Subtidal Reef Health Program: Baseline status of subtidal reefs and associated biodiversity patterns in the AMLR region.

James Brook, Kristian Peters, Simon Bryars, Sam Owen, Jamie Hicks, David Miller, Daniel Easton, Yvette Eglington, Craig Meakin and Danny Brock

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Government of South Australia
Department for Environment and Water

Department for Environment and Water

GPO Box 1047, Adelaide SA 5001

Telephone National (08) 8463 6946

International +61 8 8463 6946

Fax National (08) 8463 6999

International +61 8 8463 6999

Website www.environment.sa.gov.au

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Cover photograph: Danny Brock, Ornate cowfish (*Arcana ornata*)

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Executive Summary

Subtidal reefs are a major component of the Adelaide and Mount Lofty Ranges (AMLR) Natural Resources Management (NRM) region's coastal marine ecosystems. They extend from Port Parham in the north of Gulf St Vincent to Goolwa in the south of the region. Subtidal reefs in the AMLR NRM region provide habitat, food and shelter for a wide diversity of coastal marine organisms including several iconic species of conservation concern, including the leafy seadragon, southern blue devil and western blue groper. In addition to their importance for biodiversity conservation, subtidal reefs provide a range of critical ecosystem services, support thriving commercial fishing and tourism businesses, and are valued recreational assets.

In recognition of the importance of subtidal reefs and in line with responsibilities under the *Natural Resources Management Act 1984*, the AMLR NRM Board in partnership with the Department for Environment and Water established the AMLR Subtidal Reef Health (SRH) Program to improve our understanding and management of these marine systems. The aims of this program are to develop a consistent and strategic approach to monitoring subtidal reefs that provides information on the status and health of these systems that is relevant to management objectives. To date the AMLR Subtidal Reef Health Program has: established a suite of 41 sites within eight subregions of the AMLR region for long term monitoring of subtidal reefs (see Figure 1); identified a standardised approach to data collection and storage; and developed a framework and associated conceptual models that underpin our current understanding of the pressures and functions of these systems (Imgraben et al. 2019).

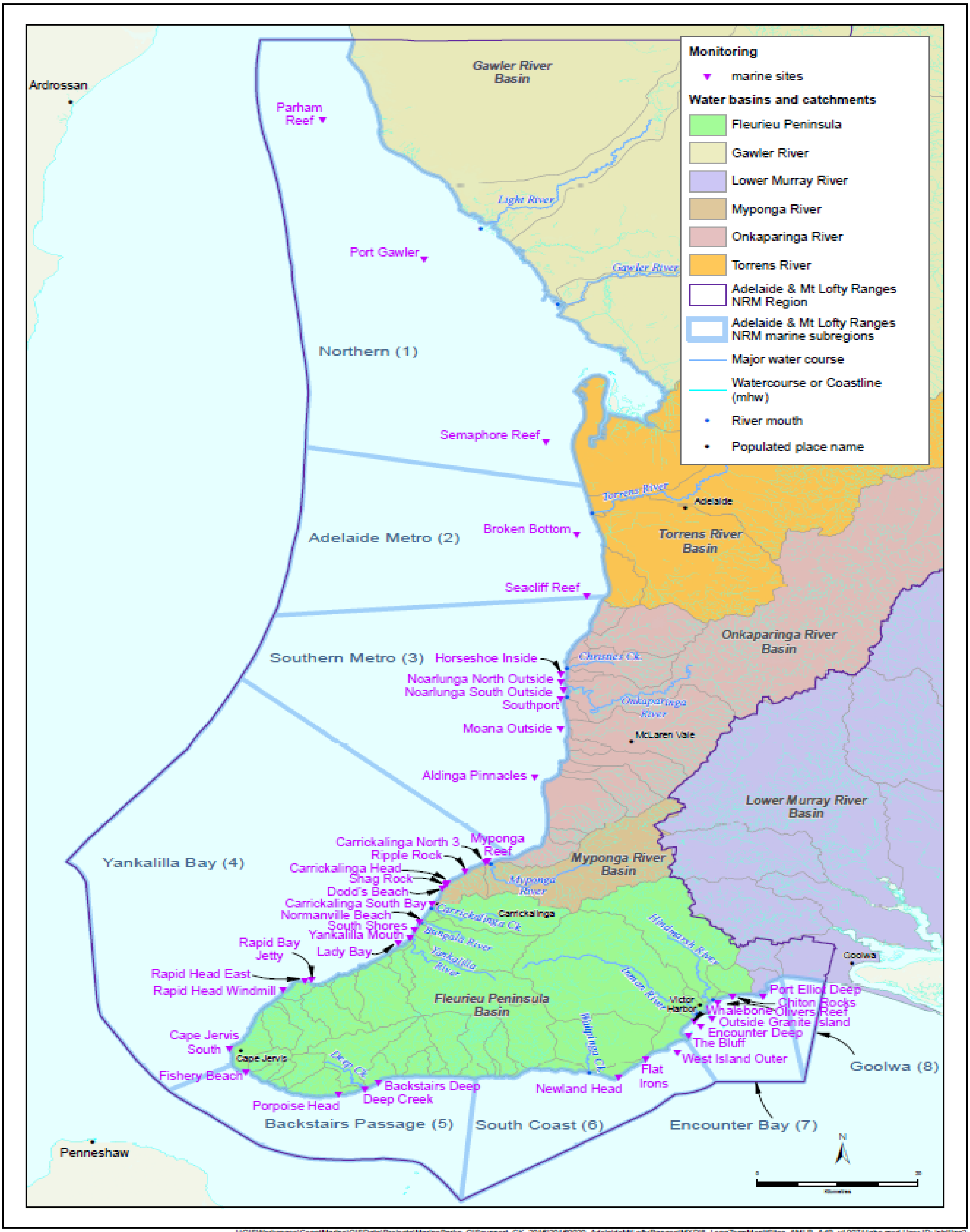
The structure of the SRH program enables management of subtidal reef ecosystems at different spatial scales including broad landscape, as a combination of sub-regions (i.e. Adelaide metro and South metro), or as independent sub-regions and stand-alone sites to accommodate changes to management boundaries or to answer specific questions on local scale biodiversity. This includes providing information that can be used to report on ecological monitoring goals. The SRH is currently the only landscape scale marine program that captures broad spatial information on the influences of coastal and terrestrial processes including catchment discharge on nearshore marine habitats. While seagrass habitat condition monitoring is also conducted, it is spatially restricted to the Southern Fleurieu and Port Adelaide coasts. Nonetheless, when combined with SRH, these two programs provide complementary and appropriate spatial coverage for management to assess regional health of nearshore marine habitats and status of species over time.

A key component of the SRH program is the engagement of community volunteers in the collection of monitoring data. Through the international Reef Life Survey (RLS) Program, several volunteer divers have now been trained and accredited in RLS survey methods which enables them to contribute to the ongoing monitoring of key reef locations of the program. This approach provides an invaluable social outcome by building capacity and knowledge in the community.

This report provides a first summary of the baseline status of subtidal reefs throughout the AMLR region, based on assessments against 10 indicators of reef condition, and documents the associated regional patterns in marine biodiversity.

In 2017 and 2018, standardised reef surveys using the RLS program protocols were conducted at 41 reef sites grouped into subregions identified for long term monitoring. The data collected were used to:

- establish the baseline status of subtidal reefs in the AMLR Region
- assess the subregional approach taken to partitioning variation in the system
- characterize regional biodiversity patterns
- evaluate the suitability of the sites selected for monitoring



The eight indicators of reef condition were derived from conceptual modelling undertaken as part of the AMLR SRH Program (Imgraben et al. 2019), and were used to assess the baseline condition of subtidal reefs across the study area. The indicators were chosen to reflect the main pressures impacting on reefs and included internationally adopted indicators such as the abundance of large reef fish and the Community Temperature Index (CTI, Stuart-Smith et al. 2018). The values for the 10 indicators were calculated for 2017 and 2018. This information established for the first time a baseline status for AMLR subtidal reefs that is regional, standardised, repeatable and comparable with other temperate reef systems around the world. This baseline will be invaluable for ongoing monitoring and management of these marine ecosystems.

Analysis of the data showed that there were subregional differences in the assemblages of macroalgae, mobile invertebrates and fish. In general, each subregion was represented by a unique combination of marine organisms. While this is expected, given physical gradients of temperature and wave exposure within the AMLR region, it is nevertheless important to document as there are obvious implications for monitoring and management. The subregional approach, which grouped reef sites into eight broad locations (subregions) outlined by Brock et al. (2017), reflects real ecological differences in subtidal biological communities and provides a useful, practical and conceptual framework for long term monitoring and management of these systems.

Macroalgal diversity was relatively consistent throughout the region, however canopy cover was much higher in southern facing subregions reflecting the influence of higher wave energy. Fish species richness was highest along the Adelaide Metro to Yankalilla subregions, however, different regions were important for different species. For example, nearly all records of blue groper came from south facing subregions while the southern blue devil was found only at more protected sites with a west facing aspect, particularly Seacliff reef which is a hot spot for this species in the region. In general, sites found within Marine Park Sanctuary Zones tended to have higher abundance of large fish species reflecting the exclusion of fishing pressure from these areas. Mobile marine invertebrate communities also showed differences in assemblages across the region. No marine pests were recorded during the surveys.

The collection of data from the 41 monitoring sites offered an opportunity to review the suitability of sites in relation to management objectives. The original criteria for site selection promoted representation of the subregions and reef types within them, assessment of catchment impacts and monitoring a subset of species of conservation concern. Some sites are more suitable than others depending upon the management focus. In light of this an analytical scenario tool in Excel was developed in this study to rationalise the future selection of monitoring sites according to management priorities.

It is recommended that ongoing monitoring continues where resources allow. In addition this report makes a number of recommendations that are summarised here:

- An analysis of trends in the 10 indicators be undertaken for reef sites where long term data exists as this will significantly improve reporting for these ecosystems.
- The condition of subtidal reefs in most NRM regions is unknown because there are no agreed condition benchmarks for statewide reporting. It is recommended that further work be undertaken to investigate how the results of this program can contribute to establishing agreed benchmarks for condition.
- Explore options for developing data visualization product to extend the results of this work to all relevant stakeholders including the general public.
- Identify flagship species not adequately assessed by the current monitoring program
- If management objectives remain the same the number of sites included for long term monitoring should be rationalised to 36.

1 Introduction

1.1 Subtidal Rocky Reefs

Near-shore subtidal reefs are a major component of the coastal ecosystems of the Adelaide and Mt Lofty Ranges (AMLR) Natural Resources Management (NRM) region. They extend in patches along the coastline from Port Parham in the north of Gulf St Vincent (GSV) to Cape Jervis and across the Fleurieu Peninsula to Goolwa in the south (Brock et al. 2017). Subtidal reefs provide valuable coastal protection and are biodiverse, and continue to deliver important ecosystem services providing both breeding habitat for a range of species. Reef systems are culturally significant to Kaurna and Ngarrindjeri across the AMLR region (Telfer and Malone 2012) and support a broad range of industries and recreational activities. These systems are extremely important to the functioning of the Gulf St Vincent marine environment and if maintained in a healthy state will help ameliorate the impacts of climate change by providing genetic diversity for adaption, coastal protection and resilience to disturbance (Roberts et al. 2017).

Subtidal reefs support the growth of canopy forming macroalgae that provide critical habitat for a range of fish and invertebrate species (Teagle et al. 2017). Several species dependent on these reefs (e.g. lobsters, abalone, squid and sweep) support important commercial and recreational fishing industries and their activities, while a range of other species are considered to be of conservation concern including leafy seadragons, southern blue devils (Baker 2007) and black cowries (Baker 2011). The combination of iconic species and high diversity make these reefs popular places for recreational snorkeling and scuba diving.

Subtidal rocky reefs in the AMLR region typically range in depth from the intertidal zone to more than 20 m and are comprised mainly of limestone, schist or granite formations with profiles that vary from flat platform-like structures to high relief complexes (Brock et al. 2017). Because of the extent and range of differences among reefs across the region, any assessments of habitats and species require indicators and methodologies that can account for site variation in order to provide adequate and consistent long-term data used to track status and to inform ecosystem management.

1.2 Natural resources management framework

The South Australian Government, through the State Natural Resources Management Plan, has responsibilities under the *Natural Resources Management Act 2004* (The Act) to provide for monitoring and evaluation of the state and condition of the natural resources of the state on an ongoing basis.

Marine ecosystems are ecologically and socio-economically important for the AMLR region, and near-shore reefs provide critical habitat for local and regional biodiversity and are significant public amenity assets. The nearshore proximity of reefs subjects them to extrinsic pressures from the land, e.g. catchment and stormwater discharge, and sedimentation, which can influence long-term condition and resilience.

The AMLR NRM Board has a responsibility under the Act to ensure that the Regional NRM Plan developed for the region includes information about the issues surrounding the management of natural resources at the regional and local level. More specifically, the NRM Plan must include information about arrangements to ensure proper management of wetlands and estuaries, and marine resources, with particular reference to the relationships between catchment, wetland, estuarine and marine systems.

The Regional NRM strategic plan for the region is intended by The Act to apply to all stakeholders managing natural resources in the AMLR region.

1.3 Health of Rocky Reefs in the AMLR region

A number of pressures have been identified that impact on rocky reefs and nearshore ecosystem environments in the AMLR region. Bryars (2013) for example, provided a detailed spatial review of key threats and remediation actions by dividing the AMLR region into 51 coastal and marine cells highlighting sedimentation, pollution, and discharge from storm water and catchments as contributing factors. Similarly, the GSV bioregional assessment of nearshore marine ecosystems by the EPA (Nelson et al. 2013) also suggest threats and pressures are spatially explicit but inputs commonly include wastewater discharge, agricultural runoff, storm water and catchment discharge carrying sediments, nutrients and pollutants.

Most recently, a temperate reef ecosystem workshop using expert elicitation identified that, in addition to climate change, sedimentation, nutrients and fishing are the major pressures affecting subtidal reefs in the AMLR region (Imgraben 2019). These pressures are often cumulative and can result in reduced ecosystem function and services associated with loss of habitat leading to simplified food webs and reduced biodiversity (Ling et al. 2018).

Over the years there have been a number of reef monitoring programs established across the AMLR region (Cheshire & Westphalen 2000, Turner et al. 2006, Brook & Bryars 2014, Westphalen 2015) which have aimed to characterise the health or status of reef systems. These studies have contributed to our understanding of the composition and changes to algal, fish and invertebrate subtidal reef communities, however, the efforts have mainly been focused on reef systems found adjacent to the Adelaide metropolitan coast with limited studies and knowledge of reef ecosystems outside of the urban Adelaide region. Therefore there is limited consolidated information and spatial understanding of the drivers and natural assets of temperate subtidal reefs across the AMLR region.

Currently there is no agreed framework or consistent method for reporting on the status of subtidal reefs (Brook & Bryars 2014, State Environmental Trend and Condition Report Cards 2018). However the approach outlined in Brock et al 2017 has been adopted as the endorsed framework to adequately monitor changes to these ecosystems and manage potential pressures and threats (e.g. sedimentation, pests) and contribute to the broader strategic plan for integrated reporting on the health and condition of marine assets (e.g. seagrass and marine pests) in AMLR region.

1.4 Subtidal Reef Health Program

The AMLR Subtidal Reef Health (SRH) Program, funded by the AMLR NRM Board in partnership with the Department for Environment and Water was established to improve our ability to assess the status of subtidal rocky reefs in the AMLR region to inform management of these important assets. The program was established in 2016 and is iterative with each successive step built on previous steps. The objectives of the SRH program are to:

1. Identify a suite of sites for long term monitoring of the health of subtidal reefs that align with AMLR NRM management objectives and recommend a standard, repeatable and consistent approach to data collection at these sites.
2. Develop conceptual models of how AMLR subtidal reefs function, by identifying knowedge gaps, indicators and the drivers, pressures and threats that affect them.
3. Develop community capacity and foster knowledge building through workshops and training events to contribute to collecting scientific data on reef ecosystems to assist in management
4. Collect baseline data on the current status of reefs using a standardized and internationally recognised sampling platform and approach
5. Document the ecological characteristics of reefs in the AMLR region and establish baseline status

6. Define condition and assess trends in reef sites where long term data are available to align with and improve current reporting frameworks (e.g. State Environmental Trend and Condition Report Cards, state and national State of the Environment reports)
7. Evaluate the SRH program to guide future investment

The first two objectives of the SRH program have been achieved and are fundamental steps to assist the longer term objectives. Brock *et al*. (2017) reviewed previous subtidal reef projects in the AMLR region and identified 41 sites across eight spatial subregions that represent the range of water temperature, wave exposure, depths, substrate composition and relief of inshore reefs (<10m deep). The sites were also chosen to align with certain management objectives such as potential pressures from land based discharge and provision of habitat for a range of regionally significant resident species. The conceptual models report by Imgraben et al. (2019), is the first report of its kind to consolidate and characterize the current knowledge of AMLR reefs, highlighting key threats, pressures and outcomes, and the current gaps in knowledge.

The models and technical reports herein are testable, and it is envisaged that when new data become available, the models would be updated so that knowledge and management objectives can be improved. Ongoing use of the RLS method will ensure that data are collected in a standard and consistent manner.

Objective 3 has engaged the broader dive community and is an ongoing process that envisages to increase community awareness, build knowledge and skills through training, and improve efficacy to deliver the reef program through the use of certified citizen scientists. This program encourages and provides opportunity for competent members of the public to be upskilled and trained using internationally recognised scientific diving methodology RLS. These skills provide divers with an opportunity outside of the SRH citizen scientist program to extend their involvement in reef health surveys on a global scale. The SRH citizen science program report (Hicks 2019) highlights effective engagement, upskill and successful accreditation of divers involved in the program.

Objectives 4 and 5 are the subject of the present report.

1.5 Objectives

The objectives of this project and report were to:

1. Collect baseline data for the 41 reefs identified for long term monitoring by Brock et al. (2017) using the RLS as a standardised and internationally recognised sampling approach;
2. Document the ecological characteristics of selected subtidal reefs within each of the eight subregions;
3. Establish a baseline status using indicators recommended by Brock et al. (2017) and those derived from conceptual models (Imgraben et al. 2019); and
4. Using the baseline data, evaluate the appropriateness of the long term monitoring sites for reporting against management objectives.

2 Methods

2.1 Baseline data collection

Forty-one subtidal reef sites were recommended for long term monitoring of AMLR by Brock et al. (2017). The aim was to survey all of these reefs in 2017 and 2018 to establish a baseline status and provide data to evaluate the suitability of these sites to inform management priorities.

DEW have established protocols for acquiring field data on reef ecosystems (Brock et al. 2017), based on the RLS methods (Reef Life Survey 2015).

The RLS methods are based on linear transects of 50 m length, and include:

- 'Method 1': a visual diver survey of all fish and other swimming animals (including marine mammals, turtles, cephalopods and jellyfish), covering two blocks, each 5 m wide, on opposing sides of the transect line;
- 'Method 2': an intensive diver search of particular taxonomic groups of mobile invertebrates and cryptic fish, covering two blocks, each 1 m wide, on opposing sides of the transect line; and
- 'Method 3' – Photoquadrats: assessment of major habitat cover using 20 evenly spaced photoquadrats covering approximately 0.3 m x 0.3 m of seafloor.

The DEW protocols require four contiguous 50 m transects at a site, i.e. a total length of 200 m providing coverage of 2000 m^2 for method 1, 400 m^2 for method 2 and 80 photoquadrats. These transects provide a useful indication of the heterogeneity at a site but are not spatially independent replicates and caution should be exercised when making statistical inferences from the variability between them. The use of four transects also provides for comparison with historical surveys that extended over fewer transects.

The prescribed set of cryptic fish taxa can be recorded during both the 'method 1' and 'method 2' surveys. Examples of species for which this typically occurs in the AMLR region include bullseyes (family Pempheridae) and the southern blue devil (*Paraplesiops meleagris*). The use of two spatially overlapping methods to record fish species presents some challenges for the analysis and presentation of the data. For all calculations and analysis relating to fish, a standard/accepted approach combining RLS Method 1 and Method 2 was used, with results presented as the mean of two blocks along a 50 m transect (Edgar et al. 2009).

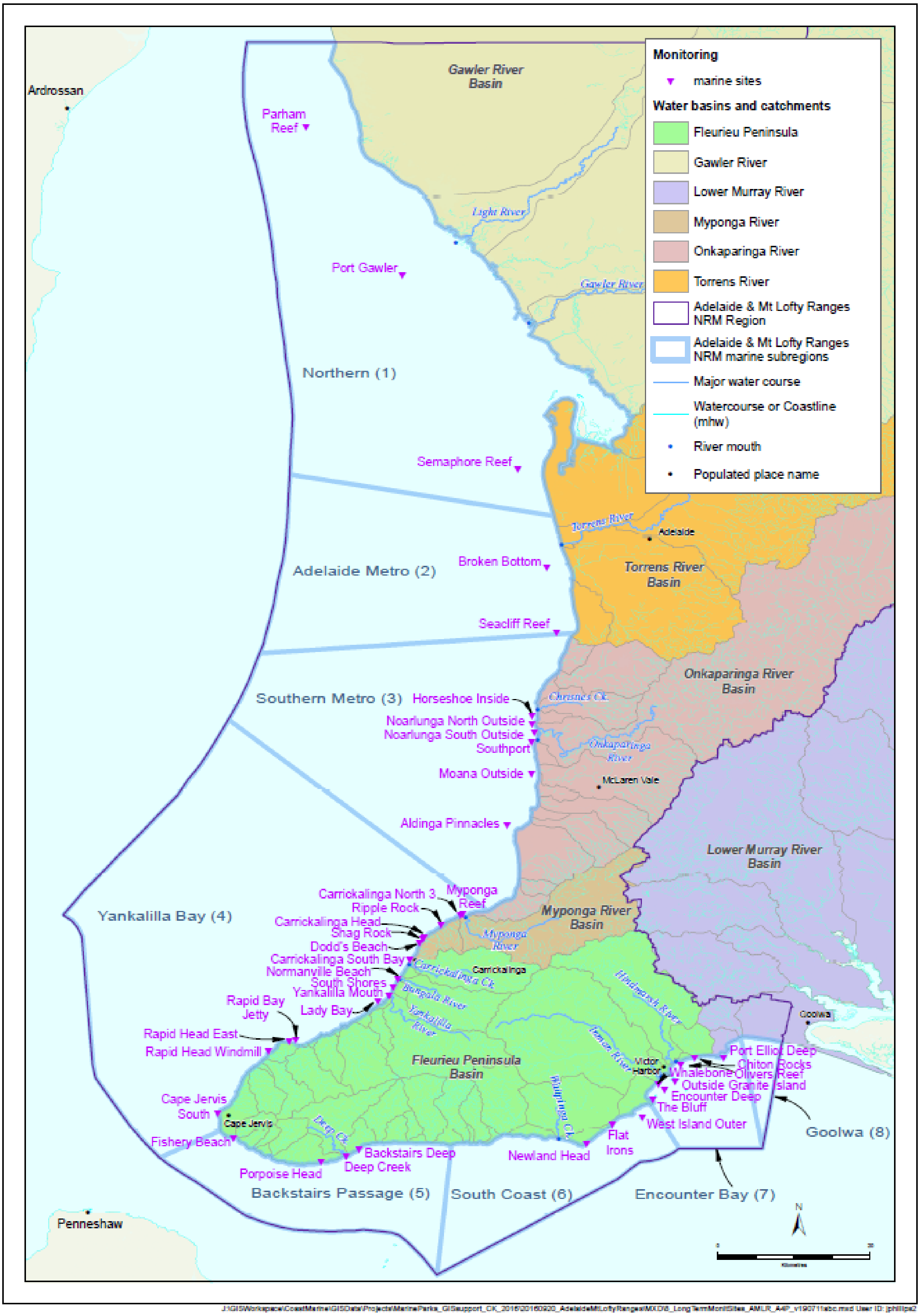


Figure 1. Sites surveyed during 2017 and 2018 in relation to subregions, catchments and river discharges

2.2 Indicators of Reef status

2.2.1 Rationale

A number of indicators have been selected to assess the current status of subtidal reefs in the AMLR region. The indicators have been chosen based on the recommendations from the review of reef monitoring in the AMLR region (Brock et al. 2017 pp. 67-68) and conceptual models developed by Imgraben et al. (2019). The conceptual models identified sedimentation, nutrients and extractive resource use attributed largely to fishing; as the main pressures on subtidal reefs in the AMLR region, and described the physical drivers and ecosystem impacts associated with these pressures. Climate change is explicitly recognized as a longer term pressure

There are a wide variety of physical, chemical and biological indicators that could (and are) used to assess the status of reefs to determine condition or health. This study uses RLS dive surveys as the main method of data collection as is commonly used in temperate reef studies (Edgar & Stuart-Smith 2009, Stuart-Smith et al. 2014, Soler et al. 2015) and as such this effectively focuses the choice of indicators in the current work to those based on biological measurements (i.e. number of fish, percent cover of major habitats). This does not exclude, in the future, the use of indicators associated with data collected by other means where recommended (e.g. physical indicators such as sediments).

Based on the ecological impacts of the pressures described by Imgraben et al. (2019) a number of indicators have been derived that can be used as relative measures to assess each site and provide long-term information to assess status or change. These indicators are summarized in Table 1. While the drivers for change e.g. reduced light availability, increased nutrients or removal of biomass may be different, there is a high degree of commonality in the type of biological change in response to these pressures and therefore the indicators that can measure them (Table 1).

Based on the functional table developed for the reef conceptual models (Imgraben et al. 2019) and summarized in Table 1, three key biological changes can be described in response to the pressures associated with sedimentation, eutrophication and extraction:

i) reduction or loss of canopy forming macroalgae

ii) change in trophic structure of fish

iii) change in trophic structure of mobile invertebrates

In the case of sedimentation and eutrophication there is a direct impact with a reduction in canopy forming macroalgae potentially followed by a change in fish and macro-invertebrate trophic structure, while for the pressure of resource extraction there is a direct impact on fish and macro-invertebrate trophic structure with potential indirect impact on canopy forming macroalgae. Independently or in combination, each of these biological changes can reduce the resilience of reef ecosystems by reducing biological complexity and simplifying food web structure, which can impact system integrity and the scale of ecosystem services they provide.

The following 8 indicators have been identified for establishing the baseline status of AMLR reefs (see section 2.2.2 for definitions), with many of these indicators being globally recognised and used for RLS and other programs internationally:

- community structure of fish and mobile invertebrates
- community temperature index of fish (CTI)
- species richness of fish and mobile invertebrates
- percent cover of canopy forming macroalgae
- composition of macroalgae functional groups

- biomass of large fish
- biomass of targeted fish
- size and abundance of focal species

The indicators suggested here are divided into community level (e.g. community structure of fish and invertebrates), focal groups (e.g. % cover macroalgae, biomass of large fish) and focal species (e.g. species of conservation concern such as blue groper) to ensure that different components of the marine ecosystem are assessed.

Table 1. Summary of pressures, biological impacts and potential indicators derived by Imgraben et al. (2019)

Pressure	Biological Change	Indicators
Sedimentation	**Change in habitat:** Reduction/loss of canopy forming macroalgae associated with reduced light, scouring and sediment deposition	• Percentage cover of macroalgae • Percentage cover of functional groups
	Change in trophic structure: Potential for reduced fish and mobile invertebrate size and abundance as prey abundance and available habitat changes with reduction in canopy forming macroalgae cover	• Fish and mobile invertebrate community structure • Size and abundance of key species (e.g. resident reef fish, species of conservation concern/economic value)
	Reduced resilience: Potential for invasion by marine pests as colonization space opens up and reduced resistance and slower recovery from disturbance	• Marine pest size and abundance • Percentage cover of macroalgae • Fish and mobile invertebrate community structure
Nutrients	**Change in habitat:** Reduction/loss of canopy forming macroalgae associated increased competition from phytoplankton and turfing algae.	• Percentage cover of macroalgae • Percentage cover of functional groups
	Change in trophic structure: Reduced fish and mobile invertebrate size and abundance as prey abundance and available habitat changes with reduction in canopy forming macroalgae cover. Shift in mobile invertebrate communities associated with increase in filter feeders	• Fish and mobile invertebrate community structure • Size and abundance of key species (e.g. resident reef fish, species of conservation concern/economic value)
	Reduced resilience: Potential for invasion by marine pests as colonization space opens up and reduced resistance and slower recovery from disturbance	• Marine pest size and abundance • Percentage cover of macroalgae • Fish and mobile invertebrate community structure
Fishing	**Change in habitat:** Reduction/loss of canopy forming macroalgae associated change in trophic balance between predators and herbivores	• Percentage cover of macroalgae • Percentage cover of functional groups
	Change in trophic structure: Reduction in number and size targeted fish which are often larger in size and/or high order predators. Change in community structure associated with altered predator/prey relationships, reduced reproductive rates or reduced food/habitat associated with canopy forming macroalgae	• Fish and mobile invertebrate community structure • Size and abundance of large fish/targeted fish • Size and abundance of key species (e.g. resident reef fish, species of conservation concern/economic value)
	Reduced resilience: Potential for invasion by marine pests as colonization space opens up and reduced resistance and slower recovery from disturbance	• Marine pest size and abundance • Percentage cover of macroalgae • Fish and mobile invertebrate community structure

2.2.2 Definition and context of indicators

Descriptions of the indicators adopted for this report are provided below, with detail on their calculation provided in Appendix B.

Species richness of fish and invertebrates

Species richness is the total number of species recorded and is a measure of ecosystem biodiversity. Higher species richness is an indicator of higher biodiversity. Maintaining biodiversity is often a key requirement of Natural Resource Management and is important because loss of biodiversity reduces ecosystem resilience and function and can compromise ecosystem services (Duffy et al. 2016).

Community structure of fish and mobile invertebrates

Community structure is defined as what species are present in a given location, in what numbers and how they relate to each other. Examination of community structure is a powerful tool for examining changes through time; including recovery from disturbance and change in trophic status. Research has shown that protected marine communities can revert to a state quite different from unprotected ones (Edgar et al. 2009). Community structure is assessed using multivariate statistical techniques to display species assemblages across sites in multidimensional space (Clarke 1993).

Community temperature index

Community temperature index (CTI) is a measure of the average thermal affinity of communities (Bates et al. 2014, Stuart-Smith et al. 2015). Most communities are comprised of species with a broad range of thermal distributions. One of the potential outcomes of global warming is the replacement of cooler-affinity species with warmer ones. Well managed and intact systems are predicted to improve resilience in some cases and therefore buffer ecosystems to some extent, from the impacts of external drivers such as climate change. A recent study has shown that diverse, intact communities are less affected by rising temperature than less diverse ones (Duffy et al. 2016). CTI can be used to measure community responses to climate change.

Size and abundance of targeted fish species

Targeted species often come from higher trophic levels (e.g. snapper, kingfish, harlequin fish) and these fish can be extremely important in regulating ecosystems as they can exert top down control by reducing prey numbers (Baum & Worm 2009, Boyce et al. 2015). Measuring the size and abundance of targeted fish species by commercial and recreational fishers will give an indication of harvesting levels. For the purposes of this report targeted fish species are considered to be those species actively sought by recreational or commercial fishers (see Appendix B).

Size and abundance of large fish

Large fish are prized by both commercial and recreational fishers and are often caught in disproportionately high numbers. Larger fish play an important role in structuring communities as they consume larger prey and have much higher fecundity than smaller fish resulting in the production of disproportionately higher numbers of recruits than smaller fish (Berkeley et al. 2004, Sato & Suzuki 2010). A reduction in the number of large fish can contribute to reduced ecosystem function and resilience. Large fish are defined here as fish >200 mm and this measure has been demonstrated to be a robust indicator of fishing pressure (Stuart-Smith et al. 2017).

Percent cover of canopy forming macroalgae

Large, brown canopy-forming macroalgae, defined here as species from the orders Laminariales (kelps) and Fucales, are important within temperate marine ecosystems for primary productivity and creating habitat complexity in support of substantial faunal communities (Turner et al. 2007). Due to their central role in a range of ecological processes, the loss of canopy forming algae is likely to lead to the significant loss of associated species and ecological function (Gaylard et al. 2013). These taxa have also been shown to be susceptible to declining water quality (e.g. Cheshire and Westphalen 2000, Gorgula and Connell 2004, Turner 2004).

Composition of macroalgae functional groups

Healthy ecosystems tend to support a larger number of species, which in turn assists healthy ecosystem function by increasing stability. The richness of a community can be an indicator of the health of an ecosystem, but is best used as an indicator of change (i.e. a temporal comparison within sites) rather than for the spatial comparison of different reefs (Turner et al. 2007). For the current study, richness was measured at the level of life forms or functional groups.

Size and abundance of focal species

Individual species can be important for a range of reasons. They may be keystone species, critical to ecosystem functioning (e.g. rock lobsters, kelp *Ecklonia radiata*), iconic species valued by divers or just in general (e.g. blue groper, leafy sea dragon), fishes of conservation concern (FCC, e.g. blue devil), highly sought after recreational species (e.g. sweep, snapper), or vulnerable species less resilient to environmental change. The size and abundance of focal species are relatively easy to measure, and assessing them can provide a good indicator of management efforts to maintain subtidal reef health. Increases in their abundances can also be used as an effective communication tool to demonstrate the value and raise awareness of the importance of these marine ecosystems. Table 2 lists the focal species chosen for the current report and identifies some of the features of why they were included. It should be noted that RLS methods provide data on a range of individual species and focal species chosen to monitor can be changed according to need.

Table 2. Focal species and characteristics for its inclusion to be monitored

Focal Species	**Protected**	**Keystone**	**Iconic**	**Conservation concern**	**Fished**
Fish species					
Western blue groper	✓	✓	✓	✓	✓
Southern blue devil			✓	✓	✓
Bluethroat wrasse		✓		✓	✓
Sea sweep				✓	✓
Invertebrate species					
Southern rock lobster		✓	✓		✓
Abalone		✓	✓		✓
Urchins		✓			

In the case of abalone, it is relatively easy to distinguish the greenlip abalone *Haliotis laevigata,* and large (>10 cm) blacklip abalone *H. rubra*, but more difficult to distinguish smaller blacklip abalone from other species including *H. scalaris, H. roei* and *H. cyclobates,* all often found under rocks or in crevices making close inspection difficult. Therefore *H. rubra, H. scalaris, H. roei* and H. *cyclobates* are grouped together for monitoring purposes.

2.3 Evaluation of monitoring sites

The list of sites for the current study was developed by Brock et al. (2017), using an iterative process to choose a set of sites that met the following criteria:

1. at least two sites for each subregion defined by physical factors (representative)
2. all combinations of depth, profile and substrate composition (representative)
3. a control and impact site (where possible) with similar characteristcs in each subregion in relation to major land based threats as identified by Bryars (2013) (land based impacts)
4. one near and one far site (where possible) for each major river discharge (land based impacts)
5. at least one of the top three sites identified for monitoring each of the 20 priority Fish of Conservation Concern (monitoring FCCs).

Dive surveys, while effective at collecting data about a broad range of marine organisms, can be resource intensive and limited by the availability of trained scientific divers. It is therefore useful to consider minimizing the number of sites required to adequately monitor subtidal reefs in the AMLR Region. The collection of data during two annual surveys from the 41 sites provides the opportunity to review the list of sites and consolidate where appropriate.

In cases where there is more than one site that satisfies the criteria then preference will be given to sites that meet the following secondary criteria:

6. Have existing data
7. Are part of an ongoing monitoring program
8. Are shallow (<10 m) for practicality in relation to dive surveys, noting that there will still need to be some deep sites to achieve representativeness.

Furthermore, management priorities may change as a result of information gained from the 2017 and 2018 surveys, leading to modifications to or different priorities placed on the criteria above. Depending on the management focus there may be different suites of sites recommended as shown in Figure 2, which summarizes the evaluation process. The Solver add-on to Microsoft Excel was applied to the full set of possible dive sites to determine the minimum number of monitoring sites required for each of these scenarios.

