Inagural Chain of Bays near shore marine life survey

21 - 28 February 2009

Friends of Sceale Bay

CARING FOR OUR COUNTRY

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1 Executive Summary

The temperate reefs of southern Australia form an important component of South Australia's ecologically and socio-economically valuable coastal ecosystems, and are remarkable for their productivity, diversity, and uniqueness. Various inter-related biotic and abiotic factors over a range of spatial and temporal scales influence these reefs, creating a complex mosaic of reef compositions and structures.

Temperate reef systems are also subject to a range of human impacts, including increased sedimentation, nutrient enrichment, the invasion of exotic taxa, and extractive resource use. The establishment of the Natural Resource Management Boards and the declaration of 19 Marine Parks in South Australian waters have led to increased interest in reef habitats, with a number of regional surveys being carried out around the State.

The present study reports on field surveys conducted on reefs in the Chain of Bays region to address knowledge gaps and to inform the Marine Parks planning and monitoring processes. Thirteen sites were surveyed by a team from the Reef Life Survey (RLS) program, a National program based at the University of Tasmania. At the same time, a team from the Department for Environment and Heritage surveyed additional sites at locations to complement those of the RLS team. In total, 21 sites were surveyed at depths ranging from 3-10 metres, from Cape Bauer to just south of Baird Bay. Surveys of fish, mobile invertebrates and benthic flora were conducted using non-destructive visual census techniques and underwater photography.

Analysis of the fish and invertebrate communities showed that reefs in the Chain of Bays region are very biodiverse, with considerable variation between sites, reflecting a long stretch of coastline with a variety of wave exposures, substrates and adjacent marine and terrestrial habitats. For this study, it was not possible to conclusively attribute community structure to any particular environmental factors. Distance between sites, however, was a significant factor influencing the variability amongst invertebrate communities.

The variety of species recorded was particularly high at four sites, including Cave Beach Point, The Mad Mile, Wayne's World, and The Dreadnaughts. This latter site was particularly remarkable with about ten species recorded only at that or one other site, and an unusually high abundance of sea stars.

Consistent with previous surveys, western blue groper were found at most locations along the coast, with the highest abundance of sub-adults at Baker's Hole and adults found in the vicinity of Point Westall and Cave Beach. Juvenile groper were not recorded at any sites. Their absence from Smooth Pool, where they had previously been found in high abundances, warrants further study.

Other species of conservation concern recorded less frequently on the survey included the blue morwong, long-snouted boarfish and western blue devil. Species not generally found to the east of the South Australian gulfs included the banded sweep and three urchin species, and the records for Gunn's leatherjacket and the common weedfish were to the west of their previously known range.

There were more than 100 species recorded, of which more than 30 species were found at only one or two sites. Further survey work would probably increase the number of recorded species and strengthen the baseline for future monitoring of the region's biodiversity. Despite the high level of variation between reefs, the study found that the overall patterns of community structure could be largely explained by relative abundances of just six fish and six invertebrate species or groups of species, which could facilitate community involvement in monitoring. Those species/groups were the blue-throated wrasse, sea sweep, yellow-headed hulafish, common bullseye, Wood's siphonfish, the zebra fish, abalone, feather stars, Gunn's six-armed sea star, the purple urchin, warrener, and turban shell.

2 Introduction

2.1 Temperate reefs of southern Australia

Reefs are important life-rich environments that contribute significantly to South Australia's coastal ecosystems that are valuable both ecologically (e.g. in terms of productivity, diversity and nutrient cycling) and socio-economically (e.g. in terms of fisheries, tourism and amenity). Importantly, the temperate reefs of southern Australia are unique both in terms of the variety of species that they harbour, and the levels of endemism within the reef communities. Reefs consist of either a naturally-occurring or artificially-introduced hard surface, to which an array of algae and sessile animals attach, the whole forming a structured habitat for a diversity of flora and fauna. The macroalgal assemblages associated with reefs in South Australia are regarded as being highly productive, with primary production rates being comparable to that of cereal crops or sugar cane stands (Cheshire *et al* 1998).

There are a number of inter-related biotic and abiotic factors that influence the composition and structure of reef assemblages (Turner *et al.* 2006). Such processes operate over a variety of temporal scales ranging from years (e.g. growth and development) to hours (e.g. larval settlement), and spatial scales from thousands of kilometres (e.g. temperature) to less than a metre (e.g. light and substrate), creating a complex mosaic of reef compositions and structures.

Temperate reef systems also respond to both persistent and acute disturbances and stresses. Increased sedimentation on reefs, nutrient enrichment, the invasion of exotic taxa and extractive resource use have all been documented as factors capable of, and instigating community change on reefs in southern Australia (eg. Goodsell and Connell 2002, Turner and Cheshire 2002).

Growing awareness of the need to understand reef systems has prompted a number of research and monitoring programs, particularly on the Adelaide coast (e.g. Cheshire *et al.* 1998; Cheshire and Westphalen 2000; Westphalen *et al.* 2004; Turner *et al.* 2007), but also in systems believed to be pristine (e.g. Fleurieu and Yorke Peninsulas; see Turner *et al.* 2007). The establishment of the Natural Resource Management Boards and the declaration of 19 Marine Parks in South Australian waters have also seen increased interest in reef habitats and in carrying out a number of regional surveys around the State (e.g. Edgar *et al.* 2005; DEH in press).

2.2 Reefs of the Chain of Bays region

The Chain of Bays region abuts the western boundary of the large Eyre Bioregion which extends to the south-east as far as Port Lincoln and the south coast of Kangaroo Island. Along the coast, from Cape Bauer south-east to Baird Bay, is an alternating series of open bays (Corvisart, Sceale, Searcy) and granite headlands, often with an overlying calcarenite cap. The coastal cliffs of Cape Bauer, Point Westall, Cape Blanche, and Cape Radstock, and many of the beaches between them, are exposed to strong winds and high swell (up to several metres) from the Southern Ocean, for most of the year. There are steep depth gradients close to the coast along most of the headland sections between Cape

Bauer and Cape Radstock. For example, waters 30 m deep abut the coast at Point Westall extending down to 50 m deep about three kilometres from shore (Baker & Shepherd, submitted). Other habitats typical of this region include very sheltered coastal embayments featuring islands and seagrass meadows (DEH 2009).

In winter the Chain of Bays is influenced by warm water masses originating in Western Australia (the Leeuwin Current) and the Head of the Bight. In summer, however, nutrient-rich cool-water upwellings or uplifts occur off south-western Eyre Peninsula but extend north-westwards to the Chain of Bays, sometimes resulting in summer temperatures of near-shore waters that are substantially lower than off-shore waters (Figure 1).

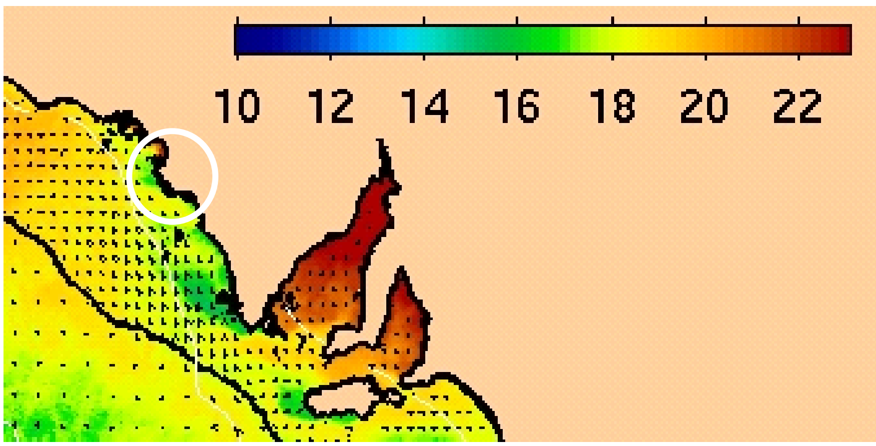

Figure 1. Cool-water upwelling extending north-west from Port Lincoln to Chain of Bays (circled) – three day (March) sea surface temperature composite (source CSIRO).

Some studies of subtidal reef communities in the Chain of Bays have taken place over the last decade (refer Figure 2 for locations):

- Shepherd and Brook (2004) found that the headlands and offshore reefs from Cape Bauer to Jones Island were important habitats for sub-adult western blue groper, with adult groper being recorded at Point Westall and Speeds Point. They also found hotspots for juvenile groper in sheltered habitats at Speeds Point (more abundant in juveniles than all but one of 125 sites across SA), The Granites and Smooth Pool.

  Headlands and offshore reefs in the region are also known to be important habitats for other species potentially of conservation concern such as the harlequin fish *Othos dentex* and blue morwong *Nemadactylus valenciennesi* (Baker & Shepherd, submitted). The nearshore pools of the Chain of Bays region also provide havens for a variety of reef fish including the herring cale *Olisthops cyanomelas*, scalyfin *Parma victoriae*, moonlighter *Tilodon sexfasciatus*, zebra fish *Girella zebra*, magpie perch *Cheilodactylus nigripes*, sea sweep *Scorpis* *aequipinnis* and banded sweep *S. georgianus*, and a variety of wrasses (Shepherd, unpublished data).

- Currie and Sorokin (2005, 2009) conducted surveys of fish, mobile invertebrates and macroalgae/sessile invertebrates at a range of depths (maximum 20 m) both inside and outside the Point Labatt Aquatic Reserve. They found that the blue-throated wrasse and sea sweep accounted for almost three quarters of the abundance of resident fish. The invertebrate community was dominated by echinoderms (sea stars, feather stars, urchins and sea cucumbers), with 2-3 times more species than molluscs or crustaceans. However, the periwinkle *Turbo undulatus* and blacklip abalone *Haliotis rubra* accounted for almost three quarters of the invertebrate abundances, with the feather star *Cenolia trichoptera* being the next most abundant species.

- Benthic surveys at a few sites in the 1990s suggested that macroalgal communities are quite variable within the region (Edyvane and Baker 1998), which is likely to enhance the overall diversity of habitats and associated species.

Other interesting species recorded in the Chain of Bays region include (from Baker & Shepherd, submitted):

- The western form of the green moray *Gymnothorax prasinus*, a large moray that is uncommon in South Australia; it is a nocturnally active species and hides in caves or crevices, or in macroalgae on reefs during the day.

- Seadragons recorded at a number of locations in the Chain of Bays region, including Point Westall, near Jones Island, and the Dreadnaughts for the leafy seadragon *Phycodurus eques*, and Smooth Pool for the weedy seadragon *Phyllopteryx taeniolatus*. Periodic "mass strandings" of both species (with up to 200 seadragons observed on one occasion) on the beach at Corvisart Bay indicate the relative abundance of these species in adjacent waters.

- Castelnau's wrasse *Dotalabrus aurantiacus*, the red velvetfish *Gnathanacanthus goetzeei*, snake-blennies including the spotted snake-blenny *Ophiclinops pardalis*, and various weedfish (*Heteroclinus*) species.

A more general conclusion that can be drawn from these studies is that the reef communities in the region comprise wide-ranging southern Australian temperate species but include a number of taxa with affinities for warmer Western Australian waters.

Figure 2 - Map of the study area showing the Chain of Bays region and survey sites

2.3 Current management and conservation measures in the Chain of Bays Region

The environmental significance of the Chain of Bays coastal area, particularly for sea lions and coastal birds, is recognised in a number of national listings, including the *Register of the National Estate* (on which the conservation parks at Baird Bay Islands, Point Labatt, and Olive Island are included), and the Commonwealth's *Directory of Important Wetlands* (Baird Bay and its islands, and Point Labatt. These listings provide little "on the ground" protection for the Chain of Bays region, and, with the exception of the Aquatic Reserve at Point Labatt and a small marine component of the recently proclaimed Nicholas Baudin Island Conservation Park, the marine area is largely unprotected from impacts (Baker & Shepherd, submitted).

