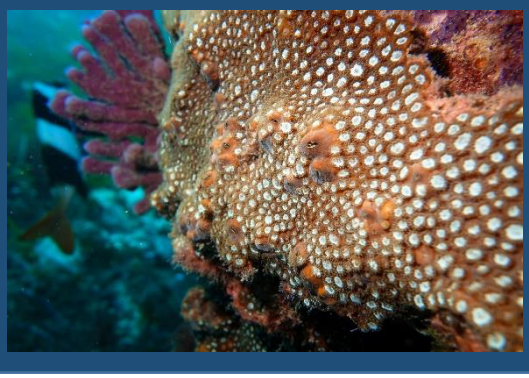
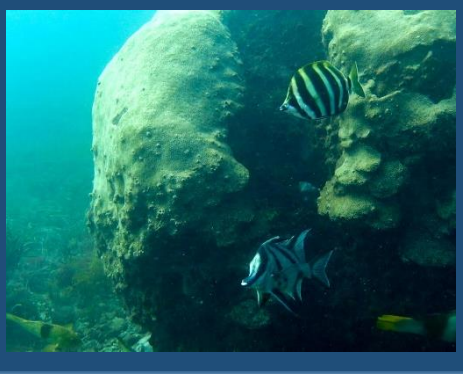
Australian Ocean Lab

(AusOcean)

SMITH BAY
MARINE ECOLOGY REPORT

2019

AusOcean

SMITH BAY
MARINE ECOLOGY REPORT

A report prepared for

AusOcean

by

Ms Catherine Larkin

Marine Biologist

Copyright

Acknowledgements

A big thanks to the AusOcean expedition crew for both enjoyable and productive expeditions. It was valuable to have a multidisiplinary team of engineers and scientists that worked so well together. Thanks also to Dave Muirhead from the Marine Life Society of South Australia for joining two expeditions. Your marine expertise, your insight and knowledge of marine species and marine ecology helped immensely.

We would also like to thank molecular biologist and on-board syngnathid expert Graham Short from the California Academy of Sciences for joining our third expedition. Your knowledge and expertise all things syngnathid was invaluable. Finally, thanks also to AusOcean intern Trek Hopton for his wonderful underwater photos.

Contents

Tables and Figures

Foreword

I learned to dive in the cold, clear waters of the Monterey Bay, California, and for that I am very grateful. Had I learned in warmer waters, I might never have donned a 7mm-thick wetsuit. Many divers never experience the wonders of temperate waters, eschewing them for the tropical coral reefs that attract so much media and research attention. Yet temperate waters hold a great diversity of marine life and few more so than the waters of southern Australia, increasingly referred to as the *Great Southern Reef (GSR)*. Unlike tropical reefs in which species are distributed globally, 90% of species found in the Great Southern Reef are endemic to southern Australia, and what marvellous creatures they are; from the colony-forming bryozoans that rival corals in their fantastic shapes and colours, to those masters of camouflage, the stunning seadragons. These are not cosmopolitan species that might just as easily pop up on the Great Barrier Reef (GBR) as a reef in Belize, The Maldives or The Philippines. These are marine species that are native to Australia and geographical isolation has confined them to *our* waters. They are as much a part of the Australia's wonderful natural heritage as our unique terrestrial wildlife.

Kangaroo Island's marine environment is particularly significant as it encompasses semi-protected Gulf waters, unprotected Southern Ocean waters and areas of confluence between the two. While several marine studies have been conducted over the years, generally these have been quite sparse in their geographical coverage. During the summer of 2018-2019 AusOcean therefore embarked upon a series of expeditions to intensively study Smith Bay on the North Coast of Kangaroo Island. This bay was chosen for two reasons. Firstly, it is the location of a proposed port, and it therefore seemed prudent to study a place that might be impacted by development. Secondly, preliminary work suggested that Smith Bay would present a great range of benthic environments, namely sandy seafloor, rocky reef, dense seagrass, kelp and combinations of all of the above.

As such, it would represent a microcosm of the marine environment of Kangaroo Island's North Coast. We anticipated that such a range of habitats would foster good species diversity. We were not disappointed.

Prof. Alan Noble

Founder, AusOcean

B.Eng. (Hons) (Adelaide), M.S. (A.I.) (Stanford), Fellow, Engineers Australia

Introduction

Kangaroo Island (KI) is uniquely situated at the confluence of several oceanographic systems (Kinloch, 2005). This unique positioning and, the effects of the warm waters of the Leeuwin current have a profound influence on marine assemblages (Middleton & Bye 2007). The northern coastline comprises a mixture of macroalgal ("seaweeds" such as kelp) dominated rocky reef systems and dense seagrass communities. These systems form part of the wider Great Southern Reef (GSR) spanning the entire southern coastline of the Australian continent (Bennett *et al.* 2015). In addition to the many significant economic and social benefits, these systems provide key ecological services such as nutrient cycling, sediment stabilisation, enhanced biodiversity, trophic transfers and carbon sequestration (Orth *et al.* 2006; Smale *et al.* 2013).

KI's marine environment exhibits high species richness and endemism supporting an abundance of emblematic and threatened species with high conservation value such as the Leafy sea dragon *(Phycodurus eques),* the Western blue groper *(Achoerodus gouldii)*, Blue devil *(Paraplesiops meleagris)* and Harlequin fish *(Othos dentex)* (McArdle *et al.* 2015, Reinhold *et al*. 2013*)*. KI's coastline provides unique habitat that is paramount for the existence and longevity of these species, whose numbers have declined significantly elsewhere. Additionally, valuable commercial fisheries such as Yumbah aquaculture- the world's largest exporter of Greenlip abalone and the Rock lobster industry rely heavily on the local environment for quality production.

Eleven species of fish and one invertebrate are listed as 'in peril' by the SA conservation Council (Reef Watch, 2018). These species are known to frequent South Australian waters and have been previously noted on KI (McArdle *et al*. 2015, Reinhold *et al*. 2013, Shepherd *et al.* 2009*)*. The Western blue groper is listed as *Vulnerable* on the IUCN red list of threatened species (Choat *et al.,* 2010) and the giant cuttlefish is listed as *Near threatened* with populations declining drastically since the turn of the century (Prowse *et al.* 2015) (table 1). All members of the Syngnathidae family (seahorses, sea-dragons and pipefish) are listed as protected species under the Australian Commonwealth's *Environmental Protection and Biodiversity Conservation (EPBC) Act (1999)*.

Table 1: Focal species of Kangaroo Island.

Conservation Value	Commercial Value
Western blue groper	Southern rock lobster
Southern blue devil	Greenlip abalone
Harlequin fish	Blacklip abalone
Queen snapper	
Long-snout boarfish	
Leafy sea dragon	
Weedy sea dragon	
Spotted wobbegong	
Gulf wobbegong	
Cobbler wobbegong	
Black cowrie	
Giant cuttlefish	

Southern Australia's marine macroalgal flora has the highest levels of species richness and endemism of any regional macroalgal flora in the world (Phillips 2001). However, despite their intrinsic and economic value, temperate reef systems are often overlooked by their tropical reef counterparts. A defining feature of these reef systems is the kelp *(Ecklonia Radiata*), which is largely supported by neighbouring seagrass systems that facilitate both reef interconnectivity (Heck *et al.* 2008; Ricart *et al.* 2015) and provide important 'nursery' areas for fishes (Jenkins and Wheatley 1998; McDevitt-Irwin *et al.* 2016). In South Australia, seagrass habitats are protected under the *Native Vegetation Act* (1991).

