SURVEYS ACROSS REEFS IN THE ADELAIDE AND MT LOFTY RANGES NATURAL RESOURCE MANAGEMENT REGION FOR THE 2014 FINANCIAL YEAR

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

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Note that the author was a member of the Reef Watch Scientific Steering Committee at the time of writing this report.

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OVERVIEW

Since 2009 the Reef Watch voluntary coastal monitoring program has conducted surveys of six nearshore reefs in the Adelaide and Mt Lofty Ranges (AMLR) Natural Resources Management Region. The basic aim of these surveys is to maintain a "standing watch" on the status or "health" of reefs across the Fleurieu Peninsula with particular emphasis on establishing whether the degradation observed on Adelaide's metropolitan reefs (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008) is extending southwards.

Each reef site was assessed according to a subset of the status indices developed by Turner *et al.* (2007) using seasonal observations from a range of reef strata, including:

- Sessile community cover;
- Fish community data; and
- Invertebrate community data.

This report for the period from July 2013 to June 2014 comprises the sixth annual summary, building on the results and interpretation from previous analyses (see CCSA 2009, Westphalen 2009, 2010, 2012, 2012, 2013). Results from the 2014[1] Reef Watch surveys indicate an ongoing capacity to provide valuable insights into the status of reef systems on the Adelaide metropolitan coast.

Although there are signs of improvement in status at Hallett Cove this location, as well as the Noarlunga sites remain as areas of concern (see Westphalen 2011, 2012, 2013), as there are continued indications of stress, notably in the form of reduced or highly fluctuating macroalgal canopy cover on the reef platforms. More formal surveys of reefs across the Adelaide metropolitan coast (Semaphore, Dredge and Barge, Glenelg and Broken Bottom) and further south (Marino, Hallett Cove, Noarlunga Reef and Horeshoe Reef, Southport, Moana, Aldinga, Second Valley and Carrickalinga) are overdue.

RECOMMENDATIONS FROM THE 2014 SUMMARY

1. While site-season coverage has improved, there should be focus on obtaining twice yearly surveys at all sites;
2. A closer scrutiny should be given to reefs within the transitional area between urbanised and rural coasts, in particularly the zone between Noarlunga and Hallett Cove and reefs around Marino;
3. There is a need for more data on suspended sediment loads on nearshore ecosystems, in particular between Noarlunga and Hallett Cove; and
4. A comprehensive analysis of the Reef Watch data should be conducted for the six established sites, based on all available data rather than only those used for index calculations. Use of the full dataset and a more flexible approach to analyses has the potential to expand upon current insights, particularly given that there is several years' worth of data available.

Additional recommendations carried over from previous years are listed in Appendix C.

[1] Years used to describe different reporting periods refer to the financial year (i.e. 2013-14 is 2014).

INTRODUCTION - REEF WATCH OBSERVATIONS

Investigations into the status or "health" of reefs 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 reef monitoring via the Reef Watch program has occurred for most of this period, with the initial aims of developing awareness of coast and marine threats and threat sources as well as the challenges faced in trying to assess their impact (Turner *et al.* 2006, CCSA 2009). However, as the skill base within Reef Watch evolved, coupled with the implementation of a more appropriately targeted sampling protocol, the data generated by the program were considered capable of generating useful insights into reef status.

To this end, six reef sites in the Adelaide and Mt Lofty Ranges (AMLR) Natural Resource Management (NRM) Region have been subject to ongoing Reef Watch surveys and annual reports (see Westphalen 2009, 2010, 2011, 2012, 2013; Figure 1), including:

- Broken Bottom, a highly degraded reef off Glenelg;
- Hallett Cove, an exposed reef that previous surveys had confirmed as being healthy, although there are signs that the reef's health may be deteriorating;
- Noarlunga North Inside and Noarlunga South Inside, which are considered "at risk" due to signs of decline. The reef is now a designated marine sanctuary zone;
- Second Valley on the Fleurieu Peninsula which is considered to be a healthy reef; and
- The Bluff (Rosetta Head) at Victor Harbor which is also considered to be a healthy reef.

This report is the sixth annual summary of Reef Watch surveys of these sites.

AIMS

The aims of the 2014[2] Reef Watch report are to:

1. Describe and summarise Reef Watch data obtained in the 2014 reporting period;
2. Consider the status of each reef site;
3. Compare the reef status results with previous years; and
4. Provide recommendations on improving sampling protocols.

[2] Years used to describe different reporting periods refer to the financial year (i.e. 2013-14 is 2014). Although note that the *actual* reporting period for Reef Watch data includes observations across continuous months within each season, meaning that analyses include observations undertaken from and including June 2013 through to the end of May 2014. Otherwise the summary would use data potentially split across two winters (i.e. June 2014 along with July and August 2013), which would add an uninformative level of variability to results.