Under the *Natural Resources Management Act 2004*, Natural Resource Management (NRM) Boards have the responsibility to develop and maintain an NRM Plan for their region. The Plans will guide the Boards, related State government agencies, and other stakeholders in their efforts to maintain and enhance the region's natural resources, including portions of State waters adjacent to their region (Figure 2). The Eyre Board's Regional NRM Plan is in four volumes. The first of these, entitled *Managing our resources* (EPNRM Board 2009), includes the vision, goals, three strategic priorities and regional targets and intermediate outcomes to be achieved. The coast and marine environment is one of the three strategic priorities:

> *The significant coastline of the region and its resources are sensitive to marine activities, coastal hazards and impacts of land management and human impacts in areas that discharge to the coast. The protection of these Coast and Marine areas must be considered in land use planning and implementation of activities throughout the region.*

The plan identified clear linkages with the South Australian Government's commitment to the development of a representative network of Marine Parks, as per the State Strategic Plan. The South Australian Government has declared a network of 19 multiple-use Marine Protected Areas across State waters to protect representative examples of all of the different ecosystems and habitats occurring in the marine environment. Management plans for these Parks have been targeted for completion during 2011. Park 3, also currently known as the West Coast Bays Marine Park, overlaps with a considerable portion of the Chain of Bays region.

Despite the studies that have occurred to date, there is a paucity of information on the reefs in the Chain of Bays region. The Friends of Sceale Bay, a local non-government organisation, have been involved in a ten-year campaign to have the area's wealth of coastal and marine biodiversity recorded and managed, in order to protect it for future generations. With this objective, they sought funding to help address this gap in knowledge of the regional biodiversity.

2.4 Study scope

The primary focus of the present report is to present the results of a study undertaken by the Friends of Sceale Bay (assisted by the Reef Life Survey (RLS) team), through a 2008 Caring for our Country Coastcare grant.

The aim of the study was to undertake the first-ever comprehensive assessment of reef communities in the Chain of Bays area (Western Eyre bioregion), providing data on benthic cover, common mobile reef fishes, cryptic reef fishes, and mobile macro-invertebrates (Friends of Sceale Bay 2008). The 13 sites surveyed (referred to hereafter as the core sites) are shown in Figure 2, together with eight other sites discussed below.

It was intended that the data collected during the surveys would contribute to (after Friends of Sceale Bay 2008):

- the South Australian Representative System of Marine Protected Areas (specifically Park 3, the West Coast Bays Marine Park). The surveys will provide relevant site-specific information that could assist the zoning process, and complement any future baseline surveys undertaken in proposed sanctuary zones and surrounding areas.

- marine planning initiatives (and associated performance assessment system) for waters in the eastern Great Australian Bight.

- actions associated with the State and regional (Eyre Peninsula) Natural Resources Management Plans. Specifically, this study provides an inventory and baseline data on the biodiversity content of reef systems in the Eyre Peninsula NRM region.

- the National Reef Life Survey program; a national framework for monitoring the state of the inshore environment and identification of those threats and locations of greatest conservation concern.

This report incorporates, where relevant, complementary data collected by the Department for Environment and Heritage (DEH) at eight additional sites in the same area (see Figure 2), at about the same time. These data were collected for similar reasons to those listed above.

The scope of the present report is largely restricted to describing the fish and invertebrate communities, with only brief descriptions of the dominant macroalgae. At the time of writing this report, the raw data for the benthic cover survey had not been collated into a form suitable for analysis for either the RLS or DEH datasets.

This report has been prepared primarily for the Friends of Sceale Bay. However, the analysis of the data has entailed considerably more detail and rigour than would normally be required for a report of this nature. This level of analysis has been undertaken to maximise the contribution of the data for planning, management and monitoring of the West Coast Bays Marine Park, consistent with the aspirations of the Friends of Sceale

Bay. As a consequence, the reader may find that the data analysis parts of the Methods (Section 3.3) and the Results (Section 4) have a technical content and level of detail that does not necessarily need to be read. The Discussion (Section 5) is aimed at the primary audience and makes reference to appropriate figures or findings from the Results where necessary.

3 Methods

3.1 Study Teams

Sampling for the core study sites was undertaken by a team comprising one staff member and three volunteer participants of the Reef Life Survey (RLS) program (RLS 2009a). These core sites extended from just south of Streaky Bay to just east of Baird Bay (Figure 2)

During the same month, DEH undertook a survey of reefs in the Nuyts Archipelago as well as onshore sites in the same vicinity as the core study area. These coastal sites, extending from Cape Bauer (west of Streaky Bay) to just south of Sceale Bay, were generally chosen to complement those surveyed by the RLS team.

3.2 Field Sampling Methods

The census techniques adopted by the RLS and DEH teams were both developed by the Tasmanian Aquaculture and Fisheries Institute (TAFI) of the University of Tasmania. The former methods (RLS 2009b), designed for use by an elite group of trained community divers since 2008, are a variant of the latter (Barrett & Buxton 2002), which have been used to undertake reef surveys across southern Australia since 1992 (including surveys of Kangaroo Island, Fleurieu Peninsula, Yorke Peninsula, Lower Eyre Peninsula and Upper Spencer Gulf since 2004). These latter TAFI methods as adopted by DEH will be referred to hereafter as the “DEH methods”.

Both survey sampling methods are non-destructive and permit the collection of large amounts of data on a broad range of species and hence a number of different ecosystem components (Edgar *et al.* 2005). They include methods for surveying large fish (“fish method”), mobile invertebrates/cryptic fish (“invertebrate method”), and macroalgae/sessile invertebrates.

A schematic diagram showing the areas sampled by the two programs is shown in Figure 3 and described as follow:

- The DEH method uses four contiguous transects each of 50 m length, with data recorded separately for each. For the fish method, there was an outward and return pass of 5 m width either side of the transect line, but for the invertebrate method a single pass of 1 m width on one side of the transect line. Statistically, the smallest independent sampling unit is a single 200 m transect.

- The RLS method provides for any number of 50 m transects that can be spatially separated. Both the fish and invertebrate methods have an outward and return pass, each of which have data recorded separately. For the purpose of this report, however, the results were summed for the fish blocks and averaged for the invertebrate blocks, to conform to the total area surveyed within the DEH 50 m transects. Statistically, the smallest independent sampling unit is a 50 m transect.

For the purpose of this report, the RLS methods have an important advantage over the DEH methods, as they allow the data analysis to include a range of procedures based on estimating the variation within sites (only possible by obtaining multiple, independent replicates at each site). The results from the RLS survey are therefore the main focus of the report, with information from the DEH surveys included where possible without impeding the statistical rigour of the analysis.

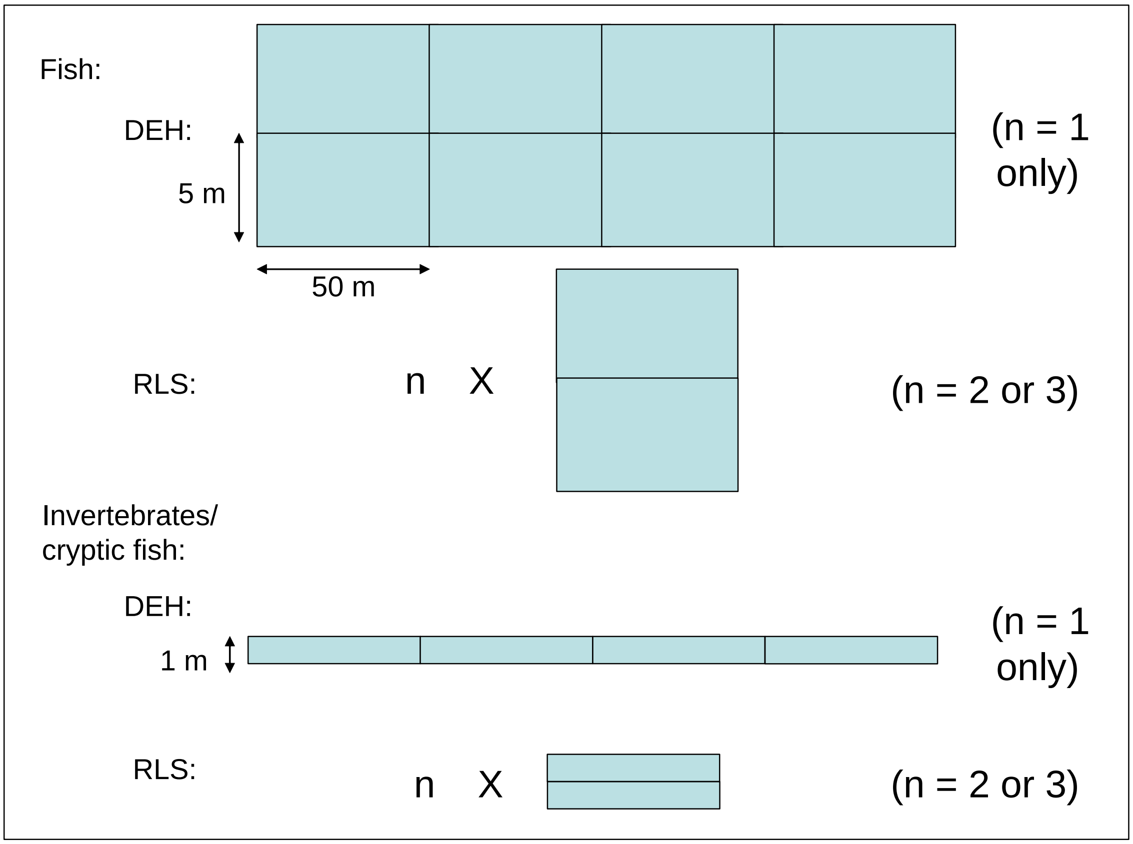

Figure 3. Sampling design for the RLS and DEH survey methods

Note that the macroalgal data collected by the DEH team (using point intercepts on a 0.25 m^2 quadrat) were not available at the time of writing this report. Similarly, the photoquadrats collected by the RLS team have not yet been digitised, but were inspected by the author in order to summarise the dominant benthic flora.

In February and March 2009, 13 reef sites (ranging 2-9 metres depth) by the RLS team and eight sites by DEH (at 5m or 10m depth) were surveyed along a 50 km segment of the western Eyre Peninsula coast (see Figure 2 for map and Table 2 for site names, abbreviations, depths, GPS marks and descriptions of the benthic flora). The study area lies at the western extremity of the Eyre Bioregion, which covers approximately 500 km of coastline. Sites were selected to represent the spatial extent and range of environmental conditions that occur on the western Eyre Peninsula coast. The only methodological constraint was that sites needed to contain reef habitat of sufficient extent for placement of up to three spatially-separated 50 m transects at a similar depth (RLS) or four contiguous 50 m transects (DEH).

3.3 Data Analysis

In line with the aims and objective of the present study, the data manipulation and analyses were targeted to examine:

- measures of diversity across the Chain of Bays region;
- spatial variation in the Chain of Bays reef ecosystems; and
- physical variables that may be determinants of reef biodiversity.

The Coast and Marine Conservation Branch of DEH have now undertaken reef surveys in a number of regions, including the Fleurieu, Yorke and Eyre Peninsulas. The analysis of the Yorke Peninsula data for a report to the Northern and Yorke NRM Board (DEH in press) has provided a template for analysis of similar datasets to meet similar objectives. Where possible, this template has been adopted for the current report.

Data analyses were performed predominantly using PRIMER software (Version 6, Clarke and Warwick 2001; Clarke and Gorley 2006), using the steps summarised in Table 1. Further information is provided below.

Table 1. Sequence of analytical steps in PRIMER used to explore patterns of biodiversity

Description of analysis
1. Standardise and transform data using increasing steps of severity of the transformation (i.e. none, square root, log (x + 1), fourth root, presence/absence), and aggregate the data to several decreasingly smaller group (based on uncertainty of identification). Apply this to the fish and invertebrate sampling methods individually and collectively.
2. Use the 2STAGE function to compare the dissimilarity matrices for the various transformations and aggregations, and select the most appropriate data set(s) for further analysis.
3. Create species diversity indices for each site using the DIVERSE function and identify potential biodiversity hotspots (as per Benkendorff and Davis 2002 approach).
4. Create Bray-Curtis similarity matrices among transects/sites using the Resemblance function on the selected data sets.
5. Use MDS procedure to graphically display the samples on an ordination scatterplot so that their dissimilarity is proportional to distance shown on the plot.
6. Use MVDISP procedure to analyse transect-level data using Site as the factor to give a description of the relative within-site variability of each site. This could only be performed at the transect level and was thus limited to the RLS data set which had independent replicate transects.
7. Use ANOSIM procedure to test for differences between sites using Site as the factor and transects as the replicates for each site. This could only be performed at the transect level and was thus limited to the RLS data set which had independent replicate transects.
8. Use SIMPER procedure to identify those species most responsible for similarities within and differences between sites.
9. Explore correlations of the biological patterns at the site level with all combinations of the eight environmental variables using the BEST (BIOENV) procedure.

