SURVEYS ACROSS REEFS IN THE ADELAIDE AND MT LOFTY RANGES NATURAL RESOURCE MANAGEMENT REGION 2011 - 2012

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

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OVERVIEW

This report summarises Reef Watch monitoring data for the period from (and including) June 2011 to May 2012 across six coastal reef sites in the Adelaide and Mt Lofty Ranges Natural Resources Management Region. Reef cover, fish and invertebrate community data from each site were summarised within continuous seasons and interpreted using the reef status index calculations defined by Turner *et al.* (2007).

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

Results from 2011-2012 would seem to be in line with those of previous years, but with yet further improvements in terms of coverage with no need to exclude observations on the basis of not enough LIT.

Hallett Cove and the Noarlunga sites remained largely unchanged relative to the 2009-2010 and 2010-2011 reporting periods and remain a cause for concern relative to the more pristine sites at Second Valley and The Bluff. With few occurrences in the Good status category over recent years, particularly for Hallett Cove, there is increasing 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.

There are other survey data available (notably the surveys conducted by Russell and Connell 2010), that may assist in clarifying the nature of the reefs within this transitional area, but there is a growing need for a scientifically rigorous targeted investigation of reefs between Hallett Cove and Second Valley. The aim of this survey should be to establish how far to the south the concerns observed at Hallett Cove and Noarlunga extend.

RESULTS OF SURVEYS

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

- 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 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 Reef Watch to consider:

- A better approach to sampling may be to consider a summer-winter (or hot-cold) comparison of each site. This would add a degree of flexibility to the organisation of surveys, allow for a degree of spillage outside the official summer and winter periods as well as encourage a more orthogonal dataset. Note that the minimal LIT length of 20 m should be maintained, but the overall amount of LIT would not be diminished under a simplified approach.

- 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 and whether the current target audience for the program can be better

engaged, although promotion of the new and improved online reporting system may reverse this trend (see http://www.reefwatch.asn.au/fpreport.html, accessed August 2012).

- 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

Current index scores are useful in establishing relative spatial and temporal differences, but the underlying reasons for any observed differences are difficult to identify as the relative importance of individual index scores and their underlying data to the overall status is not clear. 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).

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

Recommendations for index review and development include:

- 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

INTRODUCTION - REEF OBSERVATIONS AND REEF WATCH

The history of formal reef status investigations on the Adelaide metropolitan coast began in 1996, with subsequent surveys in 1999, 2005 and 2007 (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008). Community-based monitoring has been operating more or less throughout this period with the initial aim of developing a broader awareness and education of reef health issues (Turner *et al.* 2006). However, as the skill base amongst members has evolved, coupled with a more appropriate sampling protocol, a more rigorous analysis and reporting of Reef Watch data has been possible (see CCSA 2009, Westphalen 2009, 2010, 2011). Reef Watch monitoring now has a substantial level of sampling rigor and data integrity, particularly across the last four years such that it can be readily employed against environmental decision-making objectives, most appropriately as a "standing watch" on a number of reefs within the Adelaide and Mt Lofty Ranges NRM region.

In particular this objective relates to reef systems at the southern fringes of the Adelaide metropolitan coast in the transitional area between degraded and more pristine systems.

There are a range of extant and potential threats to nearshore systems on the Adelaide metropolitan coast including (amongst others):

- Wastewater treatment outfalls
- Stormwater inputs
- Coastal development, most notably the expanding urbanisation of the coasts to the south of Adelaide
- The development and operation of the Adelaide desalinisation plant
- Marine pest incursions

This report comprises the fifth analysis of Reef Watch community monitoring data that began with the analysis of an accumulation of 10 years of Reef Watch data (CCSA 2009) and subsequent annual reports (Westphalen 2009, 2010, 2011).

AIMS

The aims of the 2011-2012 Reef Watch report are to:

1. Describe and summarise Reef Watch data obtained in the 2011-2012 period in light of recommendations from previous analyses.
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.
4. Propose areas where sampling might be further improved.

REEFS CONSIDERED

In the mid to late 1990s and 2000s, Adelaide University and the South Australian Research and Development Institute (SARDI) Aquatic Sciences conducted surveys of reefs along the metropolitan coast (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Collings *et al.* 2008) and indeed more broadly across the South Australian coast (Turner *et al.* 2007).

A consistent observation across all these surveys was a zone of degraded reefs corresponding to the more urbanised Adelaide coast, possibly extending as far south as Seacliff (i.e. from Semaphore to Brighton). However, there have been disturbing signs of decline within reefs further south, in particular Horseshoe Reef and Noarlunga Reef, where there has been substantial urban and industrial development (Cheshire and Westphalen 2000, Turner *et al.* 2007).

Expansion of the zone of degradation to the extensive reef systems on the Fleurieu Peninsula coast has been raised as a key area of concern (Cheshire and Westphalen 2000, Turner *et al.* 2007), although note that Collings *et al.* (2008) indicated that there were signs of improvement in the status of some sites.