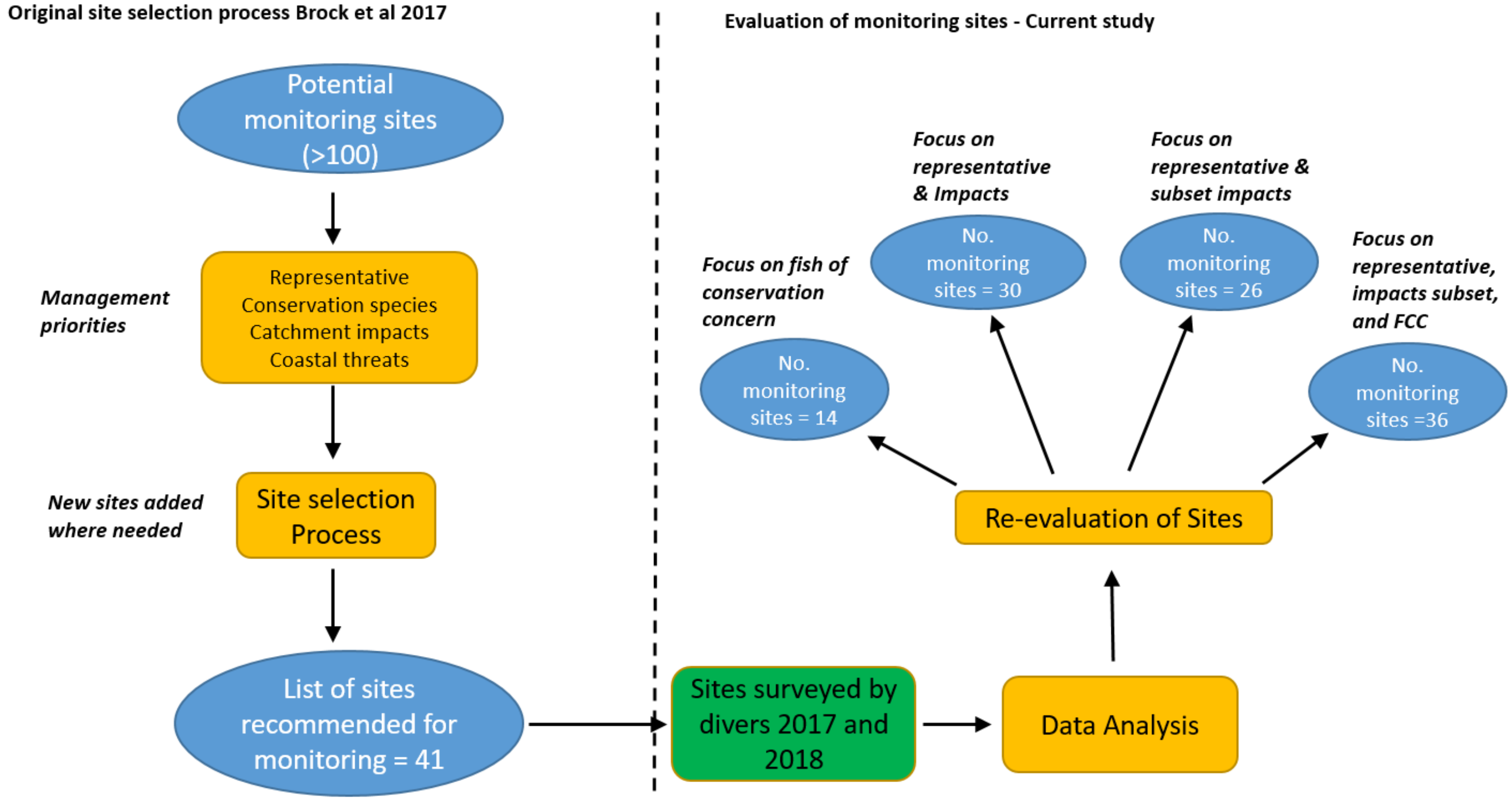


Figure 2. Summary of evaluation of sites selected for long term monitoring

3 Characteristics of AMLR reefs

All of the 41 sites recommended for long term monitoring of subtidal reefs in the AMLR region by Brock et al. (2017) were successfully surveyed in 2017 and 2018 giving two years of data to establish baseline status. The number of sites and their respective location within subregions surveyed during autumn 2017 and 2018 are shown in Figure 1. Further details are provided in Appendix A. Sites were surveyed typically in late summer and autumn. In 2017 surveys of three sites were delayed by weather and poor visibility until early winter. In 2018, surveys commenced during the last week of summer in order to capitalise on good conditions at those sites that typically have poor visibility. This section utilizes the data from the 2017 and 2018 surveys to summarize the physical characteristics, macroalgal communities, fish communities, and mobile invertebrate communities of the 41 sites and eight subregions.

3.1 Physical characteristics

A subregional monitoring framework was defined by Brock et al. (2017) using physical characteristics that included summer sea surface temperature, wave exposure, depth, relief and substrate composition. The characteristics of these subregions are summarized in Table 3. In several cases new monitoring sites were required to be added in addition to existing sites to represent the range of depth, relief and substrate types. Upon commencement of survey work within the Goolwa subregion, no suitable low profile reef was found (DEW 2019) and so this subregion was not included in the SRH program.

Table 3. Physical characteristics of reefs surveyed within the AMLR region during 2017 and 2018.

No.	Subregion	Defining features
1	Northern	Warmest summer water, very low wave energy, depth < 10m, limestone platform reefs
2	Adelaide Metro	Warm summer water, low wave exposure, depth 10–20 m, limestone, relief 0.5–1 m
3	Southern Metro	Warm summer water, low wave exposure, variable depth, limestone, variable relief
4	Yankalilla Bay	Cool summer water, moderate wave energy, depth < 10 m, schist, platform reef or relief 1–3 m
5	Backstairs Passage	Coolest summer water, moderate wave energy, depth variable, schist, relief 1–3 m
6	South Coast	Coolest summer water, high wave energy, depth variable, schist, relief 1–3 m
7	Encounter Bay	Cool summer water, moderate wave energy, depth variable, granite and limestone reefs, relief 0–3 m
8	Goolwa	Coolest summer water, high wave energy, depth 15 m, low profile reef, likely limestone.

3.2 Macroalgal communities

3.2.1 General features

A total of 38 functional groups describing macroalgae, sessile invertebrates or substrate were recorded during post-field analysis of photoquadrats from the two survey years. The most commonly recorded functional groups were large, branched canopy-forming brown macroalgae, typically from the order Fucales (40%), the canopy-forming kelp *Ecklonia radiata* (16%), and turf mats (10%). Bare substrate and rock with encrusting calcareous or other red encrusting algae accounted for 7%. Several functional groups described substrate where macroalgae would not occur or could not be recorded, including sand, seagrass and drift macroalgae/seagrass (13% collectively). Sessile invertebrates including sponges, ascidians and cnidarians accounted for 2%. The remaining algal cover was a mixture of brown, red and green understorey species.

Sessile community structure was generally consistent between the 2017 and 2018 surveys at each of the 41 sites, relative to the variation between sites (Figure 3).

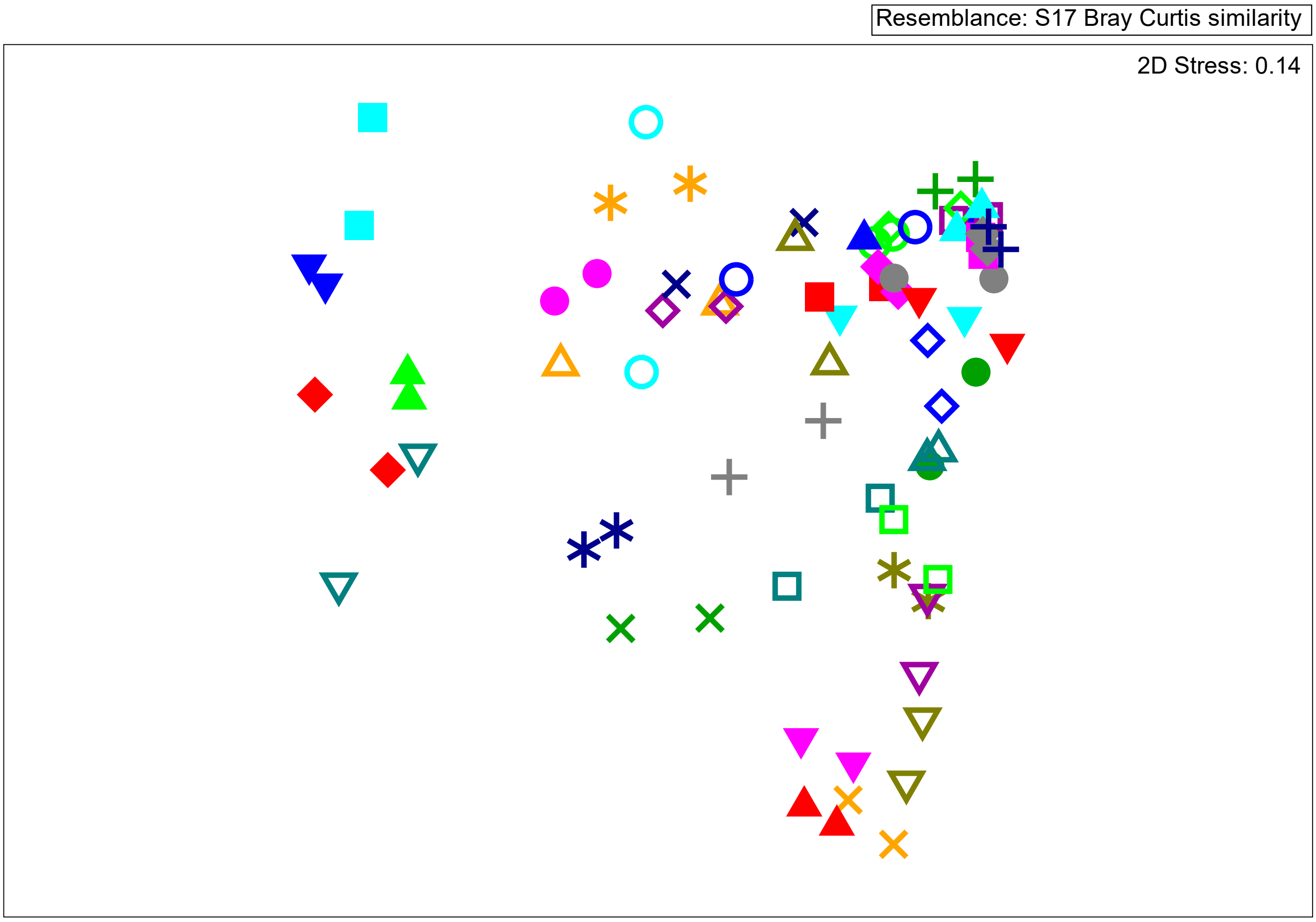


Figure 3. MDS plot of macroalgal communities by site. Symbol/colour combinations distinguish 41 individual sites, each of which was surveyed in 2017 and 2018. The symbol used to represent each site is shown in Appendix A.

3.2.2 Subregional features

Sites within the same subregion generally had similar communities, although the relatively small number of sites from the Adelaide Metro and South Coast subregions were more dispersed (Figure 4). Sites which were outliers from others in their subregion included Rapid Bay Jetty (Yankalilla Bay, towards the bottom left of the MDS scatter plot), Chiton Rocks (the left-most points of the Encounter Bay sites), Moana Outside (Southern metro, towards the bottom right) and Cape Jervis South (2018 value is the left-most point of the Backstairs sites).

SIMPER analysis showed that the subregions were characterized by the following functional groups (Appendix D):

- Northern: filamentous red algae and drift macroalgae
- Adelaide metro: turf and patches of coarse sand
- Southern metro: turf and kelp (*Ecklonia radiata*)
- Yankalilla Bay and Backstairs Passage: brown branched canopy-forming macroalgae

- South Coast: kelp and brown branched canopy-forming macroalgae
- Encounter Bay: kelp

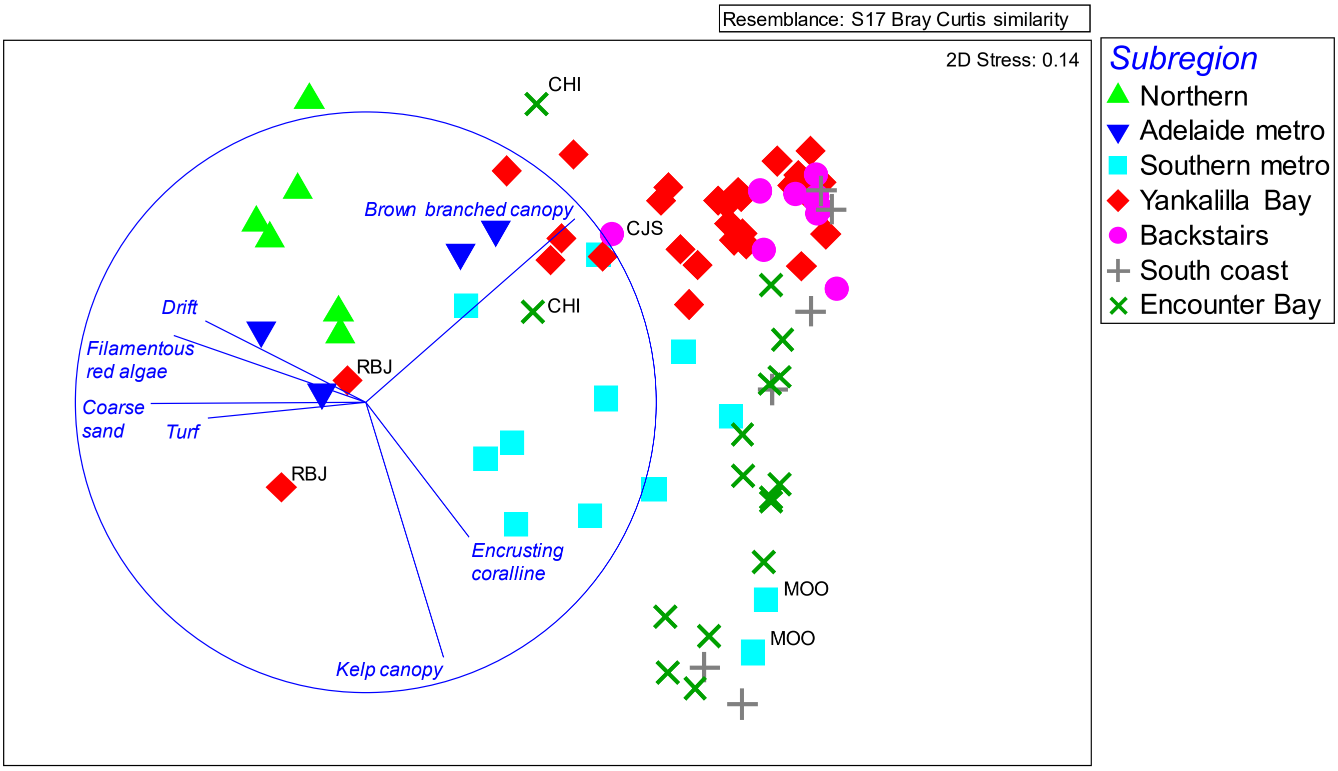


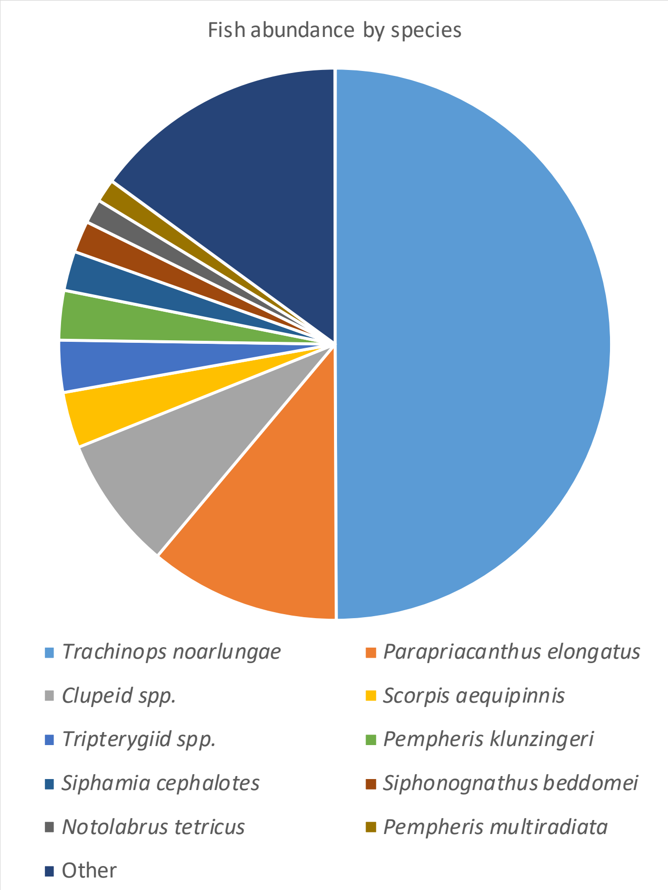
Figure 4. MDS plot of macroalgal communities by AMLR subregion. Outliers from subregions are labelled using abbreviations listed in Appendix A.

3.3 Fish communities

3.3.1 General features

A total of 127 species of fish including 10 elasmobranchs, were recorded from 55 families across the two survey years, with 35 species recorded only during the cryptic fish surveys (Appendix C). The best represented families were the Monacanthids (leatherjackets) with 10 species, Odacids and Clinids each with 8 species, and Kyphosids and Labrids each with 6 species.

The most abundant fish were the small schooling species yellow-headed hulafish (*Trachinops noarlungae*) (~44,000) and slender bullseye (*Parapriacanthus elongatus*) (~10,000), unidentified small schooling fish (~5000), sea sweep *Scorpis aequipinnis* (~2900) and black-throated threefin (*Helcogramma decurrens*) (~2700), the latter generally recorded during the cryptic fish surveys. The species with highest biomass were silver drummer (*Kyphosus sydneyanus*), dusky morwong (*Dactylophora nigricans*), sea sweep, horseshoe leatherjacket (*Meuschenia hippocrepis*) and bluethroat wrasse (*Notolabrus tetricus*). High abundance does not necessarily correlate to high biomass, with only sea sweep and yellow-headed hulafish among the species with the highest (top ten) abundance and biomass (Figure 5).



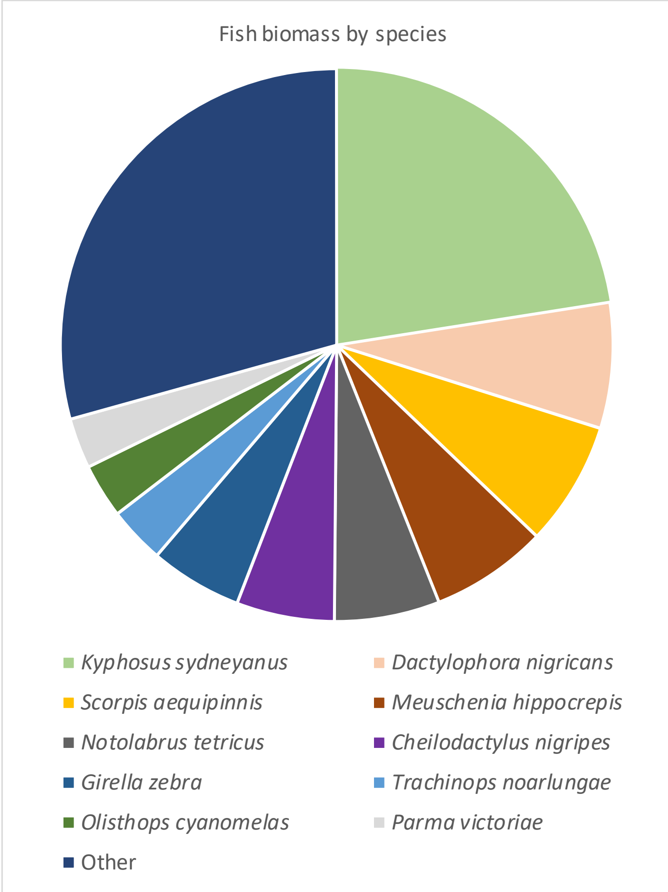


Figure 5. Fish species with the highest abundance and biomass from reef surveys in 2017 and 2018.

The fish species most commonly recorded on transects were magpie perch (*Cheilodactylus nigripes*), Victorian scalyfin (*Parma victoriae*), bluethroat wrasse, brown-spotted wrasse (*Notolabrus parilus*), sea sweep and black-throated threefin. Thirteen species were recorded only once, including southern fiddler ray (*Trygonorrhina dumerilii*) at Parham Reef, blue rock whiting (*Haletta semifasciata*) at Semaphore Reef, globe fish (*Diodon nicthemerus*) at Noarlunga North Outside, black stingray (*Bathytoshia lata*) and numbfish (*Hypnos monopterygius*) at Southport, spotted stingaree (*Urolophus gigas*) at Yankalilla Mouth, southern eagle ray (*Myliobatis tenuicaudatis*) at Lady Bay, western smooth boxfish (*Anoplocapros amygdaloides*) at Rapid Bay Jetty, stars and stripes leatherjacket (*Meuschenia venusta*) at Rapid Head East, queen snapper (*Nemadactylus valenciennesi*) at Porpoise Head and silver sweep (*Scorpis lineolata*) at Backstairs Deep.

The largest fish were the black stingray (150 cm size class), southern fiddler ray and Port Jackson shark (*Heterodontus portusjacksoni*) (100 cm), dusky morwong (*Dactylophora nigricans*), southern eagle ray, estuary catfish (*Cnidoglanis microcephalus*) and yellowtail kingfish (*Seriola lalandi*) (87.5 cm) and blue groper (*Achoerodus gouldii*), varied catshark (*Parascyllium variolatum*) and snook (*Sphyraena novaehollandiae*) (75 cm).

The silver sweep (*Scorpis lineolata*) was recorded in 2018 at Backstairs Deep (near Deep Creek) and observed off-transect during the two surveys at West Island, Flat Irons and Encounter Deep. It is regarded as an eastern Australian species with its westernmost extent reported as Port Phillip Bay and Tasmania (Edgar 2008, Gomon et al. 2008) and 'South Australia' (Hutchins & Swainston 1999). There are records from near Seal Rock (in Encounter Bay) and Deep Creek and numerous others from the south-east of South Australia (ALA 2019).

The red-banded morwong (*Cheilodactylus spectabilis*) recorded in 2017 at West Island, Newland Head and Ripple Rock (and Carrickalinga North 2, a marine parks monitoring site) also has eastern affinities, with the eastern extent of its range reported as Robe (Hutchins & Swainston 1999) or Victor Harbor (Edgar 2008), although there are records from further west including Geographe Bay in Western Australia (ALA 2019).

Further detail about a number of fish of conservation concern is provided in Section 4.

Fish communities were generally consistent between the 2017 and 2018 surveys at each of the 41 sites, relative to the variation between sites (Figure 6).

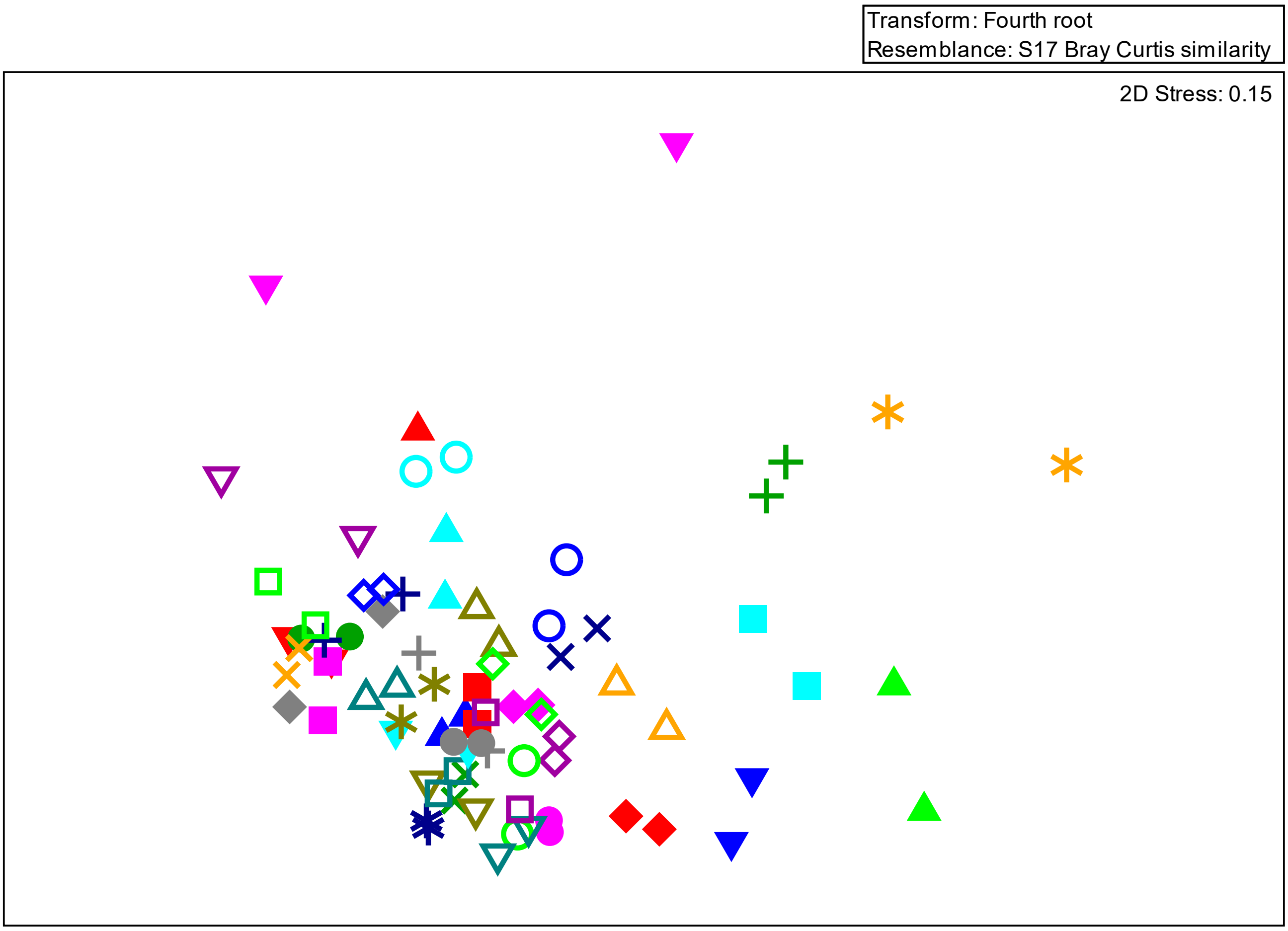


Figure 6. MDS plot of fish communities by site. Symbol/colour combinations distinguish 41 individual sites, each of which was surveyed in 2017 and 2018. The symbol used to represent each site is shown in Appendix A.

3.3.2 Subregional features

Sites within the same subregion generally had similar fish communities (Figure 7). Sites which were outliers from others in their subregion included Southport (the right-most of the Southern metro sites), Basham's Beach (top-most of the Encounter Bay sites) and two of the shallow reefs in Yankalilla Bay, namely Normanville Beach and Yankalilla Mouth (groups at centre-right and far right).

SIMPER analysis showed that the subregions were characterized by the following species (Appendix D):

- Northern: wavy grubfish (*Parapercis haackei*), little weed whiting (*Neoodax balteatus*), Wood's siphonfish (*Siphamia cephalotes*) and southern goatfish (*Upeneicthys vlamingii*)
- Adelaide metro: yellow headed hulafish (*Trachinops noarlungae*), slender bullseye (*Parapriacanthus elongatus*), wavy grubfish, rough bullseye (*Pempheris klunzingeri*), western talma (*Chelmonops curiosus*) and undifferentiated threefins (Tripterygiid spp.) including the blackthroat threefin (*Helcogramma decurrens*)

- Southern metro: yellow-headed hulafish, rough bullseye, threefins, magpie perch (*Cheilodactylus nigripes*), moonlighter (*Tilidon sexfasciatus*), sea sweep (*Scorpis aequipinnis*), black-spotted wrasse (*Austrolabrus maculatus*) and brown-spotted wrasse (*Notolabrus parilus*)
- Yankalilla Bay: threefins, yellow headed hulafish, brown-spotted wrasse, moonlighter, goatfish, magpie perch, bluethroat wrasse (*Notolabrus tetricus*) and pencil weed whiting (*Siphonognathus beddomei*)
- Backstairs Passage: bluethroat wrasse, Victorian scalyfin (*Parma victoriae*), magpie perch, senator wrasse (*Pictilabrus laticlavius*) and horseshoe leatherjacket (*Meuschenia hippocrepis*)
- South Coast: sea sweep, bluethroat wrasse, magpie perch, herring cale (*Olisthops cyanomelas*) and horseshoe leatherjacket
- Encounter Bay: sea sweep, bluethroat wrasse, Victorian scalyfin and brown-spotted wrasse.

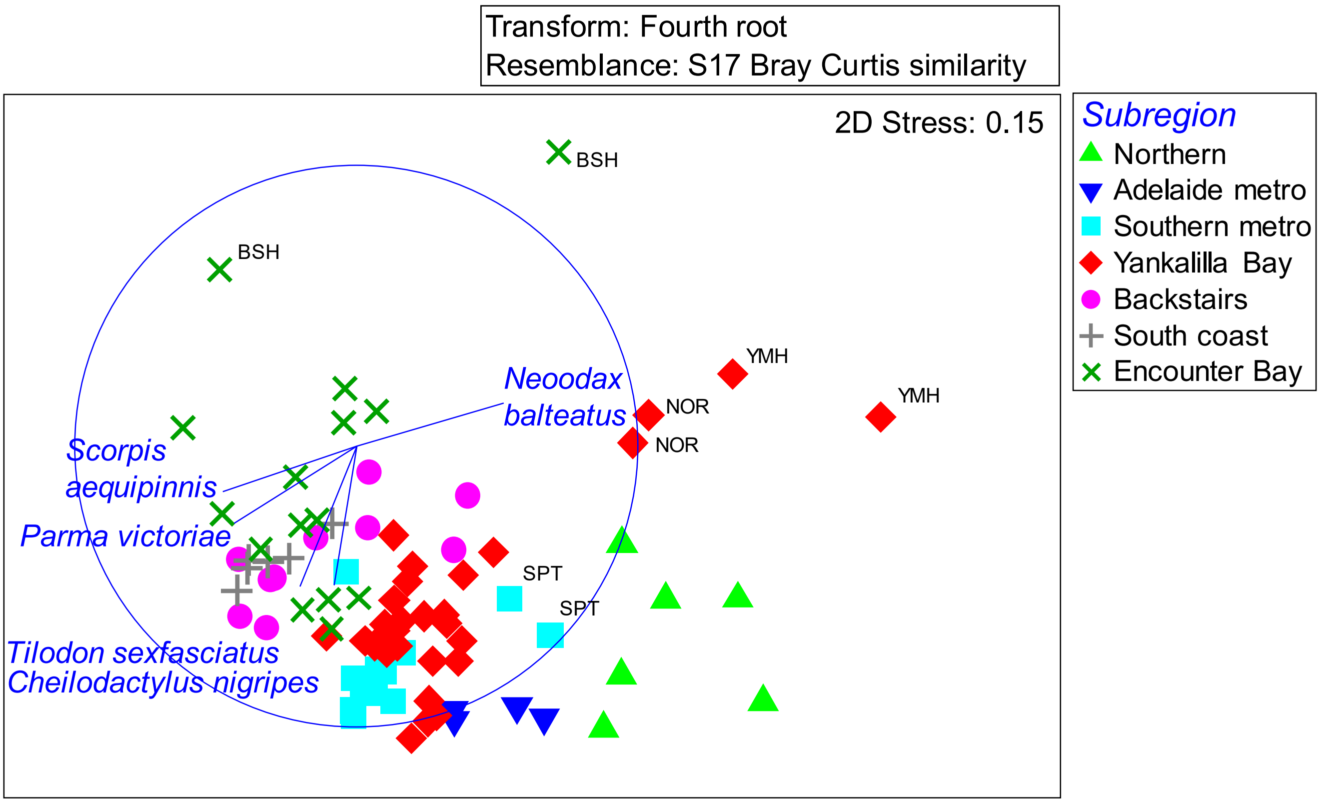


Figure 7. MDS plot of fish communities by AMLR subregion. Outliers from subregions are labelled using abbreviations listed in Appendix A.

3.4 Mobile invertebrate communities

3.4.1 General features

A total of 90 mobile invertebrate species were recorded across the two survey years, including 11 crustaceans (crabs), 36 echinoderms (feather stars, sea stars, urchins and holothurians), 42 molluscs (gastropods and a few bivalves and a cephalopod).

The most abundant mobile invertebrates were the warrener *Turbo undulatus* (~9000), purple urchin (*Heliocidaris erythrogramma*) (~4000), a complex of black-lipped abalone including *Haliotis rubra* and *H. scalaris* (~1600), turbo shell (*Turbo torquatus*) (~1000), feather star (*Comanthus trichoptera*) (~800) and red whelk (*Pleuroploca australasia*) (~800). The mobile invertebrate species most frequently recorded on transects were red whelk, southern biscuit star (*Tosia australis*), southern hermit crab (*Paguristes frontalis*), purple urchin and warrener. Ten species were recorded only once, including nudibranch *Goniobranchus epicurius* at Broken Bottom, king scallop (*Pecten fumatus*) at Seacliff Reef, gastropod (*Lyria mitraeformis*) at Southport, sea hare (*Bursatella* sp.) at Myponga Reef, wavy volute (*Amoria undulata*) and the nudibranch *Mexichromis macropus* at Rapid Bay jetty, the gastropod *Ranella australasia* at Olivers Reef, greenlip abalone (*Haliotis laevigata*) at Chiton Rocks, and western passion star (*Ptilometra macronema*) at Port Elliot Deep.

The sea hare *Bursatella* sp., recorded in 2018, is regarded as a western Australian species ranging from Perth to Albany (Edgar 2008, Nimbs et al. 2017). Large aggregations have been observed in shallow South Australian coastal waters during summer 2017-18 (Janine Baker, marine ecologist, comment on iNaturalist website, September 2018).

Invertebrate communities were generally consistent between the 2017 and 2018 surveys at each of the 41 sites, relative to the variation between sites (Figure 8). Although the ordination plot stress is close to the threshold (0.20) for acceptable representation of the data (Clarke 1993), a three-dimensional ordination with stress 0.14 showed a similar same pattern of grouping of surveys form the same site.