Current levels of both scientific and public engagement threaten the health and longevity of these significant systems (Bennett *et al.* 2015). As part of AusOcean's first expedition to KI's north coast, Smith Bay was selected as an appropriate site for a comprehensive marine life survey due to both its high diversity of flora and fauna and unique variety of habitats. Although a number of both scientific and community-based programs have conducted surveys along the north coast of KI collecting baseline data on fish, invertebrate and algae communities for long term reef health monitoring (McArdle *et al*. 2015, Reinhold *et al*. 2013, Scorseby & Baker 2008), Smith Bay remains relatively lightly studied.

Methods

Ten survey locations within Smith Bay on the northern coast of Kangaroo Island were selected for marine life surveys (figure 1). Sites were strategically selected to encompass both the eastern and western sides of the bay and deeper waters located more centrally (table 2). Survey data was collected on two dive trips in December of 2018 and one in February of 2019. All dives were off a boat and undertaken during daylight hours.

Standardised Reef Life Survey (RLS) methods were adapted to gather substrate, fish and invertebrate species composition and abundance data at each site (Reef Life Survey Foundation 2013). The standard RLS method involves laying out 50m long transects along continuous depth contours to assess reef biodiversity. A complete survey consists of the following components:

- Photo quadrats taken at 2.5m intervals along the transect line (20 per 50m transect).
- Fish surveyed in two 5m wide by 5m high bands parallel with the transect line.
- Cryptic fish and large (>2.5cm) macroinvertebrate (mollusc, echinoderm and crustacean) searches in 1m wide by 2m high bands either side of the transect line.

Each survey location was located >200m apart. Multiple transects within a survey location were located within 50m of each other. The only sites in which transects were not undertaken was Smith Bay North (N) and North Central (NC) as they did not adhere to the requirements of the RLS methods. However, location species was noted via an area 'swim around'. Therefore, these sites have been excluded from the main data analysis but are included in Appendix 1. Species identifications were supported by - Fishes of Australia's Southern Coast (Gomon *et al.,* 2008).

Table 2: Number of transects at sites.

Smith Bay	No of transects
East Rocks (ER)	1
East (E)	2
East Shore (ES)	2
North Central (NC)	N/A
North (N)	N/A
Creek Channel (C)	1
West Central (WC)	2
West Shore (WS)	2
West (W)	2
West Rocks (WR)	2

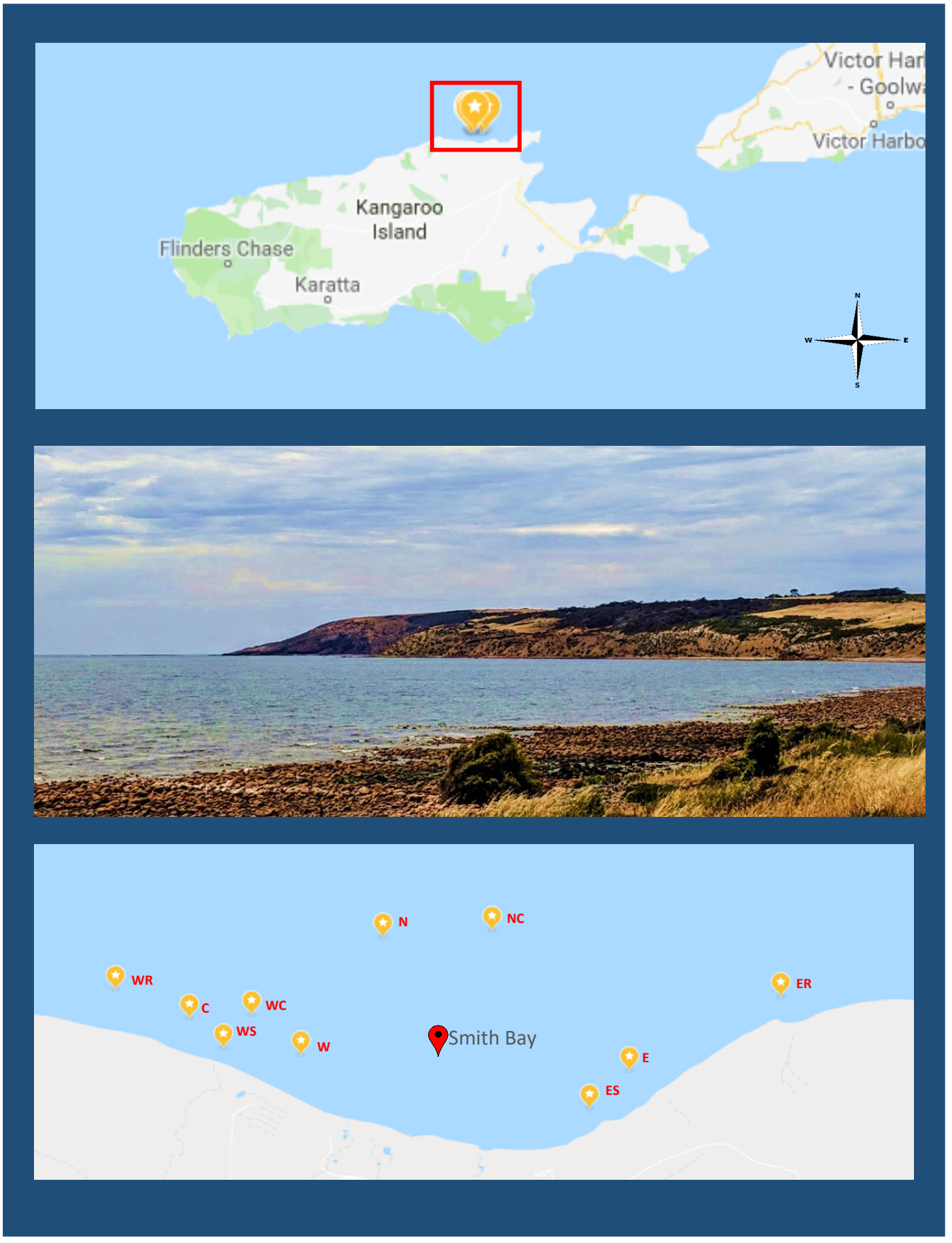


Figure 1: Map of survey locations and image of Smith Bay facing east.

Plate 1: Divers preparing to survey.