Reefs in the transitional zone between urbanised and rural coasts to the south of the Adelaide metropolitan area thus require ongoing scrutiny, particularly in light of developments within this region, including the desalination plant development at Pt Stanvac, as well as growing "sea-change" urban expansion within satellite townships along the Fleurieu Peninsula (e.g. Moana, Aldinga, Sellicks, etc.). Data obtained by Reef Watch for this area, specifically for Noarlunga Reef and Hallett Cove, can form a critical baseline against which any changes can be assessed.

Reef Watch surveys for 2011-2012 (June – May inclusive) include the same six reefs from the AMLR coast that were examined in previous surveys (2008-9009, 2009-2010 and 2010-2011; 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 the 2009-2010 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.
- The Bluff (Rosetta Head) at Victor Harbor, also considered a healthy reef.

Reef Watch observations therefore encompass reefs that may be cause for concern in the Noarlunga and Hallett Cove areas, a reef previously ranked as degraded (i.e. Broken Bottom) and sites considered as healthy (Second Valley and The Bluff). Changes in reef status at any of these sites can thus be placed in an appropriate context.

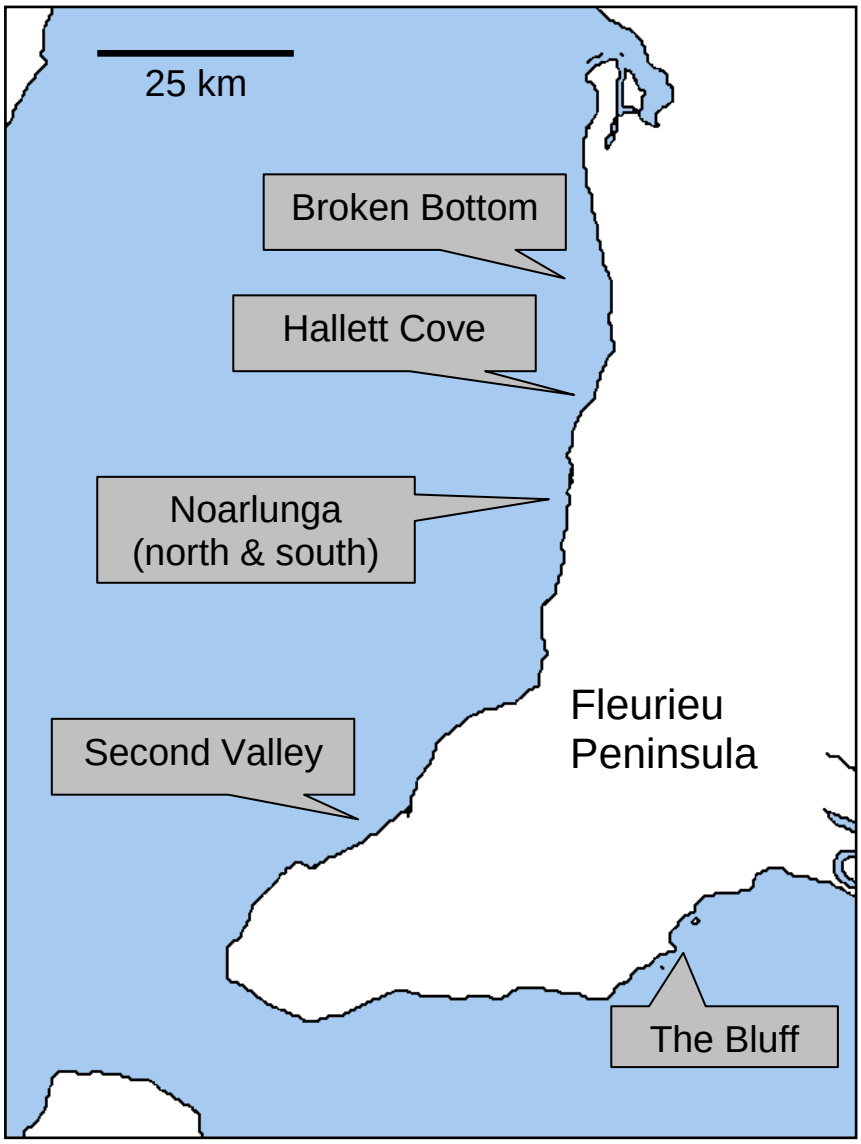

Figure 1 - Map of Fleurieu Peninsula within the AMLR NRM region showing the locations of the reefs surveyed.

METHODS AND INDICES

Reef status (or "health") in the context of Reef Watch observations is based on data obtained from four reef community strata:

- Sessile reef community composition
- Fish community composition
- Invertebrate community composition
- Invasive species observations

Survey methods and interpretation of the data are based on those used in Reef Health investigations, a comprehensive description of which may be found in Turner *et al.* (2007). However, Reef Watch observations employ a somewhat simplified taxonomy within each of the major survey components, in particular the Line Intercept Transects (LITs), but also Fish and Invertebrate surveys (see Appendix A).

The Feral or in Peril program conducted through Reef Watch comprises observations that are not based on a structured sampling approach, but nonetheless form a useful additional data resource (see Reef Watch; http://www.reefwatch.asn.au/fpreport.html, accessed August 2012).