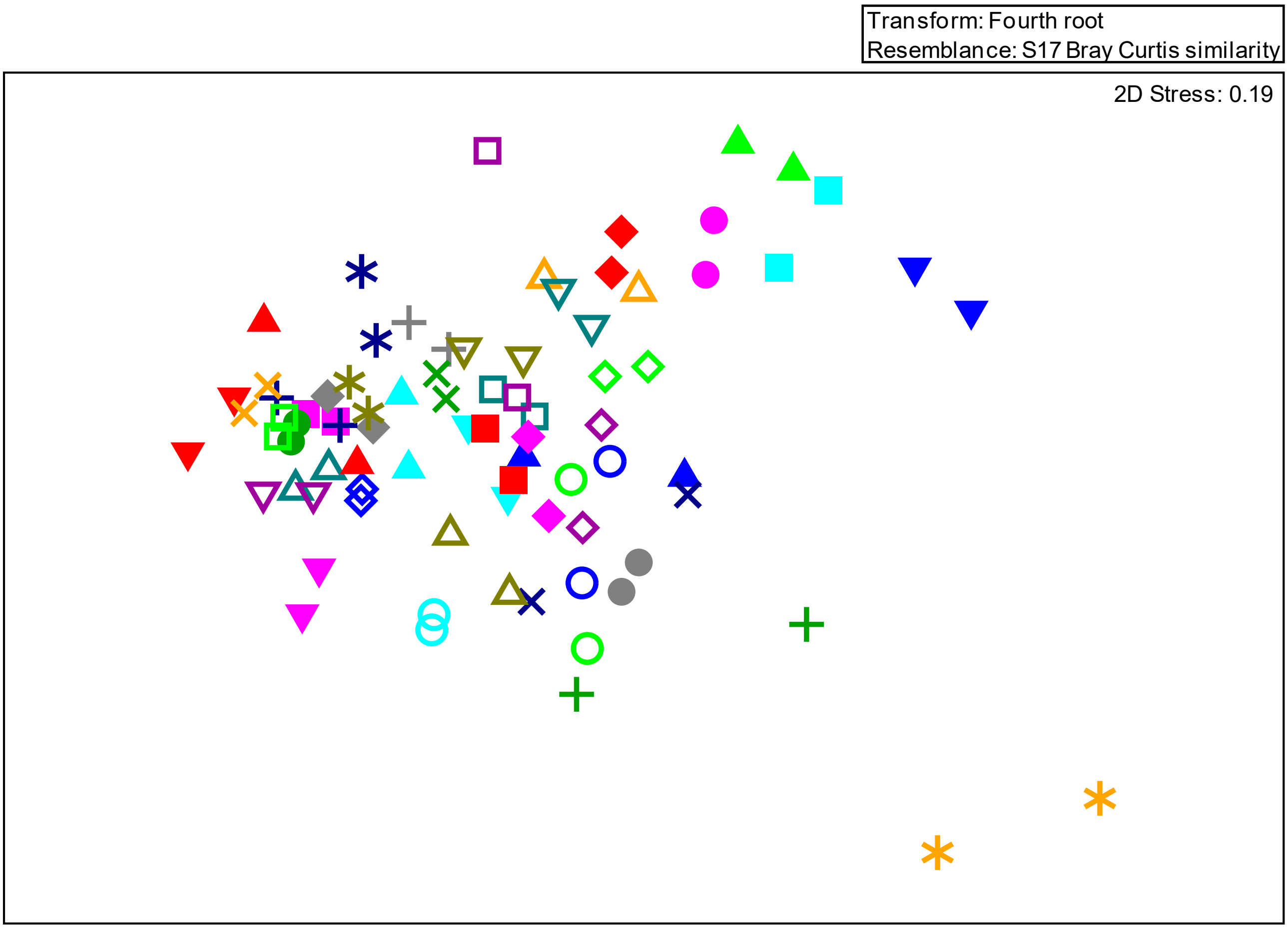


Figure 8. MDS plot of mobile invertebrate communities by site. Symbol/colour combinations distinguish 41 individual sites, each of which was surveyed in 2017 and 2018. The symbol used to represent each site is shown in Appendix A.

3.4.2 Subregional features

Sites within the same subregion generally had similar mobile invertebrate communities (Figure 9). Sites which were outliers from others in their subregion included Cape Jervis South (the right-most of the Backstairs Passage sites) and Yankalilla Mouth (from Yankalilla subregion, towards the bottom right of the MDS scatter plot).

SIMPER analysis showed that the subregions were characterized by the following functional groups (Appendix D):

- Northern: sea cucumbers (Stichopid spp.), abalone *Haliotis* spp. and southern hermit crab (*Paguristes frontalis*)
- Adelaide metro: queen scallop (*Equichlamys bifrons*), southern hermit crab, blue swimmer crab (*Portunus armatus*), sea cucumbers, slate-pencil urchin (*Phyllacanthus irregularis*) and red swimmer crab (*Nectocarcinus tuberculosus*)
- Southern metro: purple urchin (*Heliocidaris erythrogramma*), red whelk (*Pleuroploca australasia*), southern hermit crab, abalone, velvet star (*Petricia vernicina*) and warrener (*Turbo undulatus*)
- Yankalilla Bay: southern hermit crab, red whelk, biscuit stars (*Tosia* spp.), pheasant shells (*Phasianella* spp.) and velvet star
- Backstairs Passage: biscuit stars, abalone, purple urchin, Troughton's seastar (*Pseudonepanthia troughtoni*), velvet star, red bait crab (*Plagusia chabrus*) and red whelk
- South Coast: Troughton's seastar, abalone, feather stars (*Comanthus* spp.), purple urchin, dog whelk (*Dicathais orbita*), red bait crab and Saori's sea star (*Nectria saoria*)
- Encounter Bay: dog whelk, purple urchin, biscuit stars, warrener (*Turbo undulatus*), turbo shell (*T. torquatus*), feather stars and red bait crab.

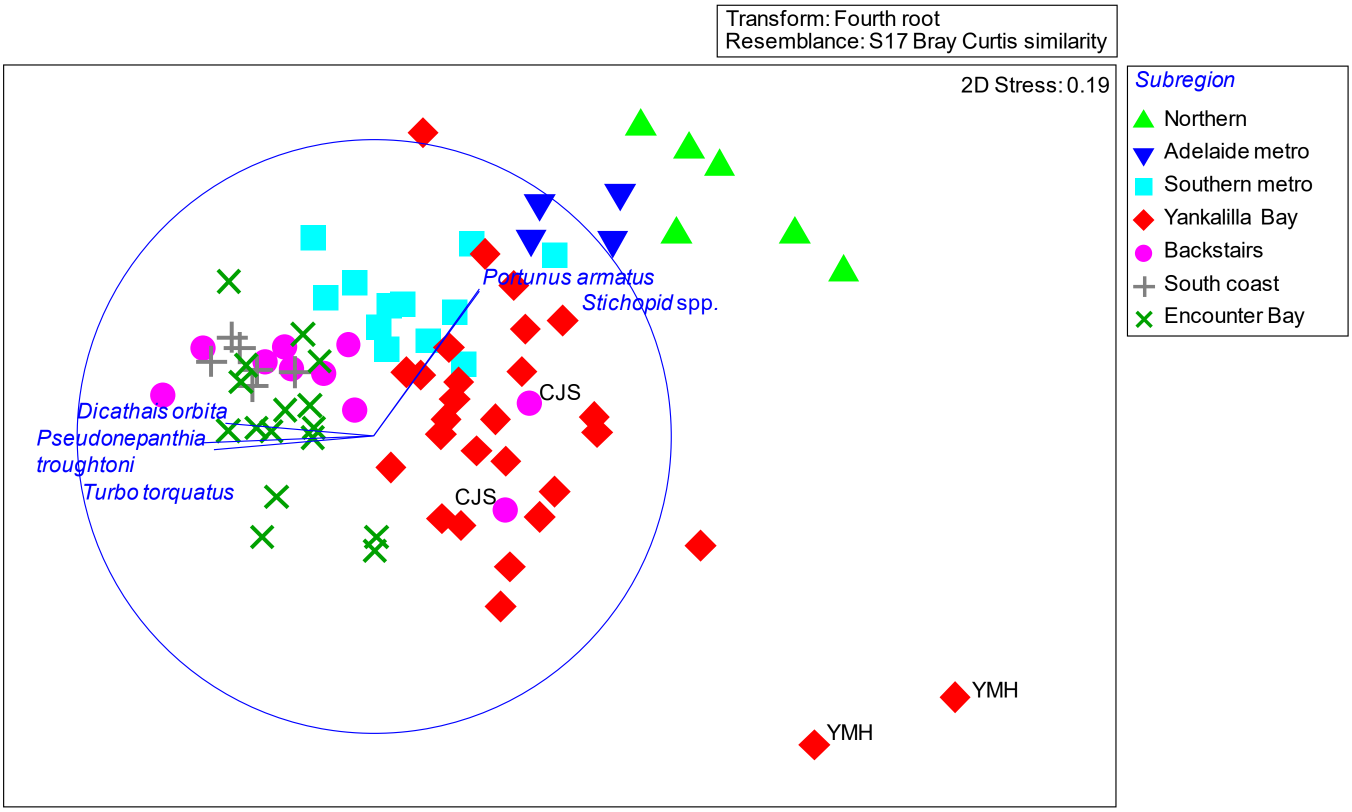


Figure 9. MDS plot of mobile invertebrate communities by AMLR subregion. Outliers from subregions are labelled using abbreviations listed in Appendix A.

4 Fish species of conservation concern

A comprehensive study by Baker (2007) identified a list of 248 fishes of conservation concern (FCCs) in the AMLR region, many of which have habitat associations with reef. Brock et al. (2017) considered 64 of these species which had been recorded during standardised surveys for Marine Park monitoring or the RLS program in the AMLR region. Of these, 20 species were prioritized for monitoring during 2017 and 2018, based on the frequency and abundance of their records, and priority sites were identified for monitoring of these species (Brock et al. 2017).

During the 2017 and 2018 surveys, 19 of the prioritized monitoring FCCs were recorded, the exception being Luderick (*Girella tricuspidata*) which was not observed during any survey (Table 4). In some cases, FCCs were not observed at their priority sites. In addition to the 20 species prioritised by Brock et al. (2017), 21 other FCCs were recorded across 31 of the 41 sites (Table 5).

In addition to the standard surveys, incidental (off-transect) sightings were made of 22 FCCs across 34 sites.

Table 4. Mean number of individuals of each FCC prioritised for monitoring (per 200 m transect, methods 1 and 2, both blocks) across 2017 and 2018 surveys. Pink shaded areas show the priority monitoring sites identified by Brock et al. (2017) for all except the four most common species. New sites established for the 2017 and 2018 survey are marked with an asterisk (*).

Site	*Acanthaluteres brownii*	*Achoerodus gouldii*	*Aplodactylus arctidens*	*Austrolabrus maculatus*	*Dactylophora nigricans*	*Dotalabrus aurantiacus*	*Eubalichthys mosaicus*	*Girella tricuspidata*	*Hypoplectrodes nigroruber*	*Meuschenia freycineti*	*Meuschenia galii*	*Meuschenia hippocrepis*	*Notolabrus parilus*	*Notolabrus tetricus*	*Paraplesiops meleagris*	*Pentaceropsis recurvirostris*	*Pictilabrus laticlavius*	*Trachinops noarlungae*	*Trinorfolkia cristata*	*Vincentia conspersa*
Parham Reef					1.0		1.0													1.0
Port Gawler*				2.5	4.0													16.5		
Semaphore Reef				1.0	0.5								1.0					25.0		
Broken Bottom	9.0			8.5	4.0		0.5											1196		
Seacliff Reef	3.5			45.0	2.5		3.0		1.0	5.5		1.5	3.5	6.0	10.5	0.5		4022		
Horseshoe Inside				8.0	5.5	0.5						4.5	6.0	4.0				57.5	1.0	
Noarlunga North Outside	22.0			26.5	9.5	0.5			0.5	2.0	1.5	30.0	6.5	2.5			0.5	1308		
Noarlunga South Outside				3.0	3.0					6.5	1.0	34.0	8.0		1.5			192.0		
Southport				4.5	1.5	0.5							4.0	0.5				30.0	0.5	
Moana Outside	16.0			8.5	2.5	1.5			2.5	0.5		8.0	2.0	4.5	0.5			1306	0.5	
Aldinga Pinnacles	8.0			31.0	3.0	1.0			3.5		0.5	23.0	6.5	16.0	1.5	0.5	0.5	4282		
Myponga Reef				39.0	1.0	1.0			0.5				8.0	0.5	0.5	1.5	9.5	1016	0.5	
Carrickalinga North 3				63.0	1.0	2.5			1.0		1.0	0.5	3.0	1.5	0.5	0.5	15.0	1397	0.5	1.0
Ripple Rock	22.5			7.5	4.5	1.0	1.0			1.0	0.5	48.5	16.5	17.5	0.5		10.0	310.5	0.5	0.5
Carrickalinga Head				20.5	0.5						0.5	3.0	14.0	9.0	0.5		2.5	146.5	4.5	
Shag Rock				37.5	6.0				0.5		0.5	4.5	28.5	8.5			17.0	163.0		
Dodd's Beach				20.5		3.5						2.5	8.5	7.5	0.5		20.5	726.5		
Carrickalinga South Bay	2.0			6.0	2.0	4.0						18.5	5.0	10.0	0.5		8.5	3735		
Normanville Beach					2.5								1.5							0.5

Site	*Acanthaluteres brownii*	*Achoerodus gouldii*	*Aplodactylus arctidens*	*Austrolabrus maculatus*	*Dactylophora nigricans*	*Dotalabrus aurantiacus*	*Eubalichthys mosaicus*	*Girella tricuspidata*	*Hypoplectrodes nigroruber*	*Meuschenia freycineti*	*Meuschenia galii*	*Meuschenia hippocrepis*	*Notolabrus parilus*	*Notolabrus tetricus*	*Paraplesiops meleagris*	*Pentaceropsis recurvirostris*	*Pictilabrus laticlavius*	*Trachinops noarlungae*	*Trinorfolkia cristata*	*Vincentia conspersa*
South Shores*					5.0							2.0	7.0	6.0						
Yankalilla Mouth*																				
Lady Bay*					1.0							4.5	5.5	13.0			0.5	22.5		
Rapid Bay Jetty	38.5			70.5	3.5		33.5		4.0	4.5	0.5	16.5	16.5	13.5	0.5		19.0	1373		
Rapid Head East	21.5			7.5	2.0	8.0				5.5		3.0	2.5	22.5	1.0		11.5	268.0	1.5	
Rapid Head Windmill	6.5	0.5		15.0	1.5	2.5						1.0	9.0	29.5	6.0		23.0	165.0	1.5	
Cape Jervis South				2.5	3.5	1.5							7.0	28.0			31.0		1.0	
Fishery Beach	3.0				1.0				0.5	0.5		9.5	1.0	29.5			11.5			
Porpoise Head		2.0	0.5		1.0						1.0	72.0	1.0	62.5			1.0			
Deep Creek*			1.0		2.0				0.5	0.5	0.5	16.0	0.5	54.0	0.5		6.5			
Backstairs Deep*			1.0		3.5				0.5	0.5	0.5	3.5		19.5			6.5			
Newland Head			0.5		1.5							10.0	5.0	69.5			6.0			
Flat Irons		0.5			1.0							4.5	1.5	29.0			4.0			
West Island Outer		3.0	1.5									4.5	1.0	25.0		1.0	1.5			
The Bluff		0.5		1.0	1.0	1.0						3.0	2.5	1.0			0.5			10.5
Whalebone		5.5			15.5							19.5	8.5	96.0			2.0			
Encounter Deep*		1.0			0.5								1.5	3.0			1.5			
Outside Granite Island			0.5									7.5	0.5	14.0			1.0			
Olivers Reef				0.5	2.0							3.0	8.5	10.0			2.5			
Chiton Rocks*				1.0	0.5	0.5							10.5	12.5			2.5			
Port Elliot Deep*														2.5		0.5				
Basham's Beach*					0.5									1.0						

Table 5. Mean number of individuals of other (not monitoring priority) species (per 200 m transect, methods 1 and 2, both blocks) across 2017 and 2018 surveys. New sites established for the 2017 and 2018 survey are marked with an asterisk (*).

Site	*Aetapcus maculatus*	*Anoplocapros amygdaloides*	*Aploactisoma milesii*	*Cheilodactylus spectabilis*	*Chrysophrys auratus*	*Cnidoglanis macrocephalus*	*Diodon nichthemerus*	*Genypterus tigerinus*	*Glyptauchen panduratus*	*Heteroclinus johnstoni*	*Heteroclinus roseus*	*Heteroclinus tristis*	*Meuschenia venusta*	*Myliobatis tenuicaudatis*	*Nemadactylus valenciennesi*	*Orectolobus halei*	*Othos dentex*	*Phycodurus eques*	*Platycephalus speculator*	*Scorpis georgiana*	*Threpterius maculosus*	*Torquigener pleurogramma*
Parham Reef			0.5																			3.5
Port Gawler*					1.5																	
Semaphore Reef																						
Broken Bottom	0.5								0.5													
Seacliff Reef																0.5						
Horseshoe Inside									0.5							0.5				1		
Noarlunga North Outside							0.5		0.5													
Noarlunga South Outside						0.5													1	5		
Southport																				0.5		
Moana Outside									1			1.5								1.5	0.5	
Aldinga Pinnacles																					0.5	
Myponga Reef																						
Carrickalinga North 3																						
Ripple Rock				0.5																		
Carrickalinga Head									1	0.5												
Shag Rock									0.5											0.5		
Dodd's Beach											1											
Carrickalinga South Bay	1					0.5																
Normanville Beach																						
South Shores*																				2.5		
Yankalilla Mouth*																			0.5			

Site	*Aetapcus maculatus*	*Anoplocapros amygdaloides*	*Aploactisoma milesii*	*Cheilodactylus spectabilis*	*Chrysophrys auratus*	*Cnidoglanis macrocephalus*	*Diodon nicthemerus*	*Genypterus tigerinus*	*Glyptauchen panduratus*	*Heteroclinus johnstoni*	*Heteroclinus roseus*	*Heteroclinus tristis*	*Meuschenia venusta*	*Myliobatis tenuicaudatis*	*Nemadactylus valenciennesi*	*Orectolobus halei*	*Othos dentex*	*Phycodurus eques*	*Platycephalus speculator*	*Scorpis georgiana*	*Threpterius maculosus*	*Torquigener pleurogramma*
Lady Bay*	0.5													0.5						0.5		
Rapid Bay Jetty		0.5																0.5				
Rapid Head East									1				0.5					1.5				
Rapid Head Windmill									0.5													
Cape Jervis South						0.5												0.5				
Fishery Beach																						
Porpoise Head										0.5					1							
Deep Creek*																	0.5					
Backstairs Deep*																						
Newland Head				1																		
Flat Irons																						
West Island Outer				0.5													1					
The Bluff										0.5		0.5						1		2.5		
Whalebone																						
Encounter Deep*																				0.5		
Outside Granite Island																						
Olivers Reef																						
Chiton Rocks*																						
Port Elliot Deep*																						
Basham's Beach*								0.5														

5 Baseline status of reef monitoring sites

The various indicators discussed in Section 2.2 are presented as column charts for subregions and individual sites. The indicator values and standard errors are also tabulated in Appendix E.

5.1 Macroalgae and sessile invertebrates

5.1.1 Richness of functional groups

The mean richness of functional groups was generally consistent across subregions and years, ranging from approximately five in the Northern subregion to more than seven in one year of each of the Southern Metro and Backstairs Passage subregions (Figure 10). The highest mean richness (more than 10) was at Chiton Rocks (Encounter Bay subregion), and the lowest (less than four) at Moana Outside (Southern Metro subregion) and Rapid Head East (Yankalilla subregion) (Figure 11), both of which have dense canopies (see Section 5.1.3).

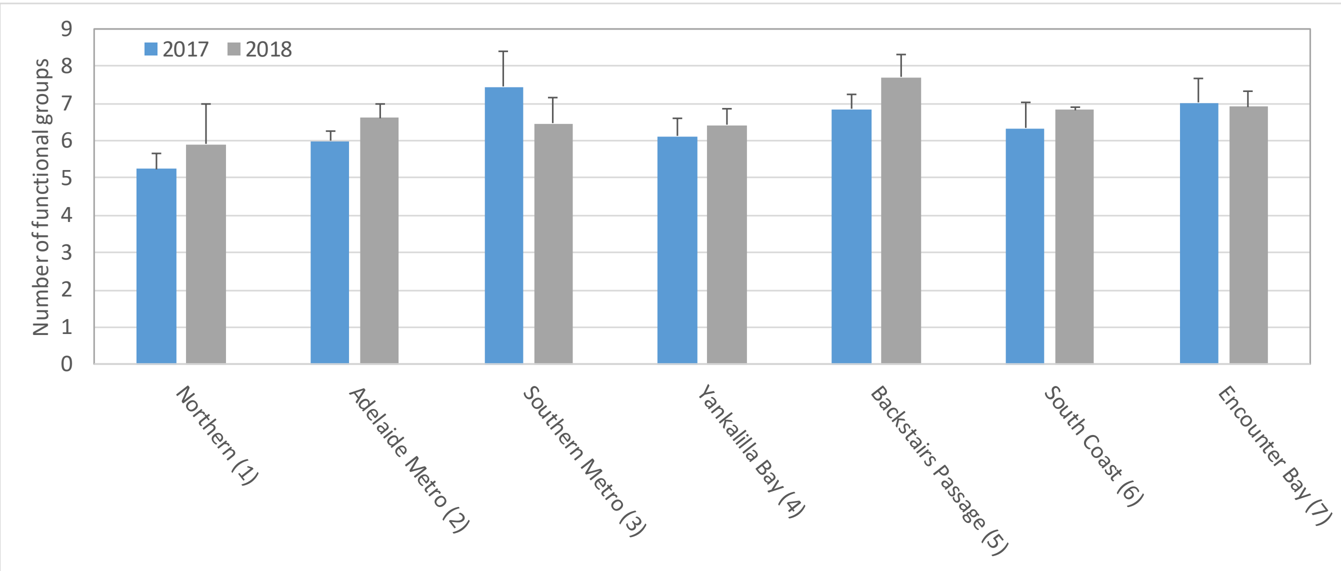


Figure 10. Richness of macroalgal functional groups by subregion and year

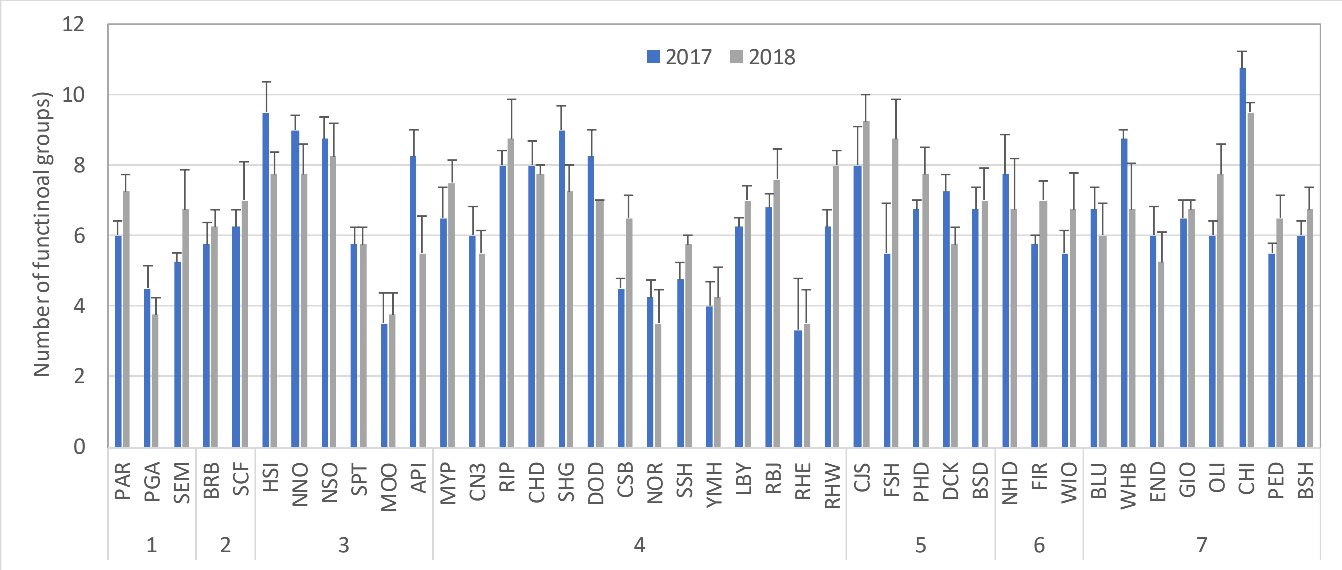


Figure 11. Richness of macroalgal functional groups by site and year. Site names corresponding to abbreviation are provided in Appendix A.

5.1.2 Macroalgal community structure

The baseline for the macroalgal community structure is illustrated by the MDS ordination plot provided in Figure 4.

A two-way PERMANOVA showed that there were significant differences in macroalgal communities between subregions for all pairs except Northern and Adelaide Metro, and South Coast and Encounter Bay, but no significant difference between years or interaction between subregion and year (Appendix D).

5.1.3 Cover of canopy-forming macroalgae

Cover of canopy forming macroalgae was consistent between years but showed a subregional pattern of increase from less than 5% in the Northern subregion to about 70–80% in the three southernmost regions Figure 12. Sites that diverged from the overall subregional pattern include Moana Outside and Aldinga Pinnacles (the southernmost two sites of the Southern Metro subregion), Myponga Reef and Rapid Bay Jetty (Yankalilla subregion) and Chiton Rocks (Encounter subregion) (Figure 13).

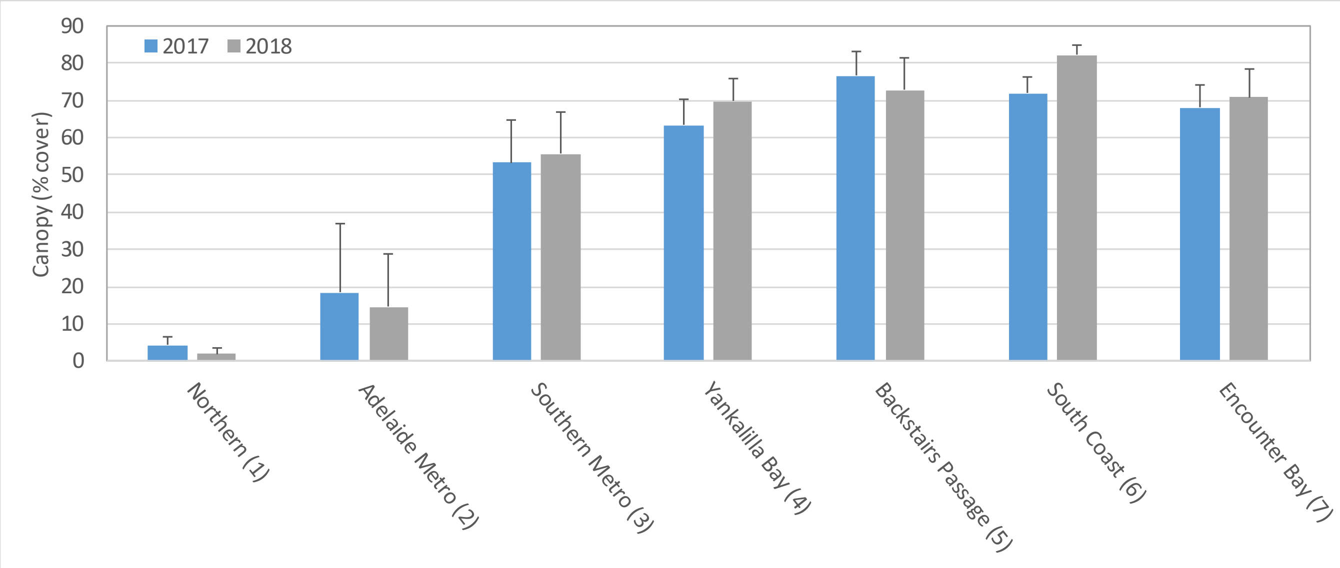


Figure 12. Percentage cover of canopy-forming macroalgae by subregion and year

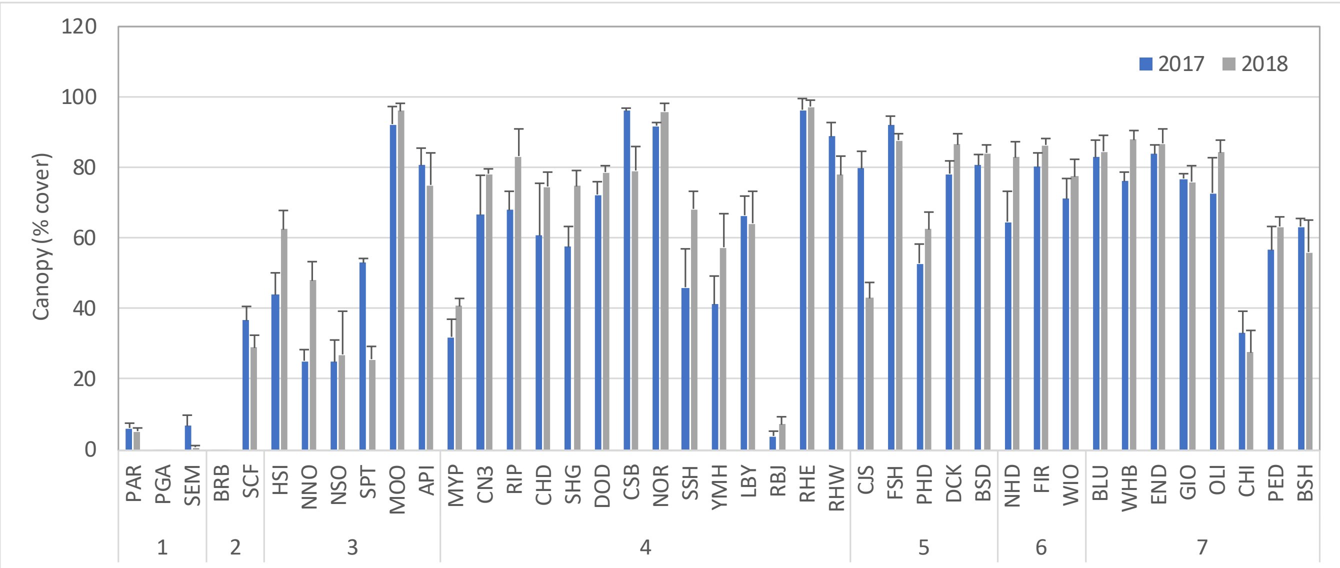


Figure 13. Percentage cover of canopy-forming macroalgae by site and year. Site names corresponding to abbreviation are provided in Appendix A.

5.2 Fish

5.2.1 Species richness

Mean fish species richness was generally consistent between years, and ranged across subregions from about 5 in the Northern subregion (in 2018) to about 17 in the Adelaide Metro subregion (in 2017). Apart from the low richness in the Northern subregion, there was a pattern of decreasing richness with distance along the coastline (Figure 14). Richness was highly variable within the Adelaide Metro, Southern Metro, Yankalilla and Encounter Bay subregions. Within the Southern Metro subregion, richness was highest at sites with long-term protection from fishing, including Noarlunga North Outside, Noarlunga South Outside and Aldinga Pinnacles, but also at Moana Outside. Within the Yankalilla subregion, fish richness was highest at Rapid Bay Jetty and Rapid Bay East, and lowest at Yankalilla Mouth and Normanville Beach. Within the Encounter Bay subregion, fish richness was highest at Whalebone Reef and The Bluff, and lowest at Port Elliot Deep and Basham's Beach (Figure 15).

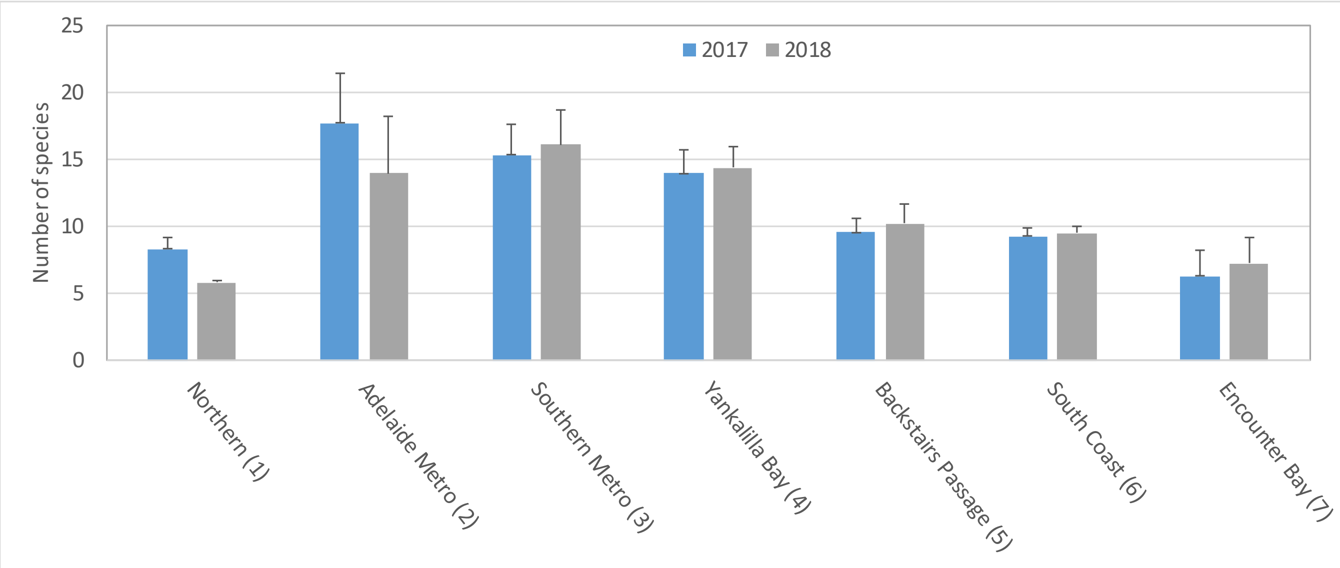


Figure 14. Richness of fish species by subregion and year

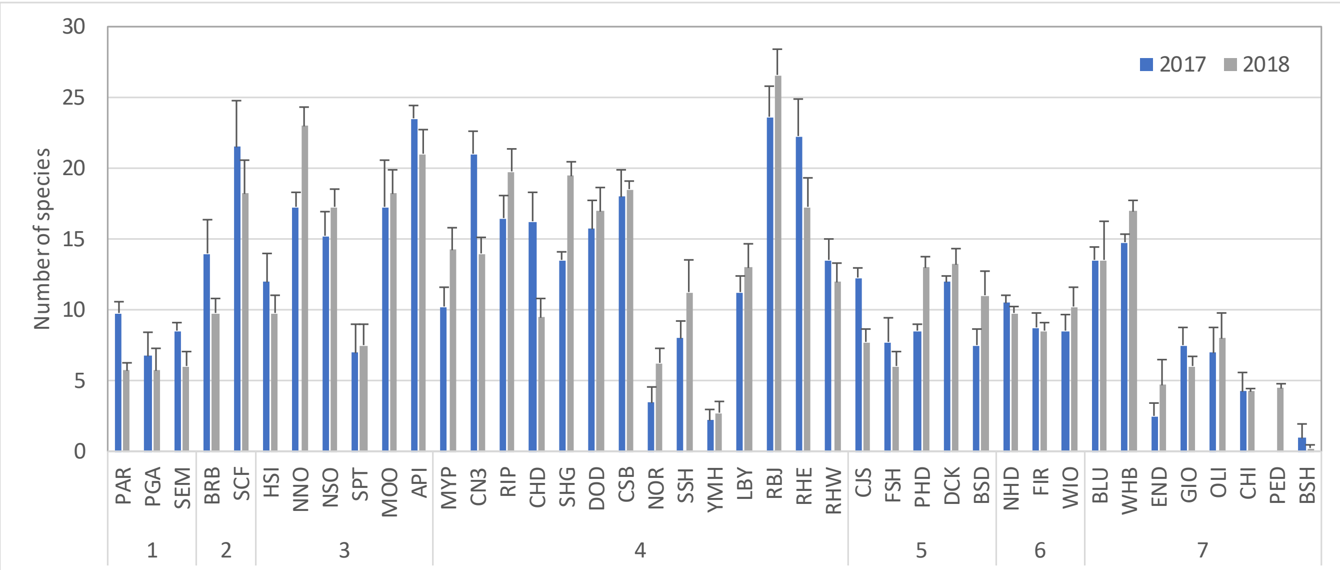


Figure 15. Richness of fish species by site and year. Note that fish surveys (method 1) were not undertaken at Port Elliot Deep (PED) in 2017. Site names corresponding to abbreviation are provided in Appendix A.

5.2.2 Biomass of large fish

The mean biomass of large fish was variable across the subregions, ranging from less than 1 kg per transect in the Northern subregion to 8 kg per transect during 2018 for the Southern Metro region (Figure 16). The high values for this latter region were driven by sites with long-term protection, namely Noarlunga North Outside, Noarlunga South Outside and Aldinga Pinnacles (Figure 17). Protected sites also had the highest biomass of large fish in the Yankalilla subregion, including Shag Rock, which had the highest biomass across all subregions. Other sites with high biomass of large fish were Rapid Bay Jetty (where spearfishing is prohibited) and Carrickalinga South Bay, both from Yankalilla subregion. Biomass estimates for Porpoise Head and Deep Creek (Backstairs subregion), and

Whalebone Reef (Encounter subregion) (Figure 17), were influenced by large dusky morwong (*Dactylophora nigricans*) or schools of silver drummer (*Kyphosus sydneyanus*).