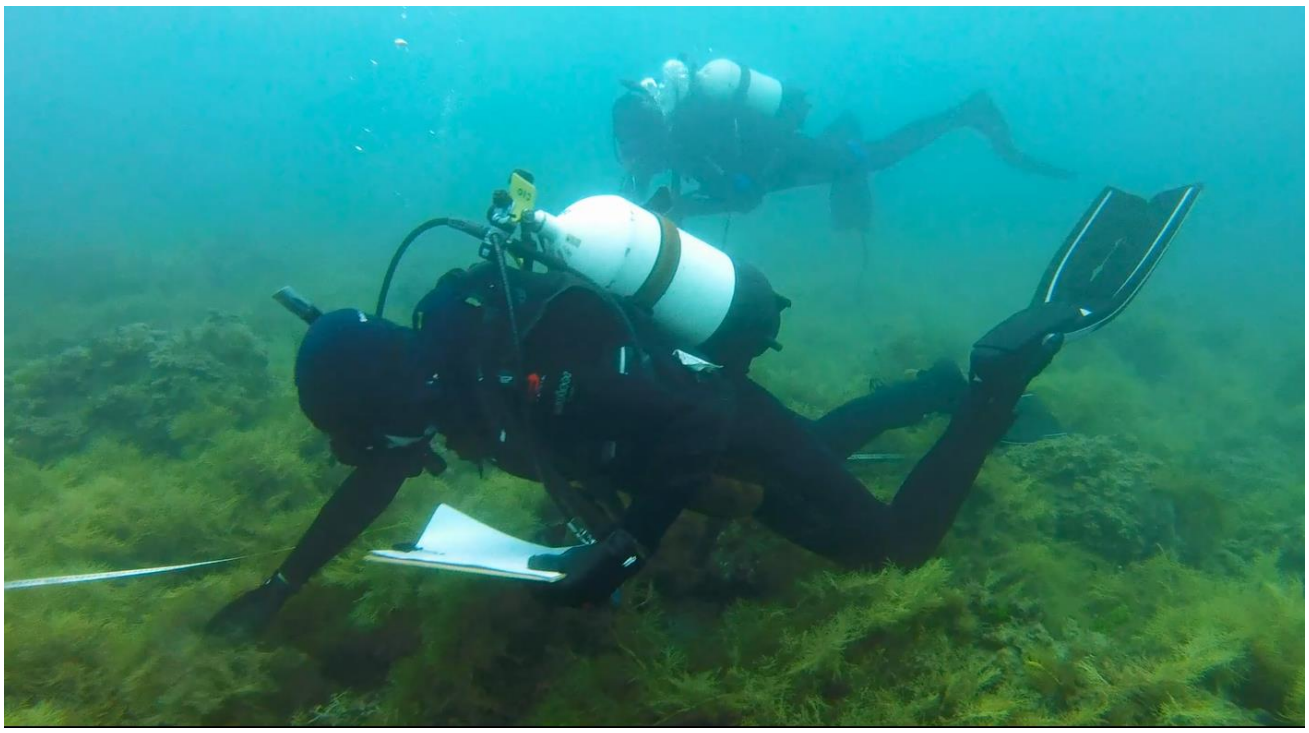


Plate 2: Divers conducting reef life surveys.

Results

Smith Bay is comprised of mixed rocky reef, dense seagrass and sponge habitat. Rocky reefs were dominated by macroalgal assemblages comprising *Cystophora* spp., *Sargassum* spp., and *Ecklonia radiata* with interstitial patches of *Posidonia spp., Amphibolis spp.* and *Zostera nigricaulis* seagrasses. Rocky reef habitat sites were often covered in the brown alga *Lobophora variegate.* Survey locations have been grouped together in relation to their area ecology (table 3). East Rocks, East shore and West Shore had much higher macroalgal cover in comparison to other sites which consisted of mixed seagrass, rocky reef and sponge with areas of bare sand. The northern sites substrate comprised of bare sand, shell fragments and rhodoliths (*Sporolithon durum*) with interspersed patches of seagrass, rocky reef and sponge. It is worth noting that although the habitat at these deeper-water sites was somewhat fragmented, supporting less dense canopies, a number of macroalgae species including *Scaberia aghardii* and several species of *Cystophora* and *Sargassum were noted* (table 3).

Table 3: Area ecology of each site.

Site	Area Ecology	Image
East Rocks **East Shore** **West Shore**	Dense macroalgae covered rocky reef.	
East **West Rocks**	Mixed macroalgae covered rocky reef and seagrass.	

West **Creek Channel** **West Central**	Mixed sponge/seagrass and patches of macroalgae covered rocky reef.	
North **North Central**	Rubble and shell fragments with mixed seagrass/sponge and patches of rocky reef.	

Across all surveyed sites within Smith Bay, 55 species of fish and 35 species of invertebrates were noted, comprising 1124 individuals (902 fish and 222 invertebrates). Of these, 539 fish and 162 invertebrates were noted within transcects. Where multiple transects were undertaken, data has been collated to assess each site. It should be noted that the scallop count from the both North and North Central has been excluded due to their occurrence in large abundances and lack of formal transects.

The Senator wrasse was the most commonly occurring species appearing at all sites followed by the Blue throat wrasse at 7 sites and the Blackspotted wrasse at 6 sites (table 4). The most frequently occurring invertebrates were the Western slatepencil urchin at 6 sites and both the Painted lady mollusc and the Biscuit star noted at 5 sites (table 4).

Table 4: Frequency of Occurrence (FOO) of the most commonly sighted species.

Fish Species (FOO)	**Invertebrate Species (FOO)**
Senator Wrasse (8)	Western slate pencil urchin (6)
Blue throat Wrasse (7)	Painted lady (5)
Black-spotted Wrasse (6)	Biscuit Star (5)
Castelnau's wrasse (5)	
Dusky Morwong, Pencil weed whiting, Magpie perch, Yellow-headed hula fish, Toadfish (4)	

Almost 50% of fish species were recorded at one site only. Over 80% of invertebrate species occurred in three or less sites (figure 2).

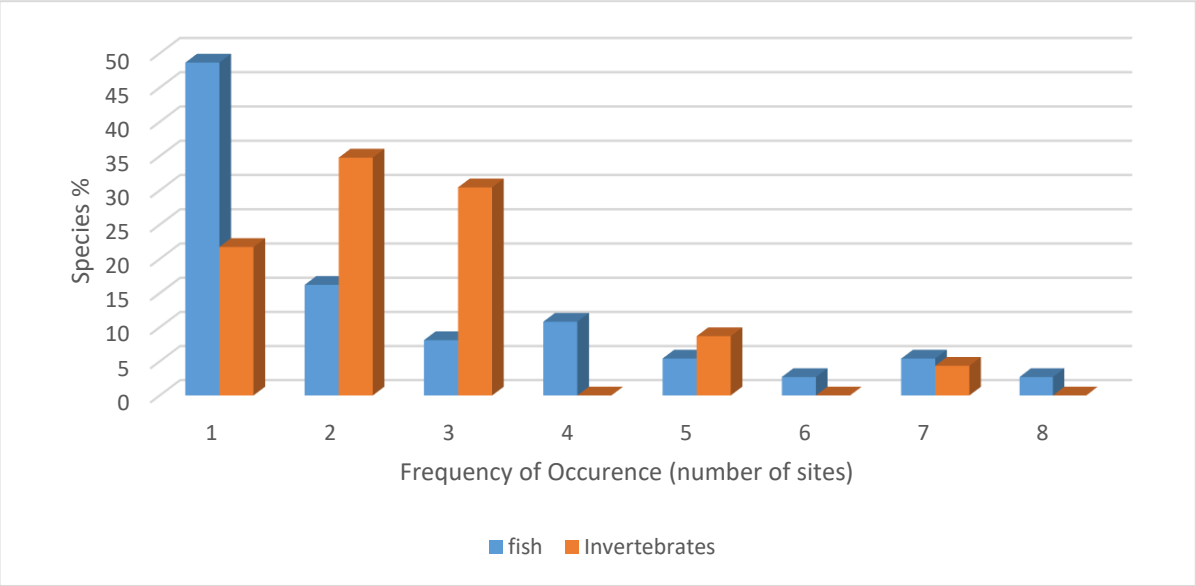


Figure 2: Frequency of Occurrence of fish and invertebrate species.

Plate 3: Senator wrasse (*Pictilabrus laticlavius*).

Plate 4: Western slatepencil urchin (*Phyllacanthus irregularis*).

The site with the highest number of species (both fish and invertebrate) surveyed was West Central, followed by East Shore, and West Shore (figure 3).