The primary tool for interpreting Reef Watch data are eight of the eleven indices of reef status developed by Turner *et al.* (2007; Table 1). Given the truncated suite of species considered in the Reef Watch surveys, the species richness indices can not be employed in this analysis. Similarly, the sedimentation index was also not used as Reef Watch does not collect these data. 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 reporting from previous years (see CCSA 2009, Westphalen 2009, 2010, Westphalen 2011).

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

Results of the index scores within each site-season combination can be averaged to calculate an overall indicator of reef health for each site-season observation (see Turner *et al.* 2007).

SURVEY DATA, INDEX RESULTS AND DISCUSSION

Reporting of Reef Watch data for 2011-2012 includes summaries of index calculations based on formal surveys as well as the "Feral" aspect of the Feral or in Peril program.

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 2011 through to the end of May 2012. Otherwise the summary would use data that are actually split across two winters (i.e. June 2012 along with July and August 2011), 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).

INDEX DATA AVAILABILITY AND QUALITY

The Reef Watch surveys for 2011-2012 included all six sites considered in previous years (Figure 1, Table 2). All sites were considered at least twice, but only Hallett Cove was examined across all seasons. Across LIT, invertebrate and fish observations there were around 36 transects that covered 18 of the 24 possible site-season combinations (Table 2). Only autumn was relatively poorly represented (only Hallett Cove and Noarlunga South Inside).

The average total LIT length within each site-season was around 39 m (± 3.2 m SE) ranging from 19 m at The Bluff in summer to 67 m at Noarlunga South Inside in autumn (Table 2).

Table 2 – Reef Watch surveys on the AMLR NRM coast from June 2011 to May 2012 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	Invertebrates	LIT	Fish	Invertebrates	LIT	Fish	Invertebrates	LIT	Fish	Invertebrates	LIT
Broken Bottom				3	4	4 (54)	4	4	2 (34)			
Hallett Cove	2	2	1 (25)	1	1	2 (52)	2	2	3 (57)	2	2	1 (30)
Noarlunga North Inside	1	1	1 (24)	2	2	2 (35)	3	1	2 (26)		1	
Noarlunga South Inside	2	2	2 (44)						1 (20)	2	3	4 (67)
Second Valley	1	2	2 (41)	1	1	2 (46)	4	3	2 (37)			
The Bluff	2	2	2 (44)	2	2	2 (50)	2	2	1 (19)			

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). This approach is based on previous Reef Watch analyses (notably CCSA 2009) which found that, while LIT data are accurately collected, transects have often been very short even when summed across a season. Given that LIT data support four of the eight health indices employed (Table 1), the representativeness of these observations was considered highly suspect. However, within the 2011-2012 observations, there was no need for any data exclusions with all site-seasons having more than the minimum length (although accepting that The Bluff in summer at 19 m is marginal; Table 2). Half the observations comprise more than 40 m of LIT 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 increasingly more comprehensive.

In spite of this steady improvement, there is still merit in considering a summer-winter (or hot-cold) comparison rather than attempt 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.

INDEX DATA

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), including six of the 18 LIT lifeforms, 17 of the 32 fish species and only five of the 32 observed species from invertebrate surveys (Appendix A). Further simplification of the taxa considered within each of the strata should be considered, particularly with regards to LITs.

Only five blue-throated wrasse were recorded across the entire fish dataset (36 transects worth; Table 3) and as with previous reporting (Westphalen 2010, Westphalen 2011) it was considered that this index was uninformative as to reef status. Blue-throated wrasse data were thus excluded from the results, reducing the total number of indices to seven.

High numbers of site attached fish (300-400 or more) at Broken Bottom-summer, Noarlunga North Inside-summer and Second Valley-winter were due to large numbers of yellow-headed hulafish (*Trachiniops norlungae*) and bullseye (*Pempheris* spp.) respectively (Table 3). Similar high numbers of yellow-headed hulafish and bullseye were observed at some site-season combinations from previous years (see Westphalen 2011), but there is no apparent pattern with respect to locations or time of year.

For abundance data, both the field observations and the ensuing index calculation 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 comparisons with previous reporting.

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	
Second Valley	Winter	3.86	73.66			3	2	406	1	1	0
Second Valley	Summer	7.15	83.42		0.44	5	3	68	2	4	0
Second Valley	Spring	8.26	70.20		1.74	3	1	4	0	1	0
Noarlunga South Inside	Winter	18.31	16.91	38.50		52	2	5	0	2	0
Noarlunga South Inside	Summer	8.24	21.95	44.17							0
Noarlunga South Inside	Autumn	17.93	18.15	54.66	6.67	26	3	26	0	2	0
Noarlunga North Inside	Winter	4.01	61.81	2.29		8	1	1	0	1	0
Noarlunga North Inside	Summer	32.24	27.14	29.06		17	1	307	2	3	0
Noarlunga North Inside	Spring	14.16	33.68	33.97		14	2	5	0	2	0
Hallett Cove	Winter	10.68	12.28		0.36	8	2	6	0	2	0
Hallett Cove	Summer	12.64	18.44		0.45	8	2	13	0	2	0
Hallett Cove	Spring	9.07	34.81			0	1	2	0	1	1
Hallett Cove	Autumn	18.70	10.23			6	2	9	0	2	0
Broken Bottom	Summer	18.46			34.68	8	4	485	0	4	0
Broken Bottom	Spring	42.31			29.26	5	4	9	0	3	1
The Bluff	Winter		88.27		0.96	5	2	51	0	2	0
The Bluff	Summer	0.89	90.37			2	2	9	0	2	0
The Bluff	Spring	4.59	87.50		1.10	6	2	17	0	2	0