3.3.1 Taxonomic resolution and implications for diversity measures

The organisms surveyed were identified to the finest possible taxonomic resolution achievable in the field. Careful interpretation of these data is necessary, however, with particular implications for the measurement of species richness and other related indices of diversity.

Species-level identification was consistently achieved for the large fish fauna as would be expected given the level of relevant training undertaken by divers of both programs. For mobile invertebrates and cryptic fish, however, it was not always possible to consistently identify species within certain genera or higher taxa, including:

- the genus *Haliotis* (abalone). The greenlip abalone *Haliotis laevigata* is unmistakeable, but several abalone with a blackish lip including *H. rubra* (if less than approximately 100 mm), *H. roei* and *H. scalaris* tend to inhabitat crevices and ledges and can be easily confused when only partially observable.

- Urchins of the family Temnopleuridae (genera *Amblypneustes* and *Holopneustes*). Several undescribed species of *Amblypneustes* were recorded during surveys of lower Eyre Peninsula in 2007 (pers. comm., Graham Edgar), and an urchin very similar to and thus often confused with *Holopneustes porosissimus* has been recorded at a number of locations in Western Australia and South Australia (Edgar 2008).

- Asteroids of the genus *Nectria*. The species *N. macrobrachia* is unmistakable, but *N. ocellata, N. multispina* and *N. pedicelligera* require an inspection of small anatomical features that is not feasible *in situ*.

- Hermit crabs, which were sometimes recorded to species level, sometimes to family (e.g. Paguridae), and sometimes as “unidentified hermit crab”.

- Fish of the Gobiidae family (gobies). These species are small and often move quickly when disturbed, making it difficult to consistently identify them to species level. It is likely that other small cryptic fish of the families Tripterygiidae (threefins/triplefins) and Blennidae (blennies) may also be confused with gobies.

- Fish of the Clinidae family (weedfishes). These species can also move quickly when disturbed. Furthermore, this family is still in the process of being described and few divers have the capacity to identify all weedfish to species.

- Fish of the Parascyllidae family (catsharks)

- Crabs of the genus *Nectocarcinus*

- Holothurians (sea cucumbers) of the genus *Stichopus*

- Crinoids of the genus *Cenolia*. The smaller *C. tasmaniae* can potentially be confused with juvenile *C. trichoptera* (Scoresby Shepherd, pers. comm.).

A number of the species recorded may not have been consistently recorded across all transects. For the mobile invertebrate/cryptic fish survey, a number of them should not have been recorded, including

- Fish species that are not regarded as "cryptic". The RLS (2009b) manual lists wrasses and damselfishes as particular examples of excluded species, while Barrett & Buxton (2002) provide a list of families to be included as "cryptic".

- Gastropods smaller than 2.5 cm adult size (RLS 2009b)

- Limpets, brittle stars and jellyfish, although not specificially listed as exclusions in the RLS (2009b) manual

On the other hand, despite being listed as an exclusion (RLS 2009b), particular ascidians (e.g. *Herdmania grandis* or *Pyura* spp.) have been targeted in previous surveys. They were recorded in this survey but it is not known whether they were consistently targeted.

Pelagic fish and mammal species that are observed haphazardly (sometimes in large schools) and not exclusively associated with reef habitats were also recorded.

Ultimately, several subsets and aggregations of the raw species lists were adopted for the analysis, and included:

- minimal change, with exclusion only of cryptic fish and invertebrates that do not conform to the RLS manual;

- as above, but with the exclusion of pelagic schooling fish and mammals. This species list, which retains species-level identification for those species that have problematic identification (see above), represents an "optimistic" set for analysis of species richness (and related diversity indices) of reef-associated animals; or

- aggregation, into genera or higher groups, of species with problematic identification. This represented a pessimistic or most conservative set for analysis of species richness, but a more accurate (if not precise) description of the reef community.

The mapping table from the raw data to the optimistic and conservative data sets is provided in Appendix 1. The RELATE function in PRIMER was used to compare the results of diversity measures between the optimistic and conservative datasets.

A single fixed-factor analysis of variance (ANOVA) was used to test the significance of the factor site for the range of diversity measures provided by PRIMER.

3.3.2 Spatial variation

Biological assemblage data were investigated at two levels, the transect level at which it was collected (for the 13 sites surveyed using the RLS method) and the site level obtained by averaging across transects for each of the 21 sites. A range of combinations of taxonomic groups (fish method, invertebrate method and combined), taxonomic resolutions (see previous section), and data transformations were initially compared using the 2STAGE routine to determine the relative sensitivity of the various choices available.

3.3.3 Classification of physical factors

Eight environmental variables were collected for each site from the desktop (Table 2), following where possible the methodology employed by DEH (in press). Depth was recorded at each site, but on-site assessments of reef relief and substrate (rock) type made for Yorke Peninsula (DEH in press) were not within the scope of either the DEH or RLS survey methods. Furthermore, there was only a single port from which to determine the mean spring tidal range (using Short 2006).

The exposure index was taken from the DEH shoreline classification GIS layer Relative Exposure (layer accessed June 2009, last updated 2008). The exposure rating categories of sheltered, moderate or exposed were assigned an ordinal value of 1, 3 or 5 respectively (consistent with DEH in press) for each site by querying the section of coast in the GIS layer perpendicular to the bathymetry contours between the site and coast. The values for aspect were the estimated direction perpendicular to the coast, using a representation of 1-4 for clockwise directions from north. The summer and winter sea surface temperature (SST) and the range between them were obtained from CSIRO GIS data layers (accessed June 2009). Latitude and longitude (the latter not used in the Yorke Peninsula analysis but investigated here) were obtained from the GPS co-ordinates for each site.

These eight variables were first tested for multi-collinearity (a measure of how inter-related they are) using Draftsman Plots in PRIMER software (Clarke and Gorley 2006) before exploring their potential influence on reef biodiversity patterns using the BEST (BIOENV) procedure in PRIMER. The similarity matrices of the raw biological data (transects averaged to site) and the environmental variables were then compared using the RELATE procedure.

Table 2. Physical factors for each surveyed site. Notes: (cat) = categorical data; Benthic flora determined from approximately 10 representative quadrat photos for RLS sites, and from personal observation by the author at the DEH sites.

Site	Abbreviation	Program	Depth (m)	Latitude	Longitude	Benthic flora	Exposure (cat)	Aspect (cat)	SST summer (°C)	SST winter (°C)	SST range (°C)
Cape Bauer East	CPBE	DEH	5	-32.7163	134.0638	*C. moniliformis*	5	1	18.86	14.41	4.45
Cape Bauer	CPB	DEH	6	-32.718	134.0614	*C. moniliformis* and *E. radiata*	5	4	18.86	14.41	4.45
High Cliff North	HCN	RLS	4.3	-32.865	134.1009	*Ecklonia radiata* with mixed *Cystophora* and *Sargassum* spp.	3	1	18.01	14.65	3.37
Dreadnaughts	DD	DEH	10	-32.8631	134.0971	*E. radiata* and foliose red algae	3	1	18.01	14.66	3.35
Dreadnaughts	DS	DEH	5	-32.8647	134.0981	*E. radiata* with some foliose red algae	3	1	18.01	14.66	3.35
The Granites	GRA	DEH	5	-32.8764	134.0875	Mixed *Sargassum* and *Cystophora* spp. with patches of *Osmundaria prolifera* and other red algae	5	1	18.02	14.63	3.40
Wayne's World	WW	RLS	7.9	-32.9059	134.0734	*E. radiata* with some *Cystophora* spp. and red algal beds	5	1	18.10	14.57	3.54
Point Westall North	PWN	RLS	7.6	-32.9067	134.0673	*E. radiata*, *Sargassum verruculosum*, beds of *Caulerpa* spp. and red algal beds.	5	1	18.06	14.63	3.42
Granites South	GRS	RLS	3.3	-32.9219	134.0796	Mixed *Cystophora* spp. (particularly *C. moniliformis*), with geniculate coralline algae	5	1	18.20	14.52	3.68
Smooth Pool	SMOO	RLS	2.1	-32.9253	134.0786	Mixed *Cystophora monilifera*, *C. ?botryocystis* and *Sargassum verruculosum* with seagrass patches	5	3	18.20	14.52	3.68
Bakers Hole	BH	RLS	2.2	-33.0121	134.1802	Mixed *Cystophora* spp. with bare patches and seagrass (including drift)	1	1	18.36	14.20	4.16
Cave Bay	CBAY	RLS	2.4	-33.0111	134.1714	Habitat photos not available	1	1	18.36	14.20	4.16
Cave Beach Point	CBP	RLS	5.3	-33.0066	134.1656	*Sargassum ?decipiens* and mixed *Cystophora* spp.	1	1	18.36	14.20	4.16
Cave Beach West	CBW	RLS	5.7	-33.0083	134.1643	Mixed *Sargassum* and *Cystophora* spp. with patches of *Osmundaria prolifera*	1	1	18.36	14.20	4.16
Eagle Rock	ERD	DEH	10	-33.0271	134.1439	*E. radiata* with some *Scytothalia dorycarpa* and red algae (particularly *Callophyllis lambertii*)	5	4	18.10	14.55	3.55
Eagle Bay	EBS	DEH	5	-33.0261	134.1476	*E. radiata* and red turfing algae	5	4	18.10	14.55	3.55
SE Slade Point	SLP	DEH	5	-33.0504	134.1737	Mixed *Cystophora* spp. (particularly *C. monilifera* and *C. subfarcinata*) and geniculate coralline algae with some *E. radiata*	5	2	18.23	14.46	3.78
Solar Tubes	ST	RLS	2.8	-33.0942	134.258	*E. radiata*,*Cystophora* spp.,*Caulerpa* mats	5	3	20.55	12.78	7.78
Mouth of Baird Bay	MBB	RLS	3.5	-33.1868	134.3529	Mixed *Cystophora* spp., particularly *C. moniliformis* and *C. ?siliquosa*	1	2	21.10	13.00	8.10
Jones Island NW	JI	RLS	3.1	-33.1851	134.3592	Mixed *Cystophora* spp.	1	4	21.06	12.97	8.10
The Mad Mile	TMM	RLS	8.7	-33.184	134.3778	Mixed *Cystophora* spp. (particularly *C. racemosa*) with some *E. radiata* and red algal beds	5	3	20.18	13.67	6.51

4 Results

4.1 Abundance, richness and diversity

There were 104 different fish and mobile invertebrate species recorded by the RLS and DEH programs on the Chain of Bays reefs, with a mean number of 160 individuals per 50m transect. The overall site abundances for each species are provided in Appendix 2.

For the western blue groper *Achoerodus gouldii*, the abundances are presented (Figure 4) in age-related size classes, namely sub-adults (20-60 cm) and adults (>60 cm), to allow for comparison with earlier work by Shepherd and Brook (2004). Juveniles (<20 cm) were not recorded at any site for this study.