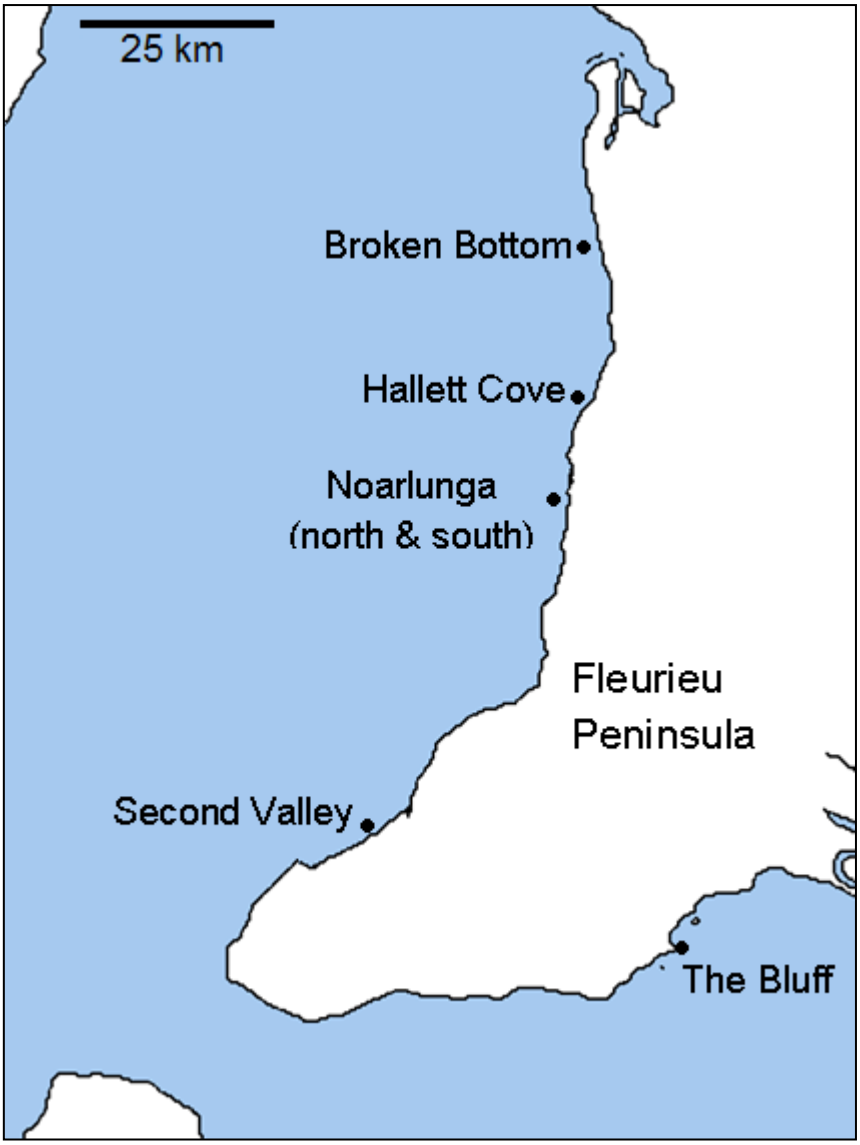

Figure 1 - Map of Fleurieu Peninsula showing the locations of the reefs surveyed.

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-forming macroalgal species cover, bare substrate cover (exposed rock), mussel cover and turfing macroalgal cover;
- Fish community composition, in particular those species within the community that maintain residency 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.

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).

Table 1 - Indices used by the Reef Watch program to describe reef status based on a subset of those developed by Turner *et al.* (2007).

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 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

In addition, 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 in support of reef status (see http://feralperil.ala.org.au, accessed November 2014).

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 can be found in the findings and recommendations reported from previous years (see CCSA 2009, Westphalen 2009, 2010, 2011, 2012, 2013) as well as a recent status summary of Fleurieu Peninsula reefs developed by Brook and Bryars (2014).

SURVEY DATA, INDEX RESULTS AND DISCUSSION

Assessment of the 2014 Reef Watch data includes:

- An appraisal of the number of transects within each of the Fish, Invertebrate and LIT surveys which was used to determine if any data should be excluded from the status assessment;
- Assessment of reef status within each season;
- A comparison of the average overall reef index with previous years; and
- A summary and interpretation of the "Feral" aspect of the Feral or in Peril program.

INDEX DATA AVAILABILITY AND QUALITY

Reef Watch surveys for 2014 covered all six sites (Figure 1, Table 2) with general, but not universal alignment between Fish, Invertebrate and LIT observations. However, because the LIT were used in the majority of indices (four of eight considered; Table 1), only those site-season combinations that included LIT as well as related fish and invertebrate observations were used in the analysis.

There were differences in the number of transects within each strata, with 31 LIT, 43 Fish and 41 Invertebrate transects (Table 2). While LIT supply relatively more data, fish and invertebrate surveys are quicker and easier and this difference may reflect volunteer preferences.

It cannot be determined if these issues relate to a lack of observation and/or errors in data collation and entry.