FERAL OR IN PERIL - FERAL OBSERVATIONS 2011-2012

Feral or in Peril data collected by Reef Watch for the period June 2011 to May 2012 were investigated for supporting information related to invasive species within the AMLR region (see Appendix B). Given that Feral or in Peril observations are not based on a fixed sampling strategy, it is impossible to determine whether multiple observations within a site cover either the same ground (and by extension the same pests) or include similar observational intensity (i.e. number of divers x time spent searching).

Feral data for the reporting period comprises 14 observations across seven locations around the AMLR NRM coast (Figure 2; Appendix B). The number of observations is relatively low compared to previous years (notably 42 observations in 2009-2010; Westphalen 2010). Reporting for at least the feral aspect of the program would seem to have tailed off in recent years. A review of the participation level in Feral or in Peril should be considered with the aim of identifying whether the current target audience is appropriate to the desired reporting outcomes.

However, when combined with Reef Watch surveys (around 36 transects) across six locations this makes for a total of 50 observations spread over the same seven locations (most of the Feral or in Peril observations were contiguous with Reef Watch sites). Note that, in the absence of any advice to the contrary, the transect observations are assumed to comprise "no sighting" observations that are essential to establishing the nature of any pest encroachment (see CCSA 2009, Westphalen 2009, 2010, 2011).

Two invasive species from the "Feral" list were reported in 2011-2012. Many of these occurred as multiple observations within a site (as they are registered more than once on the same date but often with different depths; see Appendix B).

Where the Feral observations aligned with transect surveys, the data were included in the index score. These observations therefore included 1 pest in each of Broken Bottom in spring and Hallett Cove in spring (Table 3).

European fanworm (*Sabella spallanzanii*) was observed for the first time at Broken Bottom and Hallett Cove. Along with sightings at Noarlunga Reef in 2010-2011, these observations would seem to be at odds with the impression that this pest prefers artificial substrates in sheltered areas (Boxall and Westphalen 2003).

Feral or in Peril observations also found *S. spallanzanii* at Kingscote in 2008 and subsequently at Wirrina (see Kinloch *et al.* 2010, Westphalen 2010).

The 2011-2012 reports also include sightings at the Whyalla marina.

Sabella spallanzanii is a relatively common pest on the Adelaide metropolitan coast, although the last formal surveys on its distribution were in 2002, which established a range from the Port River to Brighton (Boxall and Westphalen 2003). This pest will continue to spread, either naturally or through artificial vectors, the most probable of which is hull fouling.

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).

The European shore crab may be amongst Australia's most damaging marine pests (Thresher 1997). It is a tough, fecund, generalist predator considered to be highly damaging to benthic communities (Cohen *et al.* 1995, Groshulz *et al.* 2000). Hull fouling is considered to be the

most likely vector for *C. maenas*, although it may also be transported as larvae in ballast water (Cranfield *et al.* 1998).

Observations of *C. maenas* in Gulf St Vincent are somewhat sporadic with occurrences 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).