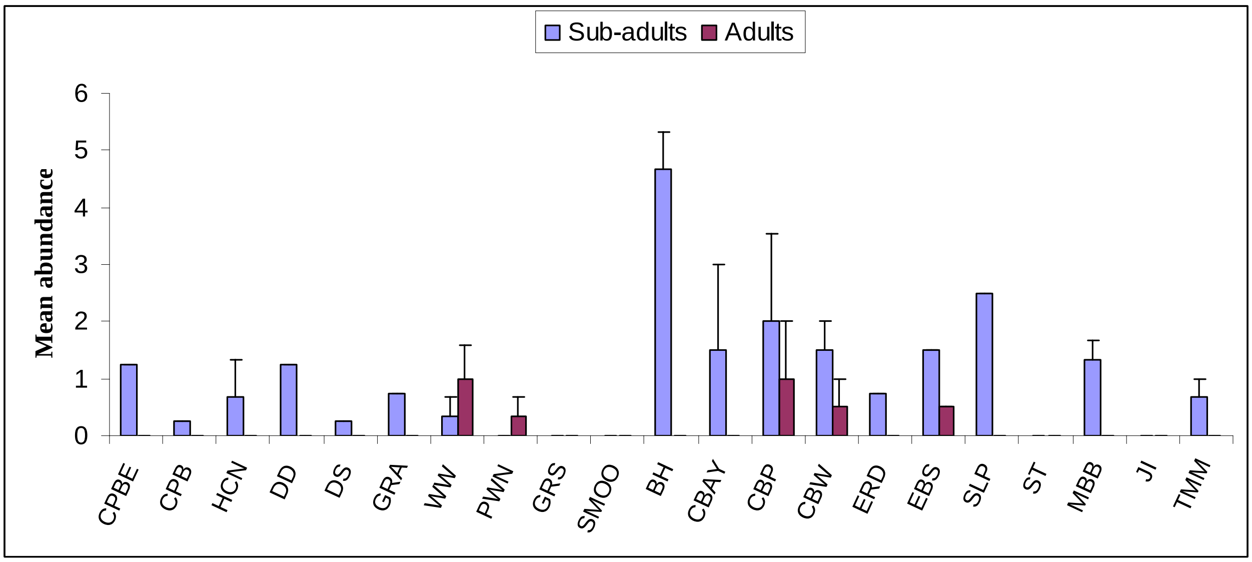

Figure 4. Mean number of sub-adult and adult groper per 50 m transect.

Error bars show standard error for RLS sites.

The species accumulation curve (Figure 5) is climbing which suggests that further species would be recorded if further sites were sampled.

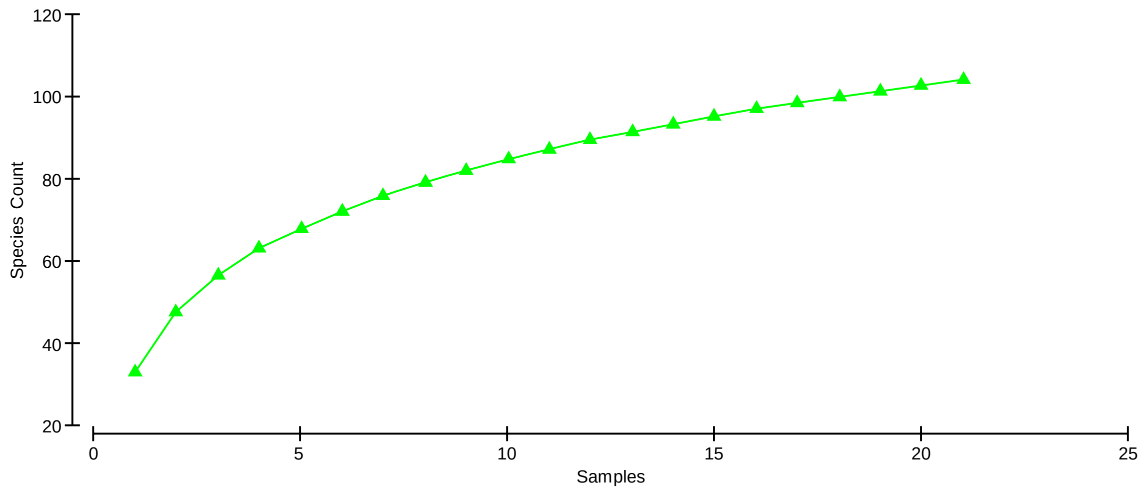

Figure 5. Species accumulation curve for Chain of Bays sites

Based on individual transect data (for the RLS program alone), the highest mean numbers of species per 50 m transect were at Cave Beach Point (26.3 species ± 6.7 standard error of mean) and the Mad Mile (26.0 ± 4.6), whilst Smooth Pool had the lowest (10 ± 1). The site with the largest range in number of species across the 2-3 transects was Cave Beach Point (max-min = 17) and the smallest range was only 2 at Smooth Pool.

For the DEH program, with total sample unit length being 200 m (c.f. 100-150 m for the RLS program), the highest mean numbers of species per 50 m block were 28.3 at the Dreadnaughts deep site and 22 at the Cape Bauer East site, whilst the lowest was 11.5 at Eagle Rock.

Fish and mobile invertebrate abundances for the RLS were highest at Smooth Pool (400 ± 26 individuals per transect) and Mouth of Baird Bay (252 ± 76), and lowest at Solar Tubes (61 ± 13) and Point Westall North (57 ± 6). The most abundant DEH site was the Dreadnaughts 10m site (average of 318 individuals per 50m block) and the least abundant was Eagle Rock (70).

An Australian sea lion was recorded on transects at the Mouth of Baird Bay site, and a single dolphin recorded at the High Cliffs site.

Eight species-diversity indices were calculated at transect level in PRIMER using the optimistic species mapping. With the exception of the species richness measure, all returned significant results for between-site variation (single-factor ANOVA, P <0.05, 0.01 or 0.001).

As would be expected, many of the diversity indices were strongly correlated with each other including three pairs with Pearson correlation coefficients greater than 0.95. Three of the indices are presented in Table 3. These included the species richness (S), which is presented for the combined data set as well as the individual fish and invertebrate methods, the number of individuals (N), the Shannon-Wiener diversity index (H') and another adjusted form of the species richness index called rarefaction (ES(n)), which standardises the number of species per transect according to the lowest number of individuals (n) found across all transects, 35 in this case. Note that the rarefied species richness did return significant results for between-site variation ($P<0.001$).

The results for the "conservative" species mapping were highly correlated with the "optimistic" set for both S and H' (Rho = 0.977 and 0.991 respectively, $P<0.001$ in both cases); note that the species mapping does not affect the calculation of N). Therefore the "optimistic" set was retained for further analysis.

Table 3. Diversity indices

(Numbers in bold were the highest and lowest number of species for each diversity measure at RLS sites. Rarefied species richness was standardised to an abundance of 35, being the lowest number of individuals on a transect for the combined methods; mean and (s.e.) values are given; all measures are based on combined data from fish and invertebrate methods unless otherwise specified).

Site	Species richness (S)	S (fish method)	S (invertebrate method)	Number of individuals	Rarefied species richness (n=35)	Shannon-Wiener index
HC	20.7 (3.9)	7.67 (2.96)	13.00 (3.00)	131.8 (74.1)	8.8 (1.3)	1.8 (0.2)
WW	25.7 (4.1)	**14.67** (2.85)	11.33 (1.86)	123.7 (15.3)	12.3 (1.1)	2.5 (0.1)
PWN	15.3 (2.2)	8.67 (0.88)	6.67 (1.45)	**57.5** (6.9)	9.8 (1.2)	2.0 (0.3)
GRS	21.0 (1.5)	6.00 (1.00)	**15.00** (2.52)	195.0 (43.5)	10.0 (1.2)	2.1 (0.2)
SMOO	**10.0** (1.0)	5.50 (0.50)	**4.50** (0.50)	**400.8** (26.3)	**3.4** (0.2)	**0.6** (0.1)
BH	24.0 (2.0)	13.67 (0.67)	10.33 (1.76)	138.8 (23.0)	12.5 (0.2)	2.4 (0.0)
CBAY	22.5 (8.5)	11.50 (3.50)	11.00 (5.00)	130.0 (59.5)	10.1 (3.1)	1.9 (0.6)
CBP	**26.3** (6.7)	12.33 (2.60)	14.00 (4.16)	97.7 (49.7)	**14.0** (1.3)	**2.6** (0.2)
CBW	23.5 (4.5)	10.50 (0.50)	13.50 (4.50)	147.8 (59.8)	10.2 (0.3)	2.1 (0.1)
ST	14.7 (0.9)	**3.00** (1.00)	11.67 (1.20)	61.7 (13.7)	9.1 (0.2)	2.0 (0.1)
MBB	18.3 (2.2)	10.00 (2.08)	8.33 (1.33)	252.5 (76.6)	7.3 (1.3)	1.5 (0.3)
JI	20.0 (1.0)	9.67 (0.33)	10.33 (0.67)	150.2 (14.5)	9.1 (0.5)	1.8 (0.1)
TMM	26.0 (4.6)	12.00 (2.86)	14.00 (2.52)	145.0 (57.7)	11.3 (0.7)	2.3 (0.1)

The Benkendorff and Davis (2002) method of identifying sites of highest biodiversity was applied to the species richness data for both the RLS and DEH sites. Because of the variable total length of reef surveyed (two or three 50 m transects for RLS and four contiguous 50 m transects for DEH), the mean number of species per 50 m transect was used.The results revealed that none of the sites would be considered 'hotspots' because none had species richness values greater than the cut-off of two standard deviations (SD) above the regional mean of 20 species (Table 8). Four sites, namely Cave Beach Point, The Mad Mile, Wayne's World and DEH site Dreadnaughts at 10 m depth, had a species richness higher than one SD above the mean (Table 8).

Table 4: Sites identified as species-rich for all taxa combined.

Cut-off	No. species	No. sites	Sites
Upper 95% confidence interval	22	7	Cave Beach Point, The Mad Mile, Wayne's World, Dreadnaughts (10 m), Cave Bay, Cave Beach West, Baker's Hole
1 standard deviation	25	4	Cave Beach Point, The Mad Mile, Wayne's World, Dreadnaughts (10 m)
2 standard deviations	30	0	(no sites)

4.2 Spatial variability in the reefs of the Chain of Bays

4.2.1 Preliminary transect-level analysis

Comparisons of the Bray-Curtis similarity matrices for different combinations of method-related datasets, taxonomic aggregrations, and data transformations (untransformed, square root or presence/absence) were undertaken using the 2STAGE routine. The resulting plot distributed the method-related datasets along the horizontal axis and the aggregation- and data transformation-related datasets along the vertical axis. Inspection of the plot showed that the relative influence on rank dissimilaries was:

- negligible for the different aggregrations of invertebrate taxa (vertical axis);

- moderate to negligible for the exclusion of pelagic schooling fish and mammals, depending on the transformation. Fish species that were excluded were yellowfin *Sillago schomburghkii* and King George whiting *Sillaginodes punctata*, silver *Pseudocaranx georgianus* and sand trevally *P. wrighti*, and Australian herring (tommy rough) *Arripis georgiana*, and unidentified bait fish that formed large schools >1000. Mammals included the bottlenose dolphin *Tursiops truncatus* and Australian sea lion *Neophoca cinerea*.

- greatest between the large fish and the mobile invertebrate/cryptic fish datasets, which were at opposite ends of the horizontal axis. The untransformed data sets for the fish and invertebrate methods were not strongly correlated with each other (*Rho* = -0.015, $P = 0.57$) but were strongly correlated with various transformations of the combined dataset (see below).

Initially, the large fish and the mobile invertebrate/cryptic fish method-based datasets were combined and the variables standardised (to maximum) to ensure that there was no arbitrary weighting of variables between the datasets arising from the different sampling characteristics of the methods. The 2STAGE analysis showed that this standardisation had a similar effect to one of the more severe transformations (e.g. presence/absence).

The MDS analysis of RLS transects indicated that the reef assemblages across the Chain of Bays displayed considerable variation in assemblage structure so that most sites sampled were different from all others. The relatively high stress (0.25) of the MDS 2D ordination plot for combined methods suggested that it may not be a good representation and so separate analysis of the data arising from the fish and invertebrate methods was warranted. This resulted in much lower stress levels (0.12-0.17).

Therefore the untransformed large fish and mobile invertebrate/cryptic fish datasets were adopted for separate analyses. These datasets were strongly correlated with the initial, combined dataset (*Rho* = 0.464, *P* = 0.001; *Rho* = 0.529, *P* = 0.001, respectively), and also with their respective presence/absence datasets (*Rho* = 0.55, *P* = 0.001; *Rho* = 0.704, *P* = 0.001, respectively).

