SURVEYS ACROSS REEFS IN THE ADELAIDE AND MT LOFTY RANGES NATURAL RESOURCE MANAGEMENT REGION 2014 - 15

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A report to the Adelaide and Mount Lofty Ranges Natural Resource Management Board and the Conservation Council of South Australia

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TABLE OF CONTENTS

OVERVIEW

Since 2009, the Reef Watch citizen science program has undertaken seasonal surveys of six coastal reefs in the Adelaide and Mt Lofty Ranges (AMLR) Natural Resources Management Region with the broad aim of establishing if the degradation of reefs observed on Adelaide's metropolitan coasts are encroaching southwards (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008).

The sites included in this program are:

- Broken Bottom, a highly degraded reef off the Adelaide metropolitan coast;
- Hallett Cove, an exposed reef that is generally considered healthy,
- Noarlunga North Inside and Noarlunga South Inside, which are considered "at risk" sites showing signs of decline;
- Second Valley on the Fleurieu Peninsula, considered a healthy reef; and
- The Bluff (Rosetta Head) at Victor Harbor, also considered a healthy reef.

Reef Watch observations of reef status (or "health") was based on biological data from four reef community strata:

- Sessile reef community composition – specifically canopy macroalgal species cover, bare substrate cover, mussel cover and turfing macroalgal cover;
- Fish community composition, in particular those species within the community that maintain territories within a reef (described as "site attached');
- Mobile invertebrate predator community composition; and
- Invasive species observed via the Reef Watch Feral or in Peril Program.

The 2014-15 report comprises the seventh annual summary of Reef Watch observations, building on results from previous years (see CCSA 2009, Westphalen 2009, 2010, 2012, 2012, 2013, 2014).

Results from the 2014-15 Reef Watch surveys indicate an ongoing capacity to provide valuable insights into the status of reef systems on the Fleurieu Coast. Overall, the Reef Watch surveys for 2014-15 are an improvement over previous years in terms of:

- Seasonal coverage across sites
- Alignment between LIT, fish and invertebrate transects and
- The aerial representativeness of the LITs, in that over half the cumulative distance was greater than 40 m, a coverage which has been considered broadly comparable in information terms to the minimal number of destructive quadrats required to characterise a patch of reef at a point in time (see Turner 1995, Collings 1996).

There is therefore a high degree of confidence in the index-based status of reefs in terms of the data, although there are a range of issues with the Turner *et al.* (2007) indices that do somewhat erode the results (see Turner *et al.* 2007, Collings *et al.* 2008. Westphalen 2009, 2010, 2011, 2012, 2013, 2014, Appendix A).

A summary of the observations within each site-season found Broken Bottom to rate at caution status, which possibly suggest some improvement but was otherwise in keeping with this sites otherwise degraded condition. Similarly, Hallett Cove, Noarlunga North Inside, Second Valley and

The Bluff were generally in good condition, which again aligns with the tenor of previous observations.

However, the Noarlunga South Inside site rated as caution and even poor, which indicates a degree of concern for this site. Given that there are healthy sites to the north (Noarlunga North Inside and Hallett Cove), this would suggest a possible localised source for reef decline.

Marine pest observations from the Feral or in Peril program found one instance of European fan worm (*Sabella spallanzanii*) at the wreck of the Norma off Semaphore, which may be considered well within the acknowledged distribution of this pest. Otherwise there were three intertidal observations of the European shore crab (*Carcinus maenas*) at Marino Rock (twice) and Port Noarlunga South. Given that this pest has also been observed at Aldinga in recent years, it is perhaps worth closer investigation.

RECOMMENDATIONS

A range of recommendations have carried through from previous reports (see Appendix A), but there are a number specific to the 2014-15 survey, including:

- Transect data should be verified to confirm that it hasn't been mislabelled.
- Fish composition within each site-season may be better considered in terms of the overall diversity, richness or species evenness rather than the "site-attached" subset. This approach would make more comprehensive use of the available data and negate some of the various issues with the site attached fish, although this would require reconfiguration of the index. Importantly, it should be noted that the identification of fish to species is not required.
- Fish abundance data for both the field observations and the ensuing index calculations may benefit from the use of a Braun-Blanquet like approach with abundances estimated according to categories (i.e. 1 = species present, ranging up to 5 = more than 500 individuals). This approach is likely to be quicker and probably more consistently applied across different observers, although the reconfiguration of the index may not be a trivial issue and it may limit capacity for comparisons with previous reporting.
- Targeted surveys for European shore crab.
- The status of both Noarlunga sites in particular the southern site, which tend to have lower canopy cover relative to supposedly healthy sites, are probably worthy of closer scrutiny.
- The potential for a localised source of reef decline a Noarlunga should also be considered.

INTRODUCTION - REEF WATCH OBSERVATIONS

Reef status investigations on the Adelaide metropolitan coast and the broader Fleurieu Peninsula began in 1996, with formal surveys undertaken either by the University of Adelaide or the South Australian Research and Development Institute (SARDI) Aquatic Sciences in 1996, 1999, 2005 and 2007 (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008).

Citizen Science-based monitoring via the Reef Watch program has been operating more or less across this period, although with the initial aim of developing a broader awareness and education of reef health issues (Turner *et al.* 2006, CCSA 2009). As the skill base amongst the Reef Watch volunteers has evolved, coupled with a more appropriate spatiotemporal sampling protocol, a more rigorous analysis and reporting of Reef Watch data has been possible. These improvements included a focus on six reef sites in the Adelaide and Mt Lofty Ranges (AMLR) Natural Resource Management (NRM) Region coast (see Westphalen 2009, 2010, 2011, 2012, 2013, 2014; Figure 1), comprising seasonal observations across:

- Broken Bottom, a highly degraded reef off the Adelaide metropolitan coast;
- Hallett Cove, an exposed reef that previous surveys had confirmed as being healthy, although the 2009-10 survey raised some concerns about this site;
- Noarlunga North Inside and Noarlunga South Inside, which might be considered to be "at risk" sites that have shown signs of decline;
- Second Valley on the Fleurieu Peninsula, considered a healthy reef well beyond the reach of current developments; and
- The Bluff (Rosetta Head) at Victor Harbor, also considered a healthy reef.