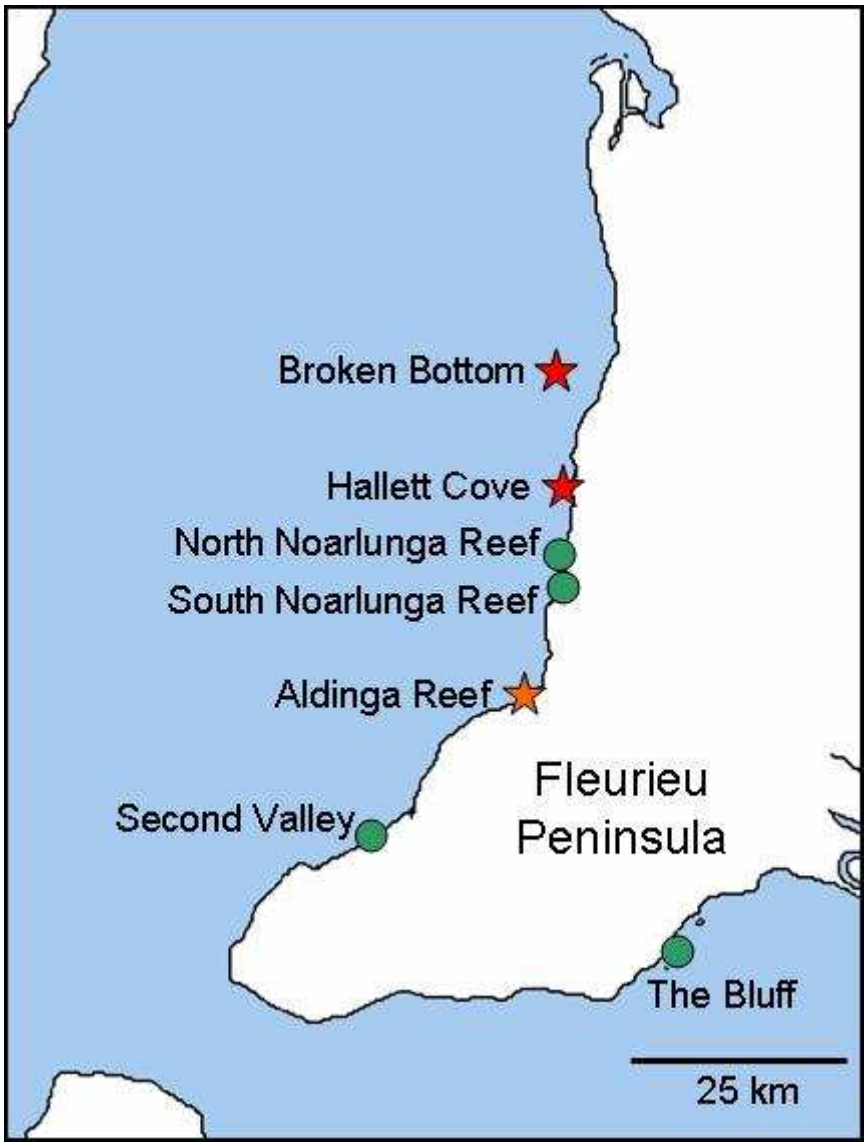

Figure 2 - Map of the Fleurieu Coast showing the location of Feral observations from the Feral or in Peril dataset from June 2011 to May 2012. Green circles indicate where nothing was found, Red stars show where *Sabella spallanzanii* was observed, Orange stars show where *Carcinus maenas* was observed.

Given the nature of the observations for this pest, it would seem that the population of this pest varies substantially both temporally and spatially (Zeidler 1997, Grosholz and Ruiz 1995) such that any control/management activity needs to be flexible.

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 also needs to be noted that the feral animals

employed in the program comprises species that are readily recognisable by non-experts and these surveys are therefore not a substitute for formal marine pest investigations.

Feral or in Peril nonetheless has a proven track record in supporting marine pest monitoring and management within South Australia.

INDEX RESULTS

Reef status index results included data for 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). However, as with previous Reef Watch summaries (CCSA 2009, Westphalen 2009, 2010, 2011) the number of blue-throated wrasse observed in the 2010-2011 reporting period was considered too few to make this index useful (only five fish seen; Table 3) and it was dropped from the assessment.

It has been previously recommended that the reef status indices as they currently stand are in need of reconsideration and review in terms of both definition and calculation (CCSA 2009, Westphalen 2009, 2010, 2011).

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).

Broken Bottom scored as Poor and Caution in the two seasons it was assessed (spring and summer; Table 4), which is in keeping with the degraded status of this site observed in previous surveys.

Table 4 - Overall reef status index results (see Turner *et al.* 2007) for the 2011-2012 reporting period.

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

Hallett Cove and the Noarlunga Reefs on the southern fringe of the metropolitan coast generally rated in as Caution or even Poor status, with only Noarlunga South Inside in autumn rating as Good (Table 4). Note that the Poor rating for Noarlunga South Inside in summer may be due to a lack of fish and invertebrate data for this observation (Table 3).

Second Valley and The Bluff returned Good status for all seasons that had data (i.e. not winter) except The Bluff-summer, which registered Caution.

All sites with Good status had high canopy cover as well as one or both high ratings for site attached fish and invertebrate predators (Table 5). Caution and Poor rating reefs were generally characterised by low canopy cover and intermediate levels of site attached fish as well as presence of mussels and bare substrate, although most scored highly for invertebrate predators, possibly because they were more visible with low canopy cover (Table 5). The exception to this trend was The Bluff in summer (that rated as Caution) which scored high canopy cover but low levels for the fish and invertebrate abundance indices.

Table 5 - Reef status indices for each site-season considered by Reef Watch in the 2011-2012. 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
The Bluff	Spring	Good	95	100				99	85	
The Bluff	Summer	Caution	60	100				52	28	
The Bluff	Winter	Good	90	100				100	71	
Broken Bottom	Spring	Poor	11	0			0	35	35	0
Broken Bottom	Summer	Caution	48	0	35			100	57	
Hallett Cove	Autumn	Caution	46	0				52	85	
Hallett Cove	Spring	Poor	15	37				23	0	0
Hallett Cove	Summer	Caution	59	0				76	100	
Hallett Cove	Winter	Caution	45	0				35	100	
Noarlunga North Inside	Spring	Caution	41	34		0		29	100	
Noarlunga North Inside	Summer	Caution	53	18		6	39	100	100	
Noarlunga North Inside	Winter	Good	70	100				11	100	
Noarlunga South Inside	Autumn	Caution	50	0		0		100	100	
Noarlunga South Inside	Summer	Poor	1	5		0		0	0	
Noarlunga South Inside	Winter	Poor	32	0		0		29	100	
Second Valley	Spring	Good	77	100				47	85	
Second Valley	Summer	Good	82	100				100	47	
Second Valley	Winter	Good	81	100				100	42	

COMPARISON BETWEEN REEF STATUS SURVEYS

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). Broken Bottom rated as Poor or Caution in spring and summer respectively (Table 5), which is in line with this sites status as a degraded reef. Second Valley rated consistently as Good across the three seasons in which it was considered while The Bluff rated as Good in winter and spring and Caution in summer (Table 5), but otherwise these locations were consistent with being more or less pristine.