Table 2 - Reef Watch surveys on the AMLR NRM coast 2014 showing to 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). Numbers in red indicate transects that were excluded from the analyses owing to a lack of corresponding LIT observations (and/or where the total length of LIT was considered too short to be representative).

Site	Autumn			Winter			Spring			Summer		
	Fish	Invertebrate	LIT	Fish	Invertebrate	LIT	Fish	Invertebrate	LIT	Fish	Invertebrate	LIT
Broken Bottom										2	2	2 (34)
Hallett Cove	1	1	1 (25)	1	2	3 (47)	1	2		4	4	4 (81)
Noarlunga North Inside	1	1	2 (39)	3	3	2 (15)	1	1	2 (30)	3	2	1 (17)
Noarlunga South Inside	3	2	1 (23)	5	4	1 (29)	1	1	1 (20)	4	4	3 (60)
Second Valley	2	3	1 (17)	1	1		2	2	1 (20)	2	2	2 (47)
The Bluff	2	2	2 (44)				2	2	2 (41)	2	1	

All sites, except Broken Bottom were considered at least twice (i.e. Hallett Cove and The Bluff), with Noarlunga South Inside and Noarlunga North Inside were comprehensively sampled in all seasons (Table 2). Broken Bottom traditionally rates as being in a degraded or "Poor" status, although sometimes within "Caution" (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008, CCSA 2009, Westphalen 2009, 2010, 2012, 2012, 2013). A lack of sampling at this site makes it difficult to determine levels of seasonal variability within the site and whether there are any signs of improvement.

At a minimum all sites should be covered at least twice across the course of the year.

LIT coverage included 17 of the 24 possible site-season combinations (Table 2), while there were 20 for fish and invertebrates. There were no sites were observed across all seasons with autumn and summer were covered in five (out of a maximum of six) instances whereas winter surveys included only three sites (Table 2).

LIT transects ranged from 15 m at Noarlunga North Inside in winter up to 81 m at Hallett Cove in summer (Table 2), although only three site-season observations had less than 20 m. 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 2013-14 observations all LIT samples were included, with the assumption that the 15 m sample at Noarlunga North 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).

Representative LIT distances (i.e. total transect length) is comparable to previous years.

In general the site-season coverage would appear to have improved slightly relative to previous years, although the relative lack of observations at Broken Bottom is a small cause for concern. Discrepancies in fish and invertebrate observations relative to LITs need to be considered in terms of whether this relates to a lack of data and/or errors in data collation.

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 in analyses (see Westphalen 2009, 2010, 2011, 2012, 2013), including six of the 16 LIT lifeforms, 16 of the 28 fish species and only five of the 30 observed species from invertebrate surveys (Appendix A). The use of the indices subsumes or excludes a substantial amount of the collected data. There may be substantial insights available from a more detailed analysis of the entire Reef Watch dataset for the six sites that have been monitored since 2009.

LIT cover data indicate the presence of bare rock at all sites and seasons except The Bluff while canopy forming species were widespread at all sites other than Broken Bottom (Table 3). Mussels occurred only at the Noarlunga sites but were found in all seasons whereas turfing algal coverage was more sporadic (Table 3).

Site attached fish numbers ranged from only three at Hallett Cove in winter to 218 at the same site in autumn and 276 at Noarlunga South Inside in winter (Table 3). The large change in site attached fish numbers at Hallett Cove between autumn and winter are perhaps due to differences in visibility, which is one of the problems with fish observations, particularly those related to counts. Yellow-headed hulafish (*Trachinops norlungae*) and to a lesser extent bullseye (*Pempheris sp.*) were species involved where large numbers were observed in previous surveys (see Westphalen 2009, 2010, 2011, 2012, 2013) and was also the case in 2014, although counts were generally lower (200 or less) than in previous years. 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).

Table 3 - Summary of the Reef Watch data used as input in status index calculation (see Turner *et al.* 2007).

Site	Season	LIT data (% cover)				Fish		Invertebrates		Invasive Species
		Bare rock	Canopy	Mussels	Turf	Site attached count	Number Transects	Invertebrate Predators count	Number Transects	
Broken Bottom	Summer	39.59			29.12	129	2	2	2	0
The Bluff	Spring		96.07			4	2	3	2	0
The Bluff	Autumn		96.52			13	2	4	2	0
Hallett Cove	Winter	9.71	26.80			3	1	11	2	0
Hallett Cove	Summer	3.52	52.62		6.30	100	4	20	4	0
Hallett Cove	Autumn	9.96	19.20		0.36	218	1	2	1	0
Noarlunga North Inside	Winter	24.62	13.53	34.75		69	3	44	3	0
Noarlunga North Inside	Spring	18.81	27.96	22.30		5	1	7	1	0
Noarlunga North Inside	Summer	31.41	49.18	4.53	3.02	108	3	19	2	0
Noarlunga North Inside	Autumn	8.73	14.92	36.75	12.11	48	1	5	1	0
Noarlunga South Inside	Winter	29.26	5.24	45.19	0.53	276	5	60	4	0
Noarlunga South Inside	Spring	12.37	10.48	48.31		9	1	3	1	0
Noarlunga South Inside	Summer	22.34	7.05	53.93	1.99	89	4	63	4	0
Noarlunga South Inside	Autumn	14.45	20.04	50.91		174	3	41	2	0
Second Valley	Spring	24.12	39.02			85	2	13	2	0
Second Valley	Summer	6.74	70.29		2.50	19	2	2	2	0
Second Valley	Autumn	13.76	76.18			157	2	7	3	0

Invertebrate predators ranged from two at Hallett Cove in autumn and Broken Bottom in summer to 60 at Noarlunga South Inside in winter (Table 3) and, like site attached fish, highly influenced by large numbers of single species, in this instance *Dicathais orbita*.