Reef Watch observations thus encompass reefs that may be cause for concern in the Noarlunga and Hallett Cove areas, relative to a reef previously ranked as degraded (Broken Bottom) and sites considered to be fundamentally healthy (Second Valley and The Bluff).

Changes in reef status at any of these sites can thus be placed in an appropriate context.

AIMS

This is the seventh report on Reef Watch surveys. The aims of the 2014-15 Reef Watch report are to:

- Describe and summarise Reef Watch data obtained in the 2014-15 period;
- Consider the status of each Reef Watch observation site through the approach provided by the Turner *et al.* (2007) indices; and
- Compare the reef status results with previous years.

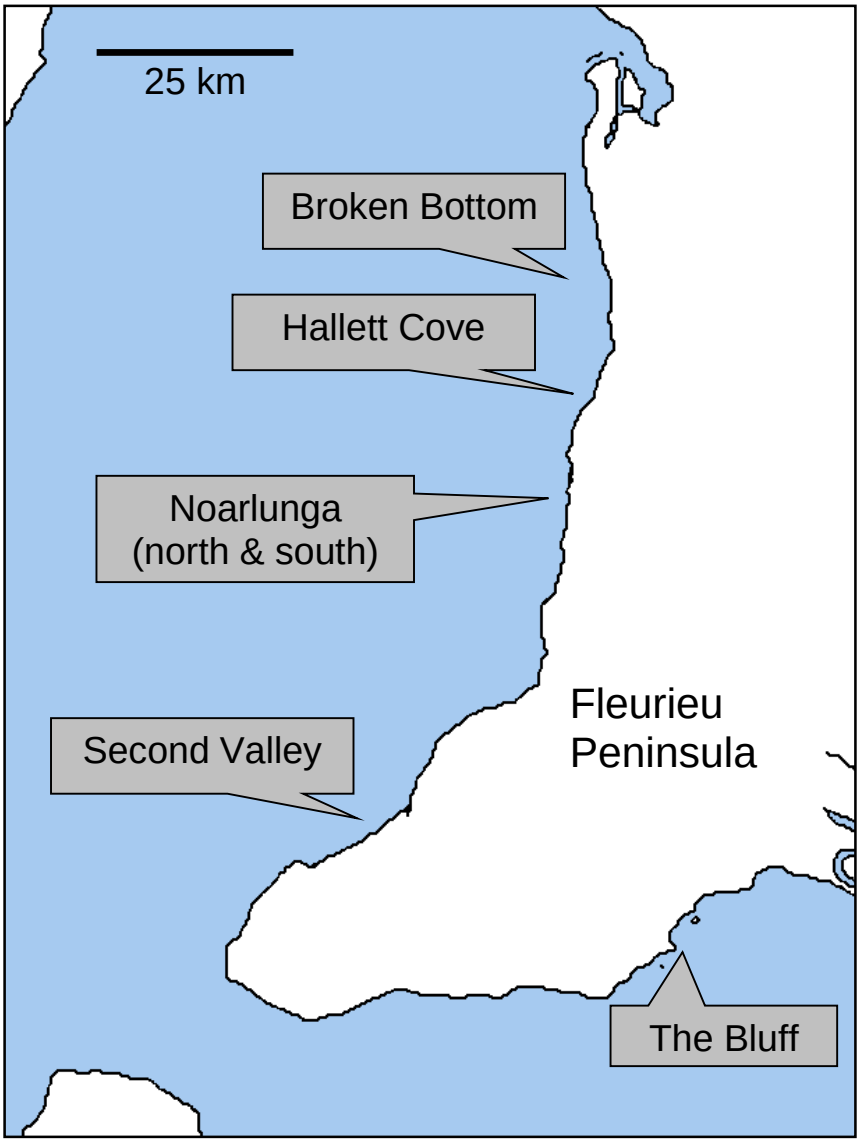

Figure 1 - Map of Fleurieu Peninsula showing the locations of the reefs surveyed by the Reef Watch program.

METHODS AND INDICES

Reef Watch observations of reef status (or "health") was based on biological data from four reef community strata:

- Sessile reef community composition – specifically canopy macroalgal species cover, bare substrate cover, mussel cover and turfing macroalgal cover;
- Fish community composition, in particular those species within the community that maintain territories within a reef (described as "site attached');
- Mobile invertebrate predator community composition; and
- Invasive species both as part of surveys as well as those observed via the Reef Watch Feral or in Peril Program.

Survey methods and data interpretation were based on those employed in Reef Health investigations (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008, although see Turner *et al.* 2007 for a full description). However, Reef Watch observations employed a simplified taxonomy within each survey component, in particular Line Intercept Transects (LITs), but also Fish and Invertebrate surveys (see Appendix A for the taxa considered).

Data from the invasive species aspect of the Feral or in Peril program were also considered independently of the more targeted Reef Watch observations as they form a useful additional data resource (see http://feralperil.ala.org.au, accessed August 2015).

The primary tools for interpreting Reef Watch data were eight of the eleven indices of reef status developed by Turner *et al.* (2007), in particular those derived from the LITs and abundance measures (see Table 1). Species richness derived indices could not be employed owing to the simplified taxonomy used by Reef Watch. In addition, the sedimentation index was also not used as Reef Watch does not collect these data.

Table 1 - Eleven indices developed by Turner *et al.* (2007) to describe reef "health" on the South Australian coast. Note that only those in red text were employed in this report.

Index type	Index	Data source
Areal cover	Areal cover of canopy-forming macroalgae	LIT
	Areal cover of turfing macroalgae	LIT
	Areal cover of mussel mats	LIT
	Areal cover of bare substrate	LIT
Abundance	Size and abundance of blue-throated wrasse	Fish
	Abundance of site-attached fish	Fish
	Abundance of mobile invertebrate predators	Invertebrate
Presence	Presence of invasive taxa	A general part of surveys and/or Feral or in Peril
	Presence of high sedimentation	No Data
Species richness	Richness of macroalgae	Not Used
	Richness of mobile invertebrates	Not Used

A full description of each index including their input data and calculation as well as some of their limitations is found in Turner *et al.* (2007), although the critique offered by Collings *et al.* (2008) should also be considered. Additional interpretations of the indices as they are applied to Reef Watch data can be found in the findings and recommendations from previous Reef Watch reports (see CCSA 2009, Westphalen 2009, 2010, 2011, 2012, 2013, 2014, Appendix A).

