia, June 2000. 20 *pp*.

Seddon, S., Connolly, R. M. and Edyvane, K. S. (2000). Large-scale seagrass dieback in northern Spencer Gulf, South Australia. *Aquatic Botany* **66**: 297-310.

Sheperd, S. A., McComb, A. J., Bulthius, D. A., Neverauskas, V., Steffensen, D. A., West, R. (1989). *Decline of Seagrasses*. In: Larkum, A. W. D., McComb, A. J., Sheperd, S. (Eds.), Biology of Seagrasses: A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region. Elsevier, Amsterdam, *pp*. 346-393.

Southgate, R. (2005). *The health and cover of seagrass in the bays of eastern Kangaroo Island*. Kangaroo Island Natural Resources Management Board, Kingscote. 94 *pp*.

Valesini, F. J., Potter, I.C. and Clarke, K. R. (2004). To what extent are the fish compositions at nearshore sites along a heterogeneous coast related to habitat type? *Estuarine, Coastal and Shelf Science* **60**: 737-754.

Walker, D. I. and McComb, A. J. (1992). Seagrass degradation in Australian Coastal Waters. *Marine Pollution Bulletin* **25**:191-195.

Young, P. C. (1975). *Preliminary observations on the environment and biology of juvenile king prawns (Penaeus plebejus) in Moreton Bay, Queensland*. In: Young, P. C. (Ed.), Australian Prawn Seminar, Maroochydore, 1973. *pp*. 18-36. Australian Government Publishing Service, Canberra.

Appendices

Appendix 1: Inventory of mobile epifaunal species found at nine seagrass sites on Kangaroo Island.

	Brownlow		Kingscote		Inner Spit		Outer Spit		PL East		PL West		Is. Beach		AB North		AB South	
Family Species	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**	**Sum**	**Wint**
Annelida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eunicidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eunice sp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphroditidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp.4	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Actinaria sp	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crustacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Decapoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpheidae (pistol shrimps)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alpheus edwardsii	6	4	1	2	11	26	1	27	-	1	12	-	-	-	-	5	-	-
Crangonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Philocheras intermedius	32	69	26	84	11	58	7	40	1	-	129	-	11	1	3	18	5	24
Dromiidae (sponge crabs)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Austrodromidia octodentata	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galatheidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galathea australiensis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goneplacidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Litocheira bispinosa	1	-	-	4	7	-	4	2	3	-	28	1	8	-	-	-	-	-

Hymenosomatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Halicarcinus ovatus	-	2	-	1	7	2	-	-	-	-	-	4	27	-	-	-	-	-
Halicarcinus rostratus	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Trigonoplax longirostris	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippolytidae (shrimps)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyppolyte australiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	9	10	22
Latreutes compressus	20	1	-	6	-	3	1	1	34	-	-	-	24	10	15	57	26	31
Leucosiidae (pebble crabs)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ebalia intermedia	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Majidae (spider crabs)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dumea latipes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1
Naxia aurita	-	-	-	21	1	-	-	3	-	-	2	4	2	3	1	-	-	-
Palaemonidae (shrimps)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrobrachium sp.	182	431	556	1490	413	1060	299	180	270	897	1007	-	271	71	-	-	2	-
Periclimenes aesopius	17	14	23	85	7	1	1	-	1	-	-	-	3	13	5	12	2	9
Palinuridae (lobsters)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jasus edwardsii	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pandalidae (shrimps)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorotecella spinicaudus	-	476	126	1975	28	549	44	55	-	179	6	-	201	126	-	-	-	1
Portunidae (swimming crabs)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nectocarcinus integrifrons	18	1	2	32	18	-	-	29	9	12	43	10	11	8	1	-	-	-
Ovalipes australiensis	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Proccessidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Processa australiensis	1	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-
Processa gracilis	13	5	2	27	2	18	13	-	7	-	-	-	2	15	5	467	40	186
Rhynchocinetidae (shrimps)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchocinetes sp.	33	10	47	54	20	57	12	1	10	-	4	-	137	45	8	12	24	10

Crustacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cirolanidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natatolana wowine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
Cymothoidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Irona melanostica	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Ourozeuketes sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Idoteidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crabyzos longicaudatus	34	9	-	2	8	-	10	5	3	-	-	-	16	3	2	3	5	1
Sphaeromatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerceis acuticaudata	222	144	6	136	12	171	6	69	6	-	37	21	9	23	-	-	-	-
Platycerceis hyalina	41	34	-	7	19	12	3	7	-	-	-	-	14	5	-	4	-	-
Platynympha cf.	-	105	-	3	-	29	-	-	59	-	-	-	-	3	-	-	-	-
Unidentified sp.1	-	-	-	-	-	-	-	-	-	-	-	-	7	5	79	12	40	9
Unidentified sp.2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	14	-	8	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crustacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mysidae (Mysidacea)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Notomysis australiensis	16-	-	140-	-	-	-	19	-	17	-	-	-	127	46	62	17	70	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echinodermata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asteriidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uniophora granifera	-	-	1	-	-	1	-	1	4	-	-	-	-	-	-	-	-	-
Uniophora nuda	-	-	-	-	1	-	1	-	7	-	-	-	1	-	-	-	-	-
Asterinidae (sea stars)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Allostichaster polyplax	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Patiriella brevispina	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-

Goniasteridae (sea stars)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tosia australis	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Temnopleuridae (urchins)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amblypneustes ovum	8	5	-	-	1	7	-	5	-	-	-	-	-	1	-	-	-	-
Amblypneustes pachistus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Holopneustes inflatus	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	8	-	1
Microcyphus annulatus	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Cucumariidae (sea cucumbers)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plesiocolochirus ignava	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-
Staurothyone inconspicua	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
Holothuridae (seas cucumber)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Holothuria hartmeyeri	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Stichopodidae (sea cucumber)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stichopus ludwigi	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiodermatidae (brittle star)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified sp.1	-	-	-	-	-	1	-	-	-	2	-	3	-	-	-	-	-	-
Unidentified sp.3	-	-	-	-	4	-	20	-	1	-	1	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mollusca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bivalvia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pectinidae (scallops)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlamys asperrima	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Pteriidae (pearl oysters)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Electroma georgiania	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Mollusca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cephalopoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idiosepiidae (pygmy squid)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idiosepius notoides	3	10	13	23	-	28	1	19	-	-	3	3	5	4	5	-	4	-
Octopodidae (octopus)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hapalochlaena maculosa	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Euprymna tasmanica	4	3	-	-	1	2	1	1	1	-	1	1	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mollusca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastropoda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Buccinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nassarius pauperus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Nassarius pyrrhus	-	6	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Columbellidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Columbella nux	-	-	-	1	-	-	-	-	3	9	-	16	-	-	-	-	-	-
Mitrella lincolnensis	307	174	117	366	148	361	386	202	4	-	154	46	295	153	-	-	1	-
Mitrella semiconvexa	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-
Mitrella sp.	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
Conidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conus rutilus	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Dendrodorididae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dendrodoris nigra	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Dialidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diala lauta	40	99	9	613	124	75	-	196	103	9	-	28	360	905	-	-	1	-
Fissurellidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amblychilepas omicron	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-

Haliotidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haliotis sp.	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Littorinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bembicium nanum	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Muricidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepsiella vinosa	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nassariidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nassarius pyrrhus	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planaxidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plesiotrochus monachus	-	-	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-	-
Potamididae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Australium aureum	-	-	-	-	-	25	-	1	-	-	2	-	-	-	-	-	-	-
Batillaria diemenensis	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-
Batillaria estuarina	24	-	-	-	29	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranellidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sassia sexcostata	2	4	1	6	-	14	16	18	-	-	-	7	-	1	-	-	-	-
Scyllaeidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scyllaea pelagica	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	-	-	-
Trochidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Austrocochlea concamerata	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cantharidus bellulus	342	51	-	2	-	47	63	73	53	-	6	11	216	9	-	-	-	-
Cantharidus irisodontes	44	450	-	-	-	36	75	24	-	-	10	13	88	94	-	-	1	-
Cantharidus lehmanni	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	1	-
Cantharidus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Clanculus dunkeri	6	14	-	4	7	9	60	33	30	138	156	1184	-	37	-	-	-	2
Clanculus maxillatus	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-