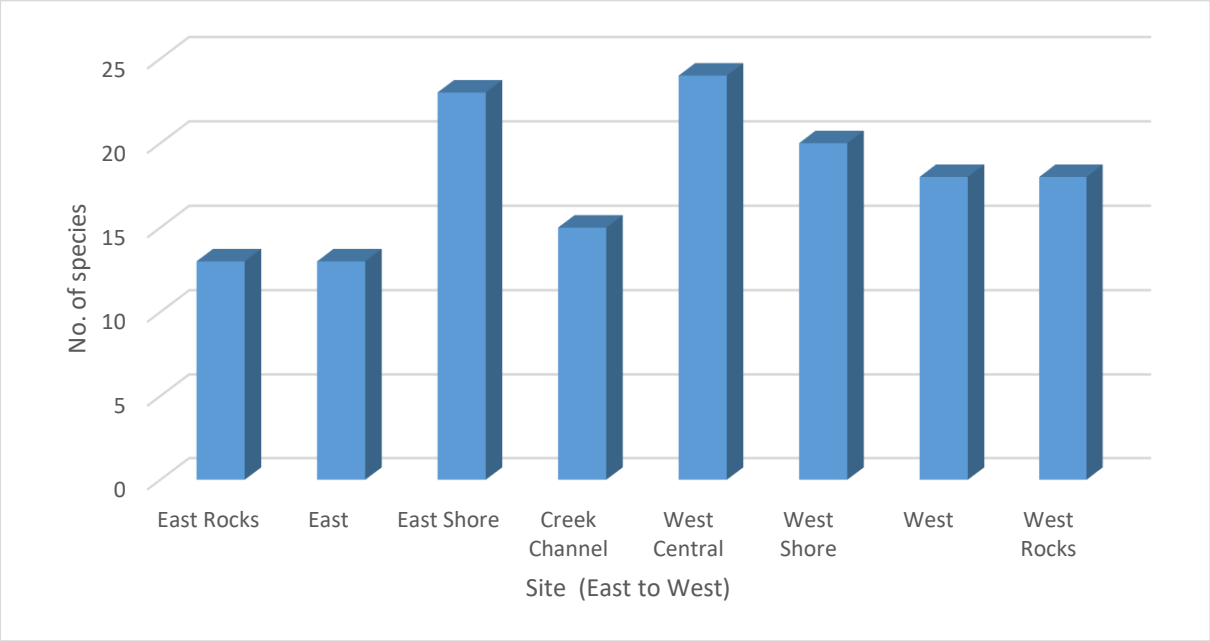


Figure 3: Total species at each site.

Both West and West Rocks exhibited the highest number of invertebrate species and sites East Shore, West Central and West Shore had the highest number of fish species (figure 4). Sites with the highest number of invertebrate species exhibited the lowest number of fish species.

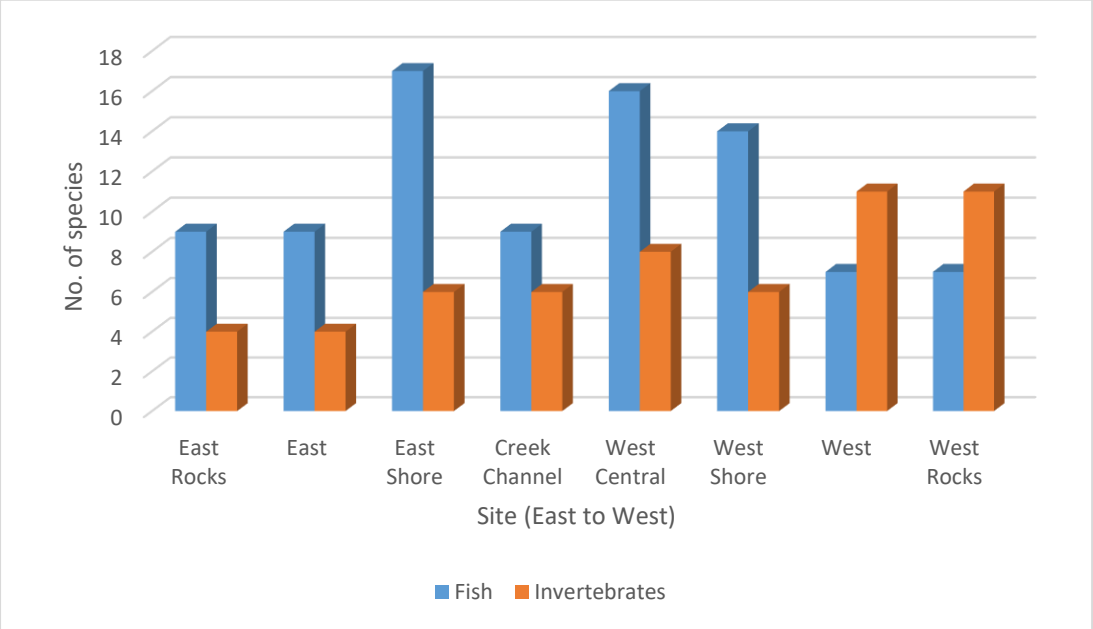


Figure 4: Fish and invertebrate species occurring in each site.

The most abundant fish (highest number of individuals) was the Black-spotted wrasse followed by the Yellow-headed hula fish and the Bluethroat wrasse. The most abundant invertebrate was the Western slate pencil urchin followed by the Painted lady mollusc and the Biscuit star (table 5).

Table 5: Most abundant fish and invertebrate species (* denotes schooling species).

Fish Species	Invertebrate Species
Black spotted wrasse (108)	Western slate pencil urchin (23)
Yellow-headed hula fish (96)*	Painted lady (17)
Bluethroat wrasse (68)	Biscuit star (14)
Zebrafish (62)*	Vermillion biscuit star (11)
Silverbelly (50)*	Southern rock lobster (11)

Sites East Shore and West Central exhibited the highest number of individuals, comprising mostly fish. These high numbers were due in part to the presence and abundance of schooling species (table 5). East Rocks and Creek Channel exhibited the lowest number of individuals (figure 5). However, this may be in part due to the lack of replicated transects. Sites West and West Rocks on the western side of the bay, were the only locations where more invertebrates than fish were surveyed.

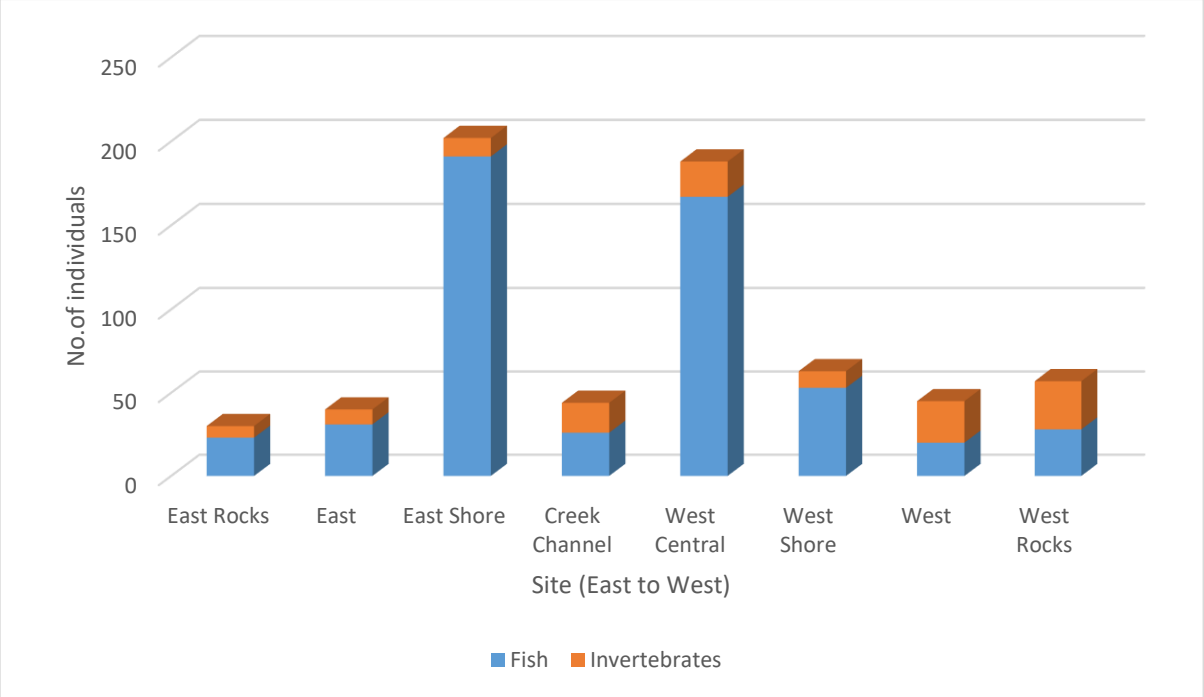


Figure 5: Total number of fish and invertebrates recorded at each site.