No invasive species were reported in the course of Reef Watch surveys.

FERAL OR IN PERIL - FERAL OBSERVATIONS 2014

Feral species observations obtained from the Feral or in Peril program includes 24 observations from the Reef Watch program, 16 observations from the Feral or in Peril program wherein an “in Peril” species was observed but no “Feral” species and seven observation where in there were no sightings (Appendix B). This level of observations (47 in total) is a substantial improvement over previous years, notably the six observations in 2013 (Westphalen 2013) and 14 in 2012 (Westphalen 2012), 16 in 2011 (Westphalen 2011) but favourably to the 42 observations in 2010 (Westphalen 2010). The decline in observations noted across the last three reporting periods thus appears to have been reversed.

Across all 47 observations there was only one of the target pests observed within the Adelaide metropolitan and Fleurieu Peninsula coasts, with European fan worm (*Sabella spallanzanii*) found at Hallett Cove in December 2013 (Figure 2; Appendix B). However, European fan worm was observed at Hallett Cove in one out of eight observations at this site (see Appendix B) with no sightings in four subsequent surveys/dives. The occurrence of *Sabella* at this site is therefore assumed to be in relatively low cover/abundance.

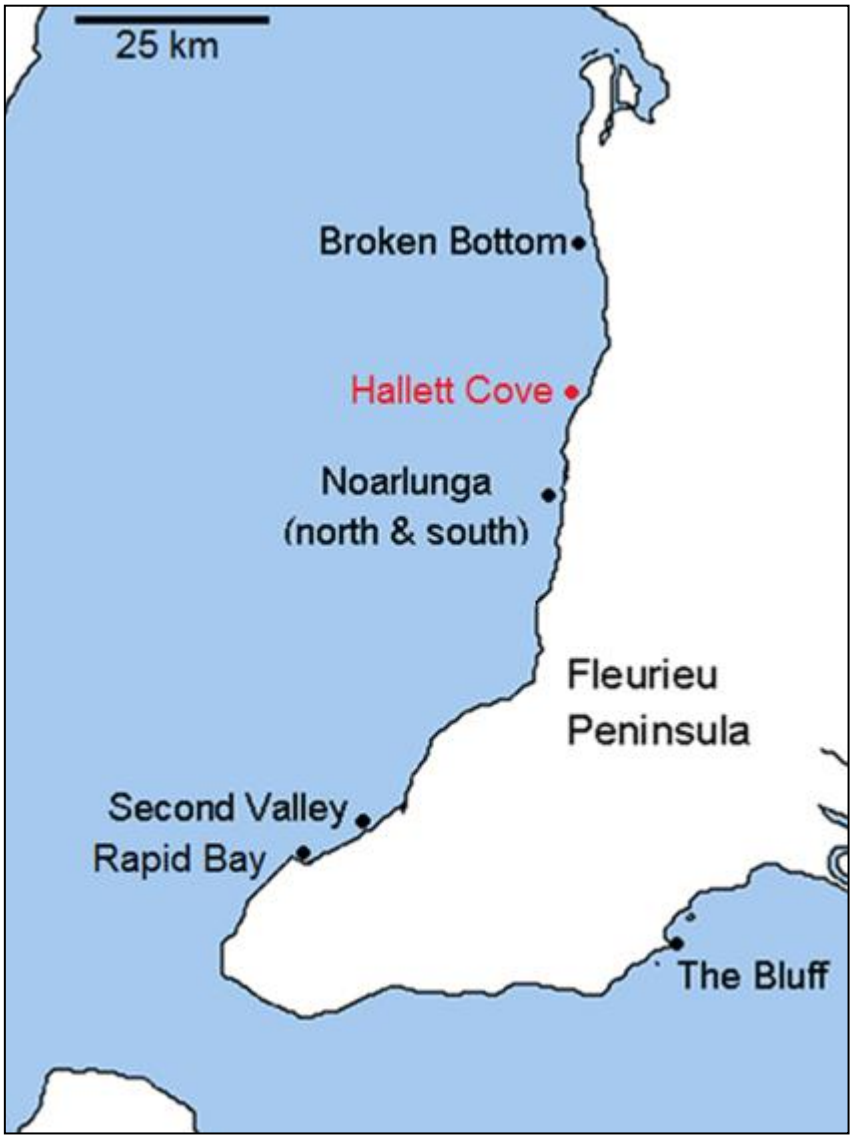

Figure 2 - Location of feral observations within the Adelaide metropolitan and Fleurieu Peninsula coast for the 2014 Reef Watch observations.