4.2.2 Within-site variability

Interpretation of the MDS plots (Figure 6 and (Figure 7) shows that some transects within sites were less-tightly grouped than others. Further investigation of within-site variation using MVDISP revealed that Smooth Pool had the lowest within-site variation (or tightest grouping of transects) for both the fish and invertebrate survey methods, with a multivariate dispersion value of 0.12 and 0.35, respectively. Granites South had the next lowest dispersion for the invertebrate method (0.43) but the second highest for the fish method (1.5); Wayne’s World had the the next lowest dispersion for the fish method (0.49). High Cliff North (1.5) and Cave Bay (1.7) had the highest variability for the invertebrate and fish methods, respectively.

Therefore, ignoring Smooth Pool, which had extremely low variability for the invertebrate method relative to the other sites, the average rank dissimilarity was 3-4 times higher between the lowest and highest ranking sites. If the spacing of survey transects was similar at all sites, then these results imply there is large local variation which would make it potentially more difficult to detect changes at the more highly-ranked sites.

Within-site variability was found to be driven by 4 out of 39 and 7 out of 58 of the species recorded by the fish and invertebrate methods, respectively (cut-off for cumulative contribution set at 50% SIMPER). The species listed in Table 5 could therefore be considered to be the most characteristic of each site. Similarity scores were highest for Smooth Pool (93% and 67% for fish and invertebrate methods, respectively) and then ranged from 66% (fish method for Wayne’s World) down to 17% (invertebrate method at Cave Bay) (Table 5).

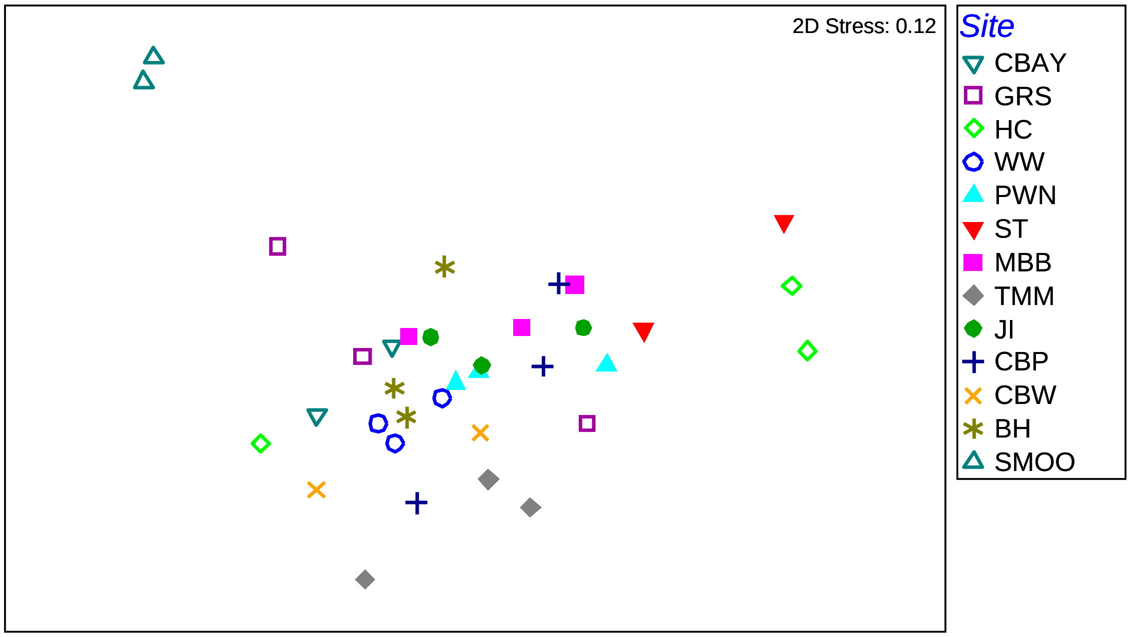

Figure 6. MDS ordination plot in two dimensions of large mobile fish transects from 13 RLS sites.

(Each data point shown represents a transect, and different sites are shown by different symbols (see **Table 2** for expanded site names). Points close together are relatively similar in terms of taxonomic composition and relative abundances; ones far apart are dissimilar)

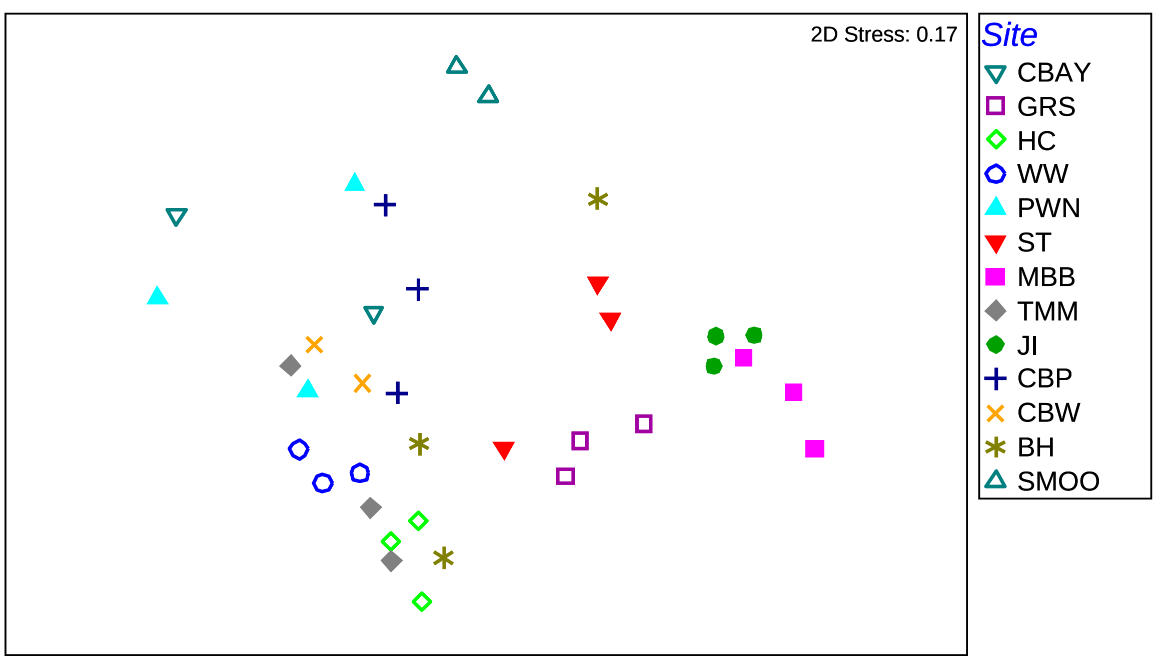

Figure 7. MDS ordination plot in two dimensions of mobile invertebrate/cryptic fish transects from 13 RLS sites

4.2.3 Between-site variability

Sites were shown to be significantly different from each other by the ANOSIM procedure (Global $R = 0.69$, $P = 0.001$). Due to the small number of replicates, the ANOSIM procedure could not test sufficient permutations to guarantee pairwise differences ($P >= 0.1$). However, the R statistic was greater than 0.6 for approximately one third of 78 pairs of sites for the fish method and two thirds for the invertebrate method. This means that most sites were contributing to the variation found amongst all 13 sites, suggesting a high degree of uniqueness for each of these reefs.

The SIMPER procedure also calculated dissimilarity between pairs of sites based on the species and their abundances at each site (using transects as replicates) with the cut-off for cumulative contribution set at 50%. This suggests species that could be considered indicators of one site or another in each pair

For the fish method, the lowest site-pair dissimilarity was 42% for Cave Bay and Baker's Hole; all other site pairs with dissimilarity below 50% included Jones Island. The highest dissimilarity was 97% (Smooth Pool and Solar Tubes), with all site pairs above 90% including Smooth Pool. The cumulative contributions (up to 50% dissimilarity) involved 12 of the 39 species recorded using the fish method, with the zebra fish *Girella zebra* and blue throated wrasse *Notolabrus tetricus* contributing most commonly.

For the invertebrate method, the lowest site-pair dissimilarity was 45% for Mouth of Baird Bay and Jones Island. The Mouth of Baird Bay site also had the highest dissimilarity, with Point Westall North (99%), and had a dissimilarity greater than 95% for eight other sites. The cumulative contributions (up to 50%) involved 11 of the 58 species recorded using the invertebrate method, with the feather stars *Cenolia* spp. and warrener *Turbo undulatus* contributing most commonly.

4.2.4 Site-level analysis

The MDS analysis of all sites undertaken by the RLS and DEH teams in the Chain of Bays region is shown for the fish and invertebrate methods in Figure 8 and Figure 9. The plots showed a single main cluster comprising most sites. The main outliers for both the fish and invertebrate methods were Smooth Pool and, to a lesser extent, the deeper Dreadnaughts site. Solar Tubes was also an outlier for the fish method, and there was a small distinct group of three sites (the Mouth of Baird Bay, Jones Island and Eagle Bay) that were separated from the main cluster for the invertebrate method. Although Smooth Pool is geographically quite close to a number of sites, Solar Tubes is more isolated. In order to investigate any relationship between the dissimilarity between sites and geographical distance, a matrix of Euclidian distances between sites (from latitude and longitude) was generated and compared with the site dissimilarity matrix for both methods, using RELATE. The correlation was significant for the invertebrate method ($Rho = 0.196$, $P = 0.026$), but not the fish method ($Rho = -0.037$, $P = 0.61$).

Table 5: Species contributing to 50% cumulative within-site similarity at each site (sim = similarity).

Site	Fish method			Invertebrate method		
	Sim (%)	Species	Common name	Sim (%)	Species	Common name
High Cliff North	21	*Notolabrus tetricus*	Blue-throated wrasse	63	*Cenolia* spp.	Feather stars
Wayne's World	66	*Scorpis aequipinnis* *Notolabrus tetricus*	Sea sweep Blue-throated wrasse	57	*Cenolia* spp.	Feather stars
Point Westall North	53	*Notolabrus tetricus*	Blue-throated wrasse	22	*Haliotis rubra* complex *Cenolia* spp.	Black lipped abalone species Feather stars
Granites South	33	*Notolabrus tetricus*	Blue-throated wrasse	65	*Turbo undulatus*	Warrener
Smooth Pool	93	*Girella zebra*	Zebra fish	67	*Meridiastra gunnii*	Gunn's six-armed sea star
Bakers Hole	58	*Notolabrus tetricus* *Girella zebra*	Blue-throated wrasse Zebra fish	20	*Cenolia* spp. *Heliocidaris erythrogramma*	Feather stars Purple urchin
Cave Bay	53	*Notolabrus tetricus*	Blue-throated wrasse	17	*Haliotis rubra* complex *Phlyctenactis tuberculosa*	Black lipped abalone species Swimming anemone
Cave Beach Point	42	*Notolabrus tetricus* *Tilodon sexfasciatus*	Blue-throated wrasse Moonlighter	33	*Meridiastra gunnii* *Cenolia* spp.	Gunn's six-armed sea star Feather stars
Cave Beach West	42	*Notolabrus tetricus* *Tilodon sexfasciatus*	Blue-throated wrasse Moonlighter	49	*Cenolia* spp.	Feather stars
Solar Tubes	61	*Notolabrus tetricus*	Blue-throated wrasse	47	*Meridiastra calcar*	Eight-armed sea star
Mouth of Baird Bay	48	*Tilodon sexfasciatus* *Notolabrus tetricus*	Moonlighter Blue-throated wrasse	51	*Turbo undulatus*	Warrener
Jones Island NW	60	*Notolabrus tetricus*	Blue-throated wrasse	65	*Turbo undulatus*	Warrener
The Mad Mile	36	*Notolabrus tetricus*	Blue-throated wrasse	40	*Cenolia* spp.	Feather stars