Species of Conservation Significance

Several species of conservation significance were noted. The Western blue groper was sighted at East Rocks, the Long-snout boarfish was sighted at Creek Channel, West Central and North and both the Southern blue devil and Weedy seadragons at North Central.

Syngnathids

Three species of Syngnathidae were noted at North Central in the deeper waters of the bay at 16-18m depth comprising three pipefish; *Stigmatopora nigra, Stigmatopora argus* and *Vanacampus margaritifer,* and six Weedy seadragons; *Phyllopteryx taeniolatus.*

Cetaceans

Three bottlenose dolphins were sighted at West rocks outside the surveyed transect. It should be noted, in transit through Smith Bay, Common bottlenose dolphins were present at each site outside surveying hours.

Coral

Two colony forming corals were sighted; *Plesiastrea versipora* and *Coscinaraea mcneilli*. One large temperate coral of *P.versipora* nearing 2m tall and 6m in circumference and a smaller coral approximately 2m in circumference was located in close proximity to East rocks. Analysis indicated that the larger coral supported at least 14 fish species visible in collected footage. A colony of *C.mcneilli* was sighted at North Central.

Commercially Valuable Species

Southern rock lobsters were sighted at West Rocks, East Shore and West Shore and Abalone at West.

Other species of interest

The only octopus sighted was located at Creek Channel outside a transect.

Plate 5: Common Bottlenose dolphin (*Tursiops spp.*) Photographed at West.

Plate 6: Weedy seadragon (*Phyllopteryx taeniolatus*) Photographed at North Central.

Plate 7: Mother of pearl pipefish (*Vanacampus margaritifer*) Photographed at North Central.

Plate 8: Western Blue groper (*Achoerodus gouldii*) photographed at East Rocks.

Plate 9: Long-snout boarfish (*Pentaceropsis recurvirostris*) photographed at Creek Channel.

Plate 10: Southern blue devil (*Paraplesiops meleagris)* photographed at North Central.

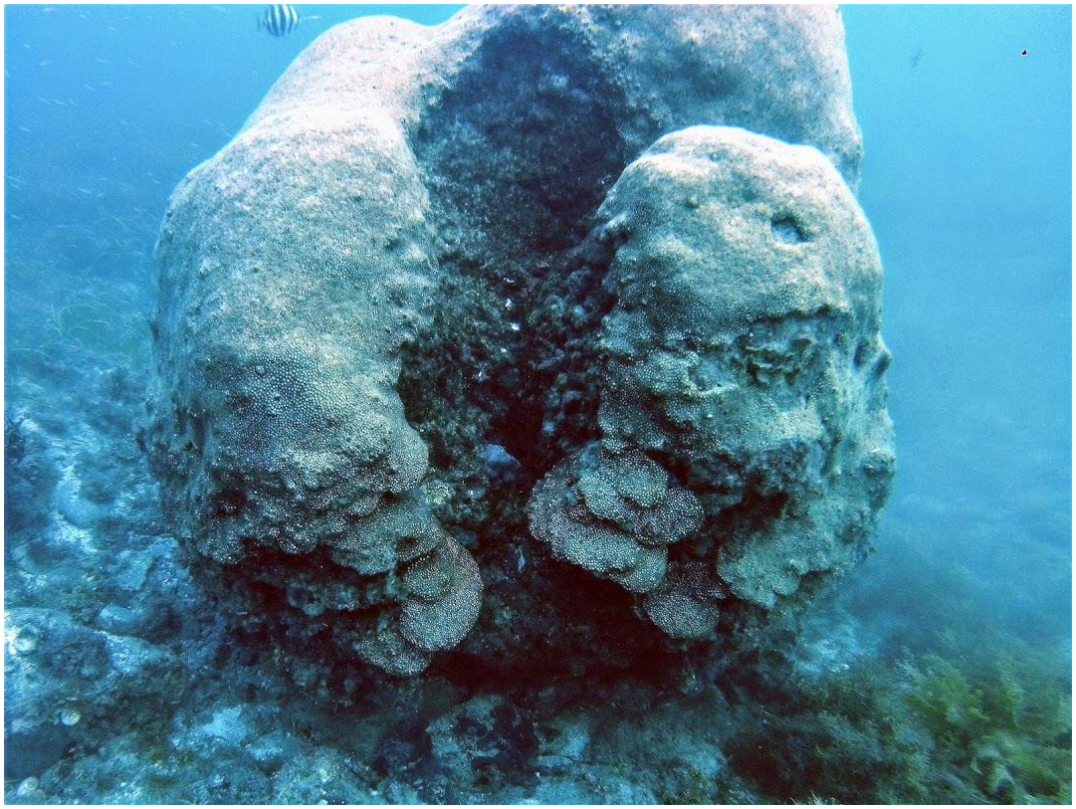


Plate 11: Coral (*Plesiastrea versipora*).

Plate 12: Diver surveying coral.

Discussion

The ecology within Smith bay is highly heterogeneous providing complex habitat for a myriad of species including fishes and invertebrates. The abundance of fishes on reefs is influenced by a variety of physical and biotic factors (Scoresby & Baker, 2008). Phillips (2001) indicates that high macroalgal speciation rates in Southern Australia are influenced by fluctuating environmental conditions, abundance of suitable rocky reef substrate, habitat heterogeneity and the warm waters of the Leeuwin current. These features aid in maintaining favourable conditions. The Leeuwin current flows South along the Western Australia coast, bringing warmer water east through the Great Australian Bight (Middleton and Bye 2007) having a profound effect on habitat conditions.

Smith Bay is part of a highly connected marine environment. To the east are Emu Bay and Boxing Bay and to the west is Dashwood Bay. The latter is particularly noteworthy as a location frequented by dolphins, which were observed in great numbers during our second expedition. High dolphin presence on the north coast is supported by new evidence that suggests population connectivity of bottlenose dolphins between Kangaroo Island and South Australian mainland waters (Cribb *et al.* 2018). The bay's diverse assemblage of organisms may be influenced in part, due to its unique location ideally situated between two marine parks. To the east lies the Encounter marine park and the southern Spencer Gulf marine park to the west (Natural Resources Kangaroo Island, 2018). Marine parks are known to influence adjacent marine environments via the 'spillover' effect, involving the movement of individuals across reserve boundaries (Rowley 1994) and exportation of larvae and recruits (McClanahan and Mangi 2000). However, the spatial extent of these effects vary considerably (Harmelin-Vivien *et al.* 2008; da Silva *et al.* 2015).

A total of 55 species of fish and 35 invertebrates were surveyed, including several species listed as 'In peril" by the conservation council (Reef Watch, 2019). The most commonly occurring species comprising the wrasses were also the most abundant appearing at survey locations in both sides of the bay. Fish exhibited strong habitat association with almost 50% recorded as single site associated species, due in part to the unique ecology of sites across Smith Bay. These ecological variations are influenced by physical complexities such as substrate composition and topography and presence and abundance of macroalgal and

seagrass communities. Many species surveyed in this study appear in earlier documents pertaining to fish and invertebrate biodiversity assessments (McArdle *et al*. 2015, Reinhold *et al*. 2013, Scoresby & Baker, 2008).

Sites dominated by dense macroalgae cover, supported species such as the Zebra fish and Silver drummer, which were not noted anywhere else in the Bay. These species frequent high algal biomass areas due to their herbivorous diets consisting of a variety of green, brown and red algae (Clements & Choat, 1997). Environments with high macroalgal cover also provide habitat complexity and protection from predation making them ideal refuges for a variety of fishes (Dayton 1985). East Shore, characterised by dense macroalgae cover supported both the highest abundance of individuals and number of fish species.