Note that the reporting period for Reef Watch data includes fish, invertebrates and LIT summaries across continuous months within each season, meaning that analyses include observations undertaken from June 2014 through to the end of May 2015. Otherwise the summary could entail data split across two winters (i.e. June 2014 along with July and August 2014), which would likely add an uninformative level of variability to results (noting the results of seasonal and inter-annual variability observed in previous reporting; see CCSA 2009, Westphalen 2009, 2010, 2011, 2012, 2013, 2014).

Approaches to Reef Watch surveys, resulting data and reef status indices remain unchanged for 2014-15. Unfortunately, this approach encompasses any of the problems identified in previous surveys, particularly with regard to the indices and their use (see Appendix A).

SURVEY DATA, INDEX RESULTS AND DISCUSSION

Reporting of Reef Watch data for 2014-15 includes:

- Summaries of observations (mostly number of transects within each season);
- Interpretation of the "Feral" aspect of the Feral or in Peril program; and
- Seasonally averaged index calculations within each reef.
- Summary reef status compared to previous years.

INDEX DATA AVAILABILITY AND QUALITY

The Reef Watch surveys for 2014-15 included all six sites as considered in previous years (Figure 1) with general alignment across fish, invertebrate and LIT samples, although there were some differences (i.e. 38 LIT versus 40 Fish and 39 invertebrate transects; Table 2). All sites were considered in at least three seasons, with Noarlunga South Inside and Noarlunga North Inside having observations in all seasons (Table 2).

Because LITs were used in the majority of indices (four of eight considered; Table 1), only those site-season combinations that included these observations (as well as corresponding fish and invertebrate observations) were used as the basis of determining reef status. However, relative to previous years there was only one discrepancy at Second Valley in autumn wherein there appeared to be fish survey without any corresponding invertebrate or LIT observation; Table 2). The underlying data for this transect should be reconsidered to confirm that it hasn't been mislabelled.

Table 2 - Reef Watch surveys on the AMLR NRM coast 2014-15 in terms of the number of transects within each of the fish, invertebrate and LIT assessment strata as well as the total length of LIT (metres in parentheses).

Site	Winter			Spring			Summer			Autumn		
	Fish	Invertebrate	LIT	Fish	Invertebrate	LIT	Fish	Invertebrate	LIT	Fish	Invertebrate	LIT
Broken Bottom				1	1	2 (54)	3	3	4 (82)	3	3	2 (43)
Hallett Cove				2	2	2 (60)	3	3	4 (105)	1	1	1 (23)
Noarlunga North Inside	3	3	2 (28)	3	3	2 (57)	1	1	1 (22)	2	2	1 (22)
Noarlunga South Inside	1	1	1 (23)	4	4	3 (62)	1	1	1 (20)	2	2	2 (50)
Second Valley	1	1	1 (22)	2	2	2 (53)	2	2	1 (30)	1		
The Bluff				2	2	2 (46)	1	1	3 (98)	1	1	1 (24)

Coverage included 20 of the 24 possible site-season combinations (Table 2). Spring and summer observations included all sites whereas autumn covered five (discounting the single fish transect at Second Valley – see above) whereas there were only three sited covered in winter.

The average cumulative LIT length within each site-season combination was around 46 m (standard deviation ± 26 m), ranging from 20 m at Noarlunga South Inside in summer to 105 m Hallett Cove in summer (Table 2). In previous Reef Watch reporting, some observations were excluded from the analysis because the total LIT length was too short to be considered representative (i.e. less than 20 m total length collected; see e.g. CCSA 2009, Westphalen 2009). However, within the 2014-15 observations all LIT samples could be included based on this criterion (Table 2). However, it is worth noting that 11 site-season combinations (55% of observations) had

a cumulative LIT greater than 40 m, which is the minimum distance used in more formal reef health surveys (see Turner *et al.* 2007).

Overall, the Reef Watch dataset in terms of seasonal coverage across sites for this reporting period is similar to previous years, but with improvements in terms of both the coverage of site-season combinations (meaning seasonal coverage has also improved) as well as the alignment between LIT, fish and invertebrate transects and finally the representativeness of the LITs.

INDEX DATA

Reef status index results include data on percentage covers of canopy-forming macroalgae, bare substrate, mussels and turfing species, as well as numbers of site attached fish, mobile invertebrate predators and invasive species (Table 1; Table 3).

As with previous reporting of Reef Watch data using the Turner *et al.* (2007) indices, only a subset of the collected data is employed (see Westphalen 2009, 2010, 2011, 2012, 2013, 2014), including six of the 16 LIT lifeforms, 17 of the 28 fish species and only three of the 29 observed species from invertebrate surveys (Appendix B).

Previous surveys had revealed very few numbers of blue-throated wrasse (see Westphalen 2010, 2011, 2012, 2013, 2014), which when combined with the additional issues as to the applicability of the index, was motivation for its being excluded from the subsequent reef status assessment (Table 3). For the 2014-15 survey there were 19 recorded sightings across 39 transects. However, in order to maintain comparable alignment with previous surveys, this index was still precluded, making the total number of indices employed to seven.

Average percent cover of canopy forming species ranged from 1.25% to 90.25% and tended to offset the other cover-based indices (Table 3).

Invertebrate predators were also quite variable, although it needs to be noted that the numbers of predators comprise the total (rather the average) across all transects and the totals need to be considered relative to the number of transects considered (up to four at Noarlunga South Inside in spring; Table 3).

Similarly, fish counts need to be considered relative to the differences in the numbers of transects (up to four again at Noarlunga South Inside in spring; Table 3). However, high numbers of site attached fish (> 400 individuals) at Noarlunga North Inside-spring and Second Valley-summer (Table 3) were also due to large quantities of yellow-headed hulafish (*Trachinops norlungae*) and bullseye (*Pempheris* sp.) at both sites along with weedy whiting (*Siphonognathus* sp.) and long-finned pike (*Dinolestes lewini*) at Second Valley as well as southern hulafish (*Trachinops caudimacuatus*) and sweep (*Scorpis* sp.) at Noarlunga North Inside. High abundances of hulafish and bullseye were observed at some site-season combinations from previous years (see Westphalen 2011, 2012, 2013, 2014), but there is no apparent pattern with respect to locations or season. Other fish species were sporadic in both occurrence and numbers.