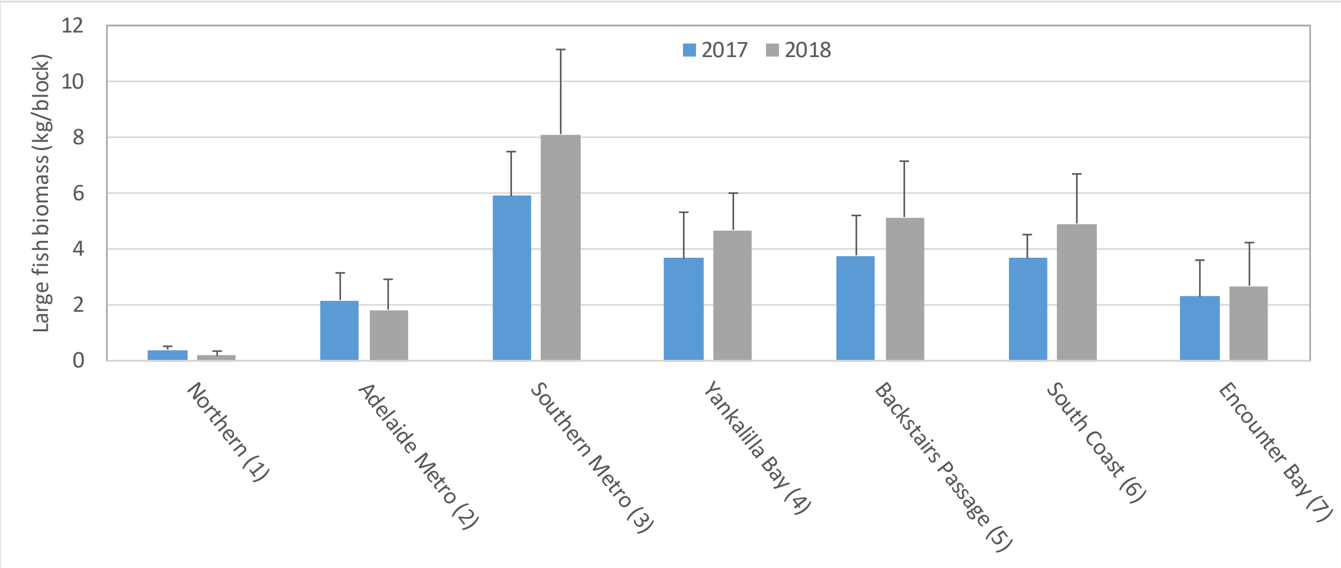


Figure 16. Biomass of large (>20 cm) fish by subregion and year

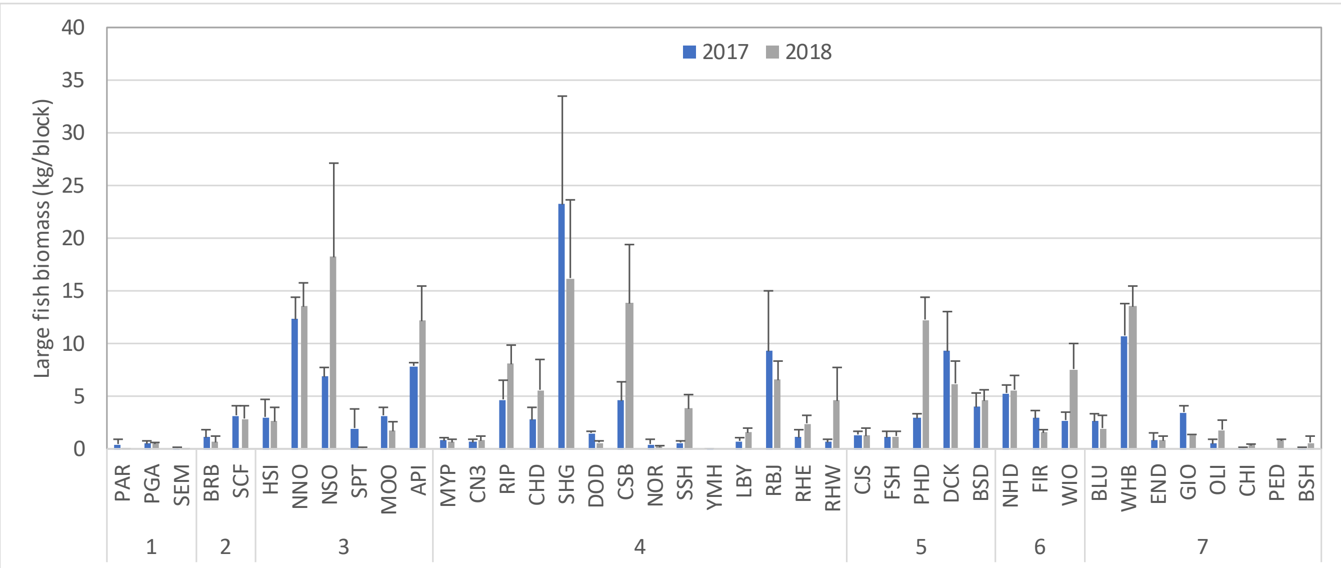


Figure 17. Biomass of large (>20 cm) fish by site and year. Site names corresponding to abbreviation are provided in Appendix A.

5.2.3 Biomass of targeted fish

Subregional patterns for the mean biomass of targeted fish were similar to the large fish indicator, ranging from less than 1 kg per transect in the Northern subregion to 5 kg per transect during 2018 for the Southern Metro region (Figure 18), driven by high values at Noarlunga North Outside, Noarlunga South Outside and Aldinga Pinnacles. Protected sites had relatively high biomass of targeted fish in the Yankalilla subregion. The highest biomass of targeted fish in this subregion was at Rapid Bay Jetty, influenced by large schools of yellowtail scad (*Trachurus novaehollandiae*) and Australian herring (*Arripis georgeanus*). Other sites with relatively high biomass of targeted fish were Porpoise Head (Backstairs Passage subregion), influenced strongly by horseshoe leatherjacket

(*Meuschenia hippocrepis*), bluethroat wrasse (*Notolabrus tetricus*) and sea sweep (*Scorpis aequipinnis*), and Whalebone Reef (Encounter subregion), influenced by bluethroat wrasse and dusky morwong (*Dactylophora nigricans*) (Figure 19).

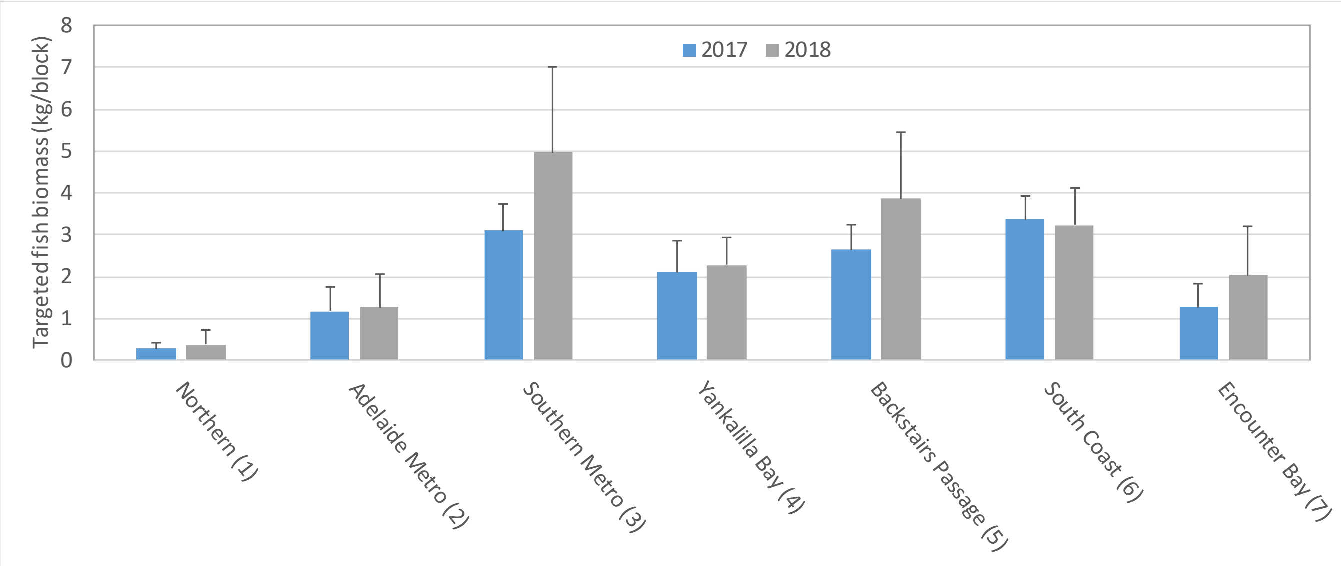


Figure 18. Biomass of targeted fish by subregion and year

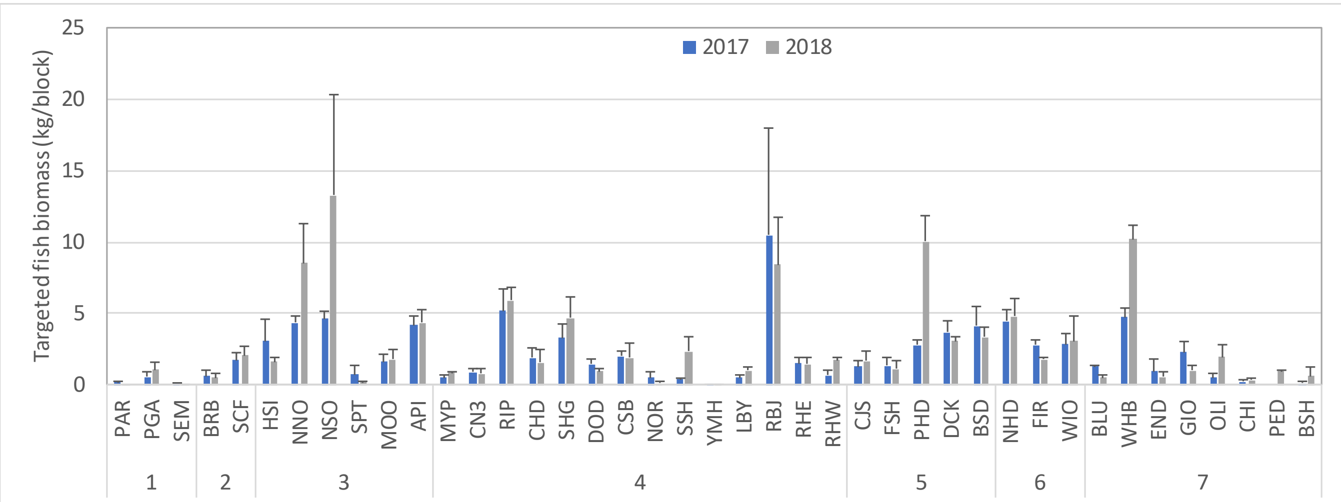


Figure 19. Biomass of targeted fish by site and year. Site names corresponding to abbreviation are provided in Appendix A.

5.2.4 Fish community structure

The baseline for the fish community structure indicator is illustrated by the MDS ordination plot provided in Figure 6.

A two-way PERMANOVA showed that there were significant differences in fish communities between subregions for all pairs except Backstairs Passage and South Coast and South Coast and Encounter Bay, but no significant difference between years or interaction between subregion and year (Appendix D).

5.2.5 Community temperature index

The community temperature index ranged from about 17.5°C in the South Coast and Backstairs Passage subregions to about 18.5°C in the Adelaide Metro subregion (Figure 20). With the exception of the Northern subregion (~17.8-18.3 °C), the pattern across the subregions appears to be strongly correlated with sea surface temperatures (one of the parameters used to define the subregions) as there is a temperature gradient from north to south. The lower values associated with the Northern subregion (particularly in the context of an inferred correlation with sea surface temperature) were influenced by the presence of little weed whiting (*Neoodax balteatus*) and cowfish (*Aracana aurita* and *A. ornata*), all of which have relatively low thermal range midpoints (University of Tasmania, unpublished data). The low value for Port Gawler in 2017 (Figure 21) was also influenced by the presence of magpie perch (*Cheilodactylus nigripes*).The low value for Basham's Beach in 2017 was influenced by magpie perch and rock ling (*Genypterus tigerinus*). The high values at Normanville Beach, particularly in 2018, were influenced by large schools of baitfish, the long head flathead (*Leviprora inops*) and the brown-spotted wrasse (*Notolabrus parilus*).

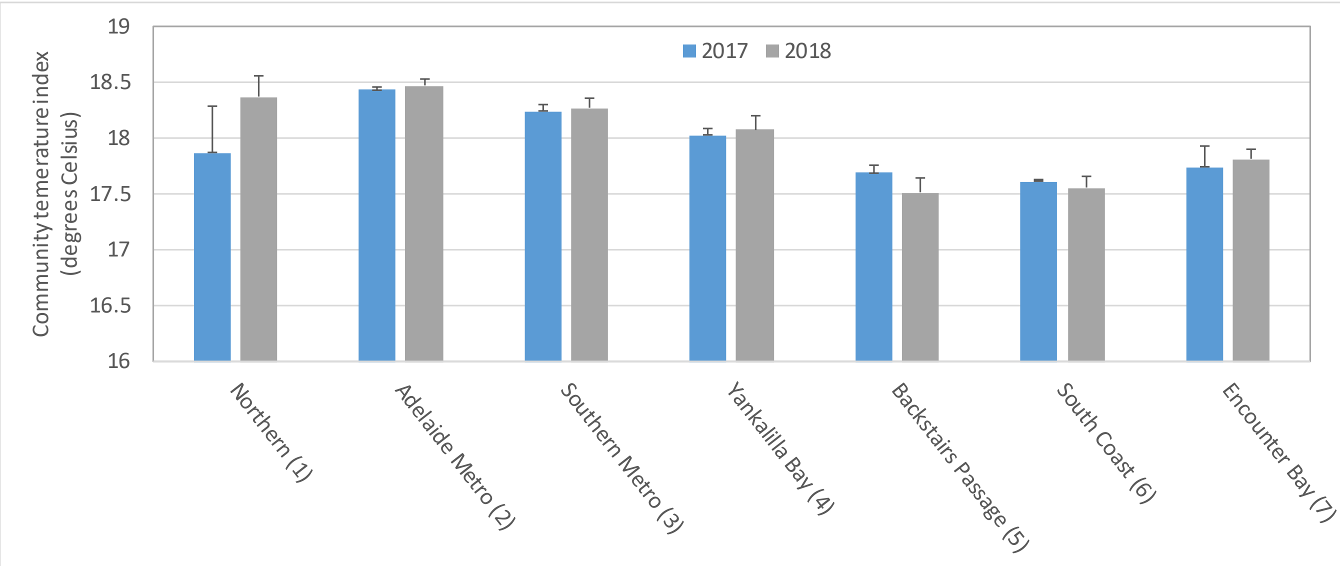


Figure 20. Community temperature index for fish by subregion and year

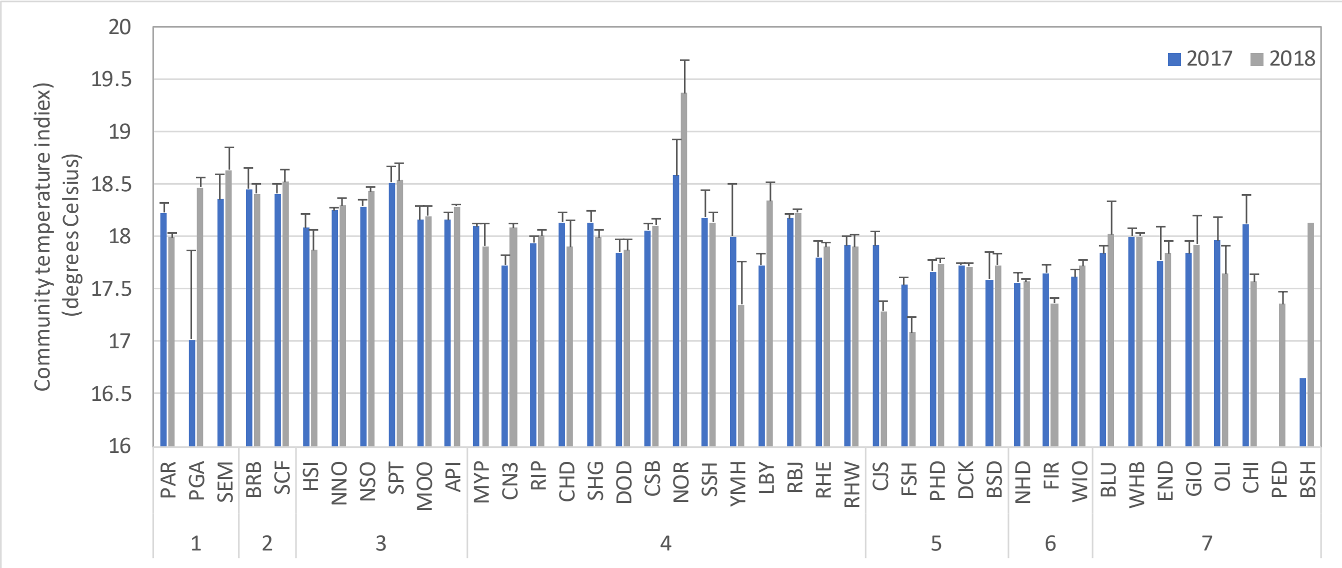


Figure 21. Community temperature index for fish by site and year. Site names corresponding to abbreviation are provided in Appendix A.

5.2.6 Focal fish species

The mean abundance of western blue groper (*Achoerodus gouldii*) ranged from zero in the Northern, Adelaide Metro and Southern Metro subregions to 0.2 per block during 2018 in the South Coast subregion (Figure 22). The Rapid Head Windmills and Porpoise Head sites were the only sites with blue groper in the Yankalilla Bay and Backstairs Passage subregions, respectively. Groper were recorded only at Flat Irons and West Island Outer within the South Coast subregion, and at the Bluff, Encounter Deep and Whalebone Reef within the Encounter subregion, with the latter site have the highest overall abundance in both years (Figure 23).

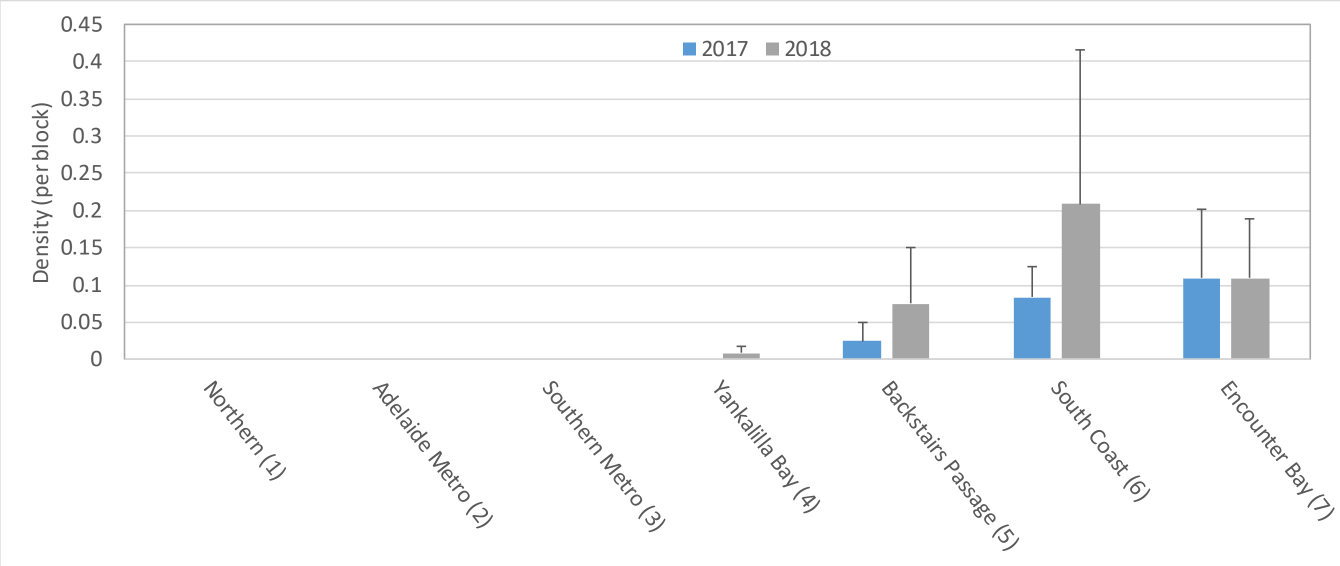


Figure 22. Mean abundance of blue groper (per block) by subregion and year. Error bars show standard error of mean abundance across individual sites.

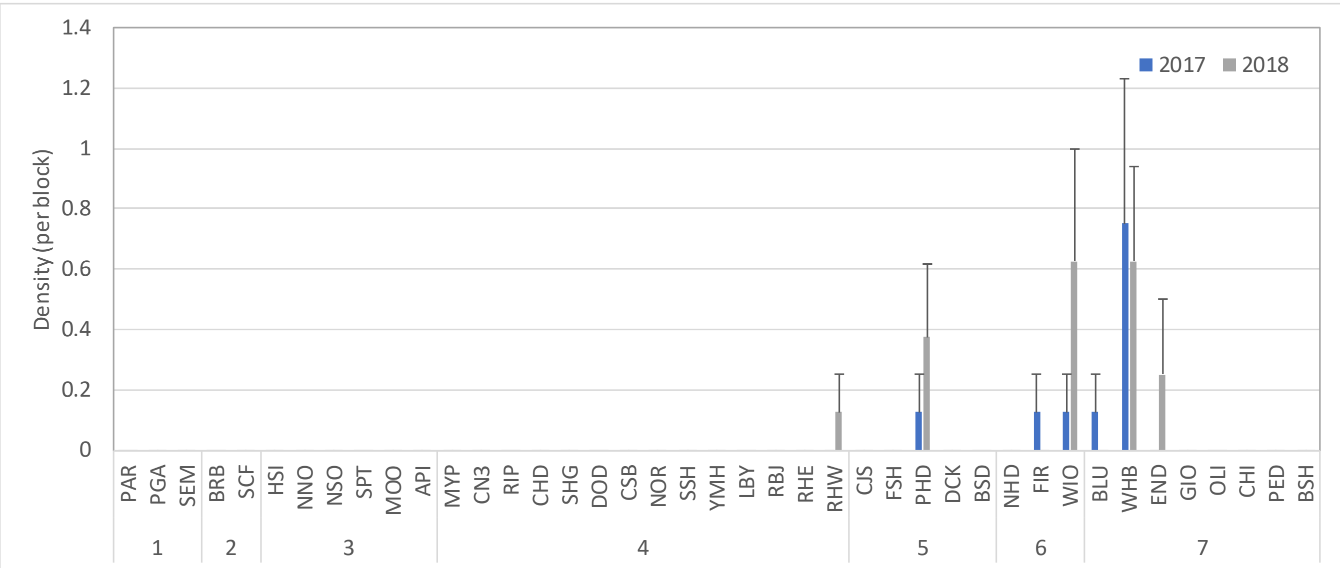


Figure 23. Mean abundance of blue groper (per block) by site and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

The mean abundance of southern blue devil (*Paraplesiops meleagris*) ranged from zero in the Northern, South Coast or Encounter subregions to 0.75 per block during 2018 in the Adelaide Metro subregion (Figure 24), all at Seacliff Reef (Figure 25). The Rapid Head Windmills site had the second highest abundance of blue devils across all regions, and was the largest contributor to the abundance of blue devils in the Yankalilla Bay subregion, where it was recorded at nine sites (Figure 25).

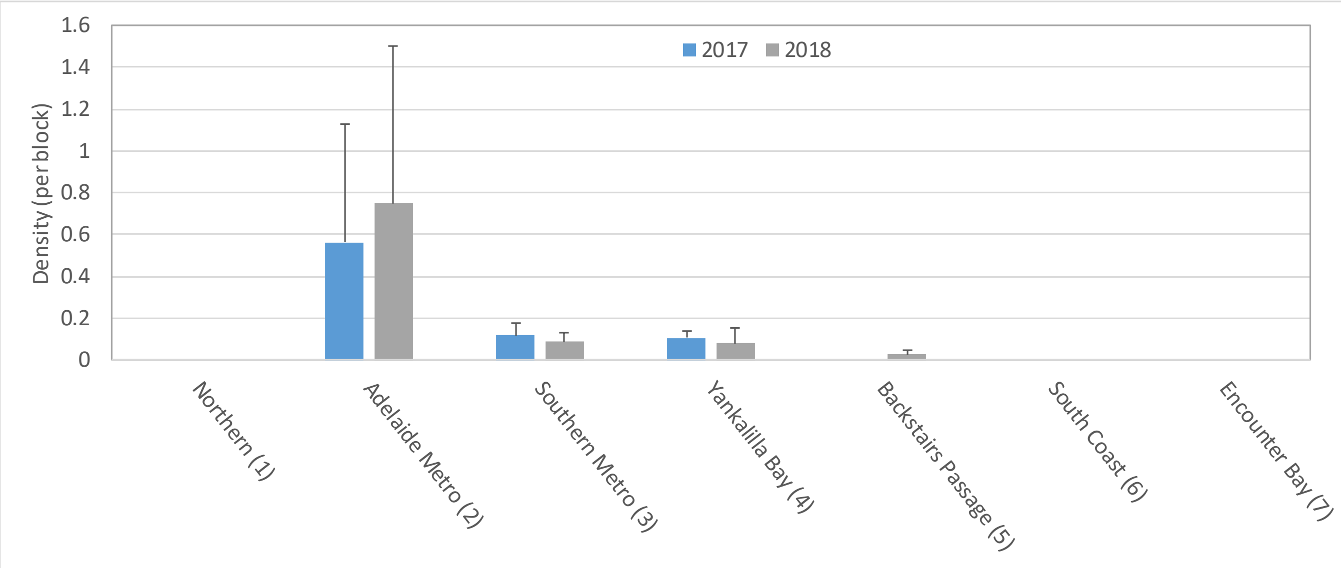


Figure 24. Mean abundance of southern blue devil (per 50 m block) by subregion and year. Error bars show standard error of mean abundance across individual sites.

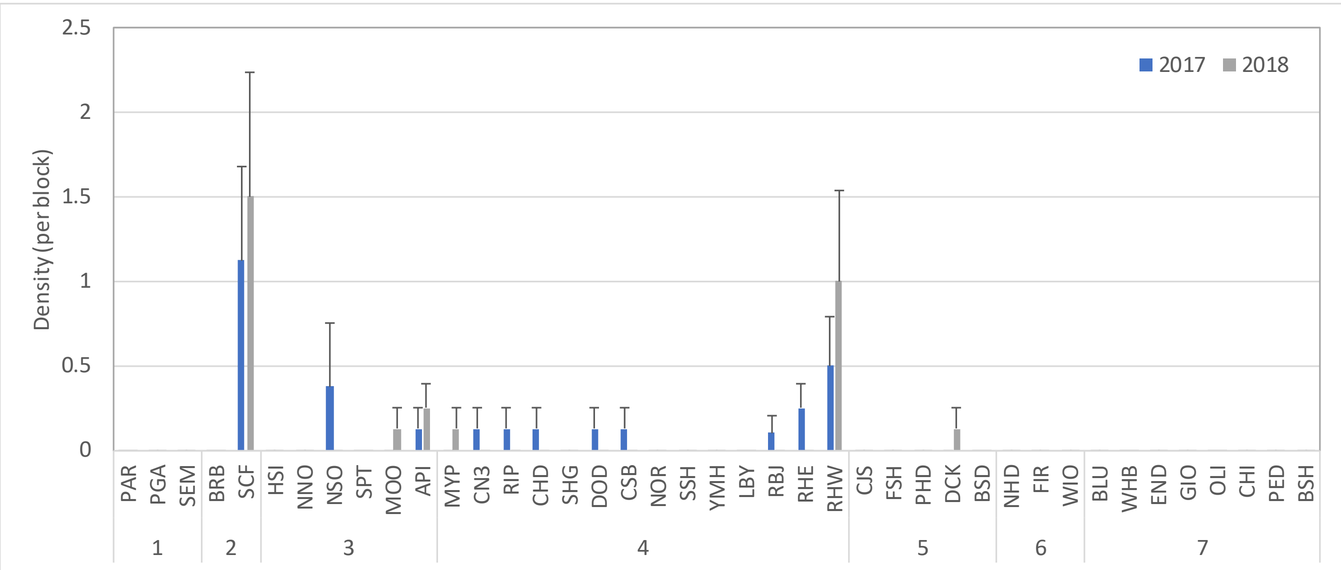


Figure 25. Mean abundance of southern blue devil (per 50 m block) by site and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

The mean abundance of bluethroat wrasse (*Notolabrus tetricus*) ranged from zero in the Northern subregion to about 6 per block during 2017 in the South Coast subregion (Figure 26). The highest abundance of bluethroat wrasse across all regions was at Whalebone Reef (Encounter Bay subregion) with about 17 per block, and abundances were relatively high (about 7–10 per block) at Porpoise Head and Deep Creek (Backstairs Passage subregion) and Newland Head (South Coast subregion) (Figure 27).

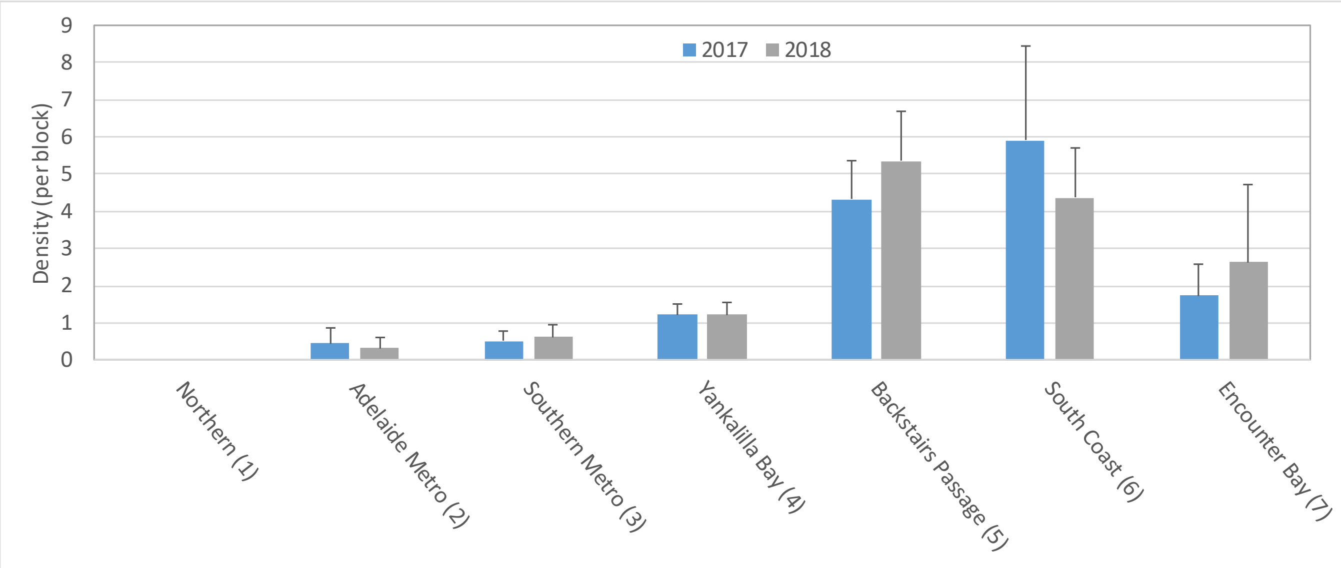


Figure 26. Mean abundance of bluethroat wrasse (per block) by subregion and year. Error bars show standard error of mean abundance across individual sites.

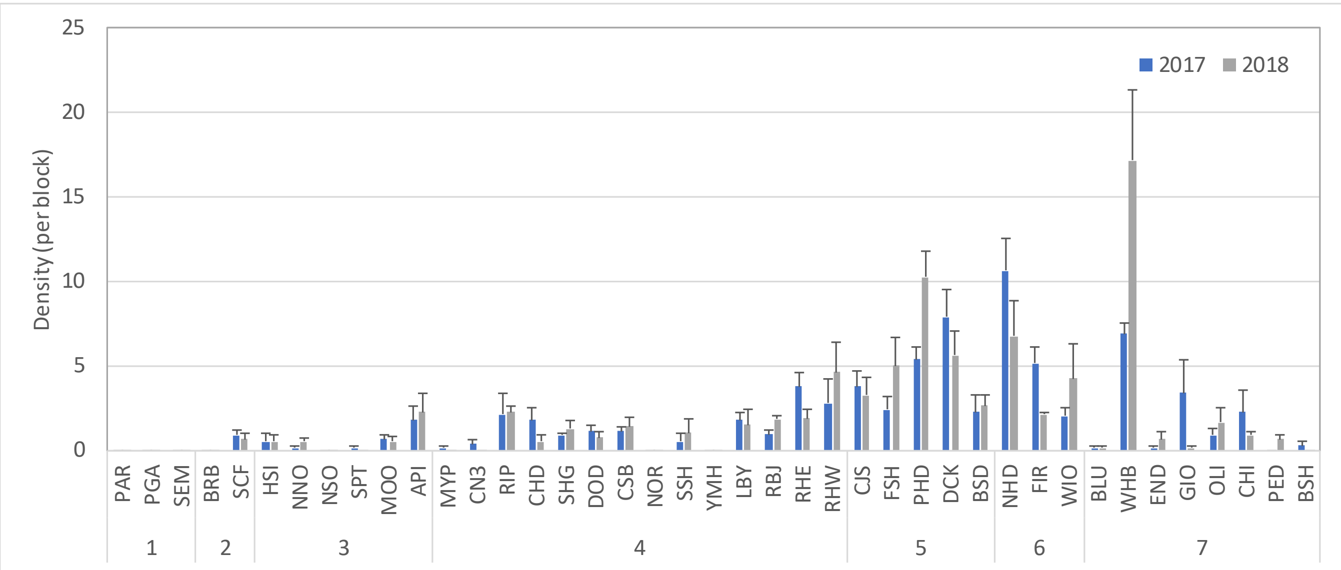


Figure 27. Mean abundance of bluethroat wrasse (per block) by site and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

The mean abundance of sea sweep (*Scorpis aequipinnis*) ranged from zero in the Northern and Adelaide Metro subregions to about 16 per block in the South Coast subregion in 2017 (Figure 28). The highest abundance of sea sweep across all regions was at Noarlunga South Outside (Southern Metro subregion) with about 31 per block, and abundances in this and the Yankalilla Bay subregion were generally highest within protected areas, but also at Horseshoe Inside. Abundances within the South Coast subregion were highest (20–25 per block) at Newland Head but were relatively high at all sites in this subregion and at sites westward to Porpoise Head (Backstairs Passage subregion) and eastwards to Granite Island Outside (Encounter Bay subregion) (Figure 29).

