SURVEYS ACROSS REEFS IN THE ADELAIDE AND MT LOFTY RANGES NATURAL RESOURCE MANAGEMENT REGION 2012 - 13

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A report to the Conservation Council of South Australia and Reef Watch

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Printed in Adelaide, October 2013.

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Distribution:	Conservation Council of South Australia
Circulation:	Public domain

ACKNOWLEDGEMENTS

I would like to thank Alex Gaut and Lesley Parton for their assistance and support in developing this report.

Alex Gaut and Tim Kildea are also thanked for editing the draft report.

The Reef Watch members are also thanked for continuing to support this program.

This project was funded by the Adelaide and Mount Lofty Ranges Natural Resource Management Board. Their ongoing support is much appreciated.

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OVERVIEW

Reef Watch has been monitoring six coastal reefs in the Adelaide and Mt Lofty Ranges (AMLR) Natural Resources Management Region since 2009. The broad aim of this monitoring program is to maintain a "standing watch" on reefs across the Fleurieu Peninsula and in particular establishing if the reef degradation observed on urbanised coasts (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008) is moving southwards.

The status (or "health") of each reef site has been based on a subset of the indices developed by Turner *et al.* (2007) that examine sessile cover, fish and invertebrate community data, with observations summarised within each season.

The report for the period from July 2012 to June 2013 is the 5th Reef Watch summary, building on results from previous years (see CCSA 2009, Westphalen 2009, 2010, 2012, 2012).

Results from the 2012-13 Reef Watch surveys indicate an ongoing capacity to provide valuable insights into the status of reef systems on the Adelaide metropolitan coast. However, there remain a range of issues with Reef Watch surveys a well as the supporting indices that remain unresolved from previous data summaries (see CCCSA 2009, Westphalen 2009, 2010, 2011, 2012 – see below).

A high degree of variability is apparent within reef systems on the Fleurieu Peninsula coast as reflected in the changed in reef status within sites, between sites as well as inter-annually. The degraded site at Broken Bottom on the Adelaide metropolitan coast has remained degraded and more pristine sites at Second Valley and The Bluff appear healthy. It is the intermediate sites at Hallett Cove and Noarlunga (north and south) that remain cause for concern as noted in previous surveys (see Westphalen 2011, 2012). While there were indications of some improvement at Hallett Cove, its "Good" status is borderline and driven by fish and invertebrate based indices rather than canopy cover, which was low. The Noarlunga sites appear to have slipped in status relative to previous years, again with generally low canopy cover as well as increases in mussels or bare rock.

Sites in this intermediate zone should remain cause for concern.

Marine pest observations from the Feral or in Peril program are substantially reduced relative to previous years, although it appears that European fan worm (*Sabella spallanzanii*) has become established at Hallett Cove, with repeated sightings in 2011-12 (Westphalen 2012) and now 2012-13. Similarly, the European shore crab (*Carcinus maenas*) has been observed at Aldinga for two consecutive years.

RECOMMENDATIONS FROM THE 2012-13 SUMMARY

1. Closer scrutiny of reef status within the transitional area between urbanised and rural coasts both as part of Reef Watch but also as a component of formal surveys (see 5 below).
2. More targeted investigation into the spread of these pests, in particular *C. maenas*, is warranted, most notably at Aldinga reef.
3. A separate summary of Feral or in Peril data.

4. Greater emphasis on ensuring alignment between the various sampling strata (LIT, Fish and Invertebrate observations), either at the field level or at the point of data capture.

In addition, a range of recommendations has carried through from previous reports.

ACTIONS THAT ARE NOT THE RESPONSIBILITY OF REEF WATCH

5. 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.
6. 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.

IMPROVEMENTS TO REEF WATCH SURVEYS

7. A better approach to sampling may be to consider a summer-winter (or hot-cold) comparison of each site.
8. The number of marine pest observations for the Feral or in Peril program appears to have declined in recent years. A review of the program should be considered with the aim of establishing whether there is a need to give greater emphasis on reporting.
9. The development of a separate, independent Feral or in Peril summary (along the lines of that employed for marine pests within current reporting) may prove useful in encouraging those contributing to the program.
10. Reconsideration of The Bluff site as one of the more pristine reef locations. While this location is certainly useful for comparison purposes, there are other locations that act as a better integrator of processes occurring within Gulf St Vincent (i.e. Aldinga, Moana or Sellicks Beach). However, there may be reasons beyond the scope of current reporting for retaining this site.

INDICES

11. Recommendations for the indices remain largely unaltered from previous years (see CCSA 2009, Westphalen 2009, 2010, 2011, 2012). It is strongly recommended that ongoing use of these indices needs to be considered in light of the need for further research and development.