Fish composition within each site-season are probably better considered in terms of the diversity and/or richness across all species rather than the “site-attached” subset.

Abundance data for both the field observations and the ensuing index calculations may benefit from the use of a Braun-Blanquet like approach with abundances estimated according to categories (i.e. 1 = species present, ranging up to 5 = more than 500 individuals). This approach is likely to be quicker and probably more consistently applied across different observers, although the reconfiguration of the index may not be a trivial issue and it may limit capacity for comparisons with previous reporting.

Table 3 - Summary of the Reef Watch data used as input to index calculation.

Site	Season	LIT data (average % cover)				Invertebrates		Fish			Invasive species
		Bare rock	Canopy	Mussels	Turf	Number predators	Number transects	Number site attached	Blue-throated wrasse	Number transects	
The Bluff	Autumn		90.25			0	1	0	0	1	0
The Bluff	Summer	2.58	82.73			3	1	2	0	1	0
The Bluff	Spring	0.38	86.17			8	2	11	2	2	0
Second Valley	Winter	5.45	75.57			1	1	4	0	1	0
Second Valley	Summer	1.80	91.60		0.47	1	2	425	2	2	0
Second Valley	Spring	10.38	75.85		0.38	7	2	205	7	2	0
Noarlunga South Inside	Winter	17.94	1.46	58.79		12	1	1	0	1	0
Noarlunga South Inside	Autumn	42.15	8.07	45.21		34	2	21	0	2	0
Noarlunga South Inside	Summer	11.11	8.41	53.90	4.58	9	1	54	0	1	0
Noarlunga South Inside	Spring	24.00	1.25	56.72	4.80	57	4	106	1	4	0
Noarlunga North Inside	Winter	22.88	16.27	26.34		38	3	148	1	3	0
Noarlunga North Inside	Autumn	20.82	35.47	20.14	3.89	23	2	318	0	2	0
Noarlunga North Inside	Summer	8.91	43.42	18.24	3.65	11	1	106	0	1	0
Noarlunga North Inside	Spring	13.61	32.91	30.67	2.13	53	3	478	1	3	0
Hallett Cove	Autumn	1.28	36.18			3	1	201	0	1	0
Hallett Cove	Summer	3.19	61.46		1.04	14	3	27	3	3	0
Hallett Cove	Spring	2.22	87.03			2	2	65	0	2	0
Broken Bottom	Autumn	38.84			2.70	5	3	45	0	3	0
Broken Bottom	Summer	23.65			16.00	5	3	54	1	3	0
Broken Bottom	Spring	49.86			26.31	3	1	121	1	1	0

FERAL OR IN PERIL - FERAL OBSERVATIONS 2014-15

Feral or in Peril data for 2014-15 comprised a total of 49 observations, of which 34 occurred within the AMLR (Appendix C). When included with the 40 Reef Watch surveys (based on LITs; Table 2), this totals 74 feral or in peril observations across around 15 locations (Figure 2; Appendix C).