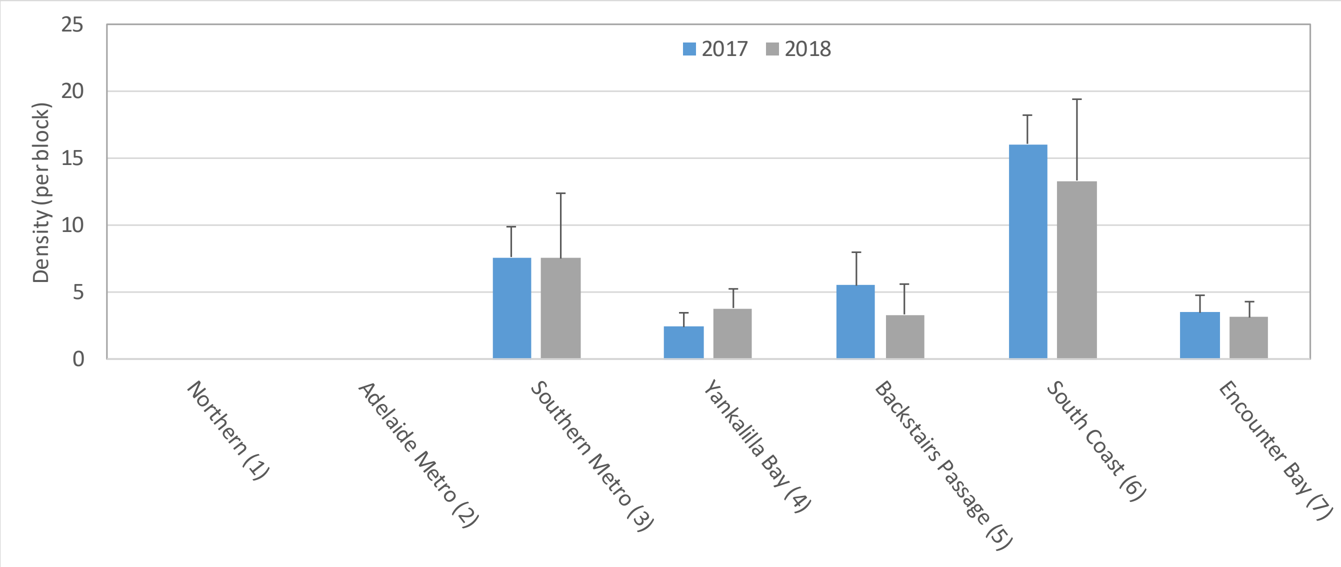


Figure 28. Mean abundance of sea sweep (per block) by site and year. Error bars show standard error of mean abundance across individual sites.

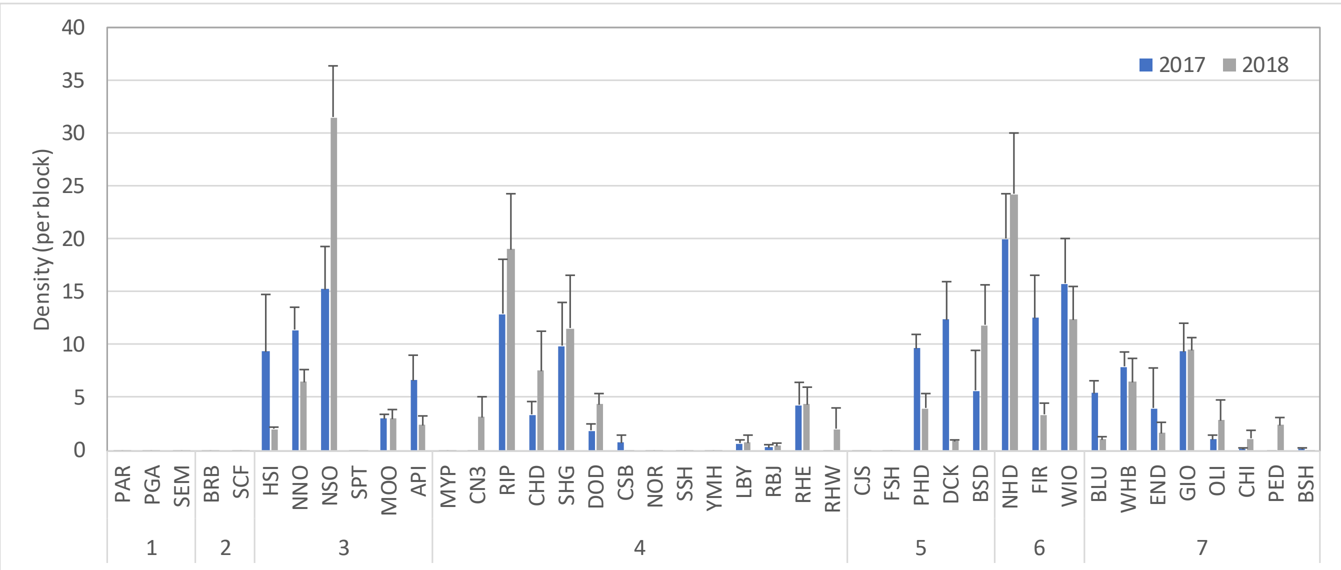


Figure 29. Mean abundance of sea sweep (per 50 m block) by subregion and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

5.3 Invertebrates

5.3.1 Species richness

Mean invertebrate species richness was generally consistent between years, and ranged across subregions from about 7 per 50 m^2 block in the Northern and Yankalilla Bay subregions to about 14 in the Adelaide Metro subregion and Backstairs Passage subregion (in 2017) (Figure 30). Richness was variable within the Yankalilla Bay subregion, ranging from less than one species at Yankalilla Mouth to 15 at Rapid Bay Jetty. The richest mobile invertebrate communities within the Southern Metro, Backstairs Passage, South Coast and Encounter Bay subregions were, respectively, Horseshoe Inside (18), Backstairs Deep (19), Flat Irons (18) and Olivers Reef (18) (Figure 31).

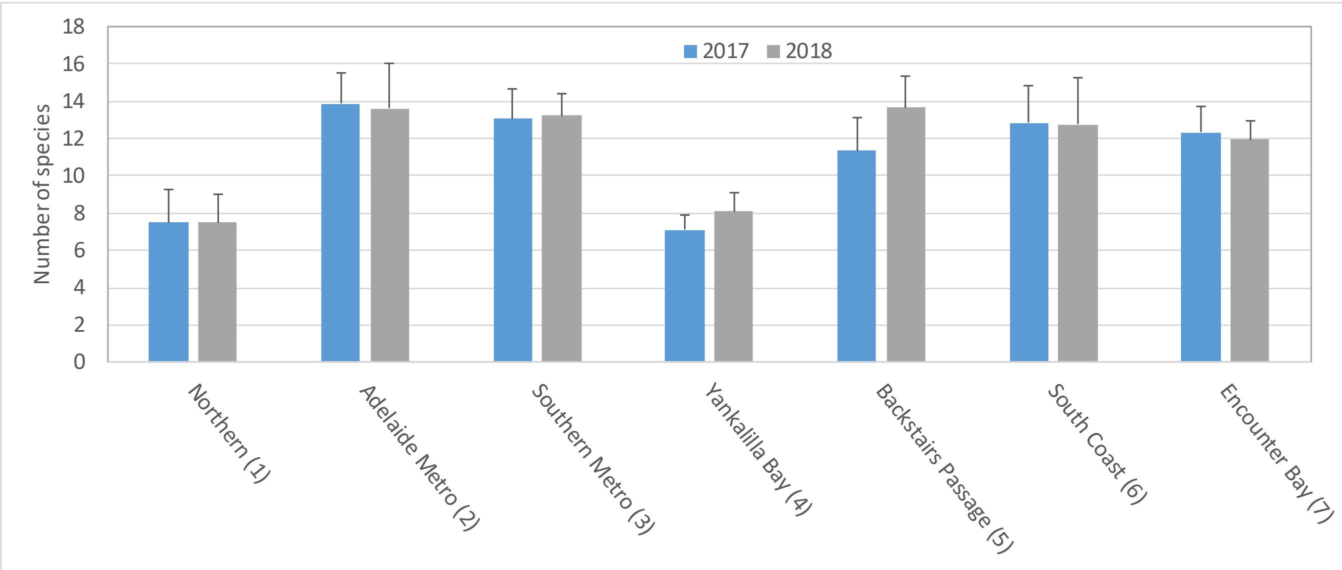


Figure 30. Richness of mobile invertebrates by subregion and year

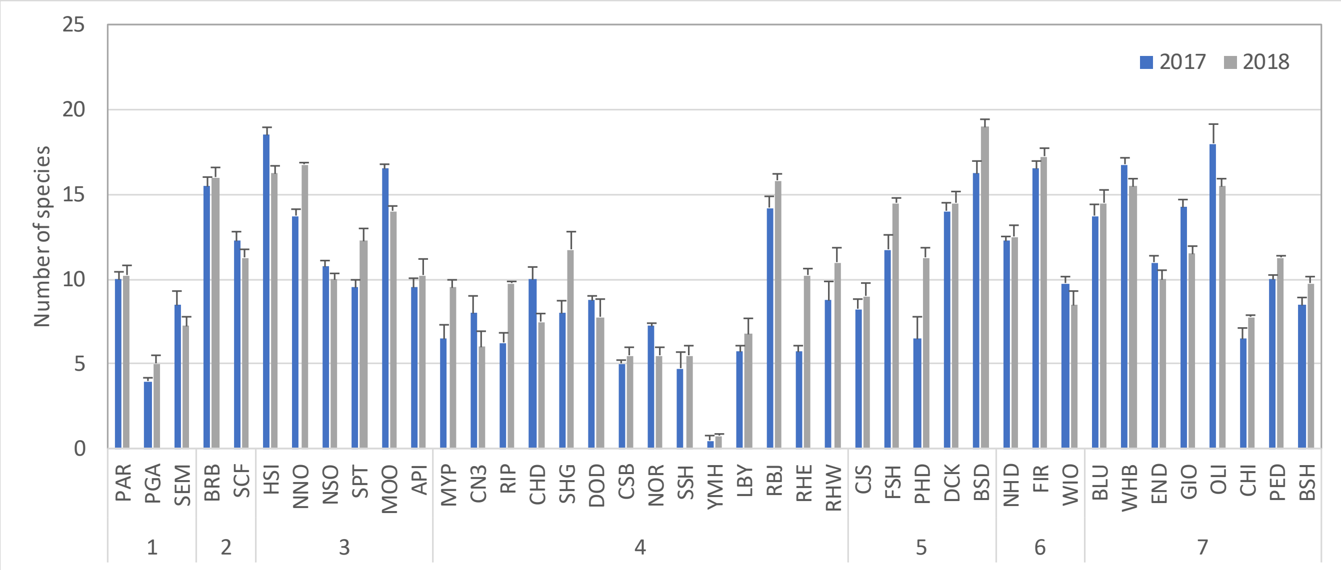


Figure 31. Richness of mobile invertebrates by site and year. Site names corresponding to abbreviation are provided in Appendix A.

5.3.2 Mobile invertebrate community structure

The baseline for the mobile invertebrate community structure indicator is illustrated by the MDS ordination plot provided in Figure 8.

A two-way PERMANOVA showed that there were significant differences in invertebrate community between subregions for all pairs except Backstairs Passage and South Coast, but no significant difference between years or interaction between subregion and year (Appendix D).

5.3.3 Focal species

The abundance of abalone (*Haliotis* spp.) was generally consistent between years but variable across the subregions, ranging from about 1 per block in the Northern subregion to about 11 in 2017 in the South Coast subregion (Figure 32). The highest site abundance was about 31 per block at Noarlunga South Outside in 2017, and the relatively high abundances in the Backstairs Passage were influenced by Deep Creek (about 18 per block in 2017) and Porpoise Head (about 12 per block in 2018), and in the South Coast subregion by Flat Irons (15 per block) (Figure 33).

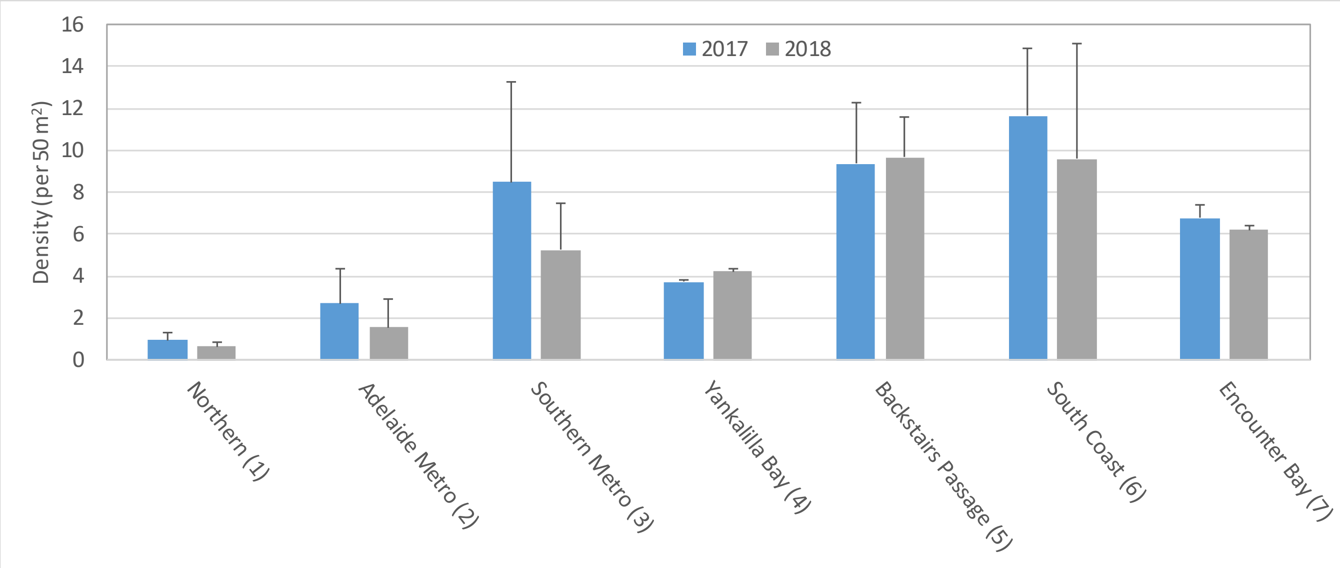


Figure 32. Density of abalone (per 50 m^2 block) by subregion and year. Error bars show standard error of mean abundance across individual sites.

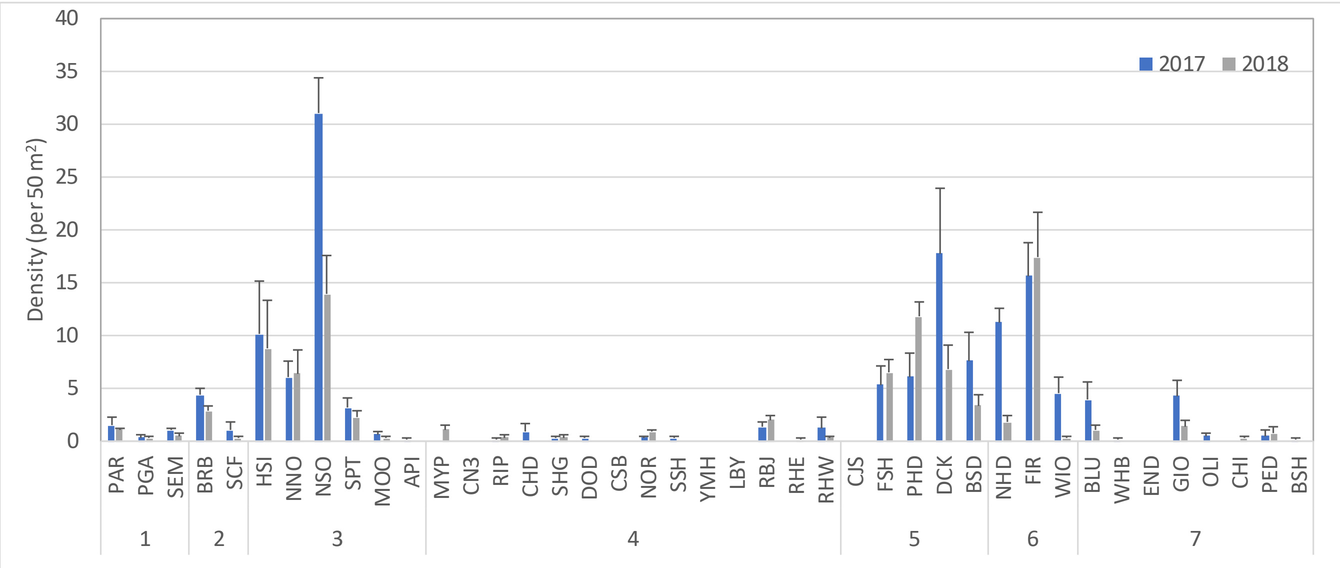


Figure 33. Density of abalone (per 50 m^{2}block) by site and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

The abundance of southern rock lobster (*Jasus edwardsii*) was higher in 2017 than 2018 and variable across the subregions, ranging from zero in the Northern, Adelaide Metro and Southern Metro subregions to about one per block in 2017 in the Encounter Bay subregion, in a trend of increasing abundance anti-clockwise along the coast from the Yankalilla subregion (Figure 34). The highest site abundance was about 2.7 per block at the Bluff in 2017 (Encounter Bay region), and were also high at Port Elliot Deep in the same subregion (about 1.9 in 2017). The highest abundances in the Backstairs Passage and South Coast subregions were, respectively, at Backstairs Deep (about 1.25 per block in 2017) and Flat Irons (about 2 per block in 2017) (Figure 35).

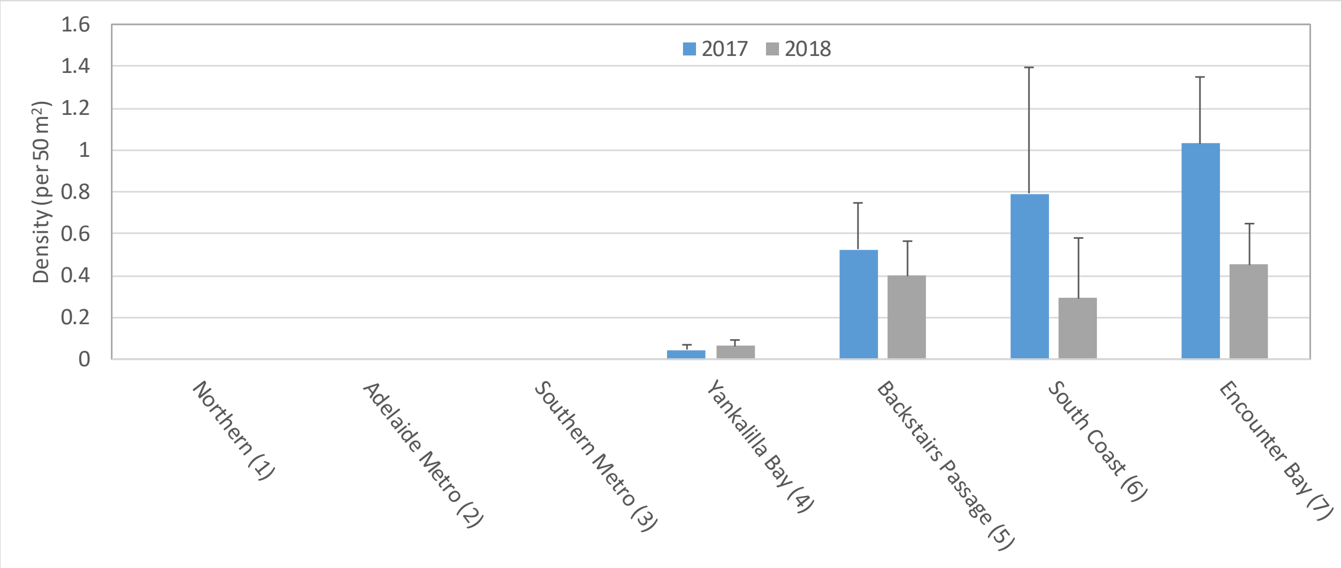


Figure 34. Density of southern rock lobster (per 50 m^2 block) by subregion and year. Error bars show standard error of mean abundance across individual sites.

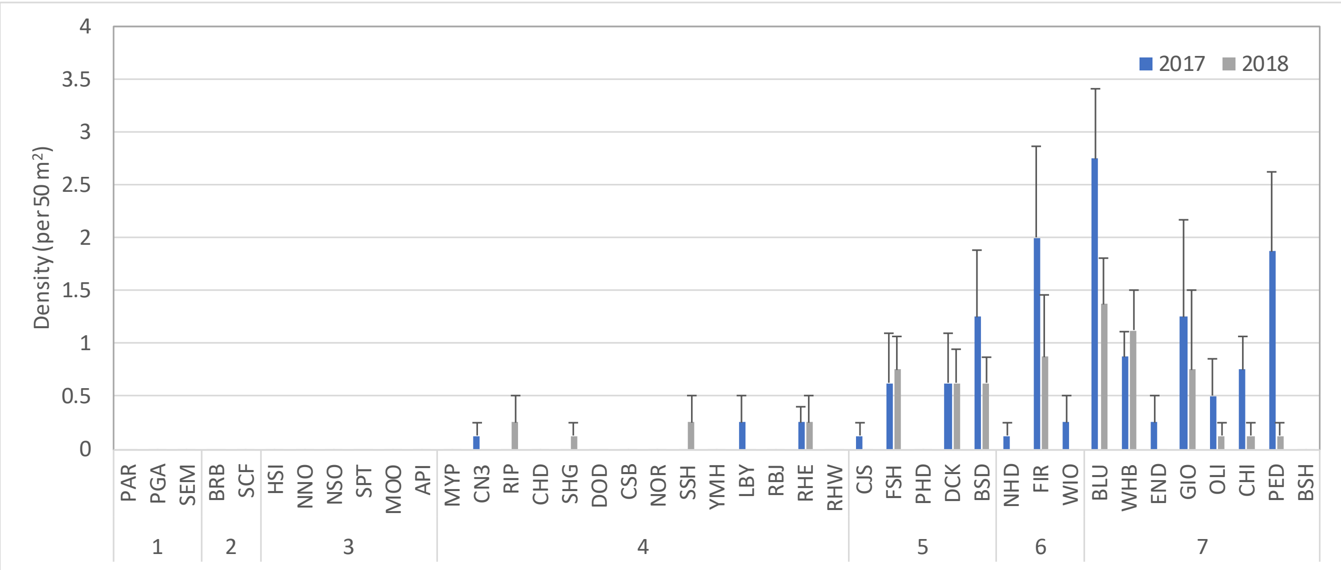


Figure 35. Density of southern rock lobster (per 50 m^2 block) by site and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

The abundance of the purple urchin (*Heliocidaris erythrogramma*) was highly variable between years and subregions. It ranged from zero in the Northern subregion to about 27 per block in 2017 in the Southern Metro subregion (Figure 36). The highest site abundance was at Horseshoe Reef Inside (Southern Metro subregion) with about 95 per block in 2017 and about 55 in 2018. Other sites with relatively high abundances of purple urchin (20–50 per block) were Moana Outside (Southern Metro subregion), and Whalebone Reef and Oliver's Reef (Encounter Bay subregion). Abundances at these sites were also higher in 2017 than 2018 (Figure 37).

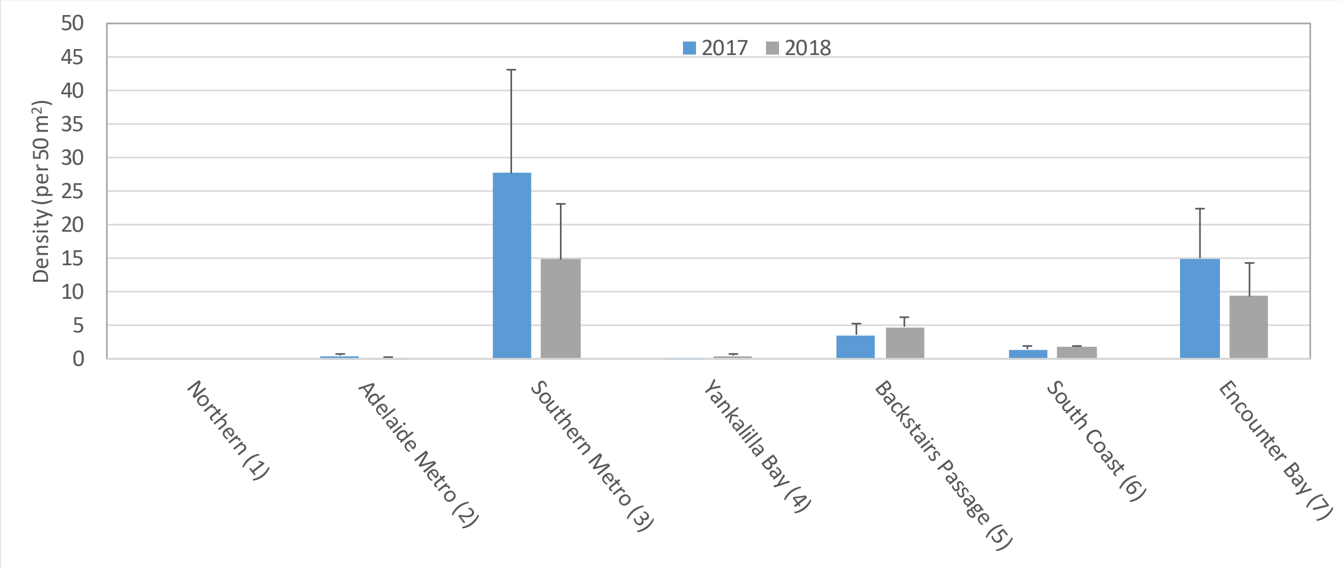


Figure 36. Density of purple urchin (per 50 m^2 block) by subregion and year. Error bars show standard error of mean abundance across individual sites.

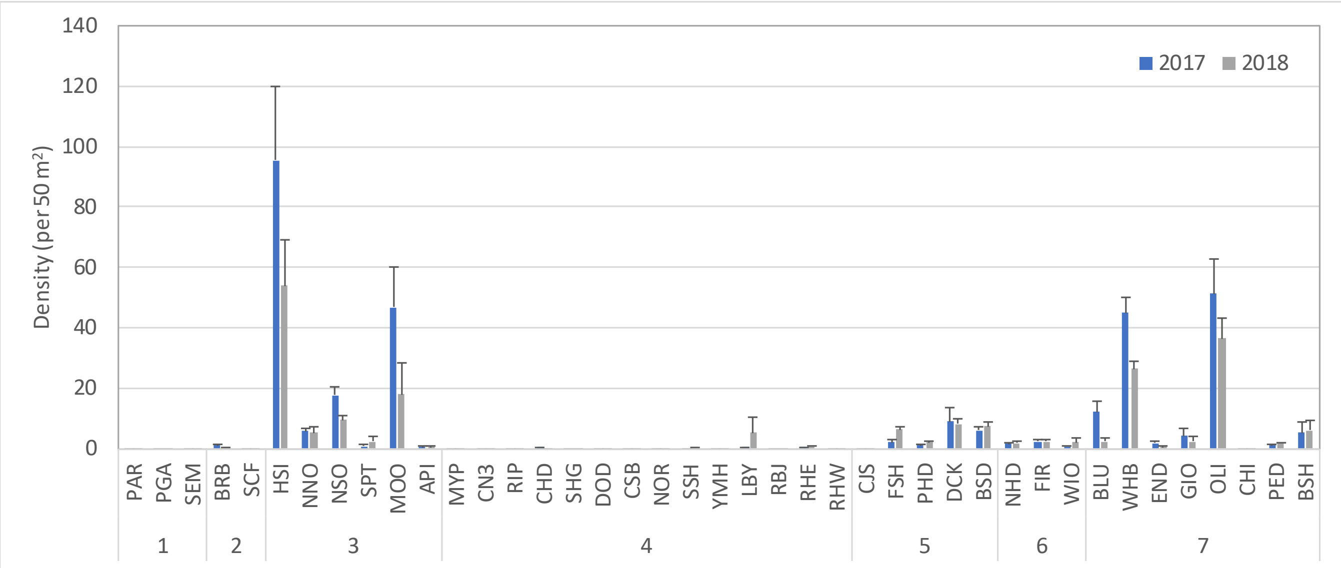


Figure 37. Density of purple urchin (per 50 m^2 block) by site and year. Error bars show standard error of mean abundance across four contiguous 50 m transects. Site names corresponding to abbreviation are provided in Appendix A.

Table 6. Summary of subregional characteristics

Subregion	Macroalgae	Fish	Mobile invertebrates
Northern	Marginally lower functional group richness (Port Gawler particularly low), lowest cover of canopy-forming macroalgae	Relatively low species richness. Lowest biomass of large and targeted fish. Intermediate community temperature index (CTI) (Port Gawler particularly low in 2017). No blue groper, blue devils, bluethroat wrasse or sweep.	Relatively low species richness (Port Gawler particularly low). Lowest abundance of abalone. No rock lobster or purple urchins.
Adelaide Metro	Typical functional group richness. Second lowest cover of canopy-forming macroalgae (Broken Bottom particularly low)	Relatively high species richness. Relatively low biomass of large and targeted fish. Highest CTI. Highest abundance of blue devil (all at Seacliff Reef). No blue groper or sweep, and relatively few bluethroat wrasse.	Typical species richness. Second to lowest abundance of abalone. No rock lobster and negligible purple urchins.
Southern Metro	Typical functional group richness (but lower at Moana Outside). Marginally lower cover of canopy-forming macroalgae than more southerly subregions	Relatively high species richness (but lower at Southport). Highest biomass of large fish (Noarlunga North Outside, Noarlunga South Outside and Aldinga Pinnacles particularly high) and targeted fish (Noarlunga North Outside and Noarlunga South Outside particularly high in 2018). Intermediate CTI. Second-highest abundance of sea sweep. No blue groper and few blue devils or bluethroat wrasse.	Typical species richness. Intermediate abundance of abalone (but highest abundance at Noarlunga South Outside). No rock lobster. Relatively high abundance of purple urchins (particularly at Horseshoe Inner and Moana Outside).
Yankalilla Bay	Typical functional group richness (but lower at Normanville Beach, South Shores, Yankalilla Mouth and Rapid Head East). Marginally lower cover of canopy-forming macroalgae than more southerly subregions (particularly low at Rapid Bay Jetty)	Relatively high species richness (but lower at the shallow sites Normanville Beach, South Shores and Yankalilla Mouth). Intermediate biomass of large fish (highly variable among sites) and targeted fish (high at Rapid Bay Jetty). Intermediate CTI. Relatively few blue groper, blue devils (except at Rapid Head Windmill), bluethroat wrasse or sweep.	Relatively low species richness (Yankalilla Mouth particularly low, but high at Rapid Bay Jetty). Relatively low abundance of abalone. Few rock lobster and negligible purple urchins.
Backstairs Passage	Typical functional group richness. Relatively high cover of canopy-forming macroalgae	Relatively low species richness. Intermediate biomass of large and targeted fish (large fish higher at Deep Creek and both higher at Porpoise Head). Lowest CTI. Relatively high abundance of bluethroat wrasse. Few blue groper, blue devils or sweep.	Typical species richness. Relatively high abundance of abalone (particularly at Deep Creek in 2017). Relatively high abundance of rock lobster. Few purple urchins.
South Coast	Typical functional group richness. Relatively high cover of canopy-forming macroalgae	Relatively low species richness. Moderate biomass of large and targeted fish. Lowest CTI. Highest abundance of blue groper (particularly at West Island), bluethroat wrasse and sea sweep. No blue devils.	Typical species richness. Relatively high abundance of abalone (particularly at Flat Irons). Relatively high abundance of rock lobster (particularly at Flat Irons in 2017). Few purple urchins.
Encounter Bay	Typical functional group richness. Relatively high cover of canopy-forming macroalgae (but lower at Chiton Rocks)	Relatively low species richness (except The Bluff and Whalebone). Relatively low biomass of large and targeted fish (but higher at Whalebone Reef). Intermediate CTI (Basham's Beach particularly low in 2017). Relatively high abundance of blue groper (particularly at Whalebone Reef, intermediate abundance of bluethroat wrasse (higher at Whalebone Reef). No blue devils and few sweep.	Typical species richness. Intermediate abundance of abalone. Relatively high abundance of rock lobster (particularly at The Bluff and Port Elliot Deep in 2017). Relatively high abundance of purple urchins (particularly at Whalebone Reef and Oliver's Reef).

6 Evaluation of long term monitoring sites

6.1 Review of representative criteria

PERMANOVA tests of the macroalgal communities showed that there were no significant differences between the Northern and Adelaide metro subregions, nor between the South Coast and Encounter Bay subregions. Such similarities between the macroalgal communities of subregions are not unexpected given the low level of taxonomic resolution (functional group rather than species).

The PERMANOVA tests of both the fish and invertebrate communities (based on species and sometimes genera) found that there were significant differences among subregions, with the pairwise tests for fish and invertebrates significant for all pairs except Backstairs and South Coast, and, for fish communities, South Coast and Encounter Bay.

The subregions were defined based on hierarchical clustering of physical characteristics, and the sites for the aforementioned subregions were relatively tightly clustered on separate sub-branches of the resulting dendrogram (Brock et al. 2017). There were some differences between individual sites in respect to temperature and substrate, but the main factor driving the classification between the Backstairs and Encounter subregions was wave exposure. The author's observations during surveys was that there was a gradation of increasing wave energy moving eastwards through Backstairs Passage, and it was likely to be at a similar level to the South Coast subregion, particularly when the swell was originating from a more southerly direction. On the basis of the lack of significant difference of fish and mobile invertebrate communities, and the above consideration of swell, it could be considered appropriate to combine the Backstairs and South Coast subregions. The case for combining the South Coast and Encounter subregions is not considered to be as strong, because there are several physical factors that distinguished those subregions, and the macroalgal and fish community data are not as useful for distinguishing subregions due to the low taxonomic resolution of the former and the mobility of the latter.

The MDS ordination plots showed that the fish, invertebrate and/or macroalgal communities at a number of sites were outliers from their prescribed subregions (Section 3). The most relevant of these were at Cape Jervis South, for which the macroalgal community in 2018 (Figure 4) and mobile invertebrate community in both years (Figure 9) were more similar to sites found in the Yankalilla Bay subregion than the Backstairs Passage subregion. Similarly, the macroalgal and fish communities in 2017 at Cape Jervis South were similar to sites found in both of these subregions, i.e. were in an area of overlap (Figure 7).

Cape Jervis South is within a transition area for temperature and wave exposure, being more similar to the Yankalilla subregion for temperature but more similar to Backstairs for wave exposure. Therefore the classification of this site into either subregion is arbitrary. The hierarchical clustering undertaken by Brock et al. (2017) was also influenced by a transition in relief from the relatively flat sites south of Rapid Head to higher relief sites in Backstairs Passage. Although the Cape Jervis South site has some areas of higher relief, the area surveyed (a new site) was generally platform reef. For the reasons above it is considered appropriate to adjust the subregion boundaries to include Cape Jervis South within the Yankalilla subregion.

6.2 Review of catchment discharge criteria

Brock et al. (2017) recommended a suite of sites, including additional unsurveyed reef monitoring sites to improve the information on the potential effect of catchment discharge on reefs from 12 catchments located across the seven subregions differentiated in their study. The proposed suite of sites included sites near the discharge point ('near sites') and control sites with potentially lower catchment impact at a distance from the catchment source characterised as 'far' sites. The catchments, their near sites and issues in regard to future monitoring are summarized in Table 7. This information (along with the conceptual models) will be used to evaluate and provide recommendations for future monitoring of nearshore health of subtidal reef systems in the AMLR region.

For the current study, four new catchment-based survey sites were established at the nearest site practicable to the relevant catchment discharge point (Table 7). Three new 'far' sites were established for the Bungala (South Shores), Yankalilla (South Shores and Lady Bay) and Hindmarsh (Chiton Rocks) Rivers. The most northern site (Gawler) has limited reef in the subregion, and is at distance from the nearest catchment (see Table 7).

The current set of sites should be adequate for ongoing monitoring of the Onkaparinga, Myponga and Deep Creek catchments, with 'near' sites close to the discharge point, and 'far' sites with similar characteristics at a range of distances.

Establishment of new 'near' sites closer to the discharge would enhance the monitoring of impacts from the Inman River and Carrickalinga Creek discharges.

Finding sites nearer to the Gawler River, Torrens River and Waitpinga Creek discharge points is considered to be unlikely or impractical.

Additional or alternative 'far' sites for the Christies and Carrickalinga Creeks and Inman and Hindmarsh Rivers would also improve the capacity to assess potential impacts to reefs from catchment discharge at these locations.

Similarly, the addition of Black's Reef (south of Whalebone Reef, towards Wright Island) would provide a 'far' site for limestone reefs, and it may be possible to find a site to the north of Whalebone Reef, closer to the discharge point.