Research and development needs:

12. 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).
13. Better use of Reef Watch data through simplification of the field requirements and/or adjustment to index calculation/interpretation.
14. Removal of indices that are not employed or only make sporadic contributions to index calculation:
    i. Sedimentation index – not used
    ii. Richness of macroalgae – not used

iii. Richness of mobile invertebrates – not used

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

15. Further simplification and/or targeting of the taxonomy used in deriving fish and invertebrate indices to specific species/genera/lifeforms.
16. Simplification of the estimation of numbers, particularly as relates to fish surveys such as the use of Braun-Blanquet style categories.
17. An expanded interpretation of reef status (or "health") to include:

    i. Consideration of marine debris

    ii. Consideration of Environment Protection and Biodiversity Conservation and/or National Parks and Wildlife Service listed species.

INTRODUCTION - REEF WATCH OBSERVATIONS

Reef status investigations on the Adelaide metropolitan coast and the broader Fleurieu Peninsula began in 1996, with formal (institutional) 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).

Community-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). However, as the skill base amongst the Reef Watch volunteers has evolved, coupled with a more appropriate sampling protocol, a more rigorous analysis and reporting of Reef Watch data has been possible with 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; Figure 1), including:

- Broken Bottom, a highly degraded reef off Glenelg (a critical data outlier);
- 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 “at risk” and 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 surveys thus encompass reefs that are potentially declining in health (Noarlunga and Hallett Cove) relative to a degraded site (Broken Bottom) and healthy reefs found in Second Valley and Victor Harbor (The Bluff).

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

AIMS

The aims of the 2012-13 Reef Watch report are to:

1. Describe and summarise Reef Watch data obtained in the 2012-13 period;
2. Consider the status of each Reef Watch observation site through the approach provided by the Turner *et al.* (2007) indices;
3. Compare the reef status results with previous years; and
4. Propose areas where sampling might be further improved.