When considered in light of sightings at Hallett Cove in 2013 (Westphalen 2013) as well as at Broken Bottom and Noarlunga in 2012 (Westphalen 2012), this would suggest little in terms of the further expansion of this pest to the south. However, 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.

INDEX RESULTS

Reef status index results were based on 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). Index scores for each parameter were used to generate an overall status score for each site-season, which were subsequently interpreted according to a predetermined scale relating each set of observations to one of Good, Caution or Poor status (see Turner *et al.* 2007; Table 4; Table 5). In addition, index scores for each site-season were averaged across seasons for each site to allow comparison across years (Figure 3).

The Bluff rated as good in autumn, but caution in spring (Table 5), with overall status scores of 55 and 78 respectively. This shift in status was probably on the basis of a decline in site attached fish (counts of 13 down to 4; Table 3, with corresponding index scores of 76 in autumn down to 23 in spring; Table 5) as canopy cover remained high (~96% on both seasons with related index scores of 100) and invertebrate predators were stable albeit rather low (counts of 4 and 3, scores of 57 and 42; Table 3; Table 5). However, given the problems with consistent assessment of fish numbers relative to changes in visibility between observations, differences in reef status based solely on differences in site-attached fish are probably less reliable than alterations in other index scores, in particular those related to canopy cover. The shift in status for The Bluff from caution to good (or indeed from good to caution) needs to be viewed with a degree of scepticism.

Broken Bottom in summer was the only site-season observation that rated as poor (Table 4), with an overall score of 33 (Table 5), but there is a lack of observations for this site in other seasons and it is thus impossible to determine if this observation is consistent across the year. It is worth noting that this site has achieved caution status in previous years (Figure 3). However, poor status for this site was in keeping with prior observations (e.g. Cheshire and Westphalen 2000, Turner *et al.* 2007, Westphalen 2012, 2013; Figure 3). There was no canopy cover (index score of zero), while bare rock cover was the highest observed (~40%) with a corresponding index score of 2 (Table 3; Table 5). This site-season also had the highest level of turf (29%; Table 3), although this appeared to have no influence on subsequent index scores as all site-seasons were rated as “null” for this parameter (Table 5). Conversely site attached fish at Broken Bottom in summer were relatively high (count of 129 and a score of 100; Table 3; Table 5).

As noted in earlier Reef Watch reports (CCSA 2009, Westphalen 2009, 2010, 2011, 2012, 2013), both the relative contribution of individual index scores to the overall status and sensitivity of each index in terms of reflecting changes within reefs is open to question.

Hallett Cove rated as caution in autumn (overall rating of 52), good in summer (rating of 94) and back to caution in winter (rating of 51; Table 5). The shift in status was due to changes in canopy cover, which was modest (27%) in winter, higher in summer (53%) and lower again in autumn (19%) with corresponding canopy index scores of 17, 82 and zero respectively (Table 3; Table 5). Caution status in winter was also due to low site attached fish (count of 3 and a corresponding index score of 35), whereas caution status the following autumn was due to reduced invertebrate predators (count of 2, score of 57; Table 3; Table 5). Other index factors, notably bare rock and turf were varied (3.5 to 9% and 0 to 6.3% respectively) but not influential in terms of index scores (all null; Table 3; Table 5). Prior surveys of this site have suggested a level of variability in status (see Westphalen 2010, 2011, 2012) although institutional surveys near this location generally indicate good status (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008).

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

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

Noarlunga North Inside rated as caution in winter and spring (overall scores of 50 and 59 respectively) with a good rating in summer (overall score of 79) but back to caution again in the following autumn (score of 50;Table 4; Table 5). Changes in status across seasons would again largely appear to be due to differences in canopy cover, which ranged from 13.5% in winter (caution) to 49% in summer (good). Despite the fact that bare substrate coverage also increased in summer (from 19% in spring up to 31% in summer with an index score of 43; Table 3; Table 5), this appeared to have little influence on the status of this site. Site attached fish also increased in summer (count of 108), but index scores were 100 for this factor across all seasons except spring (score or 43; Table 5).

Noarlunga South Inside rated as caution across all seasons (Table 4Hallett Cove rated as caution in autumn (overall rating of 52), good in summer (rating of 94) and back to caution in winter (rating of 51; Table 5). The shift in status was due to changes in canopy cover, which was modest (27%) in winter, higher in summer (53%) and lower again in autumn (19%) with corresponding canopy index scores of 17, 82 and zero respectively (Table 3; Table 5). Caution status in winter was also due to low site attached fish (count of 3 and a corresponding index score of 35), whereas caution status the following autumn was due to reduced invertebrate predators (count of 2, score of 57; Table 3; Table 5). Other index factors, notably bare rock and turf were varied (3.5 to 9% and 0 to 6.3% respectively) but not influential in terms of index scores (all null; Table 3; Table 5). Prior surveys of this site have suggested a level of variability in status (see Westphalen 2010, 2011, 2012) although institutional surveys near this location generally indicate good status (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008).