Table 7. Catchment discharge point monitoring

Catchment	Nearest site (distance in km), *=new site	Issues for ongoing monitoring
Gawler River	*Port Gawler (9)	Near site a long way from discharge point, only one far site, Near site depth is 10 m, far site 5 m. There are unlikely to be alternative sites. Note that the near site is closer to Light River delta (6 km) than Gawler River. Searches of fishing marks at five sites further inshore found no or insufficient reef to establish a new site.
Torrens River	Broken Bottom (3.6)	Indicator (canopy cover) is near zero, so cannot show further decline, only improvement.
Christies Creek	Horseshoe Reef Inner (1.1)	Possible confounding by impacts from Onkaparinga River at far sites. An additional site (North of Port Noarlunga) may be informative.
Onkaparinga River	Southport (0.7), Noarlunga South Outside (1)	Possible confounding by impacts from Christies Creek or Christies Beach waste water treatment plant at far sites.
Myponga River	*Myponga Reef (0.3)	A range of 6 'far' sites to the south-west at distances ranging from 0.6–3.6 km. Five of these sites, including Carrickalinga North 3 (one of the current study sites and the nearest to Myponga) are Marine Park monitoring sites.
Carrickalinga Creek	Carrickalinga South Bay (0.5)	Far sites at a range of distances, the near site and a far site are Marine Park monitoring sites. Monitoring Haycock Point/Carry Beach North may be informative, and it may be possible to establish a site directly offshore from the creek discharge.
Bungala River	Normanville Beach (0.2)	There are river/creek discharges about two kilometres to the north and south that may confound monitoring.
Yankalilla River	*Yankalilla Mouth (0.1)	Monitoring may be confounded by the discharge of the Bungala River about two kilometres to the north. The near site has zero relief, but adjacent sites have 0.5–1 m relief.
Deep Creek	*Deep Creek (0.2)	There are 'far' sites 1.5 km to the east (although a deeper site), and 3 km to the west. Established sites are available at 3 km to the east and 8, 9 and 10 km to the west if required.
Waitpinga Creek	Newland Head (3)	It may be possible to establish a 'near' site two kilometres to the west of the mouth, but it would only be accessible in extremely good conditions.
Inman River	Whalebone Reef (1.20, Granite Island Outside (1.7).	Adding Granite Island and/or a site towards the northern end of Whalebone Reef as 'near' sites may be informative, and Blacks Reef (near Wright Island) could be explored as an additional 'far' site.
Hindmarsh River	Oliver's Reef (0.6)	Chiton Rocks is a patchier reef interspersed with seagrass. The site could potentially be re-established a few hundred metres to the west.

6.3 Evaluation of monitoring sites

The results of the Solver analysis identifying the minimum number of sites to achieve each management focus were grouped in 5 indicative management scenarios listed below and in Table 8.

1. Focus on FCC: All 64 FCCs recorded during RLS or MPA surveys (see Section 4) could be represented by 14 sites.
2. Focus on representativeness and catchment impacts: the relevant criteria (criteria 1–4 from Section 2.3) could be met by a set of 30 sites ('core' sites). Additionally 48 FCCs have been recroded at these sites.
3. Focus on representativeness, catchment impacts and FCC: Criteria 1–4 and representation of all 64 FCCs could be met by a set of 38 sites.
4. Focus on catchment subset: Catchment monitoring was focused on Onkaparinga River/Christies Creek, Myponga River, Carrickalinga Creek, Deep Creek and Inman River, only 23 sites would be required, although the addition of 2-3 sites would enhance the monitoring of three of those discharges (see Table 7). This set would also represent 48 FCCs.
5. Focus on catchment subset and FCCs: The reduced catchment monitoring above and representation of all 64 FCCs could be met by a set of 36 sites.

From the set of 30 core sites, and the extended set of 38 sites where FCCs had been previously recorded, 4 sites are part of the Encounter Marine Park monitoring program, and a further three are part of the Adelaide Desalination Plant (ADP) monitoring plan, which the licence conditions require to be surveyed every three years until 2032 (EPA 2017). Therefore 23 of the core sites are not already monitored.

Solver was used to explore whether the objectives of the AMLR SRH program could be achieved using more of the sites that were being monitored already (using the same or similar protocols), by other programs for other reasons. When Solver was run to find the minimum core set of sites which included all relevant Marine Park monitoring sites and a relevant subset of the ADP monitoring sites, 23 additional sites were still required. In other words, the Marine Park and ADP sites were already leveraged to an optimal level.

In addition to the site lists for the above scenarios (Appendices A), an additional outcome from this study in terms of site selection is a process and tool for developing an optimal list based on management priorities.

Table 8. Sites selected to address a range of scenarios related to different monitoring objectives. Note: ADP = Adelaide Desalination Plant, MP = Marine Parks.

Site	Added to 2017/ 2018 set (N = new, E = existing)	External monitoring program	Scenarios				
			1. FCCs only	2: subregions & catchments	3: subregions, catchments, FCCs	4: focussed catchment subset	5. focussed catchment subset & FCCs
Parham Reef			✓	✓	✓	✓	✓
Port Gawler				✓	✓	✓	✓
Semaphore Reef				✓	✓	✓	✓
Broken Bottom				✓	✓	✓	✓
Seacliff Reef				✓	✓	✓	✓
Port Stanvac Jetty deep	E		✓		✓		✓
Horseshoe Inside		ADP		✓	✓	✓	✓
Port Noarlunga North	N					✓	✓
Noarlunga North Outside		ADP		✓	✓	✓	✓
Noarlunga South Outside							✓
Southport				✓	✓	✓	✓
Moana Outside		ADP		✓	✓	✓	✓
Aldinga SZ1	E		✓		✓		✓
Aldinga Pinnacles				✓	✓	✓	✓
Myponga Reef				✓	✓	✓	✓
Carrickalinga North3		MP		✓		✓	
Ripple Rock		MP			✓		✓
Myponga South	E	MP	✓		✓		✓
Dodd's Beach		MP		✓	✓		✓
Carrickalinga Beach North	E					✓	
Carrickalinga South Bay		MP		✓	✓	✓	✓
Carrickalinga Creek	N					✓	✓
Normanville Beach			✓	✓	✓		
South Shores				✓	✓		
Yankalilla Mouth			✓	✓	✓		
Lady Bay			✓		✓		✓
Lassiters Reef	E		✓		✓		✓
Second Valley Boat Shed		MP	✓		✓		✓
Rapid Bay Jetty			✓		✓		✓
Rapid Head East		MP	✓	✓			
Rapid Head North	E		✓		✓	✓	✓
Rapid Head Windmill							✓
Cape Jervis South				✓	✓	✓	✓
Porpoise Head				✓	✓	✓	✓

Site	Added to 2017/ 2018 set (N = new, E = existing)	External monitoring program	Scenarios				
			1. FCCs only	2: subregions & catchments	3: subregions, catchments, FCCs	4: focussed catchment subset	5. focussed catchment subset & FCCs
Deep Creek				✓	✓	✓	✓
Backstairs Deep				✓	✓	✓	✓
Newland Head			✓	✓	✓		
Flat Irons				✓	✓		
The Bluff				✓	✓	✓	✓
Whalebone				✓	✓	✓	✓
Encounter Deep				✓	✓	✓	✓
Inman Mouth	N					✓	✓
Granite Island				✓	✓	✓	✓
Olivers Reef				✓	✓		
Chiton Rocks				✓	✓		
Pullen Island	E		✓		✓		✓
Totals (from 46 sites)			14	30	38	26	36

7 Conclusions

7.1 Overview

The AMLR SRH Program represents the first strategic and comprehensive regional approach to monitoring the status of subtidal reefs across the AMLR region. A suite of 41 monitoring sites were chosen in a systematic manner that was underpinned by management objectives (Brock et al. 2017), and assessed using RLS survey methods that are consistent and relevant at national and international scales. The indicators used to assess reefs in the AMLR region were derived from conceptual models which capture the information underpinning our current understanding of the functioning of AMLR subtidal reef ecosystems. This study continues the implementation of the recommendations outlined by Brock et al. (2017) for the AMLR SRH Program, by collecting data in a standard and consistent manner and documenting the regional patterns of macroalgal, fish and macro-invertebrate diversity. This has enabled the first regionally representative baseline status to be established for ongoing assessment of these valuable marine ecosystems.

7.2 Subregional approach will improve management of subtidal reefs

The subregional approach, which grouped reef sites into eight, broad locations (subregions) outlined by Brock et al. (2017), reflects real ecological differences in subtidal biological communities and presents a useful, practical and conceptual framework for long term monitoring and management of these systems. The patterns in community structure of macroalgae, fish and mobile invertebrates were closely aligned with the subregions defined using physical characteristic such as wave energy, reef substrate and temperature. Analysis of community structure confirmed that each subregion has distinct fish and mobile invertebrate communities, with the exception of Backstairs Passage and the South Coast, which appeared to be comparable in their community structures and could be combined hereafter. The community structure of the site Cape Jervis South more closely aligns with the Yankalilla Bay subregion and it is recommended to allocate this site to this subregion.

It is well known that physical influences such as wave exposure are strong drivers of community structure in temperate marine environments (Shepherd & Edgar 2013) and this was confirmed for the subtidal reef communities across the AMLR region. While acknowledging environmental gradients represent a continuum, the reefs and associated biological assemblages found in each subregion are ecologically and physically distinct from one another. The subtidal reefs in each subregion may therefore require specific monitoring and management approaches in recognition of their ecological differences, overlaid by the varying pressures that impact on them. Bryars (2013) highlighted the range and spatial variability of threats and pressures to nearshore reefs across spatially defined marine cells within the AMLR region. For example, a medium risk rating was assigned to reefs at Willunga based on storm water and catchment discharge, and the same risk rating was applied to Seaford based on discharge and sedimentation from cliff erosion.

7.3 Regional baseline established for future monitoring

The baseline established using the data collected in 2017 and 2018 will be invaluable for tracking future trends in the status of AMLR subtidal reefs. The survey methods applied and data collected from this study are largely "backwards compatible" with previous work so that past trends can also be assessed where long-term data exist. The suite of indicators derived from the conceptual models developed by Imgraben et al. (2019) and calculated from the data collected in 2017 and 2018 are designed to help managers to report on the status of these reefs in a way that links to the main pressures associated with eutrophication, sedimentation and resource extraction, in addition to climate change. This information, if integrated with seagrass or other marine habitat assessment programs, will provide a valuable inventory in the context of understanding broad-level impacts at differing spatial scales across the AMLR region. The adoption and successful use of the indicators, and subsequent development of information produced as part of this program, provides an appropriate approach in which to report on the status and condition of reef ecosystems. Such an approach could be used for future iterations of regional, local, state and national reporting frameworks such as South Australia's Environmental Trend and Condition Report Cards, and state and national State of the Environment reporting.

7.4 Macroalgal communities

The richness of macroalgal functional groups (a surrogate measure of macroalgae diversity) was similar across the subregions, but there were significant differences in community structure, including the percentage cover of canopy forming macroalgae. Consistent with the findings of previous "Reef Health" studies (Cheshire & Westphalen 2000, Turner et al. 2007, Collings et al. 2008, Brook 2018), the Northern and Adelaide Metro subregions had relatively low (<20%) cover of macroalgae, compared to all other subregions (>50%). The subregions with a southern aspect (Backstairs Passage, South Coast and Encounter Bay) had the highest cover of canopy-forming macroalgae, exceeding 70%.

The percentage cover of canopy-forming macroalgae has long been considered an indicator of reef health (Cheshire et al. 1998, Turner et al. 2007) and based on this, the health of reefs from the Northern, Adelaide Metro and Southern Metro subregions with canopy cover percentages less than 35% could be interpreted as "poor". However, this is an example of the importance of analyzing trends in condition rather than only status. Whereas there are some historical data with respect to some of these reefs (Shepherd & Edgar 2013, Connell 2016), for others, e.g. Parham Reef, there are not and it is not known whether they historically supported a more dense canopy cover. The lack of canopy-forming macroalgae could be due to many factors including water temperature, water quality and substrate availability, environmental conditions that facilitate settlement of native spores or the niche breadth for the species' reproduction. Alternatively, macroalgal diversity in the northern and Adelaide Metro subregions may be constrained to species that are more adapted to disturbed conditions such as higher levels of turbidity, nutrient enrichment and sedimentation that arise from processes such as urban expansion (e.g. Shepherd et al. 2008, Connell et al. 2008).

Further examples of inferring reef health from canopy cover are given in 7.8 below in relation to potential effects of catchment discharges.

7.5 Fish communities

Fish communities showed distinct differences across the subregions, typified by smaller fish such as wavy grubfish, little weed whiting and bullseyes in the warmer, more sheltered northern subregions, and wrasses, leatherjackets and sweep in the cooler, more exposed southern subregions. Fish species richness was highest along the Adelaide Metro to Yankalilla subregions. The lower richness in the Northern subregion may be due to the low relief (Shepherd & Baker 2008), or the warmer water (see below). Low relief may have been a factor for some shallow reefs in Yankalilla Bay and the easternmost reefs in the Encounter Bay subregion, but not for Backstairs Passage and South Coast, where relief was generally at least 1–2 metres. Species richness was highest at Rapid Bay Jetty, which is a significant artificial structure extending through a water column of 10 m depth, and the next highest richness was at its nearest site, Rapid Head East (500 m away), possibly with some spillover from Rapid Bay Jetty. Differences in fish community structure could be expected as a result of reef composition (e.g. granite vs limestone), but not necessarily differences in species richness (Harman et al. 2003). Greater wave exposure in the three southernmost subregions would have influenced community structure and possibly richness, and there may have been an indirect effect with poor visibility associated with swell affecting the number of fish emerging into the water column during surveys (Barrett & Buxton 2002).

The biomass of large fish and targeted fish was much higher in the Southern Metro subregion than all other regions and this is probably associated with long term protection from fishing in three out of the six sites. Noarlunga North Outside and Noarlunga South Outside are located in the Port Noarlunga Aquatic Reserve that was established in 1971, while the Aldinga Pinnacles site is located in the Aldinga Aquatic Reserve which was also declared in 1971. Both aquatic reserves have been subsumed within sanctuary zones (SZs) of the Encounter Marine Park. Sites with protection in the Yankalilla subregion also had a relatively high biomass of large and/or targeted fish. There were five sites in this subregion located inside Marine Park SZs and these sites had on average higher biomass of large fish compared to the other sites in this region that were not protected by an SZ, with the exception of Carrickalinga South Bay. In addition, the Rapid Bay Jetty site is protected from spearfishing. It is well established that fishing selectively targets larger fish and protection from fishing can result in increases in the number of large fish (Edgar et al. 2014, Babcock et al. 2010). Although it is beyond the scope of this report to conduct a formal analysis of the effect of protection from fishing on fish community structure and conservation, it is recommended that such analysis form part of any future work.

The Community Temperature Index (CTI) is used to describe the mean thermal range of fish communities, for example the mean thermal range will be higher for fish in tropical areas than in temperate areas. CTI is used as a surrogate to track the impacts of global warming as the CTI of fish communities will rise as warmer water species expand their range in response to ocean warming as is happening down the west coast of Australia (Day et al 2018). The CTI for fish communities in the AMLR region, in general, decreased along a north-south gradient from the Adelaide Metro subregion to Backstairs Passage and the South Coast reflecting water temperature gradients. The Northern subregion is a slight outlier from the general gradient, but within error margins and could be a result of small sample size.

It is clear that some focal fish species are restricted in their distribution within the AMLR region. Western blue groper is a species of conservation concern and is protected throughout gulf waters, including Backstairs Passage eastwards to Newland Head (PIRSA 2019). The south coast subregions are clearly important for the conservation of this species as only one individual was found outside these subregions. Western Blue groper, like many reef fish, are site attached, slow growing and take years to reach sexual maturity and are therefore susceptible to pressures such as over harvesting (Coulson et al. 2007, Bryars et al. 2012).

The southern blue devil was found mainly at sites on subregions with west facing aspect, however it appears that Seacliff Reef is particularly important for this species as blue devil numbers were twice as high there as any other site. The reasons for the observed spatial pattern of blue devil abundance is unclear but the species is territorial and site-attached with a small home range (Bryars 2011), such that density at a site will be partly reliant upon reef habitat containing suitably sized ledges and caves.

Blue throat wrasse are a common temperate reef fish species and were found at nearly all reef sites (except in the Northern subregion), but abundances were highest at the more wave-exposed south facing subregions (Backstairs Passage and South Coast). Sea sweep were not recorded in the Northern or Adelaide Metro subregions, and are most abundant at exposed sites, such as in the South Coast subregion. Sweep and blue throat wrasse are commonly caught during recreational fishing on reefs and will be important species to monitor to assess fishing pressure.

Forty-one fish species of conservation concern, including 19 of the 20 species prioritized by Brock et al. (2017), were recorded across the 41 sites. Many of these species are uncommon and the level of sampling provided by the RLS method may not be sufficient to adequately monitor such species. This is reinforced by the number of incidental (off-transect) sightings of FCCs during 2017 and 2018. There are also a number of species with reef association that might be expected to be observed at AMLR STR that were not recorded during these surveys, nor have they been recorded during previous surveys, e.g. scarlet cardinalfish (*Vincentia badia*) (Brock et al. 2017).

7.6 Mobile invertebrate biodiversity

Mobile invertebrate communities showed distinct differences across the subregions, typified by sea cucumbers and hermit crabs in the warmer, more sheltered northern subregions, and feather stars, dog whelks and red bait crabs in the cooler, more exposed southern subregions. Invertebrate species richness was similar in all subregions except Northern and Yankalilla Bay, which were lower. The lower richness in the Northern subregion might be explained by the low relief and associated absence of crevices, but there is no obvious explanation for the relatively low richness in the Yankalilla Bay subregion.

Similarly, there was a discontinuity in the abundance of abalone along the coastline. Abalone abundance increased along a north-south gradient from the Northern subregion to Backstairs Passage and South Coast, but was lower for Encounter Bay, and appears to be generally correlated with wave exposure and sea surface temperature (see Brock et al. 2017). The low abundance of abalone in the Yankalilla Bay subregion, however, is an outlier from that gradient; the reason for which is unknown and worth further investigation.

Rock lobster abundance was focused around the southernmost three subregions, consistent with its preference for exposed reef (Edgar 2008) and cooler water. Abundance was higher in 2017 than 2018 at almost every site, but this does not reflect any particular trend in the rock lobster fishery resource (Linnane et al. 2019).

Purple urchin populations were patchy, with relatively high abundances at only four sites, two in each of the Southern Metro and Encounter Bay subregions. In the eastern states, high abundances of urchins have been explained by lack of protection for higher order predators of urchins such as snapper (Barrett et al. 2009), and that model may partially explain the results of the Southern Metro subregion. Of the six sites from that subregion, the two sites with high urchin abundances are outside Marine Park SZs. Southport, also outside of SZs, has a very low abundance of urchins but is comprised largely of platform reef with little suitable habitat for urchins compared with the other four sites in the subregion. The predator-prey model does not appear to be as applicable to the Encounter Bay subregion, with only one of the eight sites within an SZ and nevertheless a relatively high abundance of large fish at Whalebone Reef, which is one of the two sites with a high urchin abundance.

The sea hare *Bursatella* sp. was recorded outside of its range (west of South Australia) as recognised by Edgar (2008). It is noted that there have been other sightings of this species in the AMLR region.

7.7 Introduced Marine Pests

Some of the most invasive pest species of concern that are routinely searched for during the RLS surveys include; European fan worm (*Sabella spallanzani*), Japanese seaweed (*Undaria pinnatifida*) and North Pacific seastar (*Asterias amurensis*). However, no introduced marine species were recorded during the surveys, and there have been very few records during previous reef health studies (Turner et al. 2007, Collings et al. 2008, Brook & Bryars 2014, Brook 2018). There are a number of pests that have been recorded at boat ramps, marinas and ports near several of the sites (Wiltshire et al. 2010), but measures to contain these or natural barriers to their dispersion appears to have prevented their spread.

7.8 Catchment impacts

Monitoring of impacts on reef communities arising from catchment discharges requires long-term datasets unless immediate impacts are within close proximity and apparent (e.g. dredging discharge). Time-series of macroalgae canopy cover, which has been the primary indicator of reef condition since reef assessments commenced in 1998, are available to inform an assessment for some catchments:

- Onkaparinga River catchment: inferences have been made about impacts from sediment originating from the Onkaparinga River (Brook 2018). Sedimentation was found to be high near the Southport, Noarlunga and Horseshoe reefs (Fernandes 2008, Fernandes et al. 2008), which have shown long-term declines in canopy cover and changes in reef community structure (Brook 2018). It should be noted that impacts from sediment disturbed during dredging were also observed during the late 1990s (Turner 2004).
- Torrens River catchment: the condition of Broken Bottom, the 'near' site for this catchment, is considered to have deteriorated since the 1960s, but the cause is less clear with lower sediment levels found here, and other stressors (e.g. waste water treatment plants) also present.
- Canopy cover at Carrickalinga South Bay was greater than 80% in 2017 and 2018 and has been generally high since monitoring began in 2005 (Brook & Bryars 2014)

Some initial inferences can now be made for some catchments with new sites added near the discharge point:

- Myponga River catchment: canopy cover at the adjacent Myponga Reef is less than 40% but 60–80% at nearby Carrickalinga North 3 and Ripple Rock (Figure 13), suggesting possible effects from the Myponga River discharge
- Deep Creek catchment: canopy cover at the Deep Creek site exceeds 80%, which is the same as the nearby Backstairs Deep site and higher than the 'far' site at Porpoise Head with 60% cover, suggesting no negative impacts from the creek discharge. It is worth noting that the adjacent catchment still has a largely intact cover of native vegetation and run-off containing elevated levels of sediments and nutrients is likely to be relatively low (Bryars 2013).

The current set of sites should be adequate for ongoing monitoring of the Onkaparinga, Myponga and Deep Creek catchments. The addition of further sites would enhance the monitoring of impacts from Christies Creek, Carrickalinga Creek and Inman and Hindmarsh Rivers, but finding additional sites relevant to Gawler River, Torrens River and Waitpinga Creek is considered to be unlikely or impractical.

7.9 Site evaluation

As discussed in Sections 7.2, 7.5 and 7.8, information gained during the 2017 and 2018 surveys has informed minor changes to the subregional framework, the approach to monitoring fishes of conservation concern, and possibilities for enhancing the monitoring of catchment discharge impacts. This information has been used to develop specific scenarios with varying focus on representativeness, fishes of conservation concern, catchment impacts, leveraging of other programs and maintenance of long-term data sets. However, no particular scenario is presented as a recommendation. Importantly, the approach and tools used to develop the scenarios can be reapplied according to management priorities identified by the AMLR NRM Board to generate an efficient set of monitoring sites. If there were no change to the monitoring objectives that underpinned the selection of 41 sites by Brock et al (2017) for the current project, a reduced set of 30 sites should achieve the same objectives. With a minor shift of focus towards monitoring catchments where suitable sites are available, and towards monitoring all 64 fishes of conservation concern previously recorded, a set of 36 sites is optimal.

7.10 Contribution to NRM reporting and ecosystem assessment

The AMLR SRH program provides a useful region-wide framework that aims to facilitate the long-term understanding of changes to marine resources for the AMLR NRM Board. The hierarchical spatial structure of the AMLR SRH Program supports management at landscape, sub-regional and local spatial scales (e.g. site level). This accommodates the variety of current and impending management boundaries used for reporting on natural resource assets (e.g. Green Adelaide and Landscape Boards). For example, the spatial extent of the current program provides standardised information and approach that is used for reporting on the AMLR NRM Plan's regional targets and the regional marine health conceptual model. This includes the opportunity to provide information on local scale biodiversity and information on how localized pressures (e.g. catchment discharge) can impact or change ecosystem condition over time. The RLS approach used for the AMLR SRH program further promotes delivery of data and information used in national and international databases (e.g. RLS: https://reeflifesurvey.com/).

8 Recommendations

1. Undertake trend analysis of indicators identified for assessing reef status and protection from fishing where long term data exists.

This recommendation reflects Objective 6 of the AMLR SRH Program. Several subtidal reef monitoring sites have at least 10 surveys of monitoring data over 15 years that are compatible with the baseline data collected in this report (e.g. Second Valley Boat Shed, Rapid Head, Shag Rock and Carrickalinga South Bay), and there are other sites with at least 30 surveys from 20 years of monitoring, including community-based monitoring, that are partially compatible. Trend analysis at these sites would be invaluable for determining the trajectory of change in indicators identified to assess subtidal reef status and therefore provide some insight into the health of these systems and significantly improve current reporting for these ecosystems (State Environmental Trend and Condition Report Cards, and state and national State of the Environment reporting). Trend analysis would also be useful for quantifying the variation in these systems and the frequency of resurvey required. The effectiveness of protection from fishing should also be examined as part of this analysis.

2. Develop a conceptual framework for interpreting reef condition

While this report has identified indicators to monitor and establish a baseline for future comparisons, no formal assessment has been made of the condition of individual subtidal reef sites (i.e. "good", "average", "poor"). It is recommended that further work be undertaken to investigate how the results of this program can best feed into different state environmental reporting frameworks (i.e. Environmental Trend and Condition Report Cards or State of the Environment Reporting). This may include exploring options for synthesizing and consolidating the information across the different indicators in a simpler way.

3. Explore data visualization options to improve extension of results to NRM Managers and general public

Given the scope and breadth of information that has been and will continue to be collected as part of this program there is a need to improve how the information is made available for access by decision makers, NRM managers and the general public. For example, web-based platforms that use the latest data visualization tools are invaluable for engaging with a range of stakeholders to improve reach and uptake of information and insights gained as part of this work. It is recommended that options for extending the results of this program via integrated or standalone web-based platforms be investigated.

4. Identify flagship species/habitats not adequately assessed by the current monitoring program

The survey method and approaches outlined here are necessarily targeted at assessing the status of subtidal reefs at a subregional scale. The RLS method is a powerful survey method as it collects size and abundance data across three different components of the food web (macro-algae, mobile macro-invertebrates and fishes). However, sites are usually chosen to be representative of the surrounding reef, constrained to the 5 m depth contour and only animals that occur in the transect boundaries are counted. There will be features of these reefs for which the RLS method is not well designed to monitor.

A good example is the leafy sea dragon. The leafy sea dragon is the states marine emblem, protected and a flagship species valued by the general public and dive community, including travelers from around the world who come to South Australia to see these unique creatures. Several areas in the AMLR region including Rapid Bay Jetty and Second Valley are known locations for small populations of these animals and while a few individuals were recorded by the RLS method, this method may not be ideal for monitoring this species. The leafy sea dragon is cryptic, rare and difficult to detect using the RLS method as assessing biodiversity on the macro scale and continual movement (required by RLS) are not ideal for spotting these animals. If the status of leafy seadragon populations is an important management objective then a targeted monitoring program would be required to achieve this. There may be other significant species that have similar characteristics and it is recommended that these be identified.

5. Review management scenarios and recommend a long term approach to monitoring

A number of management scenarios were outlined that resulted in different sets of monitoring sites being required, depending on what the management focus/objectives were: i.e. representative, catchment focused. It is recommended that the scenarios outlined in this document be reviewed and the primary management focus determined, so that a suite of sites and frequency of survey can be locked in for future rounds of monitoring. At the present time if there were no change to the monitoring objectives that underpinned the selection of 41 sites by Brock et al. (2017) for the current project it is recommend that the current suite of sites be rationalized to 36 sites which would achieve the same monitoring and management outcomes. The rationalization of sites would include reallocation of allocate this site to the Yankalilla Bay subregion

6. Evaluate the SRH program to guide future investment

It is recommended that a formal evaluation of the SRH Program be undertaken at an appropriate future date. This recommendation reflects Objective 7 of the current AMLR SRH Program This would include an evaluation of the chosen indicators, assessing the effectiveness of the monitoring program at informing management decisions, the level of engagement and capacity building associated with the volunteer dive program and what intensity of monitoring effort is required over the long term.

9 Appendices

A. Sites surveyed

Note: Sym refers to symbols used in Section 3 figures. Acronyms are used in figures in Sections 3 and 5.

Site	Acronym	Sym	Subregion	Depth (m)	Dates surveyed	
Parham Reef	PAR	▲	Northern (1)	5	21/03/17	26/01/18
Port Gawler	PGA	▼	Northern (1)	10	21/03/17	26/01/18
Semaphore Reef	SEM	■	Northern (1)	8	16/02/17	25/01/18
Broken Bottom	BRB	◆	Adelaide Metro (2)	10	16/02/17	25/01/18
Seacliff Reef	SCF	●	Adelaide Metro (2)	12	6/03/17	21/02/18
Horseshoe Inside	HSI	+	Southern Metro (3)	2	10/03/17	23/01/18
Noarlunga North Outside	NNO	×	Southern Metro (3)	5	6/03/17	21/02/18
Noarlunga South Outside	NSO	✱	Southern Metro (3)	3	10/03/17	23/01/18
Southport	SPT	△	Southern Metro (3)	4	23/03/17	23/01/18
Moana Outside	MOO	▽	Southern Metro (3)	5	23/03/17	20/01/18
Aldinga Pinnacles	API	□	Southern Metro (3)	10	23/03/17	20/01/18
Myponga Reef	MYP	◇	Yankalilla Bay (4)	5	14/02/17	19/02/18
Carrickalinga North3	CN3	○	Yankalilla Bay (4)	5	26/03/17	13/03/18
Ripple Rock	RIP	▲	Yankalilla Bay (4)	5	7/03/17	30/04/18
Carrickalinga Head	CHD	▼	Yankalilla Bay (4)	5	26/03/17	16/05/18
Shag Rock Carrickalinga	SHG	■	Yankalilla Bay (4)	5	15/03/17	20/02/18
Dodd's Beach	DOD	◆	Yankalilla Bay (4)	5	4/04/17	7/03/18
Carrickalinga South Bay	CSB	●	Yankalilla Bay (4)	5	7/03/17	7/03/18
Normanville Beach	NOR	+	Yankalilla Bay (4)	2	15/03/17	20/02/18
South Shores	SSH	×	Yankalilla Bay (4)	2	15/03/17	20/02/18
Yankalilla Mouth	YMH	✱	Yankalilla Bay (4)	2	15/03/17	6/02/18
Lady Bay	LBY	△	Yankalilla Bay (4)	2	14/02/17	6/02/18
Rapid Bay Jetty	RBJ	▽	Yankalilla Bay (4)	10	20/03/17	24/01/18
Rapid Head East	RHE	□	Yankalilla Bay (4)	5	25/03/17	16/05/18
Rapid Head Windmill	RHW	◇	Yankalilla Bay (4)	6	20/03/17	24/01/18
Cape Jervis South	CJS	○	Backstairs Passage (5)	5	4/04/17	19/02/18
Fishery Beach	FSH	▲	Backstairs Passage (5)	5	12/04/17	9/02/18
Porpoise Head	PHD	▼	Backstairs Passage (5)	5	1/06/17	9/02/18
Deep Creek	DCK	■	Backstairs Passage (5)	5	6/04/17	7/02/18
Backstairs Deep	BSD	◆	Backstairs Passage (5)	10	6/04/17	7/02/18
Newland Head	NHD	●	South Coast (6)	5	10/05/17	28/01/18
Flat Irons	FIR	+	South Coast (6)	5	9/05/17	28/01/18
West Island Outer	WIO	×	South Coast (6)	10	9/05/17	8/02/18
The Bluff	BLU	✱	Encounter Bay (7)	5	15/04/17	9/03/18
Whalebone	WHB	△	Encounter Bay (7)	5	15/04/17	27/01/18
Encounter Deep	END	▽	Encounter Bay (7)	10	9/05/17	8/02/18
Outside Granite Island	GIO	□	Encounter Bay (7)	5	14/04/17	27/01/18
Olivers Reef	OLI	◇	Encounter Bay (7)	5	14/04/17	27/01/18
Chiton Rocks	CHI	○	Encounter Bay (7)	5	14/04/17	10/04/18
Port Elliot Deep	PED	▲	Encounter Bay (7)	10	13/06/17	10/04/18
Basham's Beach	BSH	▼	Encounter Bay (7)	5	13/06/17	10/04/18

B. Details of indicator calculations and interpretation notes

Indicator	Calculation Details and interpretation notes
Fish and mobile invertebrate species richness	No. of unique taxa across the total area sampled along each transect using Method 1 and Method 2, i.e. 500 m^2 for Method 1 and 100 m^2 for Method 2 for a complete transect using the RLS method. Richness indicators are sensitive to taxonomic resolution. In the case of fish, however, most identifications were to species level and are expected to be consistent among divers. The exceptions were the genera *Pseudocaranx* (trevally), *Ophiclinus* (snake blennies), the families Tripterygiidae (threefins) and Gobidae (gobies) and baitfish from the order Clupeiformes. Richness indicators are sensitive to taxonomic resolution. For mobile mobile invertebrates there are a number of organisms that cannot be identified to species level consistently by all divers in the field, and these have been grouped as genera or higher taxa, or species complexes. Furthermore, there are instances of surveyors recording species that are not from the list of mobile invertebrate groups defined by RLS (2015). Such species, for example bivalves other than scallops or razor clams, have been excluded from the dataset. The mapping from the species names recorded in the field to the more considered set used for analysis is provided in Table 9. In addition to the transect average, an overall site-level richness was calculated from the number of unique species in the pooled transect lists.
Richness of macroalgal functional groups	Functional groups were assigned to a fixed number of points overlain on photoquadrats during post-field analysis. The indicator was calculated from the number of unique functional groups assigned to a fixed number of points across 20 images per transect (occasionally plus or minus one image).
Fish and mobile invert community structure	Community structure was examined using the PRIMER 6 software package (Clarke and Warwick 2001, Clarke and Gorley 2006) with PERMANOVA+ addon (McArdle and Anderson 2001, Anderson 2001). A Bray-Curtis dissimilarity matrix was calculated from fourth-root-transformed data, which reduced the influence of schooling species, many of which are infrequently recorded. Other transformations were explored, including square-root and logarithmic, and dispersion weighting, with comparisons made of the patterns shown by multi-dimensional scaling (MDS) ordination plots and by using the 2STAGE routine. PERMANOVA factors were Site as a random factor nested in fixed Subregions, and crossed with Year as a fixed factor. Tests of the factor Year and its interaction with Subregion will indicate change in subregional communities over time.
Macroalgal community structure	As per fish and mobile invert community structure, with the Bray-Curtis dissimilarity matrix calculated from functional group percentage cover data.
Fish community temperature index	The midpoint of temperature ranges for each fish species was a provided by University of Tasmania (R. Stuart-Smith, unpublished data). The transect value is the community-weighted mean whereby the logarithm (base 10) of biomass (plus one gram) was used to weight the temperature midpoint for each species.
Biomass of large fish	Biomass of fish exceeding 20 cm length, averaged over two blocks on each transect. It should be noted that the biomass of large fish can be influenced by the uncommon occurrence of large elasmobranchs, e. g. wobbegongs or rays, or of large schools of fish, e.g. Australian salmon *Arripis truttacea*. Biomass values were calculated by University of Tasmania.
Biomass of targeted fish	Species defined as 'targeted' are listed in Table 10. As for the 'biomass of large fish' indicator, this indicator can be influenced by the uncommon occurrence of large schools of fish, e.g. Australian salmon.
Percentage cover of canopy-forming macroalgae	Two functional groups (corresponding to kelps and large brown branching macroalgae (from the order Fucales) describe canopy-forming macroalgae. The percentage cover of these points was calculated from the proportion of point overlays on each transect that were assigned one of these functional groups.
Abundance of focal species (and FCCs)	Abundance of fish were calculated a mean per block, i.e. overlapping areas of 250 m^2 and 50 m^2 for methods 1 and 2, respectively.