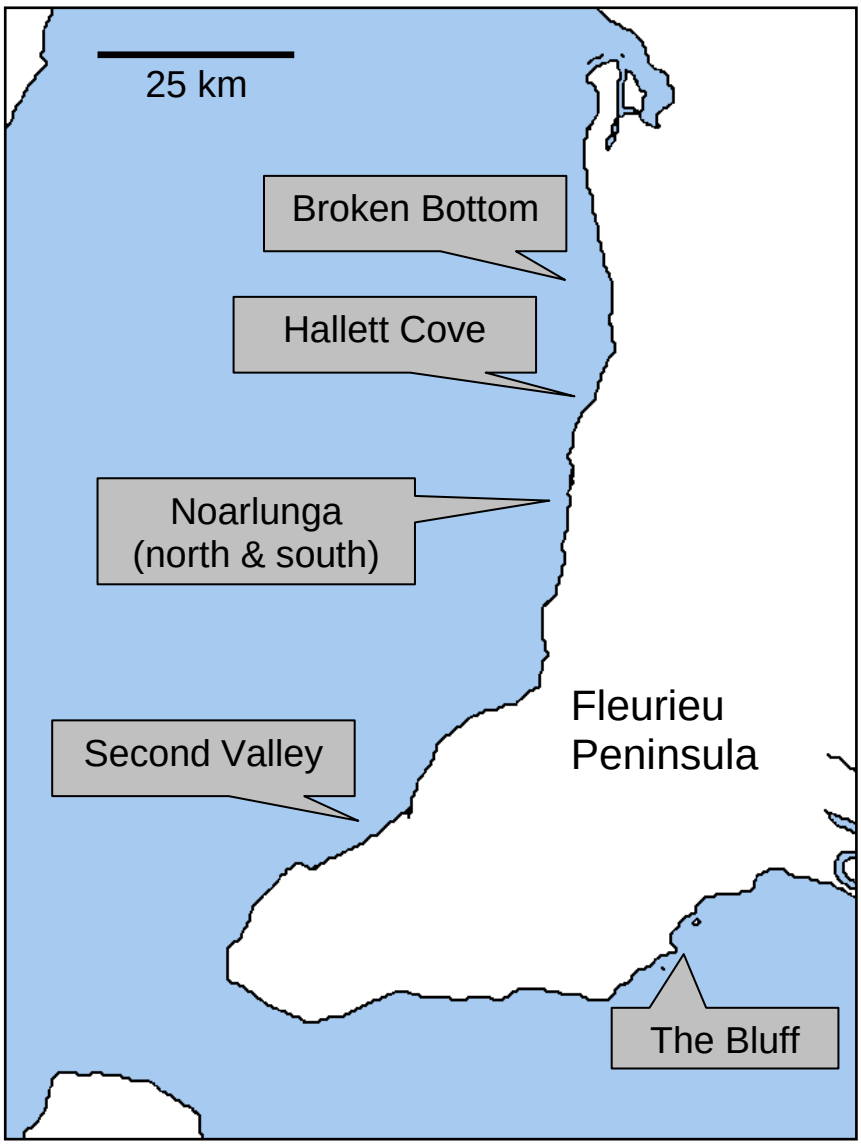

Figure 1 - Map of Fleurieu Peninsula showing the locations of the reefs surveyed

METHODS AND INDICES

Reef status (or "health") in the context of Reef Watch observations is based on 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 Feral or in Peril Program.

Survey methods and interpretation of the data are based on Reef Health investigations (see Turner *et al.* 2007 for a full description). However, Reef Watch observations employ a simplified taxonomy within each survey component, in particular Line Intercept Transects (LITs – used for cover data), 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. This program comprises observations that are not based on a structured sampling approach, but nonetheless can form a useful additional data resource (see http://feralperil.ala.org.au, accessed October 2013).

The primary tools for interpreting Reef Watch data are eight of the eleven indices of reef status developed by Turner *et al.* (2007; Table 1). Those Turner *et al.* (2007) indices that employ species richness are not used in the analysis owing to the simplified taxonomy used by Reef Watch. Similarly, 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 calculation as well as some of their limitations is found in Turner *et al.* (2007) with additional critiquing in Collings *et al.* (2008). Additional interpretations of the indices as applied to Reef Watch data can be found in the findings and recommendations reported from previous years (see CCSA 2009, Westphalen 2009, 2010, 2011, 2012).

Note that the *actual* 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 2012 through to the end of May 2013. Otherwise the summary would use data split across two winters (i.e. June 2013 along with July and August 2012), which would 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).

Approaches to Reef Watch surveys, resulting data and reef status indices remain unchanged for 2012-13. Unfortunately, this approach encompasses little, if any response to previous recommendations with regard to these indices and their use.

SURVEY DATA, INDEX RESULTS AND DISCUSSION

Reporting of Reef Watch data for 2012-13 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 for each reef.

INDEX DATA AVAILABILITY AND QUALITY

The Reef Watch surveys for 2012-13 included all six sites considered in previous years (Figure 1, Table 2). Generally there is alignment between Fish, Invertebrate and LIT samples across sites and seasons, although there are differences (35 LIT versus 40 fish transects and 42 transects for invertebrates; Table 2). However, because the LIT were used in the majority of indices (four of eight considered; Table 1), only these samples (as well as associated fish and invertebrate observations) were used as the basis of determining reef status. There are some inconsistencies across samples (i.e. where there is LIT but a lack of fish or invertebrate observations as in Noarlunga South Inside in winter; Table 2) but it cannot be determined if these issues relate to a lack of observation and/or errors in data collection and entry.

All sites were considered at least twice (i.e. Hallett Cove and The Bluff), but only Noarlunga South Inside had an LIT sample in all seasons (Table 2), albeit with incomplete sampling in winter (no fish or invertebrate samples and one 17 m long LIT).

Table 2 - Reef Watch surveys on the AMLR NRM coast 2012-13 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				2	2	2 (40)	2	2	2 (32)	3	3	2 (32)
Hallett Cove		1		2	2		2	3	1 (20)	2	2	2 (28)
Noarlunga North Inside	3	3	2 (23)	2	2		3	3	4 (70)	4	4	4 (66)
Noarlunga South Inside			1 (17)	3	3	1 (20)	5	4	2 (38)	1	1	2 (29)
Second Valley	2	2	2 (29)	1	1	2 (51)	1	2	2 (51)			
The Bluff				1	1	2 (34)	1	1	2 (43)			

LIT coverage included 17 of the 24 possible site-season combinations (Table 2), while there were 18 for fish and 19 for invertebrates. Only summer observations included all sites whereas winter was relatively poorly covered.

The average cumulative LIT length within each site-season combination was around 37 m (standard deviation ± 15 m), ranging from 17 m at Noarlunga South Inside in winter to 70 m Noarlunga North Inside 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 (less than 20 m; see e.g. CCSA 2009, Westphalen 2009). However, with the 2012-13 observations all LIT samples were included, with the assumption that the 17 m sample at Noarlunga South Inside in winter was acceptable for analysis (Table 2). It is worth noting that only six site-season combinations 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. However, there are discrepancies between fish, invertebrate and LIT observations that suggest either a lack of data and/or errors in data collection and entry. Seasonal coverage is still limited, as noted in previous surveys (e.g. Westphalen 2011, 2012), and there would be merit in considering a summer-winter (or hot-cold) comparison rather than attempting to assess seasonal nuances with a non-orthogonal dataset. This would simplify data collection to 12 observations as well as offer greater flexibility in data acquisition.