Sites consisting of a mixed sponge/seagrass/rocky reef habitat often neighboured patches of high density seagrasses. Species such as the Longtail weed whiting, Sharpnose weed whiting and Slender weed whiting were surveyed only at these sites. Research indicates weed whiting species show strong habitat association to seagrass near reef edges (Shepherd *et al*. 2009). This is consistent with the area ecology exhibited at sites where these species were noted. High numbers of invertebrates were surveyed in the western sites of the bay including West Central, West and West Rocks. This is likely due to the absence of canopy-forming macroalgae, and associated habitat structure and food webs (Grutter & Irving 2007). In support of this, research indicates areas of high density seagrass aid in sustaining large macroinvertebrate communities (Attrill *et al.* 2000). Interstitial seagrass habitats are important ecological components ensuring reef interconnectivity (Heck *et al.* 2008) whilst providing essential 'nursery' habitat for a variety of fishes (Jenkins and Wheatley 1998; McDevitt-Irwin *et al.* 2016).

At surveyed sites North and North Central reef shelfs and sponge gardens provide protection and habitat for a diverse range of species. 19 species of fish and 14 species of invertebrates present at these sites were not noted anywhere else in the bay. Although the environment is somewhat fragmented, these unique pockets of varied topography are integral components of the wider marine environment and provide important refuges for fishes. These sites were not included in the main data analysis, however, a number of species of conservation concern such as the Southern blue devil and Weedy seadragon were noted, as well as two species of protected pipefish.

A large temperate coral - *Plesiastrea versipora* was located in close proximity to surveyed site East rocks, with a smaller coral noted less than 100m away. The larger coral was approximately 6m in circumference and supported at least 14 species of fish. The smaller coral was approximately 2m in circumference. Large colonies of this coral were first discovered in South Australia over 100 years ago (Howchin 1909). Hard corals such as these are very slow growing in temperate waters, with varying rates of less than 1cm per year (Burgess *et al.* 2009). Due to the rarity of long-lived specimens in temperate waters, there have been few studies of environmental records (Burgess *et al.* 2009). Growth of these corals is dependent on upon a multitude of environmental factors including temperature, nutrient availability, turbidity, depth and light availability (Burgess *et al.* 2009). Historically, many of these larger colonies were dredged up by trawlers (Edyvane, 1999) and impacted through ecological modifications such as breakwater construction (The Register, 1909).

Species of interest such as the Long snout boarfish, Western blue groper, Southern blue devil and Weedy seadragon were noted in the bay and are listed as species of conservation concern. In Addition, two more species from the Syngnathidae family protected under the EPBC Act 1999 were also noted. Syngnathids exhibit life histories and behaviours which makes them vulnerable to decline (Foster and Vincent 2004) hence their notable protected status. Studies tracking *Phyllopteryx taeniolatus* indicate small home ranges and high site fidelity which has major implications for effective habitat management and conservation of this protected species (Sanchez-Camara and Booth 2004).

Limitations

Multiple transects were unable to be surveyed at every site. This reduced our overall data collection affecting species counts and the overall results. This should be taken into consideration when comparing data from East rocks and Creek channel where only one transect was undertaken. Additionally, the more central parts of the bay were not surveyed. This was due to both weather and time restrictions that inhibited further data collection.

All dives were undertaken during the day. As species behaviours vary at night, it would have been valuable to undertake surveys both during the day and at night.

The trips consisted of four divers, three of which were new to the RLS survey method and species identification. It was evident that diver's observational capabilities and species identification skills improved extensively during *in situ* activities. Therefore, it is likely that there are discrepancies between earlier and later conducted surveys. Variability in local conditions such as currents and/or visibility also affected surveying capabilities, which may have influenced the final results.

Utilising the RLS transect method is effective in standardising data collection methods, however many 'skittish' species of fish were likely missed due to divers presence and transect restrictions (i.e. 5m wide band).

Conclusions and Future Research

The ecology within Smith bay is highly heterogeneous providing complex habitat for a myriad of species both fishes and invertebrates. The distribution and abundance of species is influenced by a variety of physical and biotic factors including but not limited to, substrate composition and topography and, presence and abundance of macroalgal and seagrass communities. The unique ecology of sites across the bay is reflected in the high number of single site associated species.

Macroalgal covered reefs provide key ecological services, habitat protection and are an important food source for many species. Interstitial seagrass habitats are essential ecological components ensuring reef interconnectivity whilst providing vital 'nursery' habitat for a variety of fishes. These systems are integral components of the wider Great Southern Reef System spanning the entire southern coastline of Australia. Although Southern Australia marine macroalgal flora has the highest levels of species richness and endemism of any regional macroalgal flora in the world, current levels of both scientific and public engagement threaten the health and longevity of these significant systems.

Much like the rest of Kangaroo Island, Smith Bay's marine environment exhibits high species richness and endemism supporting an abundance of emblematic and threatened species with high conservation value. The now documented presence of numerous large temperate corals and a number of protected species, including those from the Syngnathidae family, outlines the importance of ongoing marine life surveys, with much left to be discovered. AusOcean aims to increase public awareness, perception and appreciation of these magnificent temperate ecosystems that are often overlooked by their tropical reef counterparts. These were the first of many Kangaroo Island expeditions highlighting the diversity and richness of Smith Bay and the north coast. Future research will involve additional marine life surveys, substantial footage collection via camera sled and/or ROV and potential analysis of the internal compositions (via coral core drilled sampling) of the coral, which can provide historic climate data of the area.

References

Attrill, MJ, Strong, JA, Rowden, AA (2000) Are macroinvertebrate communities influenced by seagrass structural complexity? *Ecography* **23**, 114-121.

Bennett, S, Wernberg, T, Connell, SD, Hobday, AJ, Johnson, CR, Poloczanska, ES (2015) The 'Great Southern Reef': social, ecological and economic value of Australia's neglected kelp forests. *Marine and Freshwater Research* **67**, 47-56.

Burgess, SN, McCulloch, MT, Mortimer, GE, Ward, TM (2009) Structure and growth rates of the high-latitude coral: Plesiastrea versipora. *Coral Reefs* **28**, 1005.

Choat, JH, Gillanders, B, Pollard, D (2010) *Achoerodus gouldii*. *The IUCN Red List of Threatened Species* 2010: e.T187520A8556943, viewed 18 January 2019<.http://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T187520A8556943.en.>

Clements, KD, Choat, JH (1997) Comparison of herbivory in the closely-related marine fish genera *Girella* and *Kyphosus. Marine Biology* **137**, 379-386.

Cribb, N, Bartram, P, Bartram, T, Seuront, L (2018) New Evidence for Bottlenose Dolphin (Tursiops spp.) Population Connectivity between Kangaroo Island and South Australian Mainland Waters. *Open Journal of Marine Science* **8**, 13.

da Silva, IM, Hill, N, Shimadzu, H, Soares, AMVM, Dornelas, M (2015) Spillover Effects of a Community-Managed Marine Reserve. *PLoS One* **10**, e0111774.

Dayton, PK (1985) Ecology of Kelp Communities. *Annual Review of Ecology and Systematics* **16**, 215-245.

Foster, SJ, Vincent, ACJ (2004) Life history and ecology of seahorses: implications for conservation and management. *Journal of Fish Biology* **65**, 1-61.

Gomon, M, Bray, D, Kuiter, R (2008) 'Fishes of Australia's southern coast.' (New Holland Publishers Pty Ltd: Sydney).

Harmelin-Vivien, M, Le Diréach, L, Bayle-Sempere, J, Charbonnel, E, García-Charton, JA, Ody, D, Pérez-Ruzafa, A, Reñones, O, Sánchez-Jerez, P, Valle, C (2008) Gradients of abundance and biomass across reserve boundaries in six Mediterranean marine protected areas: Evidence of fish spillover? *Biological Conservation* **141**, 1829-1839.