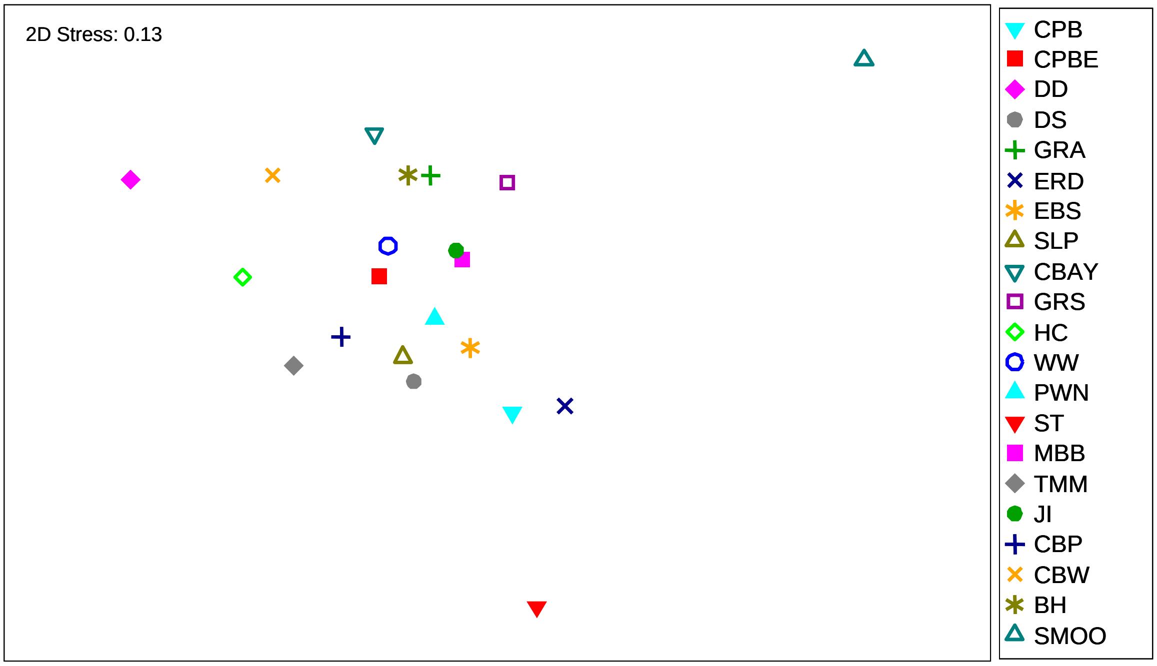

Figure 8. MDS ordination plot in two dimensions of mobile fish data from 21 sites (RLS and DEH).

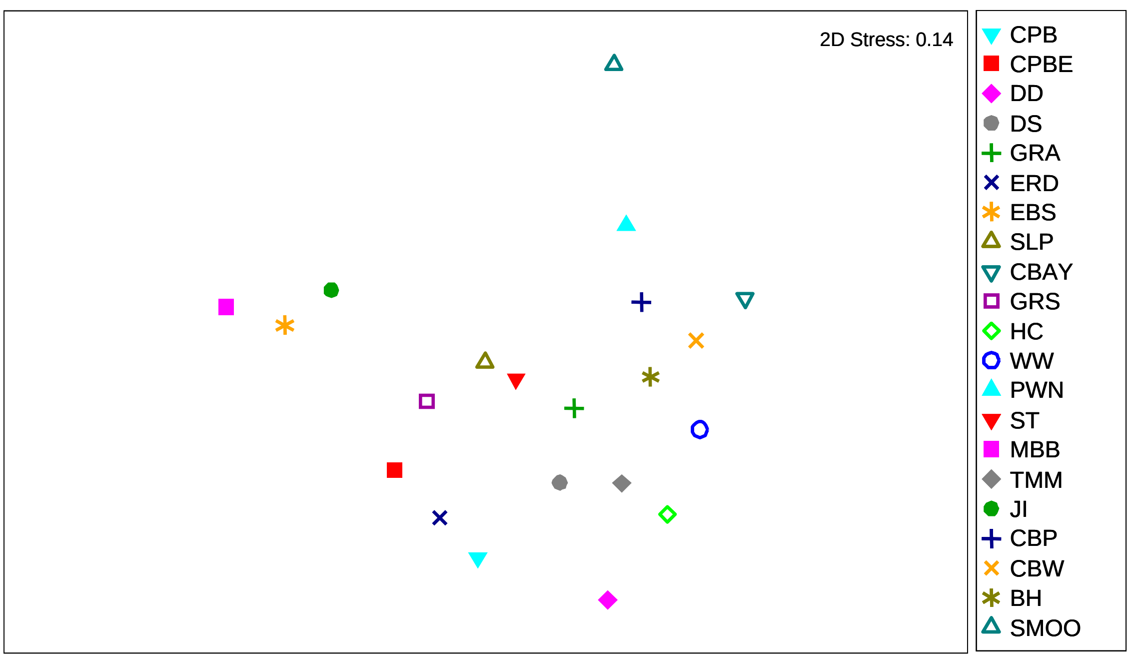

Figure 9. MDS ordination plot in two dimensions of invertebrate and cryptic fish data from 21 sites (RLS and DEH).

4.2.5 Regional surrogates

The BVSTEP analysis identified a subset of six mobile fish and five invertebrates that captured the pattern of their respective method-based data-sets (Table 6). The procedure selects a list of species from those available by adding and removing them until it finds a combination with the strongest relationship between them and in this case the whole data-set. The lists selected for fish and invertebrate survey methods were both statistically significant (respectively *Rho* = 0.955, *P* = 0.001 and *Rho* = 0.969, *P* = 0.001), so, in theory, future surveys looking for only those species at every survey site should enable the detection of important changes in the whole biological assemblages over time (i.e. a form of surrogacy).

Table 6: Species capturing the pattern of the entire data-set

Fish	**Common name**
Notolabrus tetricus	Blue-throated wrasse
Scorpis aequipinnis	Sea sweep
Trachinops noarlungae	Yellow-headed hulafish
Pempheris multiradiata	Common bullseye
Siphamia cephalotes	Wood's siphonfish
Girella zebra	Zebra fish
Invertebrates	**Common name**
Haliotis rubra complex	Black-lipped abalone species
Cenolia spp.	Feather stars
Meridiastra gunnii	Gunn's six-armed sea star
Heliocidaris erythrogramma	Purple urchin
Turbo undulatus	Warrener
Turbo torquatus	Turban shell

4.2.6 Physical factors and biodiversity

When the physical variables were assessed for multi-collinearity across the RLS data set all three sea-surface temperature (SST) measures and the latitude and longitude were found to be highly correlated (*Rho* >= 0.87). The same variables were highly correlated for an expanded dataset including the onshore sites surveyed by DEH (see Table 7), although the latitude was less strongly correlated with the SST variables than the longitude.

Due to the difficulty in assessing the individual effects of these variables on community structure when they are intercorrelated with other environmental variables, the three SST-related variables and latitude were removed from any further analyses, but longitude was retained to represent them all.

Table 7: Correlation coefficients of pair-wise comparisons of the physical variables (significant relationships in bold)

	Depth	Latitude	Longitude	Aspect	SST summer	SST winter	SST range
Depth							
Latitude	0.15						
Longitude	-0.15	**-0.90**					
Aspect	0.06	-0.34	0.38				
SST summer	-0.24	**-0.63**	**0.85**	**0.43**			
SST winter	0.35	**0.71**	**-0.86**	-0.37	**-0.96**		
SST range	-0.28	**-0.67**	**0.87**	0.41	**0.99**	**-0.98**	
Exposure	0.34	0.36	-0.40	0.28	-0.24	0.34	-0.28

Neither the fish nor invertebrate data were strongly correlated with environmental variables (*Rho* = 0.295, *P* = 0.1 and *Rho* = 0.254, *P* = 0.07, respectively). However, a comparison of the environmental variables and site biodiversity similarity matrices via RELATE revealed a significant correlation between the assemblages sampled using both the fish and invertebrate methods, and their environmental conditions (*Rho* = 0.238, *P* = 0. 027 and *Rho* = 0.251, *P* = 0.017, respectively).

5. Discussion

5.1 Variability between sites

The results showed that reefs in the Chain of Bays area are very biodiverse, with considerable variation between sites. The MDS plots for the fish (Figure 8) and invertebrate (Figure 9) methods give some insight into the nature of this variation. These figures are two-dimensional graphs of the sites, such that those points closest together have the most similar reef communities. Collectively, these figures show that the variation between sites was considerably greater for some sites, including:

- Smooth Pool, which was characterised by the lowest richness and abundance of invertebrates and a low richness but high abundance of fish, particularly of large schools of zebra fish *Girella zebra*;

- Solar Tubes, which was characterised by a low abundance and richness of fish species;

- the Dreadnaughts deeper site; with a high overall diversity and high abundances of certain taxonomic groups (see below); and

- the Mouth of Baird Bay and nearby Jones Island, as well as the Eagle Bay site, due mainly to their high abundance of the warrener *Turbo undulatus*.

For both methods, the other sites were spread relatively evenly within the large cluster comprising all the remaining sites.

The statistical test (ANOSIM, see Section 4.2.3) confirmed, for the RLS survey sites, that there was an overall difference between the reef communities that was not due to chance alone. Although the differences between each pair of sites could not be confirmed due to a lack of statistical power, the results for up to two thirds of the pairs of sites suggested that they would have been significantly different had there been more transects done at each site (at least four rather than two or three). Further analysis of the differences between sites (using SIMPER) provided additional evidence of the dissimilarities between sites, and found that the blue-throated wrasse *Notolabrus tetricus*, zebra fish *Girella zebra*, feather stars *Cenolia* spp. and the gastropod *Turbo undulatus* accounted for much of this dissimilarity.

The variation between sites is not unexpected, given that the region is comprised of a series of exposed headlands or cliffs and sheltered bays giving rise to a highly-varied coastline in terms of aspect, substrate composition, wave and wind exposure, adjacent or intervening systems (seagrass or bare sand), seafloor slope and adjacent terrestrial environments. For this study, however, it was not possible to conclusively relate any of these or other environmental factors to the structure of the reef communities. In some cases, although seemingly trivial to collect, recording the appropriate data was outside of the scope of the particular survey methods adopted. In other cases, for which appropriate data was available from existing databases, the correlations were weak and not statistically significant. Distance between sites, however, was a significant factor influencing the variability amongst invertebrate communities. This was not the case for the more mobile fish fauna.

The variation in reef communities found in this study supports the principle that the proposed West Coast Bays Marine Park (as for the other Marine Parks) needs to be large in order to bring the region's biodiversity under a conservation management regime.

5.2 Biodiversity hotspots

A comparison was made of the species richness across all the sites surveyed but none of them could be considered relative hotspots according to the cut-offs applied by Benkendorff and Davis (2002). However, there were four sites with a notably higher richness than others, namely:

- the deeper (10 m) Dreadnaughts site was the only site where the blue morwong *Nemadactylus valenciennesi*, western talma *Chelmonops curiosus*, banded seaperch *Hypoplectrodes nigroruber*, yellow-headed hulafish *Trachinops noarlungae* and Gunn's leatherjacket *Eubalichthys gunnii* were recorded; it was one of two sites for the western blue devil *Paraplesiops meleagris*, white-barred boxfish *Anoplocapros lenticularis*, the top shell *Astele subcarinatum* and the many-spotted seastar *Fromia polypora*. It had by far the highest overall abundance of sea stars, averaging more than ten large-plated seastar *Nectria macrobrachia* and eight Troughton's seastar *Pseudonepanthia troughtoni* per 50 m transect and with the highest abundance of eight of the nine species recorded there. It was also the most abundant site for feather stars *Cenolia* spp.;

- Cave Beach Point was the only site for the southern spindle whelk *Fusinus australis*, the western slate-pencil urchin *Phyllacanthus irregularis* and the nudibranch *Flabellina rubrolineata*; it was one of only two sites for the painted stinkfish *Eocallionymus papilio* and the variable feather star *Antedon incommode*;

- The Mad Mile was the only site for the blue-lined leatherjacket *Meuschenia galii,* the rosy wrasse *Pseudolabrus psittaculus*, the sharp-nosed weed whiting *Siphonognathus caninus*, and the pheasant shell *Phasianella australis*; it was one of two sites for Wood's siphonfish *Siphamia cephalotes*; and

- Wayne's World was the only site where Wilson's sea star *Nectria wilsoni* was recorded; was one of only two sites for the six-spined leatherjacket *Meuschenia freycineti* and was the other site where the western blue devil and painted stinkfish were recorded.

Species richness was also relatively high, to a lesser extent, for Cave Bay, Cave Beach West and Baker's Hole.

It should be noted, however, that the survey techniques used in this study were not designed specifically to be inventories of species richness, but more of a snapshot to characterise the biota present at each site. Other survey techniques and analysis methods would be required to adequately quantify species richness for these reefs.