There should be greater emphasis on ensuring alignment between the various sampling strata (LIT, Fish and Invertebrate observations), either at the field level or at the point of data capture.

INDEX DATA

As with previous reporting of Reef Watch data using the Turner *et al.* (2007) indices, only a subset of the collected data are employed (see Westphalen 2009, 2010, 2011, 2012), including six of the 16 LIT lifeforms, 13 of the 26 fish species and only five of the 25 observed species from invertebrate surveys (Appendix A).

Only four blue-throated wrasse were recorded across the entire fish dataset (i.e. a total of 36 transects[1]; Table 3) and as with previous reporting (Westphalen 2010, 2011, 2012) it was considered that this index was uninformative as to reef status. Blue-throated wrasse index was thus excluded from the analysis, reducing the total number of indices to seven, which is again in line with previous summaries (e.g. Westphalen 2012).

High numbers of site attached fish (> 500 individuals) at Noarlunga North Inside-autumn and Hallett Cove-autumn (Table 3) were due to large numbers of yellow-headed hulafish (*Trachinops norlungae*) at both sites. Similar high numbers of yellow-headed hulafish and bullseye were observed at some site-season combinations from previous years (see Westphalen 2011, 2012), but there is no apparent pattern with respect to locations or season.

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 – see Westphalen 2012).

[1] Note that the number of transects considered in this instance relates to those fish observations that align with LITs. The number of transects is therefore less than the total number of fish surveys.

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

Site	Season	LIT data (% cover)				Invertebrates		Fish			Invasive species
		Bare rock	Canopy	Mussels	Turf	Number predators	Number transects	Number site attached	Blue-throated wrasse	Number transects	
Broken Bottom	Spring	42.60			12.98	0	2	6	0	2	0
Broken Bottom	Summer	33.48			14.81	2	2	6	0	2	0
Broken Bottom	Autumn	9.58			4.92	3	3	102	0	3	0
Hallett Cove	Summer	15.70	6.40		7.20	31	3	25	0	2	0
Hallett Cove	Autumn	26.70	11.42		3.37	16	2	622	0	2	0
Noarlunga South Inside	Summer	24.38	9.96	52.62		-	-	161	1	5	0
Noarlunga South Inside	Winter	7.80	52.12	5.71		29	4		-	-	0
Noarlunga South Inside	Spring	17.37	11.70	50.29		21	3	20	0	3	0
Noarlunga North Inside	Summer	20.13	27.38	33.35		26	3	69	1	3	0
Noarlunga South Inside	Autumn	14.00	16.58	50.64	4.35	1	1	3	0	1	0
Noarlunga North Inside	Winter	22.70	18.57	31.06		21	3	75	0	3	0
Noarlunga North Inside	Autumn	30.22	23.03	17.18	2.79	47	4	1188	0	4	0
Second Valley	Spring	15.06	45.95	2.88	4.50	5	1	16	2	1	0
Second Valley	Summer	10.20	44.52		0.90	12	2	52	0	1	0
Second Valley	Winter	11.67	64.75			7	2	13	0	2	0
The Bluff	Spring	1.99	69.75			1	1	3	0	1	0
The Bluff	Summer	3.50	87.73			7	1	3	0	1	0

FERAL OR IN PERIL - FERAL OBSERVATIONS 2012-13

Feral or in Peril data for 2012-13 were limited with only six sightings across five locations, all of which were within the AMLR NRM Region, including Noarlunga Reef (north inside and outside[2]), Hallett Cove, Snapper Point (Aldinga) and a ship wreck off Seacliff (Figure 2; Appendix B). Relative to previous years the number of observations in 2012-13 is substantially lower, with 14 observations across seven locations in 2011-12 (Westphalen 2012) and much lower than the 42 observations in 2009-10 (Westphalen 2010). The capacity of the Feral or in Peril Program data to support the Reef Watch observations for 2012-13 is thus limited.

With changes to a new on-line data platform (see http://feralperil.ala.org.au, accessed October 2013), it may be that participants are less inclined to contribute data. However, there would appear to be an ongoing decline in contributions to the program over a number of years.

Incorporating Reef Watch data from the six survey locations makes a total of 47 feral observations for Fleurieu Peninsula in 2012-13. Note this was based on the assumption that "no sightings" observed in the Reef Watch data meant that no feral species were present on the reef surveyed by volunteers (see CCSA 2009, Westphalen 2009, 2010, 2011, 2012).