Heck, KL, Carruthers, TJB, Duarte, CM, Hughes, AR, Kendrick, G, Orth, RJ, Williams, SW (2008) Trophic Transfers from Seagrass Meadows Subsidize Diverse Marine and Terrestrial Consumers. *Ecosystems* **11**, 1198-1210.

Howchin, W (1909) Notes on the discovery of a large mass of living coral in Gulf St Vincent with bibliographical references to the recent corals of South Australia. Transactions of the Royal Society South Australia **3**, 242–253.

Jenkins, GP, Wheatley, MJ (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.

Kinloch, M. A. (2005). *Review of Kangaroo Island Marine, Coastal and Estuarine Biodiversity Monitoring and Research Programs*. Kangaroo Island Natural Resources Board, Kingscote.

McArdle, A, Lashmar, K, Klein, H (2015) Diving deeper: a community assessment of Kangaroo Island's rocky reefs. Final report, Caring for our Country Community Action Grants No. CEG-1217992-261.

McClanahan, TR, Mangi, S (2000) Spillover of exploitable fishes from a marine park and its effects on the adjacent fishery. *Ecological Applications* **10**, 1792-1805.

McDevitt-Irwin, JM, Iacarella, JC, Baum, JK (2016) Reassessing the nursery role of seagrass habitats from temperate to tropical regions: a meta-analysis. *Marine Ecology Progress Series* **557**, 133-143.

Middleton, JF, Bye, JAT (2007) A review of the shelf-slope circulation along Australia's southern shelves: Cape Leeuwin to Portland. *Progress in Oceanography* **75**, 1-41.

Natural Resources Kangaroo Island (2018) Marine Parks, Natural Resources Kangaroo Island, viewed 12 March 2019 <https://www.naturalresources.sa.gov.au/kangarooisland /park s-and-places/marine-parks>.

Orth, RJ, Carruthers, TJB, Dennison, WC, Duarte, CM, Fourqurean, JW, Heck, KL, Hughes, AR, Kendrick, GA, Kenworthy, WJ, Olyarnik, S, Short, FT, Waycott, M, Williams, SL (2006) A Global Crisis for Seagrass Ecosystems. *BioScience* **56**, 987-996.

Phillips, JA (2001) Marine macroalgal biodiversity hotspots: why is there high species richness and endemism in southern Australian marine benthic flora? *Biodiversity & Conservation* **10**, 1555-1577.

Prowse, TAA, Gillanders, BM, Brook, BW, Fowler, AJ, Hall, KC, Steer, MA, Mellin, C, Clisby, N, Tanner, JE, Ward, TM, Fordham, DA (2015) Evidence for a broad-scale decline in giant Australian cuttlefish (Sepia apama) abundance from non-targeted survey data. *Marine and Freshwater Research* **66**, 692-700.

Reef Life Survey Foundation (2013) Standardised Survey Procedures for Monitoring Rocky & Coral Reef Ecological Communities, Hobart, Tasmania, Australia.

Reef Watch (2019) Feral or in peril South Australia, viewed 29 January 2019 <https://d3n8a8pro7vhmx.cloudfront.net/conservationsa/pages/310/attachments/original/1453091193/Feral_or_in_Peril_Guide_2012_low_res.pdf?1453091193>

Ricart, AM, Dalmau, A, Pérez, M, Romero, J (2015) Effects of landscape configuration on the exchange of materials in seagrass ecosystems. *Marine Ecology Progress Series* **532**, 89-100.

Reinhold, S, Kinloch, M, Lashmar, K, McArdle, A & Brock, D (2013) Community Assessment of Reef Biodiversity on Kangaroo Island. Natural Resources Kangaroo Island Coast and Marine Program Report No. CMP13/01

Rowley, RJ (1994) Marine reserves in fisheries management. *Aquatic Conservation: Marine and Freshwater Ecosystems* **4**, 233-254.

Sanchez-Camara, J, Booth, DJ (2004) Movement, Home Range and Site Fidelity of the Weedy Seadragon Phyllopteryx taeniolatus (Teleostei: Syngnathidae). *Environmental Biology of Fishes* **70**, 31-41.

Shepherd, SA, Baker JL (2008) Reef fishes of lower Gulf St Vincent. In 'Natural history of Gulf St Vincent.' (Eds SA Shepherd, S Bryars, I Kirkegaard, P Harbison, JT Jennings) pp. 297-310 (Royal Society of South Australia: Adelaide).

Shepherd, SA, Baker JL, Brown AR, Crawford, HM (2009) Reef fishes of NE Kangaroo Island: a nursery role for Eastern Cove? Supplementary Report for Commonwealth Department of the Environment, Water, Heritage and the Arts Envirofund Project 63120.

Smale, DA, Burrows, MT, Moore, P, O'Connor, N, Hawkins, SJ (2013) Threats and knowledge gaps for ecosystem services provided by kelp forests: a northeast Atlantic perspective. *Ecology and Evolution* **3**, 4016-4038.

Tanaka, H, Chiba, S, Yusa, T, Shoji, J (2018) Day–night change in fish community structure in a seagrass bed in subarctic waters. *Fisheries science* **84**, 275-281.

The Register (1909) 'The Glenelg Corals', 7 July, p.4, viewed 29 January 2019, <https://trove.nla.gov.au/newspaper/article/56725711>

Appendices

Appendix 1: Inventory of species

*Total and FOO includes North Central and North which were excluded from the main data analysis.

Species	Common name	East Rocks	East	East Shore	North Central	North	Creek Channel	West Central	West Shore	West	West Rocks	Transect Total	FOO	Total*	FOO*
Fish															
Austrolabrus maculatus	Blackspotted wrasse		10		11	3	15	60	2	6	15	108	6	122	8
Trachinops noarlungae	Yellow-headed hula fish		4	30	100			60			2	96	4	196	5
Notolabrus tetricus	Bluethroat wrasse	5	4	25				4	26	2	2	68	7	68	7
Girella zebra	Zebra fish	2		60	2							62	2	64	3
Parequula melbournensis	Silverbelly			50								50	1	50	1
Pictilabrus laticlavius	Senator wrasse	1	4	3			1	4	5	3	5	26	8	26	8
Parapercis haackei	Wavy grubfish				5		1	11				12	2	17	3
Dotalabrus aurantiacus	Castlenau wrasse	3	1	3		2			3		1	11	5	13	6
Siphonognathus beddomei	Pencil weed whiting					4	1	5		2	2	10	4	14	5
Dactylophora nigricans	Dusky morwong	2		1	2	1		5	1			9	4	12	6
Notolabrus parilus	Brownspotted wrasse	3	1							5		9	3	9	3
Heteroscarus acroptilus	Rainbow cale							5	3			8	2	8	2
Parma victoriae	Scalyfin		2	3					3			8	3	8	3
Scorpis aequipinnis	Sea sweep	4		2				2				8	3	8	3
Upeneichthys vlamingii	Goatfish		2	1	7	4	4					7	3	18	5
Cheilodactylus nigripes	Magpie perch			1	3			3	1		1	6	4	9	5
Omegophora armilla	Toadfish						1	1	1	1		4	4	4	4
Tilodon sexfasciatus	Moonlighter			3						1		4	2	4	2
Kyphosus sydneyanus	Silver drummer	1		2								3	2	3	2