Table 4) with scores ranging from 46 to 50 (Table 5). Canopy cover was relatively low (5 – 20%) resulting in index scores of zero across all seasons. Mussels were observed in all seasons with relative stable cover ranging from 45 – 53% and resulting in index scores of

zero. Conversely site attached fish and invertebrate predator indices were higher in summer, autumn and winter (counts from 89 to 276) with corresponding index scores of 100 (Table 3; Table 5), while spring was lower (count of only 9 fish with index score of 85; Table 3; Table 5). Along with Noarlunga North, caution and poor reef status are to be expected at this site.

Second Valley was the only site that rated consistently as good across all seasons for which it was assessed (spring, summer and autumn; Table 4) with overall index scores of 83, 76 and 89 respectively (Table 5). However, factors influential in maintenance of this status varied somewhat between seasons. Canopy cover in spring was relatively low (39%; Table 3) with an index score of 48 (Table 5), while site attached fish and invertebrate predators were relatively high (count of 85, index score of 100 for fish and count of 13 and score of 100 for invertebrates; Table 3; Table 5). Conversely canopy cover in summer and autumn were higher than in spring (70% and 76%, with corresponding index scores of 100 in both seasons; Table 3; Table 5). Site attached fish had a count of 19 in summer and 157 in autumn (Table 3), but both seasons still resulted in index scores of 100 (Table 5). However, invertebrate predators were low in both seasons (counts of 2 and 7 respectively; Table 3) with correspondingly low index scores (28 and 66; Table 5).

The sensitivities underpinning index calculations and relative influence of index scores to the overall index need to be considered.

Table 5 - Reef status indices for each site-season considered by Reef Watch in the 2014 reporting period. 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 Invertebrate Predators	Invasives
The Bluff	Spring	Caution	55	100				23	42	
The Bluff	Autumn	Good	78	100				76	57	
Broken Bottom	Summer	Poor	33	0			2	100	28	
Hallett Cove	Winter	Caution	51	17				35	100	
Hallett Cove	Summer	Good	94	82				100	100	
Hallett Cove	Autumn	Caution	52	0				100	57	
Noarlunga North Inside	Winter	Caution	50	0		0		100	100	
Noarlunga North Inside	Spring	Caution	59	20				58	100	
Noarlunga North Inside	Summer	Good	79	73			43	100	100	
Noarlunga North Inside	Autumn	Caution	50	0		0		100	100	
Noarlunga South Inside	Winter	Caution	50	0		0		100	100	
Noarlunga South Inside	Spring	Caution	46	0		0		100	85	
Noarlunga South Inside	Summer	Caution	50	0		0		100	100	
Noarlunga South Inside	Autumn	Caution	50	0		0		100	100	
Second Valley	Spring	Good	83	48				100	100	
Second Valley	Summer	Good	76	100				100	28	
Second Valley	Autumn	Good	89	100				100	66	

Summer would appear to be the best season in terms of reef status with three of the six sites rated as good, although this notion is somewhat tempered by the poor status of Broken Bottom (Table 4). Otherwise there is little trend in seasons in terms of reef status, even though the site-season coverage was improved relative to previous years (see above).

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* (e.g. Edgar 1983, Edgar *et al.* 2004, Collings 1996, Collings *et al.* 2008). However, low canopy cover persisted across seasons at the Noarlunga South site (Table 5), which would suggest that a seasonal factor was not influential, or at least not influential at the scale of the index calculation. Other locations, notably Hallett Cove, Noarlunga North and Second Valley were more dynamic with higher macroalgal canopy cover occurring in summer (Table 4).

Seasonal differences between reefs, in particular the macroalgal community are probably best considered through an in depth analysis of all the available data rather than via the somewhat coarse index scores.

When considered relative to previous years, the average overall index scores across seasons were in broad alignment with 2013 results, meaning there were no unexpected jumps in status (Figure 3). The Noarlunga sites both appear to be trending upwards from low points in 2012, along with, Broken Bottom. The Bluff and Hallett Cove appear to be lurking on the fringe of good to caution status, but with no real difference relative to 2013. Second Valley remained good (Figure 3), although it is worth noting that this site did have caution status in 2011. While there are no substantial differences in 2014 relative to 2013, there is substantial volatility in reef status within all sites over time (Figure 3), and the implications of minor differences in average status from year to year should not be over emphasized, particularly given the lower intensity of sampling in Reef Watch surveys relative to more formal (institutional) observations (see Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008).

It is worth noting that Brook and Bryars (2014) found that time sequence investigations of individual indices were potentially more informative of reef status trends than the overall index score.

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].