Figure 2 - Fleurieu Peninsula coast south of Adelaide showing the feral observations for 2012-13

The pests observed within Feral or in Peril for 2012-13 were reported to be European fan worm (*Sabella spallanzanii*), European shore crab (*Carcinus maenas*) and northern Pacific seastar (*Asterias amurensis* (Figure 2; Appendix B), although the latter was later re-identified as a local species (probably *Uniophora granifera*). There was only one occurrence of a pest occurring at a Reef Watch survey site (Hallett Cove), but there was no corresponding sampling for this period (Spring 2012; Table 3; Appendix B) and therefore no implications relative to reef status indices (see below). When considered in light of sightings at Broken

[2] These sites are encompassed within a single record and are arguably worth considering separately.

Bottom and Noarlunga (Westphalen 2012), this indicates an expansion of the range of this pest, most likely via boat hull fouling (see summary Boxall and Westphalen 2003).

The other pest observed through Feral or in Peril was the European shore crab (*Carcinus maenas*) in the intertidal at Aldinga (Figure 2; Appendix B), which was also noted in the 2011-2012 Feral or in Peril summary (see Westphalen 2012). *C. maenas* has a sporadic history of occurrence in Gulf St Vincent with observations noted in the Port River in the mid-1970s (Zeidler 1976), Hallett Cove in the 1980s (Rosenzweig 1984) and then more broadly in the Coorong (Zeidler 1988) and Port Vincent (Reef Watch 2006 in Westphalen 2008).

It is suggested that a targeted survey for *C. maenas* be conducted in the Aldinga area.

It needs to be noted that observation of a feral species does not necessarily mean that the pest has become permanently established at a particular location. Conversely, not seeing a pest at a particular site cannot be construed to indicate its absence, particularly if it has been previously observed at that location. It is also important to realise that the feral animals employed in the program comprise a subset of pest species that are readily recognisable by non-experts and these surveys are therefore not a substitute for formal marine pest surveys.

Despite a limited number of reports for 2012-13, the Feral or in Peril program nonetheless has a proven track record in supporting marine pest monitoring and management within South Australia. However, engagement in the program is potentially in need of review.

It is recommended that a summary of Feral or in Peril data be presented as a separate report. A more targeted interpretation, particularly of the feral species may assist volunteers in understanding the broader value of the program, particularly in terms of year-to-year comparisons.

INDEX RESULTS

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 noted above, the blue-throated wrasse index was dropped from the assessment.

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).

Index scores were also averaged across seasons within sites to allow ready comparison across years (Figure 3).

Table 4 - Overall reef status index results (see Turner *et al.* 2007) for the 2012-13 reporting period

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

Broken Bottom rated as Poor in spring and summer and Caution in autumn (Table 4), which is in keeping with the interpretation of this reef as degraded (e.g. Cheshire and Westphalen 2000, Turner *et al.* 2007, Westphalen 2011, 2012; Figure 3), with low canopy cover (zero in both seasons), presence of bare rock (scoring zero and 33 in spring and summer respectively) as well as low levels of site attached fish (35 in both seasons) and a low score for mobile invertebrate predators (zero and 28 in spring and summer respectively; Table 5).

While there appeared to be some improvement at Broken Bottom in 2009 in terms of the average annual index score (Figure 3), the overall trend continues to be poor health at this site.

In previous Reef Watch data summaries (2010-11 and 2011-12), there was cause for concern for Hallett Cove reef, with a status of Caution and Poor reported (see Westphalen 2011, 2012, Figure 3). Hallett Cove has returned to Good condition in 2012-13 surveys (summer and autumn; Index scores were also averaged across seasons within sites to allow ready comparison across years (Figure 3).

Table 4), although this improvement is largely driven on the basis of site attached fish and invertebrate predator scores (both rating at 100), as canopy scored zero (Table 4; Table 5). This result thus indicates more about lack of balance in the weightings of the individual index scores as they are currently defined than anything about an improvement in the status if this reef.