Pempheris klunzingeri	Rough bullseye		3		1							3	1	4	2
Acanthaluteres brownii	Spiny tailed leatherjacket								2			2	1	2	1
Achoerodus gouldii	Western blue groper	2										2	1	2	1
Helcogramma decurrens	Blackthroat threefin			1				1				2	2	2	2
Hypoplectrodes nigroruber	Banded seaperch							2				2	1	2	1
Meuschenia hippocrepis	Horseshoe leatherjacket			2								2	1	2	1
Nesogobius greeni	Twinbar goby								2			2	1	2	1
Pempheris multiradiata	Common bullseye			2								2	1	2	1
Pentaceropsis recurvirostris	Longsnout boarfish					3	1	1				2	2	5	3
Siphonognathus attenuatus	Slender weed whiting				1				2			2	1	3	2
Siphonognathus caninis	Sharp-nosed weed whiting							2				2	1	2	1
Sphyraena novaehollandiae	Snook			2								2	1	2	1
Diodon nicthemerus	Globefish							1				1	1	1	1
Haletta semifasciata	Blue weed whiting								1			1	1	1	1
Heteroclinus perspicillatus	Common weedfish						1					1	1	1	1
Olisthops cyanomelas	Herring cale								1			1	1	1	1
Siphonognathus tanyourus	Longtail weed whiting						1					1	1	1	1
Aracana aurita	Shaws cowfish				1							0	0	1	1
Aracana ornata	Ornate cowfish				2							0	0	2	1
Atule mate	Yellowtail scad				30							0	0	30	1
Caesioperca lepidoptera	Butterfly perch				1							0	0	1	1
Caesioperca rasor	Barber perch				4							0	0	4	1
Centroberyx gerrardi	Bight redfish				2							0	0	2	1
Chelmonops curiosus	Western talma				3	3						0	0	6	2
Cochleoceps bicolor	Western cleaner clingfish				1							0	0	1	1
Dinolestes lewini	Longfin pike				100							0	0	100	1
Enoplosus armatus	Old wife				3							0	0	3	1
Meuschenia freycineti	Sixspine leatherjacket				2							0	0	2	1
Neosebastes pandus	Big head gunard perch					1						0	0	1	1
Paraplesiops meleagris	Southern blue devil				2							0	0	2	1

Parapriacanthus elongatus	Elongate Bullseye				20							0	0	20	1
Paristiopterus gallipavo	Brownspotted boarfish				1							0	0	1	1
Pempheris ornata	Orangelined bullseye				30							0	0	30	1
Phyllopteryx taeniolatus	Weedy seadragon				6							0	0	6	1
Stigmatopora nigra	Wide-bodied pipefish				1							0	0	1	1
Stigmatopora argus	Spotted pipefish				1							0	0	1	1
Vanacampus margaritifer	Mother-of-pearl pipefish				1							0	0	1	1
	Total Fish	23	31	191	342	21	26	167	53	20	28	539		**903**	
	Total Fish Species	9	9	17	28	8	9	16	14	7	7	37		**56**	
Invertebrates															
Phyllacanthus irregularis	Western slatepencil urchin		6	2	4	3		8	1	2	4	23	6	30	8
Phasianella australis	Painted lady	2	1					2		8	4	17	5	17	5
Tosia australis	Biscuit star	2		1	2		4			1	6	14	5	16	6
Jasus edwardsii	Southern rock lobster			5					4		2	11	3	11	3
Pentagonaster duebeni	Vermillion biscuit star				2		7			3	1	11	3	13	4
Scallop spp.	Unidentified scallop					*	4	6				10	2	10	2
Paguroidea spp.	Unidentified hermit crab								4		4	8	2	8	2
Australostichopus mollis	Southern sea cucumber				2			1		1	2	4	3	6	4
Echinaster glomeratus	Orange reef star		1					1		2		4	3	4	3
Haliotis spp.	Abalone									4		4	1	4	1
Uniophora granifera	Granular seastar								1		3	4	2	4	2
Echinaster arcystatus	Pale mosaic sea star			1					1	1		3	3	3	3
Lunella undulata	Periwinkle	2		1								3	2	3	2
Plectaster decanus	Mosaic sea star						1			1	1	3	3	3	3
Anthaster valvulatus	Mottled seastar					1					2	2	1	3	2
Coscinasterias muricata	Eleven armed seastar			1			1					2	2	2	2
Fusinus australis	Southern spindle							1			1	2	2	2	2
Paguristes frontalis	Southern hermit crab	1						1				2	2	2	2
Pinna bicolor	Pinna				20	17		1		1		2	2	39	4
Pleuroploca australasia	Tulip shell					3	1			1		2	2	5	3

Goniocidaris tubaria	Stumpy pencil urchin				1				1			1	1	2	2
Nectria pedicelligera	Multi spined seastar		1									1	1	1	1
Thylacodes sipho	Worm snail				1							0	0	1	1
Astroboa ernae	Basketstar				5							0	0	5	1
Austrofromia polypora	Many-spotted sea star				1							0	0	1	1
Ceto cuvieria	Curviers sea cucumber				10	2						0	0	12	2
Australostichopus mollis	Australasian brown sea cucumber											0	0	0	0
Conocladus australis	Southern basketstar				3							0	0	3	1
Holothuriid spp.	Sea cucumber				1	2						0	0	3	2
Meridiastra gunnii	Gunn's six armed seastar				2							0	0	2	1
Cassis fimbriata	Snail				1							0	0	1	1
Nectria saoria	Saori's seastar				2							0	0	2	1
Doris chrysoderma	Lemon lolly doris				1							0	0	1	1
Petricia vernicina	Cushion seastar				1							0	0	1	1
Phasianotrochus eximius	Snail				1							0	0	1	1
Smilasterias irregularis	Seastar					1						0	0	1	1
	Total invertebrates	7	9	11	60	29	18	21	12	25	30	162		**222**	
	Total Invertebrate Species	4	4	6	18	7	6	8	6	11	11	29		**35**	
	Total Count of fish and invertebrates	30	40	202	403	50	44	188	65	45	58	701		**1125**	
	Total number of fish and invertebrate species	13	13	23	46	15	15	24	20	18	18	66		**91**	

Appendix 2: Expedition images

Plate 13: Reef ledge photographed at North Central.

Plate 14: Old Wives (*Enoplosus armatus)* photographed at West Central.

Plate 15: Basket star's *(Astroboa ernae & Concocladus australis)* photographed at North Central.

Plate 16: Widebody pipefish (*Stigmatopora nigra*) photographed at North Central.

Plate 17: Shaws cowfish *(Aracana aurita)* photographed at North Central.

Plate 18: Weedy seadragon *(Phyllopteryx taeniolatus)* & Ornate cowfish *(Aracana ornata)* photographed at North Central.

Plate 19: Diver and sponge Photographed at West Central.

Plate 20: Doughby scallops *(Mimachlamys asperrima)* photographed at North Central.

Plate 21: Pink lace bryozoan (*Iodictyum phoeniceum)* photographed at North Central.

Plate 22: Coral *(Coscinaraea mcneilli)* photographed at North Central.

Plate 23: Diver and Coral *(Plesiastrea versipora).*

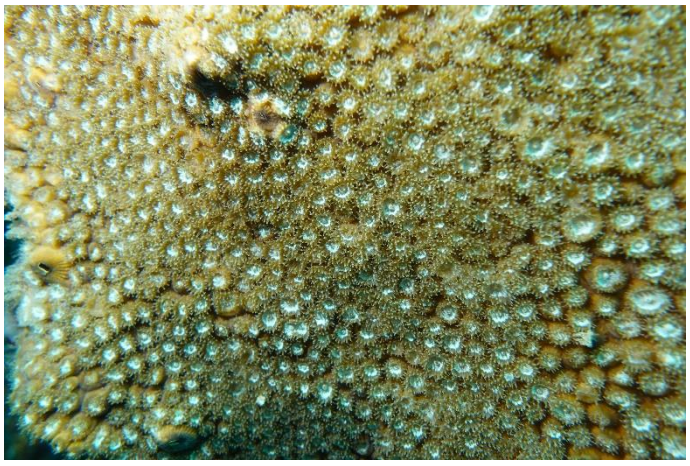


Plate 24: Coral *(Plesiastrea versipora).*