Other species that were recorded at only a single site included the short-tailed nudibranch *Ceratosoma brevicaudatum* (Cave Beach West), many-armed seastar *Allostichaster polyplax* and yellow-spined egg urchin *Amblyneustes pallidus* (Solar Tubes), the anemone cone *Conus anemone* and hairy stone crab *Lomis hirta* (Granites South), little rock whiting *Neoodax balteatus* and long-finned goby *Favonigobius lateralis* (Baker's Hole), a catshark *Parascyllium* spp. (The Granites), the rough leatherjacket *Scobinichthys granulatus* (Mouth of Baird Bay), and globe fish *Diodon nicthemerus* (Cave Bay). The magnificent biscuit star *Tosia magnifica* was also recorded at Granites South but this record should be treated with caution as this species has previously only been recorded in South Australia in 200 m depth (Scoresby Shepherd, pers. comm.).

All six species of the genus *Nectria* were recorded during this survey. However, field identification of *N. ocellata*, *N. multispina* and *N. pedicelligera* is problematic, and records of these species must be considered as uncertain.

It should be noted that many of the fish species described in this section have been identified as being of conservation concern (Baker 2009), including the western blue devil and blue morwong, which have been included as "In Peril" species within the Reef Watch *Feral or In Peril* program, along with the long-snouted boarfish *Pentaceropsis recurvirostris* which was recorded at four sites for this study.

5.3 Other findings

5.3.1 Biogeographically-significant records

Currie and Sorokin (2005) found that most species of fish and invertebrate recorded at Point Labatt are common and occur widely throughout southern Australian waters. However, while this was generally found to be the case for the regional survey conducted for this study, there were some species recorded that are restricted to the western part of the State, including:

- the banded sweep *Scorpis georgiana*, recorded at Cave Bay, Solar Tubes and both depths at Dreadnaughts, which extends eastwards only to Kangaroo Island;
- the western slate-pencil urchin *Phyllacanthus irregularis,* which extends to Gulf St Vincent;
- the western hollow-spined urchin *Centrostephanus tenuispinus*, which extends to Spencer Gulf; and
- yellow-spined egg urchin *Amblyneustes pallidus*, which extends to Port Willunga in Gulf St Vincent.

Conversely, there were some potential range extensions to eastern species:

- Gunn's leatherjacket has a current western extent of Port Lincoln (Edgar 2008), but was recorded by two divers (on separate transects at least 50 m apart) at the deeper Dreadnaughts site. A photo was taken and has been confirmed by Dr Neville Barrett of the University of Tasmania; and

- the common weedfish *Heteroclinus perspicillatus* record at Smooth Pool suggests a range extension as the current western extent of this species is Port Lincoln (Edgar 2008). Although the responsible diver is familiar with this species, a degree of caution should be associated with this record due to the inherent difficulty identifying weedfish and the lack of a photo.

5.3.2 Western blue groper

Western blue groper *Achoerodus gouldii* were recorded at most sites (see Figure 4), with with the highest abundance of sub-adults (20-60 cm) at Baker's Hole. Adult groper (>60 cm) were found at neighbouring sites Cave Beach Point and Cave Beach West, as well as neighbouring sites Wayne's World and Point Westall. This latter sighting was consistent with the findings of Shepherd and Brook (2004, 2007) at several of the same sites as the current study. No juveniles (<20 cm) were recorded at any site during this study. Shepherd and Brook (2007) recorded one of the highest statewide abundances of juveniles at Smooth Pool, as well as at Speeds Point nearby (not surveyed for this study), in early summer. Based on their findings at other sites in South Australia, the absence of juvenile (or any) groper from Smooth Pool for this survey is not likely to be a result of seasonal effect. Another possibility is that they may be washed out of or escape from the Smooth Pool lagoon during heavy seas. Clearly, further work is required to understand the dynamics of juvenile groper at this site.

Consistent with previous surveys, western blue groper were found at most locations along the coast, with the highest abundance of sub-adults at Baker's Hole and adults found in the vicinity of Point Westall and Cave Beach. Juvenile groper were not recorded at any sites. Their absence from Smooth Pool, where they had previously been found in high abundances, warrants further study.

5.3.3 Recreationally and commercially-significant species

Small schools of Australian herring (tommy rough) *Arripis georgiana* were recorded at Cape Bauer East, Baker's Hole, Cave Bay and Cave Beach Point; and a small school of silver trevally *Pseudocaranx georgianus* was also recorded at the latter site. It is not uncommon for these species to be encountered on reef habitats in southern Australia. Less commonly encountered species are King George whiting *Sillaginoides punctata* and yellowfin whiting *Sillago schomburgkii*, for which there were isolated sightings at Wayne's World and Cave Beach Point, respectively.

There were isolated sightings of southern rock lobster *Jasus edwardsii* at the deeper Dreadnaughts site, Wayne's World, and Eagle Bay.

Greenlip abalone were recorded at most sites, but were most abundant at Jones Island (9 per 50 m transect) and The Granites (4 per transect).

A suite of other abalone species, including blacklip abalone *Haliotis rubra* and the grooved abalone *H. scalaris* were grouped together due to the difficulty in distinguishing them when in crevices (unless greater than 10 cm, in which case they are likely to be *H. rubra*). They were most abundant at Eagle Bay (14 per transect), Cape Bauer and Cape

Bauer East (8 and 10 per transect, respectively), and Point Westall North and The Mad Mile (5 per transect each).

5.4 Future monitoring and recommendations

Surveys of shallow inshore reefs in the Chain of Bays region have provided a quantitative regional description of associated reef fishes and mobile invertebrates. There were 104 different fish and mobile invertebrate species recorded during the surveys at depths ranging from 3-10 m. The species lists were generally consistent with the studies by Shepherd (unpublished data) and Currie and Sorokin (2005).

The data obtained from these surveys should contribute to a baseline for future evaluation of reef status in the face of ongoing threats including fisheries, aquaculture, tourism, coastal development, land-based inputs, marine pests, and climate change. However, the species cumulation curve presented in Figure 5 suggests further sampling at new (and probably also at existing) sites would lead to additional species being recorded and would strengthen the overall baseline.

Reefs in the Chain of Bays are spatially variable and thus present a particular challenge for management and monitoring strategies. However, this study found that the patterns of community structure could be largely explained by the relative abundances of only six fish and six invertebrates (see Table 6). Adoption of this list of species for monitoring would considerably reduce the required training and increase possibilities for community involvement in monitoring.

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Appendix 1. Aggregration of species into data analysis groups.

Note: F = fish method, I = invertebrate/cryptic fish method.

Conservative	Optimistic	Recorded Species	Method
(not mapped – ommited)	(not mapped – ommited)	*Acanthaluteres vittiger*	I
(not mapped – ommited)	(not mapped – ommited)	*Arripis georgiana*	F
(not mapped – ommited)	(not mapped – ommited)	*Austrolabrus maculatus*	I
(not mapped – ommited)	(not mapped – ommited)	*Neophoca cinerea*	F
(not mapped – ommited)	(not mapped – ommited)	*Notolabrus parilus*	I
(not mapped – ommited)	(not mapped – ommited)	*Pseudocaranx georgianus*	F
(not mapped – ommited)	(not mapped – ommited)	*Sillaginoides punctata*	F
(not mapped – ommited)	(not mapped – ommited)	*Sillago schomburgkii*	F
(not mapped – ommited)	(not mapped – ommited)	*Siphonognathus beddomei*	I
(not mapped – ommited)	(not mapped – ommited)	*Tursiops truncatus*	F
(not mapped – ommited)	(not mapped – ommited)	Unidentified fish	F
(not mapped – ommited)	(not mapped – ommited)	Unidentified small silver fishes	F
(not mapped – ommited)	(not mapped – ommited)	*Upeneichthys vlamingii*	I
Amblypneustes spp.	*Amblypneustes ovum*	*Amblypneustes ovum*	I
Cenolia spp.	*Cenolia tasmaniae*	*Cenolia tasmaniae*	I
Cenolia spp.	*Cenolia trichoptera*	*Cenolia trichoptera*	I
Clinid spp.	*Heteroclinus perspicillatus*	*Heteroclinus perspicillatus*	I
Haliotis rubra complex	*Haliotis roei*	*Haliotis roei*	I
Haliotis rubra complex	*Haliotis rubra*	*Haliotis rubra*	I
Hermit crab	Hermit crab unidentified	Hermit crab unidentified	I
Hermit crab	*Paguristes frontalis*	*Paguristes frontalis*	I
Hermit crab	*Pagurixus handrecki*	*Pagurixus handrecki*	I
Hermit crab	Unidentified hermit crab	*Unidentified hermit crab*	I
Holopneustes spp.	*Holopneustes porosissimus*	*Holopneustes porosissimus*	I
Nectocarcinus spp.	*Nectocarcinus integrifrons*	*Nectocarcinus integrifrons*	I
Nectocarcinus spp.	*Nectocarcinus tuberculatus*	*Nectocarcinus tuberculatus*	I
Nectria ocellata complex	*Nectria multispina/ocellata*	*Nectria multispina/ocellata*	I
Nectria ocellata complex	*Nectria ocellata*	*Nectria ocellata*	I
Nectria ocellata complex	*Nectria pedicelligera*	*Nectria pedicelligera*	I
Small cryptic fish	*Favonigobius lateralis*	*Favonigobius lateralis*	I
Small cryptic fish	*Norfolkia clarkei*	*Norfolkia clarkei*	I
Small cryptic fish	*Trinorfolkia cristata*	*Trinorfolkia cristata*	I
Stichopus spp.	*Stichopus mollis*	*Stichopus mollis*	I

Appendix 2 Species Lists

Fish method: average abundances per 50 m x 10 m transect across all 21 sites.

Common name	Scientific name	CPBE	CPB	HC	DD	DS	GRA	WW	PWN	GRS	SMOO	BH	CBAY	CBP	CBW	ERD	EBS	SLP	ST	MBB	JI	TMM
Banded sweep	*Scorpis georgiana*				0.25	2							3.5						0.67			
Black-spotted wrasse	*Austrolabrus maculatus*				3.75		1.5	0.67							1.5			0.5				
Blue morwong	*Nemadactylus valenciennesi*				0.25																	
Blue rock whiting	*Haletta semifasciata*											0.33	0.5									
Blue-lined leatherjacket	*Meuschenia galii*																					1.67
Blue-throat wrasse	*Notolabrus tetricus*	36.5	11	12.3	22.5	16.5	30.8	26	22.3	27.7	5.5	36.7	53	15	30.5	8.75	11	15.8	6.3	14.7	20	23.7
Brown-spotted wrasse	*Notolabrus parilus*	2.75	0.75	0.33			0.25	1	0.33			5.33	5.5	0.33	0.5			0.25			0.67	
Castelnau's wrasse	*Dotalabrus aurantiacus*	0.25		1			2	1				5.67	8.5	1.33	4			0.75	0.67			0.67
Common bullseye	*Pempheris multiradiata*	2		40	46.3			0.33					10		45		1.5					1.33
Dusky morwong	*Dactylophora nigricans*	1.25	0.25					5	2.33		0.5	6.67		4.67	1.5		0.5	0.25		2.67	2.33	
Globe fish	*Diodon nicthemerus*												1									
Gunn's leatherjacket	*Eubalichthys gunnii*				0.5																	
Herring cale	*Olisthops cyanomelas*	0.25	0.75			2.75			2.67		1.5	6	0.5	1.33	1	4.5	0.75	0.75	1.67	3.33	2.33	3
Horseshoe leatherjacket	*Meuschenia hippocrepis*	4		1.67	4.25	10	0.25	0.67				0.33		11		0.75	2	1.5			0.67	9
King George whiting	*Sillaginoides punctata*							0.33														
Little rock whiting	*Neoodax balteatus*											0.67										
Long-fin pike	*Dinolestes lewini*					0.5	0.5	3.33						0.67		0.75		1.25				3
Long-snouted boarfish	*Pentaceropsis recurvirostris*			0.33	1											0.25		0.25				
Magpie perch	*Cheilodactylus nigripes*	7	1.75	1.67	6	1	1.25	8.67	2.67	3		1.67	3	3	3.5	1	3.25	3		2.67	0.67	3.67
Moonlighter	*Tilodon sexfasciatus*	0.5		1	3	0.25	0.25	12	1.67	2	0.5	6.67	5.5	8.67	21.5		1			6.67	5	
Octopus	*Octopus maorum*											0.33										
Old wife	*Enoplosus armatus*	0.5			1	0.5						0.33	1.5	6.33			0.25				1.33	1
Pencil weed whiting	*Siphonognathus beddomei*				1.5		0.25		2							3.25				0.33		
Rainbow cale	*Odax acroptilus*	0.5												0.33			0.25	0.25		0.67	0.67	
Rosy wrasse	*Pseudolabrus psittaculus*																					0.67
Rough leatherjacket	*Scobinichthys granulatus*																			0.33		
Scalyfin	*Parma victoriae*	1	0.25	1	7.25	4.5	1.25	9.33	1	3	1.5	3	3	1.33	4.5	2	4	1.5			0.67	2
Sea sweep	*Scorpis aequipinnis*	8.5	14.5	4.33	0.5	9.5	0.5	21	7	12.7	32.5	0.33		0.67		26.5	14	5.5		1.67		3.67
Senator wrasse	*Pictilabrus laticlavius*	1		1.33	3.25	1	4.25	3.33	0.67	5.33		2.67	2	2.67	7.5	0.5	0.25	3.25		1.67	1.33	2.33
Sharp-nosed weed whiting	*Siphonognathus caninus*																					0.33