Table 5 - Reef status indices for each site-season considered by Reef Watch in the 2012-13. 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 algae	Mussels	Bare rock	Site attached fish	Invertebrate predators	Invasives
Broken Bottom	Spring	Poor	9	0			0	35	0	
Broken Bottom	Summer	Poor	24	0			33	35	28	
Broken Bottom	Autumn	Caution	43	0				100	28	
Hallett Cove	Summer	Good	67	0				100	100	
Hallett Cove	Autumn	Good	67	0				100	100	
Noarlunga North Inside	Summer	Caution	55	18		0		100	100	
Noarlunga North Inside	Autumn	Caution	64	8			49	100	100	
Noarlunga North Inside	Winter	Caution	50	0		0		100	100	
Noarlunga South Inside	Spring	Caution	45	0		0		78	100	
Noarlunga South Inside	Summer	Poor	25	0		0		100	0	
Noarlunga South Inside	Autumn	Poor	16	0		0		35	28	
Noarlunga South Inside	Winter	Caution	60	80				0	100	
Second Valley	Spring	Good	88	65				100	100	
Second Valley	Summer	Good	87	61				100	100	
Second Valley	Winter	Good	92	100				76	100	
The Bluff	Spring	Caution	54	100				35	28	
The Bluff	Summer	Good	78	100				35	100	

The Noarlunga Reef sites (north and south) rated in as Caution or Poor status (Table 4), although apart from low canopy cover in most seasons, the drivers for these results varied between sites and seasons (Table 5). At Noarlunga North Inside in autumn, reef status (Caution) was based on low canopy cover (score of 8) along with high bare substrate (score of 49), whereas in summer (Caution) and winter (Caution), low canopy (score of zero) combined with mussels (also score of zero; Table 5) were the major drivers.

Noarlunga South Inside was also low in canopy cover (score of zero) across autumn (Caution), spring (Poor) and summer (Poor), combined with high mussel cover (again scoring zero), with low invertebrate predators in summer (Table 5). Conversely in winter (Poor), canopy cover at Noarlunga South rated reasonably highly (score of 80), but this was offset by a low score (zero) for site attached fish (Table 5).

Results at Noarlunga North and South would suggest a level of decline relative to observations from previous years (Westphalen 2011, 2012,), although there is a substantial degree of variability (Figure 3).

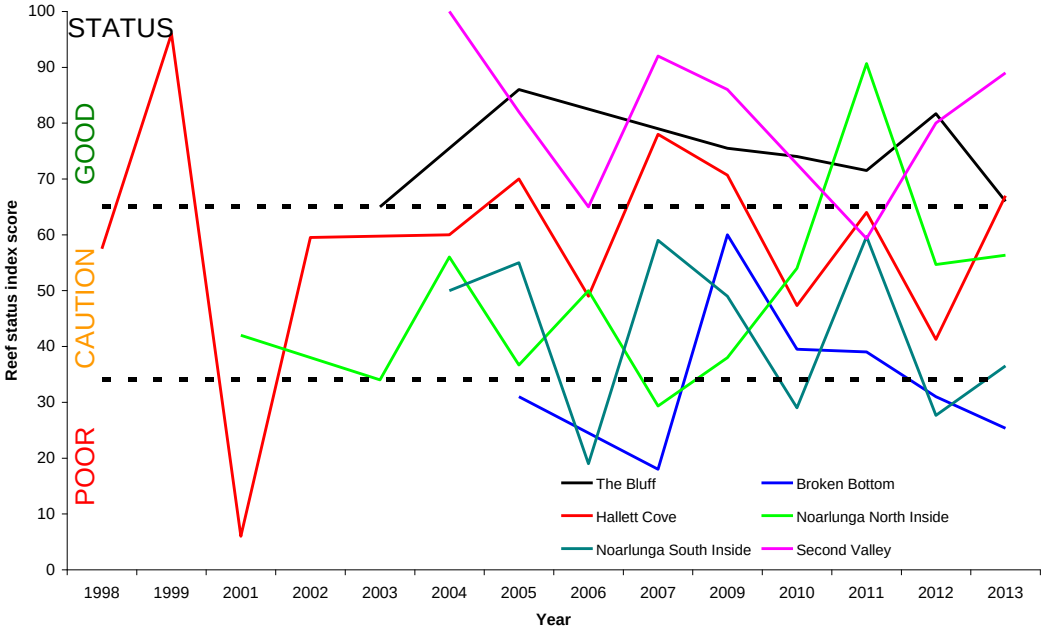

Figure 3 - Average reef status scores across seasons including all data from both formal Reef Health surveys and Reef Watch from 1998 to present[3]

Second Valley and The Bluff received Good status for all seasons considered except The Bluff in spring, which registered Caution (Table 4). All sites with Good status had reasonable or high canopy cover (scoring 61 or more) as well as one or both high ratings for site attached fish and invertebrate predators (76 or higher; Table 5). The Caution rating at The Bluff in

[3] 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.

spring was due to both a modest canopy cover score (54) as well as low site attached fish and invertebrate predator scores (35 and 28 respectively; Table 5). The Caution result for The Bluff is considered unlikely to be cause for concern unless it persists or becomes more frequent.