Clanculus sp.	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-
Ethminolia vitiliginea	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Thalotia conica	6	2	2	4	1	19	16	-	-	-	1	-	8	19	25	26	14	5
Turbinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Astrolium sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Phasianella australis	7	2	-	1	-	-	61	1	-	-	-	-	2	-	-	-	-	-
Phasianella ventricosa	-	-	-	2	-	3	-	10	-	-	-	-	11	-	1	-	-	-
Gazameda iredalei	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Ischnochitonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenochiton sp.	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chelicerata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnogonida (sea spiders)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudopallene sp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Teleostei	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apogonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siphamia cephalotes	-	1	11	21	2	2	-	-	2	-	-	-	1	12	-	-	-	-
Vincentia conspersa	-	-	-	4	1	-	-	-	20	15	-	-	-	-	-	5	-	-
Vincentia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Aracanidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aracana ornata	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aracana aurita	2	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-
Atherinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atherinosoma microstoma	2	-	-	-	-	-	-	-	3	-	-	-	2	-	-	-	-	-
Atherinosoma sp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Kestatherina brevirostris	-	3	-	10	-	18	-	1	-	1	-	-	-	5	-	-	-	-

Bythitidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinematichthys sp	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Callionymidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Repomucenus calcaratus	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cristiceps sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Cristiceps australis	3	1	5	1	1	1	7	1	-	-	1	1	1	-	4	-	-	-
Heteroclinus sp.	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-
Heteroclinus adelaidae	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	1	-	1
Heteroclinus	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	5	-
Heteroclinus macropthalmus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	6
Heteroclinus perspicillatus	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Heteroclinus sp. 5	-	-	-	6	-	-	-	5	-	1	-	-	-	1	-	-	-	1
Heteroclinus sp. Type 1	-	-	16	-	11	-	7	-	81	-	4	-	-	-	3	-	2	-
Heteroclinus sp. Type 2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Heteroclinus spp.	7	-	-	-	7	-	-	-	-	-	-	-	8	-	1	-	4	-
Heteroclinus unident.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Ophiclinus antarticus	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-
Ophiclinus brevipinnis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Ophiclinus sp.	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-
Sticharium dorsale	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diodontidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diodon nicthemerus	-	2	-	1	-	1	-	-	-	-	-	-	-	1	-	-	-	1
Gobiesocidae (Cling fishes)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cochleoceps spatula	9	-	-	-	2	6	-	42	-	-	-	-	10	3	-	-	-	-
Cochleoceps viridis	-	-	-	-	-	-	-	-	-	-	-	-	1	-	12	-	2	-
Genus A sp. 1	12	12	-	-	-	14	3	7	-	-	-	-	11	9	-	-	-	-

Parvicrepis parvipinnis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Gobiidae (Gobies)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Callogobius mucosus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Favonigobius lateralis	1	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Gobiopterus semivestitus	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-
Nesogobius sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Nesogobius pulchellus	2	3	3	2	12	2	-	-	6	-	4	-	1	-	-	-	-	-
Nesogobius sp. (unident)	-	9	-	1	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Tasmanogobius sp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Tasmanogobius gloveri	-	-	-	-	2	-	-	-	-	1	2	-	-	-	-	-	-	-
Monacanthidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthaluteres sp. T2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acanthaluteres sp.	8	-	-	-	3	-	-	-	-	-	-	-	11	-	-	-	2	-
Acanthaluteres	44	29	1	-	4	10	9	1	1	-	-	-	20	30	-	1	-	-
Scobinichthys granulatus	3	2	1	1	1	-	-	-	-	-	-	-	1	4	-	5	-	1
Unidentifiable 1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Acanthaluteres brownii	-	-	-	-	-	1	-	-	-	-	-	1	-	3	-	-	-	-
Brachaluteres jacksonianus	-	-	-	1	-	-	-	2	-	-	-	1	-	-	-	-	-	-
Meuschenia freycineti	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Mullidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Upeneichthys vlamingii	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Odacidae (Weed whiting)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haletta semifasciata	4	-	-	2	2	-	-	2	5	-	-	-	-	4	-	3	-	-
Neoodax balteatus	3	8	8	30	21	15	5	9	7	2	11	1	44	11	-	6	-	-
Siphonognathus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
Siphonognathus beddomei	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
Siphonognathus radiatus	-	1	-	5	-	2	-	-	-	-	-	-	-	6	-	2	-	-