Common name	Scientific name	CPBE	CPB	HC	DD	DS	GRA	WW	PWN	GRS	SMOO	BH	CBAY	CBP	CBW	ERD	EBS	SLP	ST	MBB	JI	TMM
Silver drummer	*Kyphosus sydneyanus*	0.25		3.33	1.25	2		0.33						0.33			0.5	0.25		0.67		3.33
Silver trevally	*Pseudocaranx georgianus*													2.33								
Six-spine leatherjacket	*Meuschenia freycineti*			0.33				0.67														
Snake-skin wrasse	*Eupetrichthys angustipes*								0.33			0.33	0.5									
Southern goatfish	*Upeneichthys vlamingii*		0.5	0.33				3.67	0.33			1	0.5		1				0.33	0.67	0.67	0.67
Spiny tailed Leatherjacket	*Acanthaluteres brownii*				0.75	0.25		1.33						5				2.5				
Tommy rough	*Arripis georgiana*	1.25									4	3.67	2	5								
Toothbrush leatherjacket	*Acanthaluteres vittiger*	0.25		0.33																		
Unidentified fish												667			1000					0.67	16.7	667
Unidentified small silver fish												333										
Western blue devil	*Paraplesiops meleagris*				1			0.67														
Western blue groper	*Achoerodus gouldii*	1.25	0.25	0.67	1.25	0.25	0.75	1.67	0.33			4.67	1.5	3	2	0.75	2	2.5		1.67		0.67
Western talma	*Chelmonops curiosus*				1.25																	
White-barred boxfish	*Anoplocapros lenticularis*				0.5							0.33										
Woods siphonfish	*Siphamia cephalotes*	2																				33.3
Yellowfin whiting	*Sillago schomburgkii*												0.5									
Yellow-headed hulafish	*Trachinops noarlungae*				96.8																	
Yellow-stripe leatherjacket	*Meuschenia flavolineata*	1.75			4	2.5		1.67					0.5	2.33		0.25		0.75		0.33		4
Zebra fish	*Girella zebra*	1.25	0.25	4.33	1.5	0.5	20.3	2.67	1.33	51.3	348	12.3	15	3	3.5		5.75	0.75		14.3	10.3	1.67

Invertebrate/cryptic fish method: average abundances per 50 m x 1 m transect for all 21 sites. Note that some fish species were recorded using both methods.

Species / (category in bold)	Scientific name	CBE	CB	HC	DD	DS	GRA	WW	PWN	GRS	SMOO	BH	CBAY	CBP	CBW	ERD	EBS	SLP	ST	MBB	JI	TMM
Cryptic fish and elasmobranchs																						
Anoplocapros lenticularis	White-barred boxfish		0.25		0.25																	
Brachynectes fasciatus	Barred Threefin						0.25			0.5												
Clinid spp.	Weedfish					0.25					0.25									0.17		
Diodon nicthemerus	Globe fish								0.17								0.25					
Eocallionymus papilio	Painted stinkfish							0.17						0.33								
Favonigobius lateralis	Long-finned goby											11.7										
Hypoplectrodes nigroruber	Banded seaperch				0.25																	
Nesogobius sp. 1 SA	Goby												1.75	1.33	1							
Norfolkia clarkei	Common threefin													0.17				0.25				
Paraplesiops meleagris	Western blue devil				0.5																	
Parascyllium spp.	Catshark						0.25															
Pempheris multiradiata	Common bullseye				2.5			0.83				0.83	0.25	0.5	0.75		1			0.33		
Trinorfolkia cristata	Crested threefin									0.5		0.17	0.25	0.33	0.75							
Unidentified fish	Unidentified fish								0.33				1	0.17							0.17	

Species / (category in bold)	**Scientific name**	**CBE**	**CB**	**HC**	**DD**	**DS**	**GRA**	**WW**	**PWN**	**GRS**	**SMOO**	**BH**	**CBAY**	**CBP**	**CBW**	**ERD**	**EBS**	**SLP**	**ST**	**MBB**	**JI**	**TMM**
Crustaceans																						
Hermit crab	Hermit crab	5.25	3.25	1.67	0.5	0.5	0.25			3		0.33	0.5	0.17		1	0.25		0.33	1.17	1.67	0.33
Jasus edwardsii	Southern rock lobster				0.25			0.5									0.25					
Lomis hirta	Hairy stone crab									0.5												
Nectocarcinus spp.	Swimmer crab		0.5															0.25				0.17
Plagusia chabrus	Red bait crab	2.25	3.25	0.5	0.25	0.25		0.17	0.33	1.17		0.33		0.33		1.5	2	1.75		0.17	0.17	1.33
Unidentified crab	Unidentified crab																					0.17
Asteroids (sea stars)																						
Allostichaster polyplax	Many-armed seastar																		0.17			
Coscinasterias muricata	Eleven-arm star		0.25	0.33				0.17		0.83		1.83	0.75	0.67	2.25				0.67		0.17	
Echinaster arcystatus	Pale mosaic seastar			0.17	0.75		0.25							0.17	0.5							0.17
Fromia polypora	Many-spotted seastar				0.5											0.25						
Meridiastra calcar	Eight-armed seastar		0.25		10.8	0.5	0.25											0.25				0.67
Meridiastra gunnii	Gunn’s six-armed star			0.5	1	0.25		0.33	0.67				0.5	0.83	0.25							0.17
Nectria macrobrachia	Large-plated seastar	0.25	0.5		2.25	2.25	0.25	0.17										0.75				0.67
Nectria ocellata complex	Spotted seastar/ multi-spined seastar							0.17							0.25							
Nectria saoria	Saori’s seastar	2	1	0.17	8.25	2.25	1.75	0.5	0.33	0.17				0.67	1.25	0.75	1.25	3.75			0.17	1.67
Nectria wilsoni	Wilson’s seastar		0.75	1			2		3.33	0.33	5	2.33	0.5	6.33	1			2.75	1		2.33	
Pentagonaster dubeni	Vermillion biscuit star			0.33						11.33		2.17		1.33					18.3	38	2	
Petricia vernicina	Cushion star	0.25	0.5	0.83	1.25	0.25		0.67	0.17					0.5				0.25				0.5
Plectaster decanus	Seastar	0.25		0.17	1.25	0.75		0.67				0.33	0.25		0.25							0.33
Pseudonepanthia troughtoni	Troughton’s seastar			0.17	2.5	0.5	0.5	0.33	0.17				0.25	0.5	0.5			0.5				0.5

Species / (category in bold)	**Scientific name**	**CBE**	**CB**	**HC**	**DD**	**DS**	**GRA**	**WW**	**PWN**	**GRS**	**SMOO**	**BH**	**CBAY**	**CBP**	**CBW**	**ERD**	**EBS**	**SLP**	**ST**	**MBB**	**JI**	**TMM**
Tosia australis	Southern biscuit star		1.25	0.17		1.25	0.5		0.17	1		0.33	0.25	0.33					0.33	0.83	0.67	
Tosia magnifica	Magnificent bscuit star									0.17												
Uniophora granifera	Granular seastar								0.17			0.5										
Crinoids (feather stars)																						
Antedon incommoda	Variable feather star													0.33	1							
Cenolia spp.	Orange/Tasmanian feather stars	0.25	3.75	40.8	43	20	16.3	11	2.83	15.8		9.17	1.25	6.33	6.75	1	1.5	5.25	7.5			27.8
Echinoids (urchins)																						
Amblyneustes pallidus	Yellow-spined egg urchin																		0.67			
Amblypneustes spp.	Egg urchins	3.5	1							0.17									0.5			0.5
Centrostephanus tenuispinus	Western hollow-spined urchin		0.25		0.25			0.33					0.25		0.25							
Heliocidaris erythrogramma	Purple urchin	9	38.8	3.17	8	2.25	1.25	1.33		12.5		9.67	2	0.33		2	0.5	2.75	4.83			1.5
Holopneustes spp.	Egg urchins	1.75	7.5				0.25									1			3			0.5
Phyllacanthus irregularis	Western slate-pencil urchin													0.17								
Holothurians (sea cucumbers)																						
Neothyonidium spp.	Sand sea cucumber	0.75	0.25	4.17																		
Stichopus spp.	Southern/Ludwig's sea cucumbers											0.17			0.25							
Molluscs																						
Aphelodoris spp.	Nudibranch																				0.17	
Astele subcarinatum	Top Shell		0.75		0.5																	
Ceratosoma brevicaudatum	Short tailed nudibranch															0.25						
Conus anemone	Anemone cone									0.17												
Dicathais orbita	Dog whelk	3.75	0.75		1	1.25	0.75			0.5				0.17	0.25	1.5	14.8	1.5		4	1.17	
Flabellina	Red-lined														0.5							

Species / (category in bold)	**Scientific name**	**CBE**	**CB**	**HC**	**DD**	**DS**	**GRA**	**WW**	**PWN**	**GRS**	**SMOO**	**BH**	**CBAY**	**CBP**	**CBW**	**ERD**	**EBS**	**SLP**	**ST**	**MBB**	**JI**	**TMM**
rubrolineata	flabellina																					
Fusinus australis	Southern spindle whelk													0.17								
Haliotis laevigata	Greenlip abalone	1.5	1.75	0.67			4	0.33	0.17		2.75	0.83	0.25	1.33	0.5		0.25		0.5		9.17	0.33
Haliotis rubra complex	Blacked lipped abalone species	10.8	8			0.5	4.5		5.67	0.33		0.5	1.5	2.67	1.5	0.5	14.5	2.75	5	0.33	3.83	5.33
Mitra glabra	Black mitre	0.25																				
Mitre shell sp. 1 SA	Mitre shell																			0.17	0.33	
Octopus maorum	Maori octopus			0.17																		
Phasianella australis	Pheasant shell																					0.17
Phasianella ventricosa	Swollen pheasant shell	0.25	0.25	0.83		0.25	0.25			0.67		0.33							0.67	0.17		0.5
Pleuroploca australasia	Tulip shell	0.75	0.75	0.33	0.25			0.67		0.33	2.75			0.17						1.17	3	0.5
Scutus antipodes	Elephant snail										0.25	0.5	1.5		0.25				0.17		0.67	
Triton sp. 1 SA	Triton shell														0.25							
Turbo torquatus	Turban shell	18.5	23	0.67	23.3	7	1.75	0.17		0.67			0.25			5.75		0.75	1	1.83	2	1.5
Turbo undulatus	Warrener	18.5	2.75	0.5		6	4.75	0.17		39.3	0.25	1.17		0.17	0.25	5.25	98.8	19.3	7.33	151	75.8	
Unidentified gastropod	Unidentified gastropod			0.17																		
Unidentified mollusc	*Unidentified mollusc*													0.33								
Other																						
Phlyctenactis tuberculosa	Swimming anemone											0.33	1.25						0.17			