However, Hallett Cove and Noarlunga North and South, which are in the transitional zone between urbanised and rural coasts, continue to be a cause for concern as to their status, which ranged across mostly Caution and Poor status (Table 5).

A comparison of status scores for the Reef Watch survey sites across all years, including formal surveys indicate a high level of inter-annual variability at all locations, even within the supposedly healthy reefs at Second Valley and The Bluff (Figure 3). Hallett Cove in particular has varied substantially since 1998, although this was the only site for which there was data from this period.

However, for this interpretation it needs to be noted that formal Reef Health surveys (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008) were collected only annually there therefore comprise only one seasonal observation at

each location relative to two to four observations for most sites in the Reef Watch data. The average across seasons within each year is thus better represented in the latter.

The Turner *et al*. (2007) and Collings *et al.* (2008) surveys also 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 will not align to the index requirements other than those for LIT.

Estimates of reef status prior to 2007 and comparisons between Reef Watch and formal surveys therefore need to be viewed with considerable caution.

Reef status across years seems to be highly variable, although the degree to which the indices themselves, in terms of their definition and calculation, are a factor in this variability should not be discounted (see Turner *et al.* 2007 for a description of index calculations). Nonetheless the status of reefs in the transitional zone between metropolitan and urbanised coast remain a cause for concern as they regularly fall into the Caution or even Poor status categories (Figure 3). Conversely, the Bluff and Second Valley are consistently rating as Good with occasional "dips" in to the Caution zone (Figure 3).

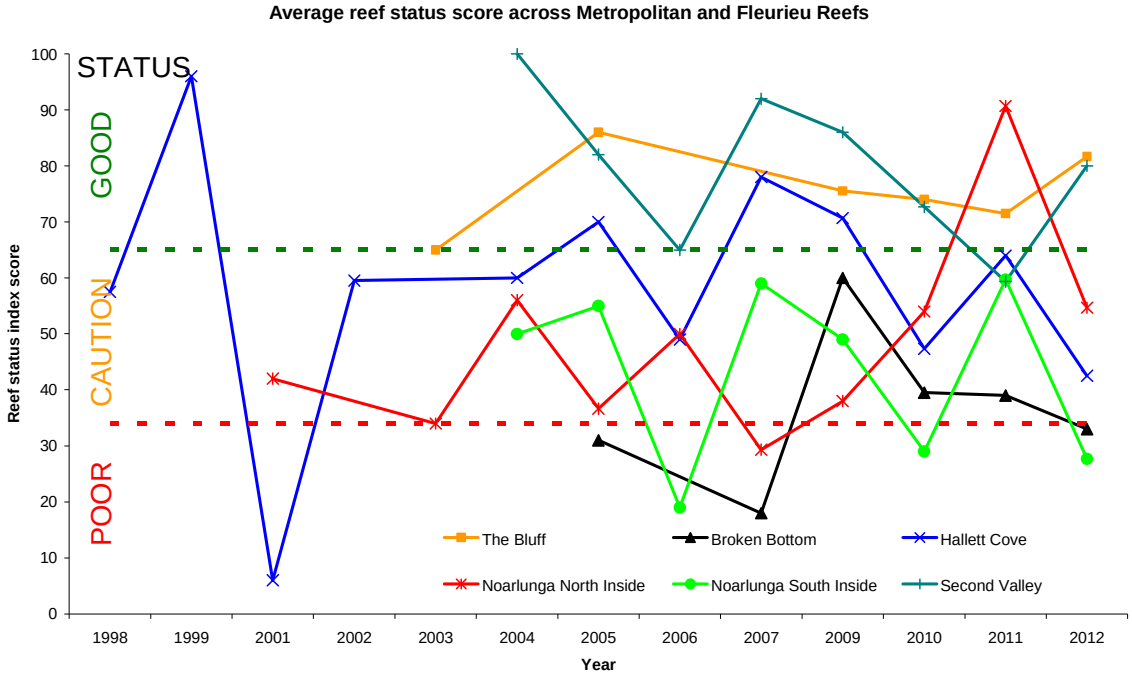

Figure 3 - Average reef status scores across seasons including all data from both formal Reef Health surveys and Reef Watch from 1998 to present.

Loss of canopy-forming algae has been considered typical of degraded reefs on the Adelaide metropolitan coast (e.g. Cheshire and Westphalen 2000, Turner *et al.* 2007), which would be in line with index results. Instead, degraded sites tend to be dominated by bare substrate and/or turfing/filamentous red macroalgal species (Cheshire and Westphalen 2000, Turner *et al.* 2007). Increased mussel cover has been observed at Horseshoe Reef and considered to be either a potential cause of or response to reef decline (Smith 2000).