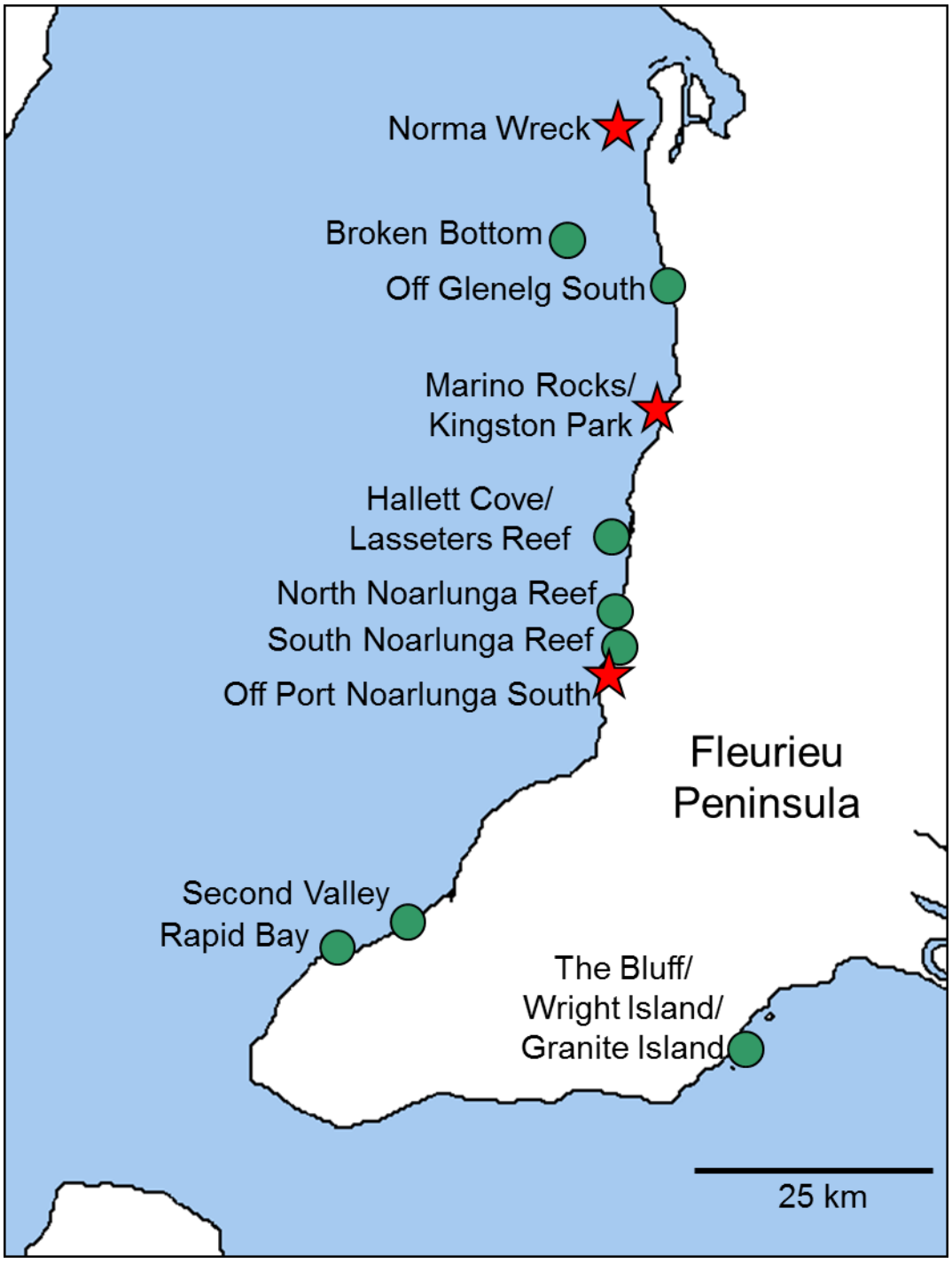

Figure 2 – Map of the Fleurieu Peninsula showing the location of Feral or in Peril observations in 2014-15.

Only four observation included feral species, but only one of these was subtidal with European fanworm (*Sabella spallanzanii*) observed at the wreck of the Norma off Semaphore (Figure 2). This observation may be considered well within the spatial constraints of the distribution of this pest (see Boxall and Westphalen 2003) and in contrast to previous years wherein *S. spallanzanii* was

seen observed at Broken Bottom and Noarlunga (Westphalen 2012) and Hallett Cove (Westphalen 2013, 2014) but also as far south as Wirrina and Kingscote in 2008 (see Kinloch *et al.* 2010).

The remainder included three observations of European shore crab (*Carinus maenas*) at Marino Rocks (two sightings) and Port Noarlunga South (Figure 2; Appendix C). Given that this pest appears to undergo sporadic increases in abundance (see Zeidler 1978, Zeidler 1988) it may be that, with four observations, 2014-15 represents a high point in their population. Targeted surveys for European shore crab would be required to confirm this assertion.

INDEX RESULTS

Individual index scores were averaged to give an overall result for each site-season combination, which was subsequently interpreted according to a predetermined scale relating each reef to one of good, caution or poor status (see Turner *et al.* 2007; Table 4; Table 5). Scores were also averaged across seasons within sites to allow ready comparison between years (see Figure 3).

Across the three seasons for which there was data (spring, summer and autumn), Broken Bottom rated at the intermediate "caution" level (Table 4), which is broadly in keeping with the supposedly degraded state of this site based on formal surveys as it well within the highly urbanised metropolitan coast (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008). The overall scores for this site (46, 49 and 38 in spring summer and autumn respectively) were driven be zero ratings for canopy cover, relatively low levels of invertebrate predators and some bare substrate (with index scores of zero; Table 5).

When considered in terms of the average index score across the 2014-15 period, there appears to be some improvement at Broken Bottom relative to previous years (Figure 3). However, this inference needs to be considered in context with the limitations of the indices (see e.g. Turner et al. 2007, Collings et al. 2008, CCSA 2009, Westphalen 2009, 2010).

Hallett Cove rated as good in all seasons for which there was data (76, 100 and 75 in spring summer and autumn; Table 5) with high canopy cover rating (100) in most seasons (although not in autumn which rated at 40), lack of turf, mussels or bare substrate as well as high levels of site attached fish and mobile predators (but not in spring, which was rated at 28; Table 5) were the major drivers for this result.

Reef Watch summaries for Hallett Cove in 2010-11 and 2011-12 indicated some cause for concern, with caution and even poor status reported (see Westphalen 2011, 2012, Figure 3). However, more formal surveys in the vicinity of the site as well as Reef Watch observation in subsequent years (2012-13, 2013-14 and now 2014-15; Westphalen 2013, 2014; Figure 3) indicated that these negative observations were not widespread and possibly indicated more about variability in community composition within reefs.

Table 4 - Overall reef status index results (see Turner *et al.* 2007) for the 2014-15 reporting period.

Site	Spring	Summer	Autumn	Winter
Broken Bottom	Caution	Caution	Caution	
Hallett Cove	Good	Good	Good	
Noarlunga North Inside	Caution	Good	Good	Caution
Noarlunga South Inside	Caution	Caution	Caution	Poor
Second Valley	Good	Good		Caution
The Bluff	Good	Good	Poor	

The Noarlunga North Inside and Noarlunga South Inside were more variable across seasons (Table 4). Noarlunga North Inside went from caution in spring (overall score of 58), good in summer (86) and autumn (80) and back to caution in winter (56; Table 5). These changes were due to a reduced level of canopy cover in the caution-rated seasons (index scores of 32 and zero in springs and winter respectively), which were matched by the occurrence of mussels (scores of zero and 24 respectively; Table 5). Site attached fish and mobile predators all scored 100.

Noarlunga South Inside rated as caution in spring (score of 50), summer (50) and autumn (40), with poor status in winter (28; Table 4; Table 5). Low canopy cover (scores of zero across all seasons, coupled with some mussel cover (scores of zero across all seasons again), with some bare substrate in autumn. Mobile predators were high (score of 100) in all seasons as was site attached fish in most seasons (100 again) except winter (score of 28; Table 5) which was probably the reason which this observation had poor status.

When considered over time, the status of Noarlunga South Inside appears to be firmly sitting within the caution band, with more similarity to Broken Bottom than the intervening Noarlunga North Inside or Hallett Cove sites (Figure 3).

Table 5 - Reef status indices for each site-season considered by Reef Watch in the 2014-15. See Turner *et al.* (2007) for the details of each index. Note that the blank cells in the results (notably the columns for turf, mussels and invasive species) are "Null" values for the index score that are not the same as zeros or "no data".