When averaged across seasons, reef status at Second Valley and The Bluff would be in keeping with previous years (Figure 3). However, as noted in previous assessments, the comparative value of The Bluff site is limited owing to its position well outside Gulf St Vincent (see Westphalen 2012).

In general terms, the status of Broken Bottom, Second Valley and The Bluff were in keeping with results of previous observations (i.e. Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008, CCSA 2009, Westphalen 2009, 2010, 2011, 2012). However, reefs in the intermediate zone between urbanised and rural coasts continue to be cause for concern. While there has been some apparent improvement at Hallett Cove relative to previous years, this change would appear to be driven by site attached fish rather than reef vegetative cover, which was low and more in line with the Caution and Poor rated sites to the north (Broken Bottom) and south (Noarlunga Reef).

Sedimentation has been considered to be a potential cause for reef decline (Cheshire and Westphalen 2000, Airoldi 2003, Turner 2004), although there is limited direct data for reefs on the Fleurieu Peninsula (although see Greig 2000, Smith 2000, Turner 2004). Given that the Reef Watch sites that are cause for concern (Hallett Cove and Noarlunga North and South) are close to shore in relatively sheltered locations, increased sediment loads may well be cause for decline, particularly after the relatively mild summers and wet winters of 2010-11, 2011-12 and now 2012-13. However, this notion has not been tested and raises the question as to whether it is sensible to compare these locations with more exposed locations such as Second Valley and especially The Bluff.

While The Bluff is undoubtedly a healthy reef, its location makes it a relatively poor integrator of processes that occur within Gulf St Vincent. The inclusion of additional sites within the Gulf, particularly in the stretch between Noarlunga and Second Valley, would serve to better inform as to the impact of changes within this system.

Seasonal variability in reef status within each site is readily apparent (Table 4). Some of these changes may be due to seasonal differences in macroalgal cover, particularly amongst canopy-forming species of *Cystophora* and *Sargassum* (Edgar 1983, Edgar *et al.* 2004, Collings 1996, Collings *et al.* 2008). However, low canopy cover tends to persist across seasons (Table 5), which would suggest that a seasonal factor was not influential, or at least not influential at the scale of the index calculation. Seasonal differences are probably best considered through an in depth analysis of all the available data rather than via the somewhat course index scores.

CONCLUSIONS AND RECOMMENDATIONS

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

Despite the apparent improvement at Hallett Cove there are disturbing signs of decline at this site, as well as the Noarlunga Reef sites further south, specifically with regard to low canopy cover, which is a hallmark of degraded reefs (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008). There is thus concern that the

reefs at the metropolitan fringe may be changing for the worse, although the variability in index scores within and between years makes it difficult to identify a consistent trend.

The reef status indices developed by Turner *et al.* (2007) were never intended to be the definitive approach to reef health assessment and any interpretation of reef health (Good, Caution or Poor) should be considered with care. In moving forward, the best approach to verification of reef status would be a formal survey of metropolitan (Semaphore, Dredge & Barge, Glenelg and Broken Bottom), transitional (Marino, Hallett Cove, Noarlunga Reef and Horeshoe Reef) and rural reef sites (Southport, Moana, Aldinga, Second Valley and Carrickalinga). Given that the last formal survey was undertaken in 2007 (Collings *et al.* 2008), a revisiting of Reef Health is perhaps overdue.

RECOMMENDATIONS FROM THE 2012-13 SUMMARY

1. Closer scrutiny of reef status within the transitional area between urbanised and rural coasts both as part of Reef Watch but also as a component of formal surveys (see 5 below).
2. More targeted investigation into the spread of these pests, in particular *C. maenas*, is warranted, most notably at Aldinga reef.
3. A separate summary of Feral or in Peril data.
4. Greater emphasis on ensuring alignment between the various sampling strata (LIT, Fish and Invertebrate observations), either at the field level or at the point of data capture.

In addition, a range of recommendations has carried through from previous reports.

ACTIONS THAT ARE NOT THE RESPONSIBILITY OF REEF WATCH

5. 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.
6. 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.

IMPROVEMENTS TO REEF WATCH SURVEYS

7. A better approach to sampling may be to consider a summer-winter (or hot-cold) comparison of each site.
8. The number of marine pest observations for the Feral or in Peril program appears to have declined in recent years. A review of the program should be considered with the aim of establishing whether there is a need to give greater emphasis on reporting.
9. The development of a separate, independent Feral or in Peril summary (along the lines of that employed for marine pests within current reporting) may prove useful in encouraging those contributing to the program.
10. Reconsideration of The Bluff site as one of the more pristine reef locations. While this location is certainly useful for comparison purposes, there are other locations that act as a better integrator of processes occurring within Gulf St Vincent (i.e. Aldinga, Moana or Sellicks Beach). However, there may be reasons beyond the scope of current reporting for retaining this site.