Siphonognathus sp.	1	-	-	-	1	-	4	-	-	-	-	-	14	-	5	-	2	-
Unidentifiable 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-
Ophiclinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiclinus antarcticus	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-
Ophidiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Genypterus tigerinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Platycephalidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leviprora inops	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platycephalus laevigatus	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plotosidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidoglanis macrocephalus	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Scorpaenidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glyptauchen panduratus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Gymnapistes marmoratus	43	22	2	8	27	6	-	6	28	1	4	24	1	12	-	-	-	-
Sillaginidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sillaginodes punctata	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Syngnathidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippocampus breviceps	3	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptoichthys fistularius	-	-	-	-	5	-	3	-	-	-	-	-	3	-	-	1	-	-
Lissocampus caudalis	-	-	-	1	-	-	-	-	7	1	-	1	-	-	-	-	-	-
Pugnaso curtirostris	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Stigmatopora argus	14	7	1	3	7	2	4	4	-	-	4	2	-	1	-	-	-	-
Unidentifiable 3	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Vanacampus phillipi	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Vanacampus poecilolaemus	2	2	-	-	6	-	1	1	6	-	-	-	4	5	2	-	1	-
Vanacampus sp.	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-
Vanacampus vercoi	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-

Plates

Plate 1: Common seagrass fish species.

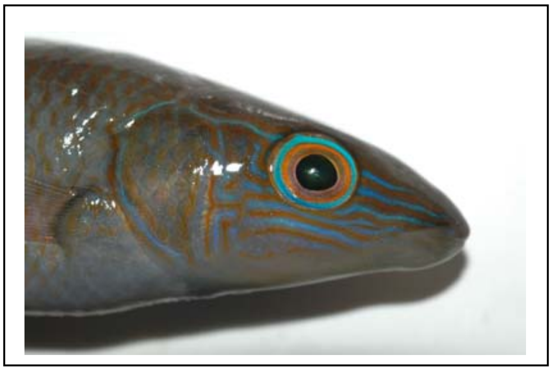
a) Scorpion Fish (*Gymnapistes marmostus*)

b) Cling Fish (*Cochleops viridis*)

c) Rough Leatherjacket (*Scorbanichtys granulatus*)

d) Weed Fish (*Heteroclinus sp.*)

e) Little Weed Whiting (*Neodax balteatus*)



f) Pipe Fish (*Vanacampus poecilolaemus*)

Plate 2: Common seagrass crustacean species.

a) Sea Centipede (*Crabyzos longicaudatus*)

b) Isopod (*Cerceis acuticaudata*)

c) Isopod (*Platycerceis hyaline*)

d) Decorator Crab (*Naxia aurita*)

e) Pistol Shrimp (*Alpheus novaezealandiae*)

f) Sand Shrimp (*Philocheras intermedius*)

Plate 3: Miscellaneous seagrass species.

a) Ascidian (*Botrylloides perspicuous*)

b) Nudibranch (*Scyllaea pelagica*)

c) Sea Biscuit (*Tosia australis*)

d) Sea Star (*Uniophora sp*)

e) Top Shell (*Thalotia conica*)

f) Kelp Shell (*Cantharidus irisodontes*)