Table 9. Invertebrate species group mapping

Species	Grouped species
Crustaceans	
Brachyura spp.	Unidentified crab
Naxia aurita	*Naxia* spp.
Naxia spinosa	*Naxia* spp.
Nectocarcinus integrifrons	*Nectocarcinus* spp.
Nectocarcinus tuberculosus	*Nectocarcinus* spp.
Paguroidea spp.	*Pagurid* spp.
Portunus pelagicus	*Portunus armatus*
Schizophrys aspera	*Schizophrys* spp.
Schizophrys rufescens	*Schizophrys* spp.
Strigopagurus strigimanus	*Pagurid* spp.
Unidentified crab (decorator)	Unidentified crab
Echinoderms	
Nectria multispina	*Nectria pedicelligera* complex
Nectria ocellata	*Nectria pedicelligera* complex
Nectria pedicelligera	*Nectria pedicelligera* complex
Tosia australis	*Tosia* spp.
Tosia magnifica	*Tosia* spp.
Uniophora granifera	*Uniophora* spp.
Uniophora nuda	*Uniophora* spp.
Comanthus tasmaniae	*Comanthus* spp.
Comanthus trichoptera	*Comanthus* spp.
Amblypneustes elevatus	*Amblypneustes* spp.
Amblypneustes ovum	*Amblypneustes* spp.
Holopneustes porosissimus	*Holopneustes* spp.
Holopneustes sp. (red)	*Holopneustes* spp.
Australostichopus mollis	*Stichopid* spp.
Stichopus ludwigi	*Stichopid* spp.
Molluscs	
Astralium aureum	*Astralium* spp.
Astralium squamiferum	*Astralium* spp.
Cabestana spengleri	*Cabestana* spp.
Cabestana tabulata	*Cabestana* spp.
Haliotis cyclobates	*Haliotis* spp.
Haliotis roei	*Haliotis* spp.
Haliotis rubra	*Haliotis* spp.
Haliotis scalaris	*Haliotis* spp.
Hypselodoris infucata	*Hypselodoris* spp.
Hypselodoris saintvincentia	*Hypselodoris* spp.
Phasianella australis	*Phasianella* spp.
Phasianella ventricosa	*Phasianella* spp.

Table 10. Targeted reef species

Species name	Common name
Arripis georgianus	Australian herring
Arripis truttaceus	Western Australian salmon
Centroberyx gerrardi	Bight redfish
Cheilodactylus nigripes	Magpie perch
Chrysophrys auratus	Snapper
Dactylophora nigricans	Dusky morwong
Girella tricuspidata	Luderick
Leviprora inops	Longhead flathead
Meuschenia hippocrepis	Horseshoe leatherjacket
Myliobatis tenuicaudatis	Eagle ray
Nemadactylus valenciennesi	Queen Snapper
Notolabrus tetricus	Blue-throat wrasse
Othos dentex	Harlequin fish
Pentaceropsis recurvirostris	Long-snouted boarfish
Platycephalid spp.	Flathead
Platycephalus laevigatus	Rock flathead
Platycephalus speculator	Yank flathead
Pseudocaranx spp.	Trevally
Scorpis aequipinnis	Sea sweep
Scorpis georgiana	Banded sweep
Seriola lalandi	Yellow-tail kingfish
Sillaginodes punctatus	King George whiting
Sphyraena novaehollandiae	Snook
Thysanophrys cirronasa	Tasselsnout Flathead
Tilodon sexfasciatus	Moonlighter
Trachurus novaezelandiae	Yellow-tail scad
Upeneichthys vlamingii	Southern goatfish

C. Species lists

Macroalgal functional groups

Category	Functional group
Canopy	Macroalgae: Erect coarse branching: Brown
	Macroalgae: Large canopy-forming: Brown
Brown understorey	Macroalgae
	Macroalgae: Erect fine branching: Brown
	Macroalgae: Filamentous / filiform: Brown
	Macroalgae: Globose / saccate: Brown
	Macroalgae: Laminate: Brown
	Macroalgae: Sheet-like / membraneous: Brown
Green understorey	Macroalgae: Erect coarse branching: Green
	Macroalgae: Erect fine branching: Green
	Macroalgae: Filamentous / filiform: Green
	Macroalgae: Globose / saccate: Green
	Macroalgae: Laminate: Green
Red understorey	Macroalgae: Articulated calcareous: Red
	Macroalgae: Erect coarse branching: Red
	Macroalgae: Erect fine branching: Red
	Macroalgae: Filamentous / filiform: Red
	Macroalgae: Globose / saccate: Red
	Macroalgae: Sheet-like / membraneous: Red
Turf	Macroalgae: Turfing
	Turf mat
Animal	Ascidians
	Cnidaria
	Sessile invertebrates
	Sponges
Bare	Boulders
	Macroalgae: Encrusting: Brown
	Macroalgae: Encrusting: Red: Calcareous
	Macroalgae: Encrusting: Red: Non-calcareous
	Rock
Omitted	Coarse sand (and/or shell fragments)
	Cobbles
	Drift (macroalgae or seagrass)
	Fine sand (no shell fragments)
	Mobile invertebrates
	Seagrass

Fish (from methods 1 and 2)

Family	Species name	Common name
Aploactinidae	*Aploactisoma milesii*	Velvetfish
Aplodactylidae	*Aplodactylus arctidens*	Southern sea carp
Apogonidae	*Siphamia cephalotes*	Little siphonfish
	Vincentia conspersa	Southern cardinalfish
Arripidae	*Arripis georgianus*	Tommy rough
	Arripis truttaceus	Western australian salmon
Blenniidae	*Blenniid* spp.	Blenny
	Parablennius tasmanianus	Tasmanian blenny
Bovichtidae	*Bovichtus angustifrons*	Dragonet
Callionymidae	*Eocallionymus papilio*	Painted stinkfish
Carangidae	*Pseudocaranx* spp.	Trevally
	Seriola lalandi	Yellow-tail kingfish
	Trachurus novaezelandiae	Yellow-tail scad
Chaetodontidae	*Chelmonops curiosus*	Western talma
Cheilodactylidae	*Cheilodactylus nigripes*	Magpie perch
	Cheilodactylus spectabilis	Banded morwong
	Dactylophora nigricans	Dusky morwong
	Nemadactylus valenciennesi	Queen Snapper
Chironemidae	*Threpterius maculosus*	Kelpfish
Clinidae	Clinid spp.	Undifferentiated weedfish
	Heteroclinus adelaidae	Adelaide weedfish
	Heteroclinus johnstoni	Johnstons weedfish
	Heteroclinus perspicillatus	Common weedfish
	Heteroclinus roseus	Rosy weedfish
	Heteroclinus tristis	Forsters weedfish
	Ophiclinus gabrieli	Frosted snake-blenny
	Ophiclinus gracilis	Black-back snake-blenny
	Ophiclinus spp.	Undifferentiated snake-blenny
	Peronedys anguillaris	Eel snake-blenny
Clupeiformes (order)	*Clupeiformes* spp.	Undifferentiated herring
Dasyatidae	*Bathytoshia lata*	Black stingray
Dinolestidae	*Dinolestes lewini*	Long-fin pike
Diodontidae	*Diodon nicthemerus*	Globe fish
Enoplosidae	*Enoplosus armatus*	Old wife
Gerreidae	*Parequula melbournensis*	Silverbelly
Gobiesocidae	*Cochleoceps bicolor*	Western cleaner clingfish
	Gobiesocid spp.	Undifferentiated clingfish
Gobiidae	*Bathygobius krefftii*	Krefft's Frillgoby
	Nesogobius spp.	Goby
Heterodontidae	*Heterodontus portusjacksoni*	Port Jackson shark
Hypnidae	*Hypnos monopterygius*	Numbfish

Family	Species name	Common name
Kyphosidae	*Girella zebra*	Zebra fish
	Kyphosus sydneyanus	Silver drummer
	Scorpis aequipinnis	Sea sweep
	Scorpis georgiana	Banded sweep
	Scorpis lineolata	Silver sweep
	Tilodon sexfasciatus	Moonlighter
Labridae	*Achoerodus gouldii*	Western blue groper
	Austrolabrus maculatus	Black-spotted wrasse
	Dotalabrus aurantiacus	Castelnaus wrasse
	Notolabrus parilus	Brown-spotted wrasse
	Notolabrus tetricus	Blue-throat wrasse
	Pictilabrus laticlavius	Senator wrasse
Monacanthidae	*Acanthaluteres brownii*	Spiny tailed leatherjacket
	Acanthaluteres vittiger	Toothbrush leatherjacket
	Brachaluteres jacksonianus	Pygmy leatherjacket
	Eubalichthys mosaicus	Mosaic leatherjacket
	Meuschenia flavolineata	Yellow-stripe leatherjacket
	Meuschenia freycineti	Six-spine leatherjacket
	Meuschenia galii	Blue-lined leatherjacket
	Meuschenia hippocrepis	Horseshoe leatherjacket
	Meuschenia venusta	Stars and stripes leatherjacket
	Scobinichthys granulatus	Rough leatherjacket
Mullidae	*Upeneichthys vlamingii*	Southern goatfish
Myliobatidae	*Myliobatis australis*	Eagle ray
Odacidae	*Haletta semifasciata*	Blue rock whiting
	Heteroscarus acroptilus	Rainbow cale
	Neoodax balteatus	Little rock whiting
	Olisthops cyanomelas	Herring cale
	Siphonognathus attenuatus	Short-nose weed-whiting
	Siphonognathus beddomei	Pencil weed whiting
	Siphonognathus caninis	Sharp-nosed weed whiting
	Siphonognathus radiatus	Long-rayed weed whiting
Ophidiidae	*Genypterus tigerinus*	Rock ling
Orectolobidae	*Orectolobus halei*	Banded wobbegong
	Sutorectus tentaculatus	Cobbler wobbegong
Ostraciidae	*Anoplocapros amygdaloides*	Western smooth boxfish
	Aracana aurita	Shaw's cowfish
	Aracana ornata	Ornate cowfish
Parascylliidae	*Parascyllium ferrugineum*	Rusty catshark
	Parascyllium variolatum	Varied catshark
Pataecidae	*Aetapcus maculatus*	Warty prowfish

Family	Species name	Common name
Pempheridae	*Pempheris klunzingeri*	Rough bullseye
	Pempheris multiradiata	Common bullseye
	Pempheris ornata	Orange-lined bullseye
	Pempheris spp.	Undifferentiated bullseye
	Parapriacanthus elongatus	Slender bullseye
Pentacerotidae	*Pentaceropsis recurvirostris*	Long-snouted boarfish
Pinguipedidae	*Parapercis haackei*	Wavy grubfish
Platycephalidae	*Leviprora inops*	Longhead flathead
	Platycephalus speculator	Yank flathead
	Thysanophrys cirronasa	Tasselsnout Flathead
Plesiopidae	*Paraplesiops meleagris*	Western blue devil
	Trachinops noarlungae	Yellow-headed hulafish
Plotosidae	*Cnidoglanis macrocephalus*	Estuary catfish
Pomacentridae	*Parma victoriae*	Victorian scalyfin
Rhinobatidae	*Trygonorrhina dumerilii*	Fiddler ray
Scorpaenidae	*Glyptauchen panduratus*	Goblinfish
Serranidae	*Hypoplectrodes nigroruber*	Banded seaperch
	Othos dentex	Harlequin fish
Sillaginidae	*Sillaginid* spp.	Undifferentiated whiting
	Sillaginodes punctatus	King George whiting
Sparidae	*Chrysophrys auratus*	Snapper
Sphyraenidae	*Sphyraena novaehollandiae*	Snook
Syngnathidae	*Maroubra perserrata*	Sawtooth pipefish
	Phycodurus eques	Leafy seadragon
Tetraodontidae	*Omegophora armilla*	Ringed toadfish
	Tetractenos glaber	Smooth toadfish
	Torquigener pleurogramma	Banded toadfish
Trachichthyidae	*Trachichthys australis*	Roughy
Tripterygiidae	*Helcogramma decurrens*	Black-throated threefin
	Lepidoblennius marmoratus	Western jumping blenny
	Trianectes bucephalus	Bighead threefin
	Trinorfolkia clarkei	Common threefin
	Trinorfolkia cristata	Crested threefin
	Tripterygiid spp.	Undifferentiated threefin
Urolophidae	*Urolophus gigas*	Spotted stingaree

Mobile invertebrates

Group	Species name	Common name
Crabs	*Austrodromidia octodentata*	Bristled sponge crab
	Jasus edwardsii	Southern rock lobster
	Naxia spp.	Spider crab
	Nectocarcinus tuberculosus	Velvet crab
	Paguristes frontalis	Southern hermit crab
	Paguroidea spp.	Undifferentiated hermit crab
	Plagusia chabrus	Red bait crab
	Portunus armatus	Blue swimmer crab
	Schizophrys aspera	Red spider crab
Sea stars	*Allostichaster polyplax*	Many-armed seastar
	Anthaster valvulatus	Mottled seastar
	Coscinasterias muricata	Eleven-arm star
	Echinaster arcystatus	Pale mosaic seastar
	Echinaster glomeratus	Orange reef star
	Fromia polypora	Many-spotted seastar
	Luidia australiae	Southern sand star
	Meridiastra calcar	Eight-armed seastar
	Meridiastra gunnii	Gunns six-armed star
	Nectria macrobrachia	Large-plated seastar
	Nectria multispina complex	Multi-spined seastar
	Nectria saoria	Saori's seastar
	Paranepanthia grandis	Grand seastar
	Pentagonaster dubeni	Fire-brick star
	Petricia vernicina	Velvet star
	Plectaster decanus	Mosaic seastar
	Pseudonepanthia troughtoni	Troughton's seastar
	Smilasterias irregularis	Irregular seastar
	Tosia australis	Southern biscuit star
	Uniophora granifera	Granular seastar
	Uniophora nuda	Bare seastar
Feather stars	*Comanthus tasmaniae*	Tasmanian feather star
	Comanthus trichoptera	Orange feather star
	Ptilometra macronema	Western passion star

Group	Species name	Common name
Urchins	*Amblypneustes elevatus*	Short-spined urchin
	Amblypneustes ovum	Short-spined urchin
	Amblypneustes pallidus	Short-spined urchin
	Centrostephanus tenuispinus	Long-spine urchin
	Goniocidaris tubaria	Pencil urchin
	Heliocidaris erythrogramma	Purple urchin
	Holopneustes porosissimus	Short-spined urchin
	Holopneustes sp. (red)	Short-spine urchin
	Phyllacanthus irregularis	Western slate-pencil urchin
Sea cucumbers	*Australostichopus mollis*	Sea cucumber
	Holothuria hartmeyeri	Sea cucumber
	Stichopus ludwigi	Sea cucumber
	Thyone okeni	Sea cucumber
Bivalves	*Equichlamys bifrons*	Queen scallop
	Mimachlamys asperrima	Doughboy scallop
	Pecten fumatus	Commercial scallop
	Pinna bicolor	Razor clam
Cephalopods	*Sepia apama*	Giant cuttlefish
Gastropods	*Amoria undulata*	Wavy volute
	Astralium spp.	Unidentified turban shell
	Bursatella spp.	Unidentified sea hare
	Cabestana spengleri	Triton shell
	Cabestana tabulata	Fringed triton
	Cassis fimbriata	Fimbriate helmet
	Conus anemone	Anemone cone
	Dicathais orbita	Dog whelk
	Doris chrysoderma	
	Fusinus australis	Spindle whelk
	Goniobranchus epicurius	
	Goniobranchus tinctorius	Red netted goniobranchus
	Haliotis cyclobates	Circular abalone
	Haliotis laevigata	Greenlip abalone
	Haliotis roei	Roe's abalone
	Haliotis rubra	Blacklip abalone
	Haliotis scalaris	Grooved abalone
	Lyria mitraeformis	Lyre shell

Group	Species name	Common name
	Mitra glabra	Black mitre
	Penion mandarinus	Mandarin whelk
	Phasianella australis	Pheasant shell
	Phasianella ventricosa	Pheasant shell
	Pleuroploca australasia	Tulip shell
	Pterynotus triformis	Triple murex
	Ranella australasia	Australian rock whelk
	Scutus antipodes	Elephant snail
	Turbo torquatus	Turban shell
	Turbo undulatus	Turban shell
	Tylodina corticalis	Umbrella shell
	Zoila friendii	Black cowrie
Opisthobranchs	*Aeolidiid* spp.	
	Ceratosoma brevicaudatum	Short tailed nudibranch
	Flabellina spp.	Nudibranch
	Hypselodoris infucata	Flame-tipped chromodorid
	Mexichromis macropus	Nudibranch
	Nudibranchia spp.	
	Pteraeolidia ianthina	Blue dragon
	Sagaminopteron ornatum	Bat-wing seaslug
Cnidarians	*Phlyctenactis tuberculosa*	Swimming anemone

D. Outputs from PRIMER/PERMANOVA+

SIMPER – macroalgal communities

SIMPER
Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Macroalgae
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 60.00%

Factor Groups
[…]
Group Northern
Average similarity: 52.78

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Macroalgae: Filamentous / filiform: Red	87.67	15.13	3.43	28.67	28.67
Drift (macroalgae or seagrass)	107.33	14.47	0.91	27.41	56.08
Coarse sand (and/or shell fragments)	68.17	10.73	1.09	20.33	76.41

Group Adelaide Metro
Average similarity: 55.47

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Coarse sand (and/or shell fragments)	87.00	15.22	5.63	27.43	27.43
Turf mat	68.75	12.67	17.85	22.83	50.26
Macroalgae: Filamentous / filiform: Red	67.00	12.48	2.14	22.50	72.76

Group Southern Metro
Average similarity: 50.71

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Turf mat	102.58	16.15	1.17	31.85	31.85
Macroalgae: Large canopy-forming: Brown	126.33	15.65	1.02	30.87	62.72

Group Yankalilla Bay
Average similarity: 57.04

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Macroalgae: Erect coarse branching: Brown	223.54	43.20	1.93	75.73	75.73

Group Backstairs Passage
Average similarity: 72.12

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Macroalgae: Erect coarse branching: Brown	285.10	62.22	3.90	86.28	86.28

Group South Coast
Average similarity: 44.68

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Macroalgae: Erect coarse branching: Brown	179.17	21.96	0.76	49.15	49.15
Macroalgae: Large canopy-forming: Brown	128.83	12.54	0.66	28.06	77.21

Group Encounter Bay
Average similarity: 54.72

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Macroalgae: Large canopy-forming: Brown	161.63	28.22	1.35	51.56	51.56
Macroalgae: Erect coarse branching: Brown	103.63	14.82	1.08	27.08	78.64

PERMANOVA – macroalgal communities, subregion by year

PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: algae
Data type: Similarity
Selection: All
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Subname	Fixed	7
SYear	Fixed	2

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Subname	6	85903	14317	11.49	0.0001	9896	0.0001
SYear	1	549.16	549.16	0.44072	0.8393	9952	0.8291
SubnamexSYear	6	2923.8	487.3	0.39108	0.9988	9889	0.9994
Res	68	84731	1246				
Total	81	1.741E5					

PAIR-WISE TESTS

Term 'Subname'

Groups	t	P(perm)	Unique perms	P(MC)
Northern, Adelaide Metro	1.2916	0.1941	4945	0.1968
Northern, Southern Metro	3.3349	0.0002	9950	0.0002
Northern, Yankalilla Bay	4.3971	0.0001	9948	0.0001
Northern, Backstairs Passage	5.3453	0.0002	9934	0.0001
Northern, South Coast	3.1015	0.002	8904	0.0008
Northern, Encounter Bay	4.3431	0.0001	9931	0.0001
Adelaide Metro, Southern Metro	2.5243	0.0025	9925	0.0034
Adelaide Metro, Yankalilla Bay	3.1845	0.0004	9944	0.0001
Adelaide Metro, Backstairs Passage	4.7878	0.0012	9798	0.0002
Adelaide Metro, South Coast	2.5061	0.0096	4926	0.0098
Adelaide Metro, Encounter Bay	3.4652	0.0003	9944	0.0001
Southern Metro, Yankalilla Bay	3.7867	0.0001	9938	0.0001
Southern Metro, Backstairs Passage	4.2693	0.0001	9952	0.0001
Southern Metro, South Coast	2.0138	0.0144	9945	0.0171
Southern Metro, Encounter Bay	2.336	0.0025	9964	0.004
Yankalilla Bay, Backstairs Passage	1.8341	0.0163	9944	0.0187
Yankalilla Bay, South Coast	2.5725	0.0009	9935	0.0002
Yankalilla Bay, Encounter Bay	4.6137	0.0001	9950	0.0001
Backstairs Passage, South Coast	2.2005	0.0192	9945	0.0247
Backstairs Passage, Encounter Bay	4.1263	0.0001	9936	0.0001
South Coast, Encounter Bay	1.2478	0.1906	9942	0.1975

SIMPER – fish communities

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Fish 4th root
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 60.00%

Factor Groups
[…]

Group Northern
Average similarity: 42.78

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Parapercis haackei	1.92	8.09	2.44	18.91	18.91
Neoodax balteatus	1.46	5.65	3.90	13.20	32.11
Siphamia cephalotes	1.81	5.07	0.77	11.84	43.95
Upeneichthys vlamingii	1.06	4.48	7.62	10.46	54.41
Chelmonops curiosus	0.90	3.41	1.36	7.98	62.39

Group Adelaide Metro
Average similarity: 63.13

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Trachinops noarlungae	5.61	10.46	5.57	16.57	16.57
Parapriacanthus elongatus	3.76	6.98	3.30	11.06	27.63
Parapercis haackei	2.33	4.92	3.97	7.79	35.43
Pempheris klunzingeri	2.80	4.63	4.67	7.34	42.77
Chelmonops curiosus	1.80	3.79	7.03	6.01	48.77
Tripterygiid spp_	1.80	3.71	8.24	5.88	54.65
Austrolabrus maculatus	1.76	3.36	5.59	5.33	59.98
Cheilodactylus nigripes	1.46	3.15	5.68	4.99	64.97

Group Southern Metro
Average similarity: 53.93

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Trachinops noarlungae	3.71	5.27	1.38	9.76	9.76
Pempheris klunzingeri	2.07	4.24	3.37	7.86	17.62
Tripterygiid spp_	1.99	3.79	1.41	7.02	24.64
Cheilodactylus nigripes	1.63	3.72	3.78	6.90	31.54
Tilodon sexfasciatus	1.45	3.23	4.81	5.99	37.53
Scorpis aequipinnis	1.91	3.06	1.37	5.67	43.20
Austrolabrus maculatus	1.45	3.04	3.56	5.64	48.84
Notolabrus parilus	1.18	2.55	1.90	4.73	53.57
Parma victoriae	1.24	2.43	1.99	4.51	58.09
Meuschenia hippocrepis	1.40	2.23	1.40	4.13	62.22

Group Yankalilla Bay
Average similarity: 44.47

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tripterygiid spp_	1.98	4.26	2.55	9.59	9.59
Trachinops noarlungae	2.94	3.87	0.91	8.70	18.28
Notolabrus parilus	1.28	2.80	2.00	6.29	24.57
Tilodon sexfasciatus	1.30	2.67	1.76	6.00	30.57
Upeneichthys vlamingii	1.27	2.50	1.68	5.63	36.21
Cheilodactylus nigripes	1.29	2.34	1.46	5.27	41.47
Notolabrus tetricus	1.19	2.07	1.17	4.65	46.12
Siphonognathus beddomei	1.42	1.90	0.92	4.28	50.40
Pictilabrus laticlavius	1.14	1.79	1.04	4.02	54.42
Austrolabrus maculatus	1.25	1.74	0.93	3.91	58.33
Parma victoriae	0.97	1.52	1.06	3.42	61.75

Group Backstairs Passage
Average similarity: 50.36

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Notolabrus tetricus	2.05	7.99	6.45	15.86	15.86
Parma victoriae	1.46	5.35	7.19	10.62	26.49
Cheilodactylus nigripes	1.26	5.10	6.31	10.13	36.62
Pictilabrus laticlavius	1.37	4.69	2.88	9.31	45.93
Meuschenia hippocrepis	1.27	3.23	1.17	6.42	52.35
Pempheris multiradiata	1.06	2.80	1.18	5.56	57.91
Scorpis aequipinnis	1.33	2.57	0.66	5.09	63.01

Group South Coast
Average similarity: 67.01

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Scorpis aequipinnis	2.70	11.21	6.74	16.73	16.73
Notolabrus tetricus	2.06	8.50	10.59	12.68	29.41
Cheilodactylus nigripes	1.52	6.71	10.09	10.02	39.43
Olisthops cyanomelas	1.73	6.45	4.50	9.63	49.06
Meuschenia hippocrepis	1.27	5.08	8.97	7.58	56.64
Pictilabrus laticlavius	1.13	4.60	6.30	6.86	63.50

Group Encounter Bay
Average similarity: 38.18

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Scorpis aequipinnis	1.66	7.24	1.73	18.96	18.96
Notolabrus tetricus	1.34	5.78	1.51	15.15	34.11
Parma victoriae	1.10	4.42	1.44	11.57	45.68
Notolabrus parilus	0.88	2.81	0.87	7.35	53.03
Cheilodactylus nigripes	0.78	2.01	0.78	5.28	58.30
Olisthops cyanomelas	0.87	2.00	0.78	5.23	63.53

PERMANOVA – fish subregion by year

PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Fish 4th root res
Data type: Similarity
Selection: All
Transform: Fourth root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Subname	Fixed	7
SYear	Fixed	2

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Subname	6	57470	9578.3	6.064	0.0001	9850	0.0001
SYear	1	1344	1344	0.85088	0.5887	9926	0.5669
SubnamexSYear	6	5556.9	926.15	0.58635	0.9977	9834	0.9971
Res	67	1.0583E5	1579.5				
Total	80	1.7102E5					

PAIR-WISE TESTS

Term 'Subname'

Groups	t	P(perm)	Unique perms	P(MC)
Northern, Adelaide Metro	1.8409	0.018	4900	0.0304
Northern, Southern Metro	3.2655	0.0001	9924	0.0001
Northern, Yankalilla Bay	2.6775	0.0002	9927	0.0001
Northern, Backstairs Passage	3.359	0.0002	9923	0.0001
Northern, South Coast	3.9421	0.0021	8922	0.0002
Northern, Encounter Bay	2.9996	0.0001	9924	0.0001
Adelaide Metro, Southern Metro	1.6811	0.011	9894	0.0231
Adelaide Metro, Yankalilla Bay	1.6923	0.024	9928	0.0214
Adelaide Metro, Backstairs Passage	2.7513	0.0008	9816	0.0009
Adelaide Metro, South Coast	4.1898	0.0042	4926	0.0004
Adelaide Metro, Encounter Bay	2.4776	0.0001	9937	0.0003
Southern Metro, Yankalilla Bay	1.6602	0.0142	9929	0.0195
Southern Metro, Backstairs Passage	2.7004	0.0001	9940	0.0001
Southern Metro, South Coast	3.0451	0.0001	9932	0.0001
Southern Metro, Encounter Bay	2.6682	0.0001	9924	0.0001
Yankalilla Bay, Backstairs Passage	2.4045	0.0002	9934	0.0002
Yankalilla Bay, South Coast	2.5794	0.0005	9915	0.0001
Yankalilla Bay, Encounter Bay	2.764	0.0001	9927	0.0001
Backstairs Passage, South Coast	1.4091	0.0866	9926	0.1005
Backstairs Passage, Encounter Bay	1.4348	0.0255	9917	0.0557
South Coast, Encounter Bay	1.2638	0.1146	9945	0.1522

SIMPER – Invertebrate and cryptic fish communities

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Inv 4th root
Data type: Abundance
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray Curtis similarity
Cut off for low contributions: 60.00%

Factor Groups
[…]

Group Northern

Average similarity: 49.75

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Stichopid spp_	1.56	9.82	6.77	19.73	19.73
Haliotis spp_	1.29	8.12	8.22	16.32	36.06
Paguristes frontalis	1.19	7.64	2.72	15.35	51.41
Equichlamys bifrons	1.12	5.37	1.32	10.79	62.20

Group Adelaide Metro
Average similarity: 72.30

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Equichlamys bifrons	2.18	7.73	15.25	10.70	10.70
Paguristes frontalis	1.93	6.89	31.49	9.53	20.22
Portunus armatus	1.60	5.76	7.13	7.96	28.18
Stichopid spp_	1.64	5.69	3.91	7.87	36.05
Phyllacanthus irregularis	1.50	5.37	8.96	7.42	43.48
Nectocarcinus spp_	1.53	4.94	4.10	6.84	50.31
Haliotis spp_	1.58	4.83	4.43	6.68	56.99
Petricia vernicina	1.42	4.76	26.36	6.59	63.58

Group Southern Metro
Average similarity: 55.19

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Heliocidaris erythrogramma	2.48	6.31	3.29	11.43	11.43
Pleuroploca australasia	1.58	4.93	6.53	8.93	20.36
Paguristes frontalis	1.52	4.78	4.55	8.65	29.01
Haliotis spp_	1.85	4.54	1.60	8.23	37.24
Petricia vernicina	1.40	4.16	4.82	7.54	44.78
Turbo undulatus	2.56	4.09	0.72	7.42	52.20
Tosia spp_	1.10	2.71	1.42	4.90	57.11
Pagurid spp_	0.97	2.37	1.38	4.29	61.39

Group Yankalilla Bay
Average similarity: 42.27

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Paguristes frontalis	1.26	6.74	1.68	15.94	15.94
Pleuroploca australasia	1.41	6.58	2.44	15.56	31.50
Tosia spp_	1.06	4.00	1.35	9.47	40.98
Phasianella spp_	0.82	2.85	0.92	6.74	47.71
Petricia vernicina	0.79	2.81	1.07	6.64	54.35
Pentagonaster dubeni	0.85	2.56	0.85	6.06	60.41

Group Backstairs Passage
Average similarity: 55.04

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Tosia spp_	1.40	5.06	4.36	9.19	9.19
Haliotis spp_	1.87	5.05	1.21	9.18	18.37
Heliocidaris erythrogramma	1.63	4.12	1.25	7.48	25.84
Pseudonepanthia troughtoni	1.31	3.90	1.68	7.09	32.93
Petricia vernicina	1.10	3.41	1.84	6.20	39.13
Plagusia chabrus	1.19	3.37	1.82	6.12	45.26
Pleuroploca australasia	1.02	2.71	1.10	4.92	50.18
Comanthus spp_	1.12	2.62	1.18	4.76	54.94
Turbo torquatus	1.32	2.36	0.65	4.29	59.24
Pagurid spp_	0.93	2.36	1.24	4.29	63.52

Group South Coast
Average similarity: 74.62

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Pseudonepanthia troughtoni	1.80	6.76	7.00	9.05	9.05
Haliotis spp_	2.16	6.47	3.31	8.67	17.72
Comanthus spp_	1.69	6.25	5.09	8.37	26.09

Heliocidaris erythrogramma	1.59	5.82	7.98	7.81	33.90
Dicathais orbita	1.53	5.57	5.88	7.47	41.37
Plagusia chabrus	1.56	5.41	4.83	7.26	48.63
Nectria saoria	1.54	5.17	4.50	6.93	55.56
Turbo torquatus	1.69	5.02	3.17	6.73	62.29

Group Encounter Bay
Average similarity: 55.43

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dicathais orbita	1.50	4.99	4.07	9.01	9.01
Heliocidaris erythrogramma	2.02	4.89	1.60	8.81	17.82
Tosia spp_	1.27	4.39	4.69	7.91	25.73
Turbo undulatus	1.66	4.14	1.41	7.47	33.20
Turbo torquatus	1.50	3.83	1.45	6.91	40.11
Comanthus spp_	1.55	3.60	1.26	6.49	46.60
Plagusia chabrus	1.25	3.59	2.28	6.48	53.08
Pleuroploca australasia	1.11	3.14	1.53	5.66	58.73
Holopneustes spp_	1.17	3.00	1.28	5.42	64.15

PERMANOVA – Mobile invertebrates and cryptic fish

PERMANOVA
Permutational MANOVA

Resemblance worksheet
Name: Inv 4th root res
Data type: Similarity
Selection: All
Transform: Fourth root
Resemblance: S17 Bray Curtis similarity

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Subname	Fixed	7
SYear	Fixed	2

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms	P(MC)
Subname	6	60603	10101	7.4379	0.0001	9858	0.0001
SYear	1	1537.5	1537.5	1.1322	0.3252	9929	0.3217
SubnamexSYear	6	1858.4	309.74	0.22808	1	9823	1
Res	68	92343	1358				
Total	81	1.5645E5					

PAIR-WISE TESTS

Term 'Subname'

Groups	t	P(perm)	Unique perms	P(MC)
Northern, Adelaide Metro	1.7601	0.0238	4932	0.0443
Northern, Southern Metro	3.0549	0.0002	9941	0.0002
Northern, Yankalilla Bay	2.6804	0.0001	9934	0.0001
Northern, Backstairs Passage	3.603	0.0003	9945	0.0001
Northern, South Coast	4.3369	0.0025	8834	0.0004

Northern, Encounter Bay	4.2686	0.0001	9925	0.0001
Adelaide Metro, Southern Metro	2.5462	0.0008	9922	0.0011
Adelaide Metro, Yankalilla Bay	2.0331	0.0018	9918	0.0008
Adelaide Metro, Backstairs Passage	3.0231	0.0011	9806	0.0011
Adelaide Metro, South Coast	5.5575	0.0044	4904	0.0003
Adelaide Metro, Encounter Bay	3.7163	0.0001	9933	0.0001
Southern Metro, Yankalilla Bay	2.148	0.0001	9926	0.0001
Southern Metro, Backstairs Passage	2.2798	0.0001	9939	0.0006
Southern Metro, South Coast	2.832	0.0001	9940	0.0005
Southern Metro, Encounter Bay	2.6623	0.0001	9925	0.0001
Yankalilla Bay, Backstairs Passage	2.449	0.0001	9913	0.0001
Yankalilla Bay, South Coast	2.7892	0.0001	9921	0.0001
Yankalilla Bay, Encounter Bay	3.1602	0.0001	9933	0.0001
Backstairs Passage, South Coast	1.448	0.0827	9939	0.1056
Backstairs Passage, Encounter Bay	1.5314	0.0198	9931	0.0337
South Coast, Encounter Bay	1.7099	0.0102	9924	0.0184

E. Baseline condition of subregions and sites in the AMLR region

Macroalgal indicators by subregion

Note: standard errors are provided in brackets where applicable for all tables in this Appendix.