INDICES

11. Recommendations for the indices remain largely unaltered from previous years (see CCSA 2009, Westphalen 2009, 2010, 2011, 2012). It is strongly recommended that ongoing use of these indices needs to be considered in light of the need for further research and development.

Research and development needs:

12. 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).
13. Better use of Reef Watch data through simplification of the field requirements and/or adjustment to index calculation/interpretation.
14. Removal of indices that are not employed or only make sporadic contributions to index calculation:
    i. Sedimentation index – not used
    ii. Richness of macroalgae – not used
    iii. Richness of mobile invertebrates – not used
    iv. Blue-throated wrasse – does not occur across all sites
15. Further simplification and/or targeting of the taxonomy used in deriving fish and invertebrate indices to specific species/genera/lifeforms.
16. Simplification of the estimation of numbers, particularly as relates to fish surveys such as the use of Braun-Blanquet style categories.
17. An expanded interpretation of reef status (or “health”) to include:
    i. Consideration of marine debris
    ii. Consideration of Environment Protection and Biodiversity Conservation and/or National Parks and Wildlife Service listed species.

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APPENDIX A – 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	Index
	Other Leatherjacket	NO
	Stingray	NO
Dactylophora nigricans	Dusky Morwong	NO
Dinolestes lewini	Long-finned Pike	NO
Girella zebra	Zebra fish	NO
Kyphosus sydneyanus	Drummer	NO
Pagrus auratus	Snapper	NO
Pentaceropsis recurvirostris	Long-Snouted Boarfish	NO
Scorpis	Sweep	NO
Sepia apama	Cuttlefish	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 hippocrepis	Horseshoe Leatherjacket	YES
Notolabrus tetricus	Blue-Throated Wrasse	YES
Odax acroptilus	Rainbow Cale	YES
Odax cyanomelas	Herring Cale	YES
Parma victoriae	Scalyfin	YES
Pempheris	Bullseye	YES
Pictilabrus laticlavius	Senator Wrasse	YES
Tilodon sexfasciatus	Moonlighter	YES
Trachinops noarlungae	Yellow-Headed Hulafish	YES

INVERTEBRATE SPECIES OBSERVED IN REEF WATCH SURVEYS

Species name	Common name	Index
Amblypneustes spp.	Amblypneustes	NO
Haliotis rubra	Blacklipped abalone	NO
Cenolia spp.	Cenolia (feather star)	NO
Centrostephanus tenuispinus	Centrostephanus	NO
Coscinasterias muricata	Coscinasterias (11 arm star)	YES
Dicathais orbita	Dicathais	YES
Goniocidaris tubaria	Goniocidaris	NO
Haliotis laevigata	Greenlip abalone	NO
Heliocidaris erythrogramma	Heliocidaris	NO
	Hermit crab	NO
Holopneustes spp.	Holopneustes	NO
Stichopus spp.	Holothurian (sea cucumber)	NO
Nectocarcinus spp.	Nectocarcinus	NO
Nepanthia troughtoni	Nepanthia	NO
Patiriella brevispina	Patiriella brevispina	NO
Patiriella calcar	Patiriella calcar	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
Equichlamys bifrons	Queen scallop	NO
Jasus edwardsii	Rock lobster	YES
Tosia spp.	Tosia	NO
Turbo torquatus	Turbo torquatus	NO
Turbo undulatus	Turbo undulatus	NO
Uniophora granifera	Uniophora	YES
	Whelk/triton complex	YES

Common Name	Location Details	Latitude	Longitude	Date	Count	Size (cm)	Depth (m)	Habitat Description
European fan worm	Ship wreck ~ 10 km off Seacliff	-35.03437	138.412841	19 Jun 2012	300	20	30	Attached to wreck
Northern Pacific seastar	Snapper Point	-35.265926	138.435672	16 Jul 2012	3	15	6	On sand adjacent to reef
European fan worm	Hallett Cove reef	-35.073173	138.495161	24 Sep 2012	1	15	4	
European shore crab	Snapper Point, north of the boardwalk ramp	-35.27206	138.44313	9 Mar 2013	1	5	0	High on the reef among rocks about five metres from the sandy shore
No pests observed	North Noarlunga Inside	-35.148791	138.463953	10 Mar 2013	na	na	6.5	
No pests observed	North Noarlunga Outside	-35.148791	138.463953	10 Mar 2013	na	na	6.5	