Site	Season	Status	Overall Score	Canopy	Turfing	Mussels	Bare	Site-attached fish	Mobile Predators	Invasive species
Broken Bottom	Spring	Caution	46	0			0	100	85	
Broken Bottom	Summer	Caution	49	0				100	47	
Broken Bottom	Autumn	Caution	38	0			6	100	47	
Hallett Cove	Spring	Good	76	100				100	28	
Hallett Cove	Summer	Good	100	100				100	100	
Hallett Cove	Autumn	Good	75	40				100	85	
Noarlunga North Inside	Spring	Caution	58	32		0		100	100	
Noarlunga North Inside	Summer	Good	86	59				100	100	
Noarlunga North Inside	Autumn	Good	80	39				100	100	
Noarlunga North Inside	Winter	Caution	56	0		24		100	100	
Noarlunga South Inside	Spring	Caution	50	0		0		100	100	
Noarlunga South Inside	Summer	Caution	50	0		0		100	100	
Noarlunga South Inside	Autumn	Caution	40	0		0	0	100	100	
Noarlunga South Inside	Winter	Poor	28	0		0		11	100	
Second Valley	Spring	Good	100	100				100	100	
Second Valley	Summer	Good	71	100				100	14	
Second Valley	Winter	Caution	58	100				47	28	
The Bluff	Spring	Good	88	100				64	100	
The Bluff	Summer	Good	69	100				23	85	
The Bluff	Autumn	Poor	33	100				0	0	

Second Valley rated as good in spring and summer (index scores of 100 and 71 respectively), was not assessed in autumn and rated as caution (58) in winter (Table 4; Table 5). This site had high canopy cover in all seasons (ratings of 100), with the poor score in winter largely due to reduced numbers of site attached fish (score of 47) and lower mobile invertebrates (score of 14; Table 5). Given that this result occurred in winter it may be that poorer visibility had some influence on these index scores, in particular the site attached fish.

The average index score over time Second Valley appears well placed within the good rating (apart from a dip in 2011; Figure 3).

The Bluff had good status in spring and summer (overall scores of 88 and 69 respectively) with poor status in autumn (Table 4; Table 5). Canopy cover rated at 100 across all seasons, whereas site attached fish and mobile predators rated at zero in autumn, which would explain the poor status for this observation. As with Second Valley, this result may be the result of lower visibility in winter, particularly given the reputation of The Bluff as a challenging location to dive.

Recordings of visibility estimates (in metres) for each observation would assist in verifying whether this factor was potentially influential.

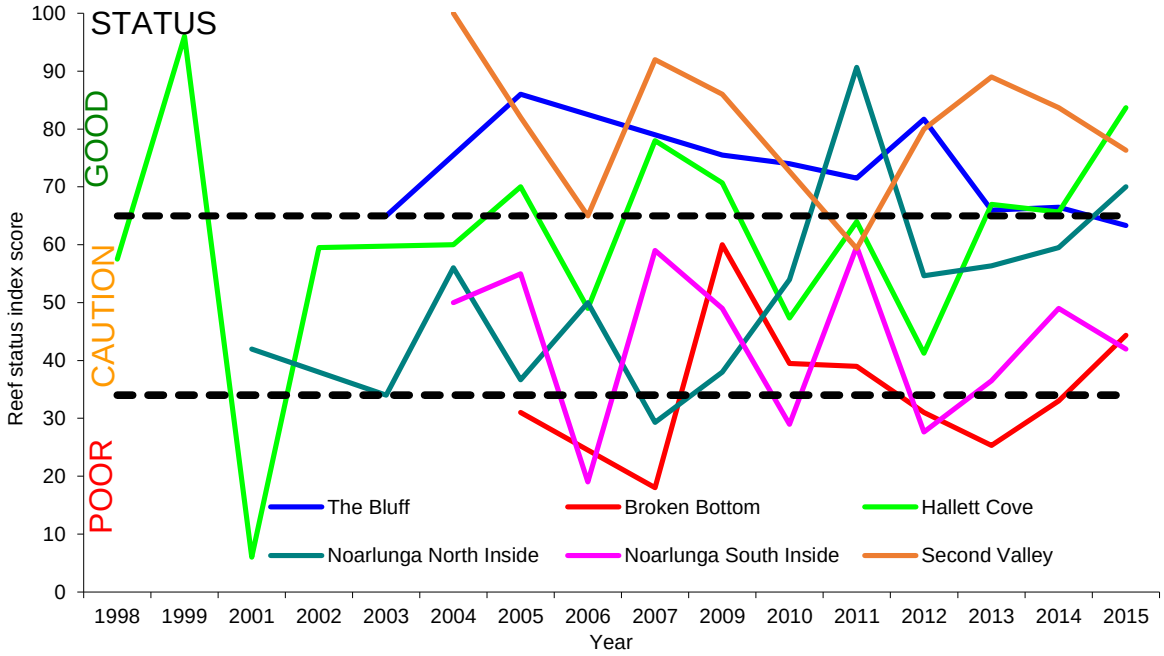

Figure 3 - Average reef status scores across seasons including all data from both formal Reef Health surveys and Reef Watch from 1998 to present[1].

[1] Formal surveys (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008) comprise one seasonal observation at each location compared to two to four seasons in Reef Watch surveys. In addition, the Turner *et al.* (2007) and Collings *et al.* (2008) surveys employed all eleven of the index scores relative to the seven (or at most eight) considered by Reef Watch. Similarly, health status indices were not employed until the Turner *et al.* (2007) observations and data from earlier surveys do not align to the index requirements other than those derived from LIT. Estimates of reef status prior to 2007 and comparisons between Reef Watch and formal surveys therefore need to be viewed with considerable caution.

In general terms, the status of sites considered to be within the healthy (i.e. non-urbanised) coast, notably Broken Bottom, Second Valley, Noarlunga North Inside and The Bluff were in keeping with this model as they range within the good or upper level of the caution status (Figure 3). Broken Bottom has indicated signs of improvement, but the status of Noarlunga South Inside appears to be tracking more closely with what would be considered a degraded location. Given that there are intervening sites between Noarlunga South Inside and Broken Bottom (Noarlunga North Inside and Hallett Cove) with better status it would appear that localised factors may be influential. Noarlunga South Inside would appear to be in close proximity to shallow water closer to shore when compared to other sites and is just north of the mouth of the Onkaparinga River. This location may therefore be subject to higher levels of sedimentation relative to other sites. However, the Noarlunga North Inside site is not far away, which raises the question as to what factors might affect one but not the other location. The status of both Noarlunga sites, which tend to have lower canopy cover relative to supposedly healthy sites, are probably worthy of closer scrutiny, in particular in terms of the identification of any localised sources of reef decline.