Site	Mean transect macroalgal functional group richness		Percentage cover of canopy-forming macroalgae	
	2017	2018	2017	2018
Northern (1)	5.25 (0.43)	5.92 (1.09)	4.29 (2.20)	1.89 (1.60)
Adelaide Metro (2)	6.00 (0.25)	6.63 (0.38)	18.37 (18.40)	14.46 (14.50)
Southern Metro (3)	7.46 (0.96)	6.46 (0.71)	53.33 (11.50)	55.66 (11.30)
Yankalilla Bay (4)	6.13 (0.47)	6.42 (0.45)	63.40 (7.10)	69.77 (6.20)
Backstairs Passage (5)	6.85 (0.41)	7.70 (0.62)	76.71 (6.50)	72.76 (8.80)
South Coast (6)	6.33 (0.71)	6.83 (0.08)	71.99 (4.50)	82.26 (2.50)
Encounter Bay (7)	7.03 (0.64)	6.91 (0.45)	68.17 (6.00)	70.81 (7.50)

Macroalgal indicators by site

Sub-region	Site	Mean transect macroalgal functional group richness		Percentage cover of canopy-forming macroalgae	
		2017	2018	2017	2018
1	Parham Reef	6.00 (0.41)	7.25 (0.48)	6.12 (1.47)	5.14 (1.04)
	Port Gawler	4.50 (0.65)	3.75 (0.48)	0.00 (0.00)	0.00 (0.00)
	Semaphore Reef	5.25 (0.25)	6.75 (1.11)	6.75 (3.15)	0.53 (0.53)
2	Broken Bottom	5.75 (0.63)	6.25 (0.48)	0.00 (0.00)	0.00 (0.00)
	Seacliff Reef	6.25 (0.48)	7.00 (1.08)	36.73 (4.01)	28.92 (3.51)
3	Horseshoe Inside	9.50 (0.87)	7.75 (0.63)	43.92 (6.06)	62.46 (5.38)
	Noarlunga North Outside	9.00 (0.41)	7.75 (0.85)	25.06 (3.25)	47.93 (5.53)
	Noarlunga South Outside	8.75 (0.63)	8.25 (0.95)	24.93 (6.34)	26.92 (12.44)
	Southport	5.75 (0.48)	5.75 (0.48)	52.94 (1.11)	25.46 (3.79)
	Moana Outside	3.50 (0.87)	3.75 (0.63)	92.35 (4.96)	96.16 (1.97)
	Aldinga Pinnacles	8.25 (0.75)	5.50 (1.04)	80.78 (4.64)	75.04 (9.31)
4	Myponga Reef	6.50 (0.87)	7.50 (0.65)	31.93 (4.97)	40.65 (2.28)
	Carrickalinga North3	6.00 (0.82)	5.50 (0.65)	66.62 (11.38)	78.18 (1.57)
	Ripple Rock	8.00 (0.41)	8.75 (1.11)	67.89 (5.28)	83.08 (7.84)
	Carrickalinga Head	8.00 (0.71)	7.75 (0.25)	60.77 (14.85)	74.63 (4.06)
	Shag Rock Carrickalinga	9.00 (0.71)	7.25 (0.75)	57.50 (5.81)	74.75 (4.53)
	Dodd's Beach	8.25 (0.75)	7.00 (0.00)	72.17 (3.70)	78.70 (1.99)
	Carrickalinga South Bay	4.50 (0.29)	6.50 (0.65)	96.22 (0.75)	79.05 (6.84)
	Normanville Beach	4.25 (0.48)	3.50 (0.96)	91.78 (1.24)	95.97 (2.20)
	South Shores	4.75 (0.48)	5.75 (0.25)	46.06 (11.13)	68.25 (4.90)
	Yankalilla Mouth	4.00 (0.71)	4.25 (0.85)	41.13 (8.23)	57.22 (9.69)
	Lady Bay	6.25 (0.25)	7.00 (0.41)	66.41 (5.52)	64.12 (9.22)
	Rapid Bay Jetty	6.80 (0.37)	7.60 (0.87)	3.85 (1.19)	7.07 (2.45)
	Rapid Head East	3.33 (1.45)	3.50 (0.96)	96.39 (3.10)	97.27 (2.11)
	Rapid Head Windmill	6.25 (0.48)	8.00 (0.41)	88.87 (4.05)	77.90 (5.55)
5	Cape Jervis South	8.00 (1.08)	9.25 (0.75)	79.79 (5.00)	42.90 (4.57)
	Fishery Beach	5.50 (1.44)	8.75 (1.11)	92.02 (2.45)	87.71 (2.07)
	Porpoise Head	6.75 (0.25)	7.75 (0.75)	52.75 (5.39)	62.53 (4.74)
	Deep Creek	7.25 (0.48)	5.75 (0.48)	78.25 (3.64)	86.66 (2.88)
	Backstairs Deep	6.75 (0.63)	7.00 (0.91)	80.74 (2.99)	83.99 (2.57)
6	Newland Head	7.75 (1.11)	6.75 (1.44)	64.64 (8.50)	83.00 (4.53)
	Flat Irons	5.75 (0.25)	7.00 (0.58)	80.25 (4.13)	86.25 (1.89)
	West Island Outer	5.50 (0.65)	6.75 (1.03)	71.09 (6.02)	77.53 (4.96)
7	The Bluff	6.75 (0.63)	6.00 (0.91)	82.97 (4.87)	84.50 (4.70)
	Whalebone	8.75 (0.25)	6.75 (1.31)	76.25 (2.67)	88.02 (2.53)
	Encounter Deep	6.00 (0.82)	5.25 (0.85)	83.84 (2.68)	86.87 (4.12)
	Outside Granite Island	6.50 (0.50)	6.75 (0.25)	76.75 (1.49)	76.00 (4.53)
	Olivers Reef	6.00 (0.41)	7.75 (0.85)	72.73 (10.23)	84.38 (3.57)
	Chiton Rocks	10.75 (0.48)	9.50 (0.29)	33.10 (5.97)	27.47 (6.38)
	Port Elliot Deep	5.50 (0.29)	6.50 (0.65)	56.55 (6.95)	63.29 (2.55)
	Basham's Beach	6.00 (0.41)	6.75 (0.63)	63.18 (2.46)	55.91 (9.22)

Fish indicators by subregion

Site	Mean transect fish richness		Site fish richness	
	2017	2018	2017	2018
Northern (1)	8.33 (0.87)	5.83 (0.08)	16.67 (1.76)	12.67 (1.20)
Adelaide Metro (2)	17.75 (3.75)	14.00 (4.25)	28.00 (5.00)	24.50 (7.50)
Southern Metro (3)	15.38 (2.27)	16.13 (2.53)	27.50 (2.36)	27.17 (3.48)
Yankalilla Bay (4)	13.97 (1.73)	14.40 (1.62)	24.64 (2.78)	24.86 (2.21)
Backstairs Passage (5)	9.60 (1.04)	10.20 (1.44)	16.80 (1.24)	20.00 (2.30)
South Coast (6)	9.25 (0.63)	9.50 (0.52)	16.00 (0.58)	16.67 (0.67)
Encounter Bay (7)	6.31 (1.94)	7.28 (1.93)	12.75 (3.34)	13.75 (3.02)

Site	Large fish biomass		Targeted fish biomass		Community temperature index	
	2017	2018	2017	2018	2017	2018
Northern (1)	381.83 (131.86)	194.86 (155.46)	282.01 (152.49)	364.63 (346.60)	17.87 (0.43)	18.37 (0.19)
Adelaide Metro (2)	2151.8 (1005.2)	1829.0 (1097.7)	1182.54 (565.86)	1277.1 (792.16)	18.43 (0.02)	18.47 (0.06)
Southern Metro (3)	5893.8 (1610.4)	8093.0 (3071.3)	3098.90 (654.42)	4961.4 (2052.5)	18.24 (0.06)	18.27 (0.09)
Yankalilla Bay (4)	3675.8 (1650.3)	4669.5 (1363.3)	2102.85 (742.34)	2271.9 (646.07)	18.03 (0.06)	18.08 (0.12)
Backstairs Passage (5)	3748.1 (1484.6)	5132.3 (2024.8)	2639.12 (588.61)	3852.0 (1606.1)	17.69 (0.07)	17.51 (0.14)
South Coast (6)	3672.82 (838.1)	4908.0 (1764.5)	3366.07 (559.62)	3230.25 (881.0)	17.61 (0.03)	17.55 (0.10)
Encounter Bay (7)	2304.6 (1289.7)	2676.4 (1565.3)	1263.60 (564.48)	2023.7 (1184.1)	17.74 (0.19)	17.81 (0.09)

Site	Blue groper		Blue devil	
	2017	2018	2017	2018
Northern (1)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Adelaide Metro (2)	0.00 (0.00)	0.00 (0.00)	0.56 (0.56)	0.75 (0.75)
Southern Metro (3)	0.00 (0.00)	0.00 (0.00)	0.08 (0.06)	0.06 (0.04)
Yankalilla Bay (4)	0.00 (0.00)	0.01 (0.01)	0.11 (0.04)	0.08 (0.07)
Backstairs Passage (5)	0.03 (0.03)	0.08 (0.08)	0.00 (0.00)	0.03 (0.03)
South Coast (6)	0.08 (0.04)	0.21 (0.21)	0.00 (0.00)	0.00 (0.00)
Encounter Bay (7)	0.11 (0.09)	0.11 (0.08)	0.00 (0.00)	0.00 (0.00)

Site	Bluethroat wrasse		Sea sweep	
	2017	2018	2017	2018
Northern (1)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Adelaide Metro (2)	0.44 (0.44)	0.31 (0.31)	0.00 (0.00)	0.00 (0.00)
Southern Metro (3)	0.52 (0.27)	0.63 (0.34)	7.60 (2.28)	7.56 (4.86)
Yankalilla Bay (4)	1.23 (0.29)	1.21 (0.33)	2.42 (1.09)	3.79 (1.49)
Backstairs Passage (5)	4.33 (1.05)	5.35 (1.34)	5.53 (2.50)	3.35 (2.25)
South Coast (6)	5.92 (2.52)	4.38 (1.34)	16.08 (2.17)	13.33 (6.05)
Encounter Bay (7)	1.73 (0.85)	2.64 (2.08)	3.48 (1.33)	3.13 (1.14)

Fish indicators by site

Sub-region	Site	Visibility		Mean transect fish richness		Site fish richness	
		2017	2018	2017	2018	2017	2018
1	Parham Reef	8	5	9.75 (0.85)	5.75 (0.48)	16	11
	Port Gawler	5	5	6.75 (1.65)	5.75 (1.55)	14	15
	Semaphore Reef	10	5	8.50 (0.65)	6.25 (1.11)	20	13
2	Broken Bottom	11	8	14.00 (2.35)	9.75 (1.03)	23	17
	Seacliff Reef	10	12	21.50 (3.28)	18.25 (2.39)	33	32
3	Horseshoe Inside	12	8	12.00 (1.96)	9.75 (1.31)	25	19
	Noarlunga North Outside	9	12	17.25 (1.03)	23.00 (1.29)	26	34
	Noarlunga South Outside	10	8	15.25 (1.65)	17.25 (1.31)	27	27
	Southport	7	8	7.00 (1.96)	7.50 (1.55)	19	15
	Moana Outside	7	15	17.25 (3.35)	18.25 (1.70)	33	32
	Aldinga Pinnacles	8	12	23.50 (0.96)	21.00 (1.78)	35	36
4	Myponga Reef	8	12	10.25 (1.31)	14.25 (1.60)	19	28
	Carrickalinga North3	6.5	9	21.00 (1.68)	14.00 (1.15)	34	24
	Ripple Rock	7	7	16.50 (1.55)	19.75 (1.65)	26	32
	Carrickalinga Head	5	7	16.25 (2.10)	9.50 (1.32)	30	18
	Shag Rock Carrickalinga	7	10	13.50 (0.65)	19.50 (0.96)	23	29
	Dodd's Beach	10	10	15.75 (2.06)	17.00 (1.68)	25	26
	Carrickalinga South Bay	7	10	18.00 (1.87)	18.50 (0.65)	31	28
	Normanville Beach	6	16	3.50 (1.04)	6.25 (1.03)	9	17
	South Shores	5	15	8.00 (1.29)	11.25 (2.25)	17	21
	Yankalilla Mouth	6	12	2.25 (0.75)	2.75 (0.85)	6	7
	Lady Bay	12	12	11.25 (1.18)	13.00 (1.68)	20	23
	Rapid Bay Jetty	8	12	23.60 (2.25)	26.60 (1.86)	40	43
	Rapid Head East	10.75	7	22.25 (2.69)	17.25 (2.06)	42	29
	Rapid Head Windmill	8	10	13.50 (1.55)	12.00 (1.29)	23	23
5	Cape Jervis South	8	8	12.25 (0.75)	7.75 (0.95)	20	15
	Fishery Beach	5	10	7.75 (1.70)	6.00 (1.08)	16	14
	Porpoise Head	4	8	8.50 (0.50)	13.00 (0.82)	13	22
	Deep Creek	5	10	12.00 (0.41)	13.25 (1.11)	19	25
	Backstairs Deep	5	10	7.50 (1.19)	11.00 (1.78)	16	24
6	Newland Head	5	6	10.50 (0.50)	9.75 (0.48)	15	16
	Flat Irons	5	8	8.75 (1.11)	8.50 (0.65)	16	16
	West Island Outer	5	12	8.50 (1.19)	10.25 (1.38)	17	18
7	The Bluff	5	5	13.50 (0.96)	13.50 (2.72)	28	29
	Whalebone	5	9	14.75 (0.63)	17.00 (0.71)	23	21
	Encounter Deep	5	6	2.50 (0.96)	4.75 (1.80)	8	13
	Outside Granite Island	5	6	7.50 (1.32)	6.00 (0.71)	14	13
	Olivers Reef	5	6	7.00 (1.78)	8.00 (1.83)	16	16
	Chiton Rocks	6	5	4.25 (1.31)	4.25 (0.25)	9	8
	Port Elliot Deep (2018 only)	2	4	0.00 (0.00)	4.50 (0.29)		9
	Basham's Beach	4	4	1.00 (1.00)	0.25 (0.25)	4	1

Sub-region	Site	Large fish biomass		Targeted fish biomass		Community temperature index	
		2017	2018	2017	2018	2017	2018
1	Parham Reef	0.50 (0.44)	0.04 (0.04)	0.16 (0.15)	0.01 (0.01)	18.22 (0.09)	17.99 (0.03)
	Port Gawler	0.53 (0.32)	0.51 (0.22)	0.59 (0.35)	1.06 (0.50)	18.44 (0.07)	18.47 (0.10)
	Semaphore Reef	0.12 (0.09)	0.04 (0.04)	0.10 (0.09)	0.03 (0.03)	18.36 (0.24)	18.64 (0.21)
2	Broken Bottom	1.15 (0.67)	0.73 (0.49)	0.62 (0.38)	0.48 (0.32)	18.46 (0.20)	18.41 (0.09)
	Seacliff Reef	3.16 (0.91)	2.93 (1.14)	1.75 (0.56)	2.07 (0.66)	18.41 (0.09)	18.52 (0.11)
3	Horseshoe Inside	3.04 (1.63)	2.70 (1.30)	3.09 (1.54)	1.62 (0.34)	18.09 (0.12)	17.87 (0.20)
	Noarlunga North Outside	12.4 (2.01)	13.6 (2.17)	4.33 (0.50)	8.55 (2.81)	18.25 (0.03)	18.30 (0.07)
	Noarlunga South Outside	6.9 (0.88)	18.3 (8.91)	4.63 (0.52)	13.3 (7.04)	18.29 (0.07)	18.43 (0.05)
	Southport	1.98 (1.93)	0.11 (0.11)	0.72 (0.67)	0.15 (0.10)	18.52 (0.16)	18.53 (0.16)
	Moana Outside	3.18 (0.83)	1.75 (0.91)	1.64 (0.53)	1.82 (0.67)	18.16 (0.12)	18.20 (0.09)
	Aldinga Pinnacles	7.87 (0.36)	12.2 (3.26)	4.18 (0.66)	4.36 (0.90)	18.16 (0.07)	18.29 (0.02)
4	Myponga Reef	0.83 (0.21)	0.72 (0.21)	0.54 (0.13)	0.84 (0.11)	18.10 (0.03)	17.91 (0.22)
	Carrickalinga North3	0.66 (0.24)	0.83 (0.39)	0.91 (0.21)	0.78 (0.41)	17.73 (0.10)	18.09 (0.04)
	Ripple Rock	4.71 (1.92)	8.15 (1.79)	5.18 (1.53)	5.93 (0.86)	17.94 (0.06)	18.01 (0.06)
	Carrickalinga Head	2.80 (1.20)	5.64 (2.84)	1.89 (0.74)	1.56 (0.90)	18.14 (0.09)	17.90 (0.26)
	Shag Rock Carrickalinga	23.3 (10.2)	16.2 (7.36)	3.32 (0.90)	4.72 (1.46)	18.14 (0.11)	17.99 (0.07)
	Dodd's Beach	1.50 (0.17)	0.63 (0.15)	1.48 (0.34)	0.96 (0.20)	17.85 (0.13)	17.87 (0.10)
	Carrickalinga South Bay	4.63 (1.79)	13.9 (5.57)	2.00 (0.40)	1.89 (1.04)	18.06 (0.06)	18.11 (0.07)
	Normanville Beach	0.49 (0.42)	0.23 (0.08)	0.49 (0.42)	0.13 (0.08)	18.58 (0.34)	19.37 (0.32)
	South Shores	0.66 (0.16)	3.84 (1.31)	0.43 (0.10)	2.36 (1.07)	18.18 (0.26)	18.14 (0.10)
	Yankalilla Mouth	0.04 (0.02)	0.00 (0.00)	0.02 (0.02)	0.04 (0.04)	18.00 (0.50)	17.35 (0.41)
	Lady Bay	0.73 (0.41)	1.61 (0.46)	0.53 (0.16)	1.00 (0.31)	17.73 (0.10)	18.34 (0.18)
	Rapid Bay Jetty	9.30 (5.68)	6.62 (1.74)	10.49 (7.48)	8.42 (3.29)	18.17 (0.05)	18.23 (0.03)
	Rapid Head East	1.16 (0.77)	2.41 (0.76)	1.49 (0.43)	1.44 (0.48)	17.80 (0.16)	17.90 (0.04)
	Rapid Head Windmill	0.70 (0.28)	4.61 (3.20)	0.66 (0.34)	1.74 (0.19)	17.92 (0.09)	17.90 (0.12)
5	Cape Jervis South	1.37 (0.40)	1.32 (0.73)	1.27 (0.50)	1.67 (0.70)	17.92 (0.13)	17.29 (0.10)
	Fishery Beach	1.15 (0.56)	1.22 (0.51)	1.32 (0.61)	1.13 (0.61)	17.54 (0.06)	17.08 (0.15)
	Porpoise Head	2.93 (0.49)	12.3 (2.14)	2.81 (0.30)	10.3 (1.76)	17.67 (0.11)	17.75 (0.05)
	Deep Creek	9.31 (3.70)	6.22 (2.20)	3.67 (0.87)	3.05 (0.32)	17.73 (0.01)	17.72 (0.03)
	Backstairs Deep	3.99 (1.36)	4.65 (1.00)	4.13 (1.34)	3.35 (0.67)	17.59 (0.27)	17.73 (0.10)
6	Newland Head	5.34 (0.80)	5.58 (1.42)	4.48 (0.78)	4.82 (1.28)	17.56 (0.09)	17.57 (0.02)
	Flat Irons	2.95 (0.79)	1.57 (0.33)	2.78 (0.39)	1.78 (0.17)	17.65 (0.08)	17.37 (0.04)
	West Island Outer	2.73 (0.75)	7.57 (2.40)	2.83 (0.76)	3.09 (1.72)	17.61 (0.07)	17.72 (0.05)
7	The Bluff	2.67 (0.75)	1.96 (1.23)	1.27 (0.10)	0.51 (0.25)	17.84 (0.07)	18.02 (0.31)
	Whalebone	10.8 (3.01)	13.5 (1.99)	4.75 (0.59)	10.2 (0.98)	18.00 (0.08)	18.00 (0.03)
	Encounter Deep	0.82 (0.75)	0.83 (0.41)	0.95 (0.92)	0.54 (0.33)	17.77 (0.32)	17.84 (0.11)
	Outside Granite Island	3.46 (0.66)	1.40 (0.09)	2.27 (0.75)	1.02 (0.33)	17.84 (0.12)	17.93 (0.27)
	Olivers Reef	0.55 (0.37)	1.84 (0.91)	0.53 (0.28)	1.97 (0.85)	17.97 (0.22)	17.64 (0.27)
	Chiton Rocks	0.11 (0.08)	0.36 (0.18)	0.22 (0.14)	0.36 (0.14)	18.12 (0.28)	17.57 (0.08)
	Port Elliot Deep (2018 only)	0.00 (0.00)	0.85 (0.13)	0.00 (0.00)	0.94 (0.13)		17.36 (0.11)
	Basham's Beach	0.09 (0.09)	0.63 (0.63)	0.11 (0.11)	0.63 (0.63)	16.65	18.14

Sub-region	Site	Blue groper		Blue devil	
		2017	2018	2017	2018
1	Parham Reef	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Port Gawler	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Semaphore Reef	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2	Broken Bottom	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Seacliff Reef	0.00 (0.00)	0.00 (0.00)	1.13 (0.55)	1.50 (0.74)
3	Horseshoe Inside	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Noarlunga North Outside	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Noarlunga South Outside	0.00 (0.00)	0.00 (0.00)	0.38 (0.38)	0.00 (0.00)
	Southport	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Moana Outside	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)
	Aldinga Pinnacles	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.25 (0.14)
4	Myponga Reef	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)
	Carrickalinga North3	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)
	Ripple Rock	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)
	Carrickalinga Head	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)
	Shag Rock Carrickalinga	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Dodd's Beach	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)
	Carrickalinga South Bay	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)
	Normanville Beach	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	South Shores	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Yankalilla Mouth	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Lady Bay	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Rapid Bay Jetty	0.00 (0.00)	0.00 (0.00)	0.10 (0.10)	0.00 (0.00)
	Rapid Head East	0.00 (0.00)	0.00 (0.00)	0.25 (0.14)	0.00 (0.00)
	Rapid Head Windmill	0.00 (0.00)	0.13 (0.13)	0.50 (0.29)	1.00 (0.54)
5	Cape Jervis South	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Fishery Beach	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Porpoise Head	0.13 (0.13)	0.38 (0.24)	0.00 (0.00)	0.00 (0.00)
	Deep Creek	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)
	Backstairs Deep	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
6	Newland Head	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Flat Irons	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	West Island Outer	0.13 (0.13)	0.63 (0.38)	0.00 (0.00)	0.00 (0.00)
7	The Bluff	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Whalebone	0.75 (0.48)	0.63 (0.31)	0.00 (0.00)	0.00 (0.00)
	Encounter Deep	0.00 (0.00)	0.25 (0.25)	0.00 (0.00)	0.00 (0.00)
	Outside Granite Island	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Olivers Reef	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Chiton Rocks	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Port Elliot Deep (2018 only)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Basham's Beach	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

Sub-region	Site	Bluethroat wrasse		Sea sweep	
		2017	2018	2017	2018
1	Parham Reef	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Port Gawler	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Semaphore Reef	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2	Broken Bottom	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Seacliff Reef	0.88 (0.31)	0.63 (0.38)	0.00 (0.00)	0.00 (0.00)
3	Horseshoe Inside	0.50 (0.50)	0.50 (0.35)	9.38 (5.43)	2.00 (0.20)
	Noarlunga North Outside	0.13 (0.13)	0.50 (0.20)	11.38 (2.24)	6.50 (1.08)
	Noarlunga South Outside	0.00 (0.00)	0.00 (0.00)	15.25 (4.12)	31.50 (4.82)
	Southport	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Moana Outside	0.63 (0.31)	0.50 (0.29)	3.00 (0.41)	3.00 (0.79)
	Aldinga Pinnacles	1.75 (0.83)	2.25 (1.11)	6.63 (2.44)	2.38 (0.90)
4	Myponga Reef	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Carrickalinga North3	0.38 (0.24)	0.00 (0.00)	0.00 (0.00)	3.13 (1.88)
	Ripple Rock	2.13 (1.23)	2.25 (0.32)	12.88 (5.21)	19.00 (5.22)
	Carrickalinga Head	1.75 (0.72)	0.50 (0.35)	3.38 (1.25)	7.50 (3.80)
	Shag Rock Carrickalinga	0.88 (0.13)	1.25 (0.52)	9.88 (4.13)	11.50 (5.13)
	Dodd's Beach	1.13 (0.38)	0.75 (0.32)	1.88 (0.66)	4.38 (1.07)
	Carrickalinga South Bay	1.13 (0.24)	1.38 (0.55)	0.75 (0.75)	0.00 (0.00)
	Normanville Beach	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	South Shores	0.50 (0.50)	1.00 (0.84)	0.00 (0.00)	0.00 (0.00)
	Yankalilla Mouth	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Lady Bay	1.75 (0.43)	1.50 (0.87)	0.63 (0.38)	0.75 (0.75)
	Rapid Bay Jetty	0.90 (0.29)	1.80 (0.25)	0.30 (0.20)	0.40 (0.29)
	Rapid Head East	3.75 (0.85)	1.88 (0.55)	4.25 (2.22)	4.38 (1.65)
	Rapid Head Windmill	2.75 (1.45)	4.63 (1.75)	0.00 (0.00)	2.00 (2.00)
5	Cape Jervis South	3.75 (0.92)	3.25 (1.05)	0.00 (0.00)	0.00 (0.00)
	Fishery Beach	2.38 (0.75)	5.00 (1.68)	0.00 (0.00)	0.00 (0.00)
	Porpoise Head	5.38 (0.72)	10.25 (1.56)	9.63 (1.36)	4.00 (1.34)
	Deep Creek	7.88 (1.60)	5.63 (1.43)	12.38 (3.58)	0.88 (0.13)
	Backstairs Deep	2.25 (1.03)	2.63 (0.59)	5.63 (3.78)	11.88 (3.78)
6	Newland Head	10.63 (1.91)	6.75 (2.09)	20.00 (4.29)	24.25 (5.75)
	Flat Irons	5.13 (1.01)	2.13 (0.13)	12.50 (4.13)	3.38 (1.09)
	West Island Outer	2.00 (0.54)	4.25 (2.03)	15.75 (4.30)	12.38 (3.20)
7	The Bluff	0.13 (0.13)	0.13 (0.13)	5.38 (1.25)	1.00 (0.35)
	Whalebone	6.88 (0.63)	17.13 (4.23)	7.88 (1.42)	6.50 (2.21)
	Encounter Deep	0.13 (0.13)	0.63 (0.47)	4.00 (3.84)	1.63 (1.01)
	Outside Granite Island	3.38 (1.95)	0.13 (0.13)	9.38 (2.68)	9.50 (1.14)
	Olivers Reef	0.88 (0.43)	1.63 (0.90)	1.00 (0.46)	2.88 (1.91)
	Chiton Rocks	2.25 (1.30)	0.88 (0.24)	0.13 (0.13)	1.13 (0.83)
	Port Elliot Deep (2018 only)	0.00 (0.00)	0.63 (0.24)	0.00 (0.00)	2.38 (0.77)
	Basham's Beach	0.25 (0.25)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)

Mobile invertebrate indicators by subregion

Site	Mean transect invertebrate richness		Site invertebrate richness	
	2017	2018	2017	2018
Northern (1)	7.50 (1.80)	7.50 (1.52)	15.67 (3.38)	13.67 (1.20)
Adelaide Metro (2)	13.88 (1.63)	13.63 (2.38)	23.50 (0.50)	22.00 (1.00)
Southern Metro (3)	13.08 (1.56)	13.25 (1.19)	22.83 (2.24)	21.67 (1.61)
Yankalilla Bay (4)	7.10 (0.83)	8.09 (0.97)	15.64 (1.45)	16.29 (1.79)
Backstairs Passage (5)	11.35 (1.79)	13.65 (1.69)	19.80 (2.87)	21.80 (2.48)
South Coast (6)	12.83 (1.97)	12.75 (2.53)	18.67 (2.33)	20.33 (2.96)
Encounter Bay (7)	12.34 (1.42)	11.97 (1.02)	20.13 (1.99)	20.00 (1.28)

Site	Abalone abundance		Rock lobster abundance		Purple urchin abundance	
	2017	2018	2017	2018	2017	2018
Northern (1)	0.96 (0.33)	0.63 (0.26)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Adelaide Metro (2)	2.69 (1.69)	1.56 (1.31)	0.00 (0.00)	0.00 (0.00)	0.44 (0.44)	0.19 (0.19)
Southern Metro (3)	8.50 (4.75)	5.25 (2.23)	0.00 (0.00)	0.00 (0.00)	27.75 (15.30)	14.83 (8.23)
Yankalilla Bay (4)	0.33 (0.12)	0.38 (0.16)	0.04 (0.02)	0.06 (0.03)	0.03 (0.01)	0.43 (0.36)
Backstairs Passage (5)	7.38 (2.90)	5.68 (1.95)	0.53 (0.22)	0.40 (0.16)	3.53 (1.67)	4.73 (1.58)
South Coast (6)	10.46 (3.24)	6.46 (5.48)	0.79 (0.61)	0.29 (0.29)	1.46 (0.44)	1.92 (0.15)
Encounter Bay (7)	1.17 (0.64)	0.42 (0.19)	1.03 (0.32)	0.45 (0.19)	15.03 (7.35)	9.42 (4.92)

Mobile invertebrate indicators by site

Sub-region	Site	Mean transect invertebrate richness		Site invertebrate richness	
		2017	2018	2017	2018
1	Parham Reef	10.00 (0.46)	10.25 (0.55)	20	16
	Port Gawler	4.00 (0.20)	5.00 (0.54)	9	12
	Semaphore Reef	8.50 (0.78)	7.25 (0.52)	18	13
2	Broken Bottom	15.50 (0.52)	16.00 (0.58)	24	23
	Seacliff Reef	12.25 (0.52)	11.25 (0.55)	23	21
3	Horseshoe Inside	18.50 (0.43)	16.25 (0.43)	29	24
	Noarlunga North Outside	13.75 (0.43)	16.75 (0.13)	22	24
	Noarlunga South Outside	10.75 (0.38)	10.00 (0.35)	16	15
	Southport	9.50 (0.43)	12.25 (0.75)	17	21
	Moana Outside	16.50 (0.32)	14.00 (0.35)	28	26
	Aldinga Pinnacles	9.50 (0.52)	10.25 (0.97)	25	20
4	Myponga Reef	6.50 (0.78)	9.50 (0.43)	15	19
	Carrickalinga North3	8.00 (1.06)	6.00 (0.98)	18	13
	Ripple Rock	6.25 (0.63)	9.75 (0.13)	18	18
	Carrickalinga Head	10.00 (0.74)	7.50 (0.43)	18	14
	Shag Rock Carrickalinga	8.00 (0.74)	11.75 (1.03)	15	23
	Dodd's Beach	8.75 (0.24)	7.75 (1.09)	20	17
	Carrickalinga South Bay	5.00 (0.20)	5.50 (0.48)	11	12
	Normanville Beach	7.25 (0.13)	5.50 (0.48)	15	11
	South Shores	4.75 (0.94)	5.50 (0.60)	14	13
	Yankalilla Mouth	0.50 (0.25)	0.75 (0.13)	2	1
	Lady Bay	5.75 (0.31)	6.75 (0.94)	13	15
	Rapid Bay Jetty	14.20 (0.67)	15.80 (0.43)	26	28
	Rapid Head East	5.75 (0.31)	10.25 (0.38)	14	19
	Rapid Head Windmill	8.75 (1.14)	11.00 (0.89)	20	25
5	Cape Jervis South	8.25 (0.55)	9.00 (0.74)	16	17
	Fishery Beach	11.75 (0.83)	14.50 (0.25)	20	22
	Porpoise Head	6.50 (1.27)	11.25 (0.63)	12	18
	Deep Creek	14.00 (0.54)	14.50 (0.66)	22	21
	Backstairs Deep	16.25 (0.69)	19.00 (0.46)	29	31
6	Newland Head	12.25 (0.31)	12.50 (0.66)	18	19
	Flat Irons	16.50 (0.48)	17.25 (0.52)	23	26
	West Island Outer	9.75 (0.43)	8.50 (0.78)	15	16
7	The Bluff	13.75 (0.63)	14.50 (0.72)	23	23
	Whalebone	16.75 (0.43)	15.50 (0.43)	22	21
	Encounter Deep	11.00 (0.35)	10.00 (0.54)	19	19
	Outside Granite Island	14.25 (0.43)	11.50 (0.43)	18	17
	Olivers Reef	18.00 (1.14)	15.50 (0.43)	32	26
	Chiton Rocks	6.50 (0.66)	7.75 (0.13)	14	20
	Port Elliot Deep	10.00 (0.20)	11.25 (0.13)	16	20
	Basham's Beach	8.50 (0.43)	9.75 (0.43)	17	14

Sub-region	Site	Abalone abundance		Lobster abundance		Purple urchin abundance	
		2017	2018	2017	2018	2017	2018
1	Parham Reef	1.50 (0.79)	1.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Port Gawler	0.38 (0.24)	0.25 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Semaphore Reef	1.00 (0.20)	0.50 (0.20)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
2	Broken Bottom	4.38 (0.59)	2.88 (0.47)	0.00 (0.00)	0.00 (0.00)	0.88 (0.55)	0.38 (0.13)
	Seacliff Reef	1.00 (0.84)	0.25 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
3	Horseshoe Inside	10.13 (5.01)	8.75 (4.60)	0.00 (0.00)	0.00 (0.00)	95.50 (24.3)	54.00 (15.2)
	Noarlunga North Outside	6.00 (1.51)	6.38 (2.24)	0.00 (0.00)	0.00 (0.00)	5.75 (0.66)	5.13 (2.3)
	Noarlunga South Outside	31.00 (3.41)	13.88 (3.63)	0.00 (0.00)	0.00 (0.00)	17.50 (2.79)	9.50 (1.34)
	Southport	3.13 (0.94)	2.25 (0.60)	0.00 (0.00)	0.00 (0.00)	0.63 (0.63)	2.13 (1.66)
	Moana Outside	0.63 (0.24)	0.25 (0.14)	0.00 (0.00)	0.00 (0.00)	46.75 (13.2)	17.75 (10.6)
	Aldinga Pinnacles	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.38 (0.38)	0.50 (0.35)
4	Myponga Reef	0.00 (0.00)	1.13 (0.38)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Carrickalinga North3	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Ripple Rock	0.13 (0.13)	0.38 (0.24)	0.00 (0.00)	0.25 (0.25)	0.00 (0.00)	0.00 (0.00)
	Carrickalinga Head	0.88 (0.72)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)
	Shag Rock Carrickalinga	0.25 (0.25)	0.38 (0.24)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)
	Dodd's Beach	0.25 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Carrickalinga South Bay	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Normanville Beach	0.38 (0.13)	0.88 (0.24)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	South Shores	0.25 (0.25)	0.00 (0.00)	0.00 (0.00)	0.25 (0.25)	0.00 (0.00)	0.25 (0.25)
	Yankalilla Mouth	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Lady Bay	0.00 (0.00)	0.00 (0.00)	0.25 (0.25)	0.00 (0.00)	0.13 (0.13)	5.13 (4.96)
	Rapid Bay Jetty	1.30 (0.54)	2.00 (0.35)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Rapid Head East	0.00 (0.00)	0.13 (0.13)	0.25 (0.14)	0.25 (0.25)	0.13 (0.13)	0.63 (0.31)
	Rapid Head Windmill	1.25 (0.95)	0.38 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5	Cape Jervis South	0.00 (0.00)	0.00 (0.00)	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	Fishery Beach	5.38 (1.74)	6.50 (1.24)	0.63 (0.47)	0.75 (0.32)	1.88 (0.97)	6.25 (1.11)
	Porpoise Head	6.13 (2.20)	11.75 (1.36)	0.00 (0.00)	0.00 (0.00)	1.00 (0.46)	2.00 (0.35)
	Deep Creek	17.75 (6.15)	6.75 (2.37)	0.63 (0.47)	0.63 (0.31)	8.88 (4.60)	8.13 (1.42)
	Backstairs Deep	7.63 (2.68)	3.38 (0.94)	1.25 (0.63)	0.63 (0.24)	5.88 (1.25)	7.25 (1.71)
6	Newland Head	11.25 (1.27)	1.75 (0.66)	0.13 (0.13)	0.00 (0.00)	1.38 (0.38)	1.63 (0.85)
	Flat Irons	15.63 (3.22)	17.38 (4.32)	2.00 (0.87)	0.88 (0.59)	2.25 (0.43)	2.13 (0.55)
	West Island Outer	4.50 (1.58)	0.25 (0.25)	0.25 (0.25)	0.00 (0.00)	0.75 (0.25)	2.00 (1.51)
7	The Bluff	3.88 (1.74)	1.00 (0.46)	2.75 (0.66)	1.38 (0.43)	12.13 (3.50)	2.38 (1.25)
	Whalebone	0.13 (0.13)	0.00 (0.00)	0.88 (0.24)	1.13 (0.38)	44.88 (5.41)	26.38 (2.68)
	Encounter Deep	0.00 (0.00)	0.00 (0.00)	0.25 (0.25)	0.00 (0.00)	1.75 (0.83)	0.38 (0.24)
	Outside Granite Island	4.25 (1.44)	1.38 (0.66)	1.25 (0.92)	0.75 (0.75)	4.13 (2.53)	2.38 (1.72)
	Olivers Reef	0.50 (0.20)	0.00 (0.00)	0.50 (0.35)	0.13 (0.13)	51.25 (11.6)	36.38 (6.85)
	Chiton Rocks	0.00 (0.00)	0.25 (0.14)	0.75 (0.32)	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)
	Port Elliot Deep	0.50 (0.50)	0.75 (0.60)	1.88 (0.75)	0.13 (0.13)	0.88 (0.43)	1.63 (0.31)
	Basham's Beach	0.13 (0.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.25 (3.54)	5.88 (3.42)

10 Units of measurement

10.1 Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

11 Glossary

FCC — Fish species of conservation concern

Functional group — A group of macroalgae or substrate types that form a similar function, e.g. canopy-forming macroalgae

RLS — Reef Life Survey

SRH – Subtidal Reef health Program

12 References

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