Reef status across all sites was in keeping with previous observations as well as the broader status model that metropolitan reefs are degraded versus more pristine coasts (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008). However, reefs in the intermediate zone between urbanised and rural coasts (notably Hallett Cove, and the Noarlunga sites) may be cause for concern given the number of caution status results and signs of persistent macroalgal cover loss at Noarlunga South.

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). The key sediment inputs to coastal waters (~67% of total) derive from stormwater drains and pipes as well as rivers and streams (Fernandes 2008). Importantly, investigations into sediment inputs at 12 reefs on Adelaide's metropolitan coast by Fernandes *et al.* (2008) and Fernandes (2008) found (at least when the study was undertaken in 2007) that the highest terrigenous loads occurred in the zone between Hallett Cove and Southport, which

[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.

encompasses the Hallett Cove and Noarlunga sites. This area would equate to the broader region of concern with regard to the encroachment of reef degradation and aligns with the major areas of terrestrial development and urbanisation.

In addition, Fernandes *et al.* (2008) indicate that single rainfall events could lead to sustained sediment suspension within nearshore systems.

CONCLUSIONS AND RECOMMENDATIONS

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

Reefs within the zone from Noarlunga to Hallett Cove appear to reflect higher sediment inputs to this area. There is a need to consider this zone in greater detail in terms of status, particularly within reefs further south of this zone, but also including additional locations at Noarlunga and north of Hallett Cove. More formal surveys of reefs across the Adelaide metropolitan coast (Semaphore, Dredge and Barge, Glenelg and Broken Bottom) and further south (Marino, Hallett Cove, Noarlunga Reef and Horeshoe Reef, Southport, Moana, Aldinga, Second Valley and Carrickalinga) are overdue.

RECOMMENDATIONS FROM THE 2014 SUMMARY

1. While site-season coverage has improved, there should be focus on obtaining twice yearly surveys at all sites;
2. A closer scrutiny should be given to reefs within the transitional area between urbanised and rural coasts, in particularly the zone between Noarlunga and Hallett Cove and reefs around Marino;
3. There is a need for more data on suspended sediment loads on nearshore ecosystems, in particular between Noarlunga and Hallett Cove; and
4. A comprehensive analysis of the Reef Watch data should be conducted for the six established sites, based on all available data rather than only those used for index calculations. Use of the full dataset and a more flexible approach to analyses has the potential to expand upon current insights, particularly given that there is several years' worth of data available.

Additional recommendations carried over from previous years are listed in Appendix C.

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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	Used
	Other Leatherjacket	NO
Dactylophora nigricans	Dusky Morwong	NO
Dinolestes lewini	Long-finned Pike	NO
Girella zebra	Zebra fish	NO
Kyphosus sydneyanus	Drummer	NO
Pseudocaranx	Trevally	NO
Scorpis	Sweep	NO
Siphonognathus	Weed Whiting	NO
Trachinops	Hulafish	NO
Trachinops caudimaculatus	Southern Hulafish	NO
Trygonorrhina fasciata	Fiddler Ray	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
Parma victoriae	Scalyfin	YES
Pempheris	Bullseye	YES
Phycodurus eques	Leafy seadragon	YES
Pictilabrus laticlavius	Senator Wrasse	YES
Tetractenos glaber	Smooth Toadfish	YES
Tilodon sexfasciatus	Moonlighter	YES
Trachinops noarlungae	Yellow-Headed Hulafish	YES

INVERTEBRATE SPECIES OBSERVED IN REEF WATCH SURVEYS

Species	Common	Index
	Small fish	FISH
Chelmonops curiosus	Western Talma	FISH
Paraplesiops meleagris	Western Bluedevil	FISH
Pempheris	Bullseye	FISH
Tilodon sexfasciatus	Moonlighter	FISH
	Hermit crab	NO
Amblypneustes spp.	Amblypneustes	NO
Cenolia spp.	Cenolia (feather star)	NO
Centrostephanus tenuispinus	Centrostephanus	NO
Equichlamys bifrons	Queen scallop	NO
Haliotis spp.	Blacklipped abalone	NO
Heliocidaris erythrogramma	Heliocidaris	NO
Holopneustes spp.	Holopneustes	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
	Whelk/triton complex	YES
Coscinasterias muricata	Coscinasterias (11 arm star)	YES
Dicathais orbita	Dicathais	YES
Jasus edwardsii	Rock lobster	YES
Uniophora granifera	Uniophora	YES