CONCLUSIONS AND RECOMMENDATIONS

Overall, the Reef Watch data continues to provide valuable insights into the status of reef systems on the AMLR NRM coast.

Improvements to the sampling offer capacity for a high degree of confidence in the index-based status of reefs in terms of the data, but there remain issues with the interpretation of reef status via Turner *et al.* (2007) indices (see Turner *et al.* 2007, Collings *et al.* 2008. Westphalen 2009, 2010, 2011, 2012, 2013, 2014, Appendix A).

Caution status at Broken Bottom indicates a potential improvement but this site was otherwise in keeping with its perceived degraded condition. Hallett Cove, Noarlunga North Inside, Second Valley and The Bluff were generally in good condition which also aligns their historical status.

However, the Noarlunga South Inside site rated as caution and even poor, which indicates a degree of concern for this site.

RECOMMENDATIONS

A range of recommendations have carried through from previous reports (see Appendix A), but there are a number specific to the 2014-15 survey, including:

- Transect data should be verified to confirm that it hasn't been mislabelled.
- Fish composition within each site-season may be better considered in terms of the overall diversity, richness or species evenness rather than the "site-attached" subset. This approach would make more comprehensive use of the available data and negate some of the various issues with the site attached fish, although this would require reconfiguration of the index. Importantly, it should be noted that the identification of fish to species is not required.
- Fish abundance data for both the field observations and the ensuing index calculations may benefit from the use of a Braun-Blanquet like approach with abundances estimated according to categories (i.e. 1 = species present, ranging up to 5 = more than 500 individuals). This approach is likely to be quicker and probably more consistently applied across different observers, although the reconfiguration of the index may not be a trivial issue and it may limit capacity for comparisons with previous reporting.

- Targeted surveys for European shore crab.
- The status of both Noarlunga sites in particular the southern site, which tend to have lower canopy cover relative to supposedly healthy sites, are probably worthy of closer scrutiny.
- The potential for a localised source of reef decline a Noarlunga should also be considered.

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APPENDIX A – RECOMMENDATIONS FROM PREVIOUS REPORTS

There are number of standing recommendations that have carried over from previous reports (see Westphalen 2009, 2010, 2011, 2012, 2013, 2014).

Recommendations for further action that are not the responsibility of Reef Watch

- A scientific survey of Adelaide metropolitan reefs along the lines of Turner *et al.* (2007), and Collings *et al.* (2008) with particular emphasis on the zone from Hallett Cove to Second Valley aimed at establishing the nature and status of the reefs in this region relative to degraded reefs to the north and more pristine reefs to the south.

- More research is required into the causal link between sediment loads and reef decline and there is a need for more data on sedimentation and turbidity levels along the Adelaide metropolitan coast as well as less urbanised areas to the south.

Recommendations for index review and development

The following based on the notion that the Reef Watch survey will continue using the Turner *et al.* (2007) indices and that the fundamentals of the related survey method are to be continued.

- There is a need for greater understanding of the sensitivities of the overall status index to changes in the underlying parameters and by extension, their definition and calculation. However, any investigative modelling of the index sensitivities needs to be made in light of any potential changes (see below).

- Better use of Reef Watch data through simplification of the field requirements and/or adjustment to index calculation/interpretation.

- Removal of indices that are not employed or only make sporadic contributions to index calculation:

    - Sedimentation index – not used

    - Richness of macroalgae – not used

    - Richness of mobile invertebrates – not used

    - Blue-throated wrasse – does not occur across all sites

- Further simplification and/or targeting of the taxonomy used in deriving fish and invertebrate indices to specific species/genera/lifeforms.

- Simplification of the estimation of numbers, particularly as relates to fish surveys such as the use of Braun-Blanquet style categories.

- An expanded interpretation of reef status (or “health”) to include:

    - Consideration of marine debris

    - Consideration of EPBC/NP&WS listed species

APPENDIX B – TAXA USED IN REEF WATCH ANALYSES

LINE INTERCEPT TRANSECTS

Lifeform	Description	Index
ATTAN	Attached animal	NA
BBIG	Brown big	Canopy
BKELP	Brown kelp	Canopy
BSMALL	Brown small	NA
DDD	No data	NOT USED
ENC	Encrusting	NA
GRASS	Seagrass	NA
MOBAN	Mobile animal	NA
MUSSELS	Mussels	Mussels
RBIG	Red big	NA
RCORAL	Red coralline	NA
ROCK	Bare rock	Bare
RSMALL	Red small	NA
SAND	Bare sand (on rock)	Bare
START	Transect start	NA
TURF	Turf	Turf

NA = Not Applicable

FISH SPECIES OBSERVED ACROSS REEF WATCH SURVEYS

Species	Common name	Index
	Other Leatherjacket	NO
Dactylophora nigricans	Dusky Morwong	NO
Dinolestes lewini	Long-finned Pike	NO
Girella zebra	Zebra fish	NO
Kyphosus sydneyanus	Drummer	NO
Othos dentex	Harlequin fish	NO
Pentaceropsis recurvirostris	Long-Snouted Boarfish	NO
Scorpis	Sweep	NO
Siphonognathus	Weed Whiting	NO
Trachinops	Hulafish	NO
Upeneichthys vlamingii	Goat Fish	NO
	Other Wrasse	YES
Cheilodactylus nigripes	Magpie Perch	YES
Chelmonops curiosus	Western Talma	YES
Enoplosus armatus	Old Wife	YES
Meuschenia flaviolineata	Yellow-Striped Leatherjacket	YES
Meuschenia hippocrepis	Horseshoe Leatherjacket	YES
Notolabrus tetricus	Blue-Throated Wrasse	YES
Odax acroptilus	Rainbow Cale	YES
Odax cyanomelas	Herring Cale	YES
Paraplesiops meleagris	Western Bluedevil	YES
Parma victoriae	Scalyfin	YES
Pempheris	Bullseye	YES
Phycodurus eques	Leafy seadragon	YES
Pictilabrus laticlavius	Senator Wrasse	YES
Tilodon sexfasciatus	Moonlighter	YES
Trachinops caudimaculatus	Southern Hulafish	YES
Trachinops noarlungae	Yellow-Headed Hulafish	YES