Mussels occurred at the Noarlunga sites across all seasons considered, turfing algae were found at all sites but not all seasons and bare substrate was found at all sites and seasons except The Bluff in winter (Table 3). The relationship between these observations, the resulting index scores and the overall reef status is thus not clear. There is a need for

greater understanding of the sensitivities of the overall status index to changes in the underlying parameters. Notably, the degree to which indices may be differently influential both singly and in combination needs to be investigated, particularly given that they are not necessarily independent of each other (i.e. loss of canopy macroalgae will likely be commensurate with an increase in bare substrate and turfing species – see CCSA 2009).

The above is yet further evidence of the need to review reef status indices as noted in previous Reef Watch assessments (see Westphalen 2009, 2010, 2011).

POTENTIAL FACTORS FOR INTER-ANNUAL DIFFERENCES

Sedimentation has been considered to be a potential cause for reef decline (Cheshire and Westphalen 2000, Greig 2000, Smith 2000, Airoldi 2003, Turner 2004).

After relatively mild summers and wet winters in 2010-2011 and 2011-2012, the declines observed at some sites at the fringe of the metropolitan coast (Hallett Cove and Noarlunga) may be related to increased sediment run-off from higher stormwater inputs. However, this model cannot be verified without specific evidence.

There is a substantial distance (and a lot of reef) between Noarlunga and Second Valley (around 22 km straight line distance) and it would be prudent to determine the status of intervening reefs (Southport, Aldinga and Moana) with the view to establishing if there are any signs of reef decline south of Noarlunga, although note that this should not be the responsibility of Reef Watch, but may be a component of formal surveys along the line of Turner *et al.* (2007) and Collings *et al.* (2008).

Similarly, while The Bluff is a good example of a healthy reef within the AMLR NRM region, its location makes it a relatively poor integrator of processes that occur within Gulf St Vincent. The inclusion of additional sites within the Gulf would serve to better inform as to the impact of any changes within this system.

Formal surveys of Adelaide metropolitan reefs along the lines of Turner *et al.* (2007) and Collings *et al.* (2008) are perhaps overdue.

In addition, 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.

SEASONAL DIFFERENCES

Seasonal variability is readily apparent in the index results within each site, in particular where there are three or more seasons considered (i.e. all sites except Broken Bottom; 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) and there may also be seasonal factors affecting site attached fish and mobile invertebrate predators.

However, as with previous years, there is no pattern of reef relative to season.

The observed differences between sites are also likely to be driven by location specific factors including (amongst others) wave energy, slope, substrate type and, not least, proximity to metropolitan Adelaide. As a consequence, specifics of the location of each site are probably more influential than any seasonal signature, which would probably be best appreciated through a more in depth analysis of all the available data rather than via the

index scores, particularly in light of the issues related to the sensitivity of the indices relative to the input data raised above.

Reef Watch survey effort might be better allocated to collecting summer and winter data only (or a hot-cold comparison dataset).

IMPROVEMENTS TO INDICES

The status indices developed by Turner *et al.* (2007) were never intended to be the definitive approach to reef health assessment. There is a need for critical assessment of the validity, parameterisation and calculation of each index, responding to the criticisms raised in both Reef Health (Collings *et al.* 2008) and Reef Watch reporting (CCSA 2009, Westphalen 2009, 2010, 2011) and indeed within this assessment. However, it needs to be pointed out that reassessment and improvement to reef status indices is not a job for Reef Watch, although it may provide an excellent forum within which modified approaches can be tested.

CONCLUSIONS AND RECOMMENDATIONS

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

Results from 2011-2012 would seem to be in line with those of previous years, but with yet further improvements in terms of coverage with no need to exclude observations on the basis of not enough LIT.

Hallett Cove and the Noarlunga sites remained largely unchanged relative to the 2009-2010 and 2010-2011 reporting periods and remain cause for concern relative to the more pristine sites at Second Valley and The Bluff. With few occurrences in the Good status category over recent years, particularly for Hallett Cove, there is increasing 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.

There are other survey data available (notably the surveys conducted by Russell and Connell 2010) that may assist in clarifying the nature of the reefs within this transitional area, but there is a growing need for a scientifically rigorous targeted investigation of reefs between Hallett Cove and Second Valley. The aim of this survey should be to establish how far to the south the concerns observed at Hallett Cove and Noarlunga extend.

RESULTS OF SURVEYS

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

- 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 Reef Watch to consider:

- A better approach to sampling may be to consider a summer-winter (or hot-cold) comparison of each site. This would add a degree of flexibility to the organisation of surveys, allow for a degree of spillage outside the official summer and winter periods as well as encourage a more orthogonal dataset. Note that the minimal LIT length of 20 m should be maintained, but the overall amount of LIT would not be diminished under a simplified approach.

- The number of 'Feral' (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 and whether the current target audience for the program can be better engaged, although promotion of the new and improved online reporting system may reverse this trend (see http://www.reefwatch.asn.au/fpreport.html, accessed August 2012).

- 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

Current index scores are useful in establishing relative spatial and temporal differences, but the underlying reasons for any observed differences are difficult to identify as the relative importance of individual index scores and their underlying data to the overall status is not clear. 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).