APPENDIX B – FERAL OBSERVATIONS

Source	Location	Scientific Name	Latitude	Longitude	Date	Depth (m)
Feral or in Peril	Hallett Cove	*Sabella spallanzanii*	-35.077369	138.509658	1/12/2013	6
Feral or in Peril	Old Rapid Bay Jetty	Negative sightings	-35.519485	138.185776	25/11/2013	8
Feral or in Peril	Old Rapid Bay Jetty	Negative sightings	-35.519734	138.186248	23/01/2014	7
Feral or in Peril	Old Rapid Bay Jetty	Negative sightings	-35.51971	138.186248	27/01/2014	8
Feral or in Peril	Old Rapid Bay Jetty	Negative sightings	-35.519391	138.185537	8/02/2014	10
Feral or in Peril	Old Rapid Bay Jetty	Negative sightings	-35.519184	138.184606	3/03/2014	8
Feral or in Peril	Old Rapid Bay Jetty	Negative sightings	-35.519538	138.185733	2/06/2014	8
Feral or in Peril	Port Noarlunga	Negative sightings	-35.152283	138.464339	30/11/2013	6
Feral or in Peril	Port Noarlunga	Negative sightings	-35.152879	138.463653	7/12/2013	6.6
Feral or in Peril	Port Noarlunga	Negative sightings	-35.148098	138.463953	10/03/2014	4
Feral or in Peril	Rapid Bay Jetty	Negative sightings	-35.519631	138.185926	3/03/2014	8
Feral or in Peril	Rapid Bay Jetty	Negative sightings	-35.519372	138.185647	6/04/2014	10
Feral or in Peril	The Bluff	Negative sightings	-35.588965	138.605703	9/03/2014	6
Feral or in Peril	Second valley	Negative sightings	-35.508816	138.215302	27/01/2014	9
Feral or in Peril	The Bluff	Negative sightings	-35.588468	138.605638	2/11/2013	6
Feral or in Peril	The Bluff	Negative sightings	-35.588468	138.605638	1/06/2014	6
Feral or in Peril	Hallett Cove	Negative sightings	-35.074797	138.494069	12/01/2014	
Feral or in Peril	Port Noarlunga	Negative sightings	-35.150172	138.464703	1/02/2014	5
Feral or in Peril	Hallett Cove	Negative sightings	-35.074797	138.494069	10/03/2014	5
Feral or in Peril	Port Noarlunga	Negative sightings	-35.150172	138.464703	30/03/2014	6
Feral or in Peril	Port Noarlunga	Negative sightings	-35.150172	138.464703	9/06/2014	4
Feral or in Peril	Rapid Bay Jetty	Negative sightings	-35.519372	138.185647	8/12/2013	10
Feral or in Peril	Broken Bottom	Negative sightings	-35.519372	138.185647	15/12/2013	10
Reef Watch	The Bluff	Negative sightings			Nov-13	4-6
Reef Watch	The Bluff	Negative sightings			Jan-14	4-6
Reef Watch	The Bluff	Negative sightings			Mar-14	4-6
Reef Watch	Broken Bottom	Negative sightings			Dec-13	4-6
Reef Watch	Hallett Cove	Negative sightings			Aug-13	4-6
Reef Watch	Hallett Cove	Negative sightings			Oct-13	4-6
Reef Watch	Hallett Cove	Negative sightings			Dec-13	4-6
Reef Watch	Hallett Cove	Negative sightings			Jan-14	4-6
Reef Watch	Hallett Cove	Negative sightings			Mar-14	4-6
Reef Watch	Noarlunga North Inside	Negative sightings			Sep-13	4-6
Reef Watch	Noarlunga North Inside	Negative sightings			Dec-13	4-6
Reef Watch	Noarlunga North Inside	Negative sightings			Feb-14	4-6
Reef Watch	Noarlunga North Inside	Negative sightings			Mar-14	4-6
Reef Watch	Noarlunga North Inside	Negative sightings			Jun-14	4-6
Reef Watch	Noarlunga North Inside	Negative sightings			Aug-14	4-6
Reef Watch	Noarlunga South Inside	Negative sightings			Sep-13	4-6
Reef Watch	Noarlunga South Inside	Negative sightings			Dec-13	4-6
Reef Watch	Noarlunga South Inside	Negative sightings			Feb-14	4-6
Reef Watch	Noarlunga South Inside	Negative sightings			Mar-14	4-6
Reef Watch	Noarlunga South Inside	Negative sightings			Jun-14	4-6
Reef Watch	Second Valley	Negative sightings			Nov-13	4-6
Reef Watch	Second Valley	Negative sightings			Feb-14	4-6
Reef Watch	Second Valley	Negative sightings			Apr-14	4-6
Reef Watch	Second Valley	Negative sightings			Aug-14	4-6

APPENDIX C – STANDING RECOMMENDATIONS

The following comprises a list of recommendations developed over several years of Reef Watch reporting (CCSA 2009, Westphalen 2009, 2010, 2011, 2012, 2013), including:

1. 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;
2. Research on the causal link between sediment loads and reef decline;
3. 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);
4. Better use of Reef Watch data through simplification of the field requirements and/or adjustment to index calculation/interpretation;
5. Further simplification and/or targeting of the taxonomy used in deriving fish and invertebrate indices to specific species/genera/lifeforms;
6. Simplification of the estimation of numbers, particularly as relates to fish surveys such as the use of Braun-Blanquet style categories; and
7. An expanded interpretation of reef status (or "health") to include:
    i. Consideration of marine debris; and
    ii. Consideration of Environment Protection and Biodiversity Conservation Act and/or National Parks and Wildlife Act listed species.