INVERTEBRATE SPECIES OBSERVED IN REEF WATCH SURVEYS

Species	Common name	Index
Chelmonops curiosus	Western Talma	FISH
Paraplesiops meleagris	Western Bluedevil	FISH
Pempheris	Bullseye	FISH
Tilodon sexfasciatus	Moonlighter	FISH
Small fish		FISH
Hermit crab		NO
Whelk/triton complex		NO
Amblypneustes spp.	Amblypneustes	NO
Cenolia spp.	Cenolia (feather star)	NO
Centrostephanus tenuispinus	Centrostephanus	NO
Equichlamys bifrons	Queen scallop	NO
Goniocidaris tubaria	Goniocidaris	NO
Haliotis spp.	Blacklipped abalone	NO
Heliocidaris erythrogramma	Heliocidaris	NO
Nectocarcinus spp.	Nectocarcinus	NO
Nepanthia troughtoni	Nepanthia	NO
Patiriella brevispina	Patiriella brevispina	NO
Pentagonaster dubeni	Pentagonaster (firebrick star)	NO
Petricia vernicina	Petricia	NO
Phasianella spp.	Phasianella	NO
Phyllacanthus irregularis	Phyllacanthus	NO
Plagusia chabrus	Plagusia (red bait crab)	NO
Stichopus spp.	Holothurian (sea cucumber)	NO
Tosia spp.	Tosia	NO
Turbo torquatus	Turbo torquatus	NO
Turbo undulatus	Turbo undulatus	NO
Dicathais orbita	Dicathais	YES
Jasus edwardsii	Rock lobster	YES
Uniophora granifera	Uniophora	YES

All positions use WGS 84 datum

Scientific Name	Common Name	Latitude	Longitude	Date	Location	Count	Size (cm)	Depth (m)	Activity
Phycodurus eques	Leafy seadragon	-35.519437	138.185443	22/07/2014	Rapid Bay	2	30	8	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.588585	138.605606	22/07/2014	The Bluff	4	35	5	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.519437	138.185454	8/08/2014	Rapid Bay	5	30	9	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.51907	138.184177	8/08/2014	Rapid Bay	2	30	9	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.519987	138.184843	10/08/2014	Rapid Bay	1	20	7	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.519361	138.185336	20/08/2014	Rapid Bay	5	30	9	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.519345	138.185411	24/09/2014	Rapid Bay	6	30	9	SCUBA diving
Zoila friendii thersites	Black cowry	-35.149635	138.46445	27/09/2014	North Noarlunga Reef	1	7	5	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.509602	138.215007	26/11/2014	Second Valley	1	20	6	SCUBA diving
Paraplesiops meleagris	Blue devil	-35.509565	138.215247	26/11/2014	Second Valley	7	5	6	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.588592	138.605121	29/11/2014	The Bluff	1	20	6	SCUBA diving
Pentaceropsis recurvirostris	Longsnout boarfish	-34.962861	138.480367	21/12/2014	Broken Bottom	1	25	9	SCUBA diving
Carcinus maenas	European shore crab	-35.041671	138.510639	21/12/2014	Marino Rocks	2	3	0.1	Intertidal
Carcinus maenas	European shore crab	-35.165245	138.467987	25/12/2014	Off Port Noarlunga South	1	5	0.3	Intertidal
Paraplesiops meleagris	Blue devil	-35.50972	138.214706	27/12/2014	Second Valley	4	10	5	SCUBA diving
Paraplesiops meleagris	Blue devil	-35.508525	138.218349	27/12/2014	Second Valley	2	20	6	SCUBA diving
Sutorectus tentaculatus	Cobbler wobbegong	-34.98839	138.508247	28/12/2014	Off Glenelg South	1	100	2	Snorkeling
Sabella spallanzanii	European fan worm	-34.8233	138.462623	28/12/2014	Norma Wreck	1	10	14	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.657173	138.32495	8/01/2015	The Bluff	1	3	7	SCUBA diving
Carcinus maenas	European shore crab	-35.045053	138.50774	18/01/2015	Marino Rocks	1	4	0.1	Intertidal
Othos dentex	Harlequin fish	-35.519466	138.185068	1/02/2015	Rapid Bay	1	20	9	SCUBA diving
Achoerodus gouldii	Western blue groper	-35.583084	138.604887	7/02/2015	Near Wright Island	2	40	5	SCUBA diving
Achoerodus gouldii	Western blue groper	-35.565256	138.621967	7/02/2015	Near Granite Island	3	30	5	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.074756	138.493542	10/02/2015	Hallett Cove	1	8	6	SCUBA diving
Pentaceropsis recurvirostris	Longsnout boarfish	-35.509523	138.215139	22/02/2015	Second Valley	3	20	7	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.509492	138.215289	22/02/2015	Second Valley	1	10	7	SCUBA diving
Paraplesiops meleagris	Blue devil	-35.509466	138.215343	22/02/2015	Second Valley	10		7	SCUBA diving
Othos dentex	Harlequin fish	-35.509457	138.215075	22/02/2015	Second Valley	1		7	SCUBA diving
Paraplesiops meleagris	Blue devil	-36.303936	136.534179	27/02/2015	South Noarlunga Reef	1	30	6	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.590492	138.606733	14/03/2015	The Bluff	4		6	SCUBA diving
Nemadactylus valenciennesi	Blue morwong	-35.520323	138.184928	15/03/2015	Rapid Bay	1	10	6	SCUBA diving
Paraplesiops meleagris	Blue devil	-35.509643	138.214808	29/03/2015	Second Valley	2	25	5	SCUBA diving
Paraplesiops meleagris	Blue devil	-35.509643	138.214572	29/03/2015	Second Valley	6	25	6	SCUBA diving
Phycodurus eques	Leafy seadragon	-35.076386	138.49482	3/05/2015	Hallett Cove	1	15	5	SCUBA diving