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

Recommendations for index review and development include:

- 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

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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
GBIG	Green big	NA
GLETTUCE	Green - Ulva spp.	NA
GRASS	Seagrass	NA
GSMALL	Green small	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 name	Common name	Site Attached
Arripis trutta	Australian salmon	NO
Achoerodus gouldii	blue groper	YES
Notolabrus tetricus	blue-throated wrasse	YES
Pempheris	bullseye	YES
Aracana	cowfish	YES
Sepia apama	cuttlefish	NO
Kyphosus sydneyanus	drummer	NO
Dactylophora nigricans	dusky morwong	NO
Upeneichthys vlamingii	goat fish	NO
	gurnard	NO
Odax cyanomelas	herring cale	YES
Meuschenia hippocrepis	horseshoe leatherjacket	YES
Trachinops	hulafish	NO
Phycodurus eques	leafy seadragon	YES
Dinolestes lewini	long-finned pike	NO
Pentaceropsis recurvirostris	long-snouted boarfish	NO
Cheilodactylus nigripes	magpie perch	YES
Tilodon sexfasciatus	moonlighter	YES
Enoplosus armatus	old wife	YES
Aracana ornata	ornate cowfish	YES
	other leatherjacket	NO
	other wrasse	YES
	pipe fish	YES
Brachaluteres jacksonianus	pygmy leatherjacket	NO
Odax acroptilus	rainbow cale	YES
Parma victoriae	scalyfin	YES
Pictilabrus laticlavius	senator wrasse	YES
Aracana aurita	Shaws cowfish	YES
Parequula melbournensis	silver belly	NO
	small fish	NO
	spider crab	NO
	squid	NO

Species name	Common name	Site Attached
Scorpis	sweep	NO
Arripis georgianus	tommy ruff	NO
Pseudocaranx	trevally	NO
	trumpeter	NO
Siphonognathus	weed whiting	NO
Paraplesiops meleagris	western bluedevil	YES
Chelmonops curiosus	western talma	YES
Trachinops noarlungae	yellow-headed hulafish	YES
Meuschenia flaviolineata	yellow-striped leatherjacket	YES
Girella zebra	zebra fish	NO

INVERTEBRATE SPECIES OBSERVED IN REEF WATCH SURVEYS

Species name	Common name	Index
	hermit crab	NO
	small fish	FISH
	whelk/triton complex	YES
Amblypneustes spp.	Amblypneustes	NO
Cenolia spp.	Cenolia (feather star)	NO
Centrostephanus tenuispinus	Centrostephanus	NO
Chelmonops curiosus	western talma	FISH
Coscinasterias muricata	Coscinasterias (11 arm star)	YES
Dicathais orbita	Dicathais	YES
Equichlamys bifrons	queen scallop	NO
Goniocidaris tubaria	Goniocidaris	NO
Haliotis laevigata	greenlip abalone	NO
Haliotis spp.	blacklipped abalone	NO
Heliocidaris erythrogramma	Heliocidaris	NO
Holopneustes spp.	Holopneustes	NO
Jasus edwardsii	rock lobster	YES
Nectocarcinus spp.	Nectocarcinus	NO
Nepanthia troughtoni	Nepanthia	NO
Paraplesiops meleagris	western blue devil	FISH
Patiriella brevispina	Patiriella brevispina	NO
Patiriella calcar	Patiriella calcar	NO
Pempheris	bullseye	FISH
Pentagonaster dubeni	Pentagonaster (firebrick star)	NO
Petricia vernicina	Petricia	NO
Phasianella spp.	pheasant shell	NO
Phyllacanthus irregularis	Phyllacanthus	NO
Plagusia chabrus	red bait crab	NO
Stichopus spp.	holothurian (sea cucumber)	NO
Tilodon sexfasciatus	moonlighter	FISH
Tosia spp.	Tosia	NO
Turbo torquatus	Turbo torquatus	NO
Turbo undulatus	Turbo undulatus	NO
Uniophora granifera	Uniophora	YES

APPENDIX B – FERAL OR IN PERIL – FERAL OBSERVATIONS

Location	Date	Observation	Depth (m)
Noarlunga North	20/08/2011	Negative sightings	5
Noarlunga South	20/08/2011	Negative sightings	5
Broken Bottom	18/09/2011	European fan worm	9
Broken Bottom	18/09/2011	European fan worm	9
Broken Bottom	18/09/2011	European fan worm	10
Second Valley	03/10/2011	Negative sightings	7
Hallett Cove	06/10/2011	European fan worm	6
The Bluff	23/10/2011	Negative sightings	6
The Bluff	23/10/2011	Negative sightings	0
Hallett Cove	06/11/2011	European fan worm	1
Whyalla Marina	03/12/2011	European fan worm	0
Whyalla Marina Jetty	03/12/2011	European fan worm	2
Hallett Cove	12/02/2012	Negative sightings	4
Snapper Point Aldinga Intertidal	13/02/2012	European shore crab	0
Snapper Point Aldinga Intertidal	25/02/2012	European shore crab	0
Broken Bottom	26/02/2012	Negative sightings	11
Whyalla Marina	15/03/2012	European fan worm	1