# *SURVEYS ACROSS REEFS IN THE ADELAIDE AND MT LOFTY RANGES NATURAL RESOURCE MANAGEMENT REGION 2009 - 2010*

Grant Westphalen

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

Reef Watch Monitoring Program
Conservation Council of SA
157 Franklin St, Adelaide SA 5001
Ph: (08) 8223 5155 Fax: (08) 8232 4782
Web: www.reefwatch.asn.au

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



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Author(s): Westphalen, G.

Reviewers: Alex Gaut and Sue Murray-Jones

Approved by: Alex Gaut

Signed:

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## OVERVIEW

This report summarises Reef Watch monitoring data for the period from June 2009 to May 2010 across seven coastal reef sites on the Adelaide and Mt Lofty Ranges Natural Resource Management Region. The available data were interpreted using the reef status index calculations defined by Turner *et al.* (2007).

The index results indicate that there has been marked decline in the status of what had previously been considered a "healthy" reef at Hallett Cove to "Caution" or even "Poor" status. All other sites were in keeping with observations from previous years, including one in generally "Poor" condition (Broken Bottom), two reefs considered to be in "Good" condition (Second Valley and The Bluff) as well as three sites of intermediate or "Caution" status (Noarlunga North Inside, Noarlunga South Inside and Noarlunga North Outside).

Decline in the status of Hallett Cove is a cause for concern and there is consequently a need to determine:

- The precise nature of the decline and the causal mechanism, specifically sedimentation and turbidity loads.
- The spatial scale over which the causal factor is expressed.
- If it is not a localised influence, are there signs of decline within reefs further south (between Noarlunga and Second Valley)?

A number of recommendations can be identified based on the results of the Reef Watch 2009-2010 surveys.

**Recommendations for further action include:**

- A formal survey of Adelaide metropolitan reefs along the lines of Turner *et al.* (2007), Collings *et al.* (2008) aimed at establishing the nature of the decline at Hallett Cove and verifying if there is any degradation south of Noarlunga. These surveys would also form an important baseline prior to the commissioning of the desalination plant and should engage the skills available at DEH, SARDI Aquatic Sciences, and the Universities or similar, with a view to determining the status of reefs independently of Reef Watch.
- In conjunction with the above, the available data on sedimentation and turbidity within the Adelaide metropolitan coast as well as related inputs from rivers, creeks and stormwater drains should be analysed to see if water quality correlates with reef status. Specifically, this should aim to determine whether there is an overall increase in sedimentation and turbidity along the Adelaide nearshore or if there is a localised factor at Hallett Cove.
- In light of the above investigations, the availability of water quality data from the Adelaide nearshore environment should be reviewed.
- More research into causal linkages between sediment/turbidity inputs and reef decline is required with specific reference to southern temperate reef systems.

Results of data summaries and index calculation suggest that there has been further improvement to Reef Watch surveys, following on from the recommendations of previous analyses (CCSA 2009, Westphalen 2009). However, there are a range of factors that

influence the interpretation of the results in terms of identification of seasonal and inter-annual differences as well as the need to target survey effort such that there is adequate data from all site-season observations.

**Recommendations for Reef Watch to consider:**

- While seasonal comparisons between reefs can be undertaken using the Reef Health indices, consideration of differences between sites and/or seasons may require more comprehensive use of the available data rather than the subset currently used in index calculation.

- Reef Watch observations should focus on collecting a minimum of 20 m worth of Line Intercept Transects (LIT) from each of the six core sites in each season. Development of summary views of the online database that indicate to the total current LIT length collected relative to season would enable a quick check by field organisers to track survey effort and where it should be applied.

Continued use of the Turner *et al.* (2007) indices upholds a number of issues related to their definition and calculation (see Turner *et al.* 2007, Collings et al, 2008, CCSA 2009, Westphalen 2009) and some care needs to be taken with interpretation of the results, including comparisons with earlier observations.

**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.

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

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

    - Consideration of marine debris,

    - Consideration of EPBC/NP&WS listed species.

## INTRODUCTION - REEF OBSERVATIONS AND REEF WATCH

Community-based monitoring of reef systems on the Adelaide metropolitan coast has occurred since the late 1990s, building on the results of more formal and comprehensive surveys conducted in 1996, 1999, 2005 and 2007 (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008).

The initial emphasis of the Reef Watch program was on developing broader awareness and education of reef health issues (Turner *et al.* 2006). However, more rigorous analysis and reporting of Reef Watch data have been undertaken (see CCSA 2009, Westphalen 2009) and the monitoring has developed a substantial level of sampling rigor and data integrity such that it can be readily employed against environmental decision making objectives.

This report summarises results of subtidal reef surveys undertaken by Reef Watch between August 2009 and May 2010 from across seven reef sites on the Adelaide and Mt Lofty Ranges Natural Resource Management (AMLR NRM) coast (Figure 1). This report builds on earlier interpretations of the Reef Watch data (see CCSA 2009, Westphalen 2009).

Since reef surveys were initiated in the 1990s it is readily apparent that there is a zone of degraded reefs corresponding to the most urbanised stretch of the Adelaide coast, possibly extending as far south as Seacliff (i.e. from Semaphore to Brighton; Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008). Disturbingly, there have been indications of a possible decline of reefs further south, in particular Horseshoe Reef and Noarlunga Reef, where there has been substantial expansion of building in the southern suburbs (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 from Reef Health surveys (Cheshire and Westphalen 2000, Turner *et al.* 2007). Note that Collings *et al.* (2008) suggested that there were signs of improvement in reef health status for some metropolitan reefs.

Reefs in the transitional area between urbanised and rural coasts are in need of more focussed scrutiny, particularly in light of the Adelaide Desalination Plant development at Pt Stanvac. Data obtained by Reef Watch for this area, notably for Noarlunga and Horseshoe Reefs to the south and Hallett Cove to the north, may form a critical baseline against which any unforseen impact can be assessed.

Reef Watch surveys for the 2009-2010 financial year have included the six reefs from 2008-9009 along with one additional site (Figure 1):

- Broken Bottom, a degraded reef off Glenelg
- Hallett Cove, a healthy exposed reef
- 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 to be a healthy reef
- The Bluff (Rosetta Head) at Victor Harbour, also considered a healthy reef
- Noarlunga North Outside, as an additional location, which has been rated “Good” to “Caution” status in previous surveys

Reef Watch observations therefore encompass reefs for which there may be cause for concern (Noarlunga area), as well as reefs previously ranked as degraded (Broken Bottom) or healthy (Hallett Cove, Second Valley and The Bluff). Changes in reef community composition at any of these sites can thus be placed in an appropriate context.

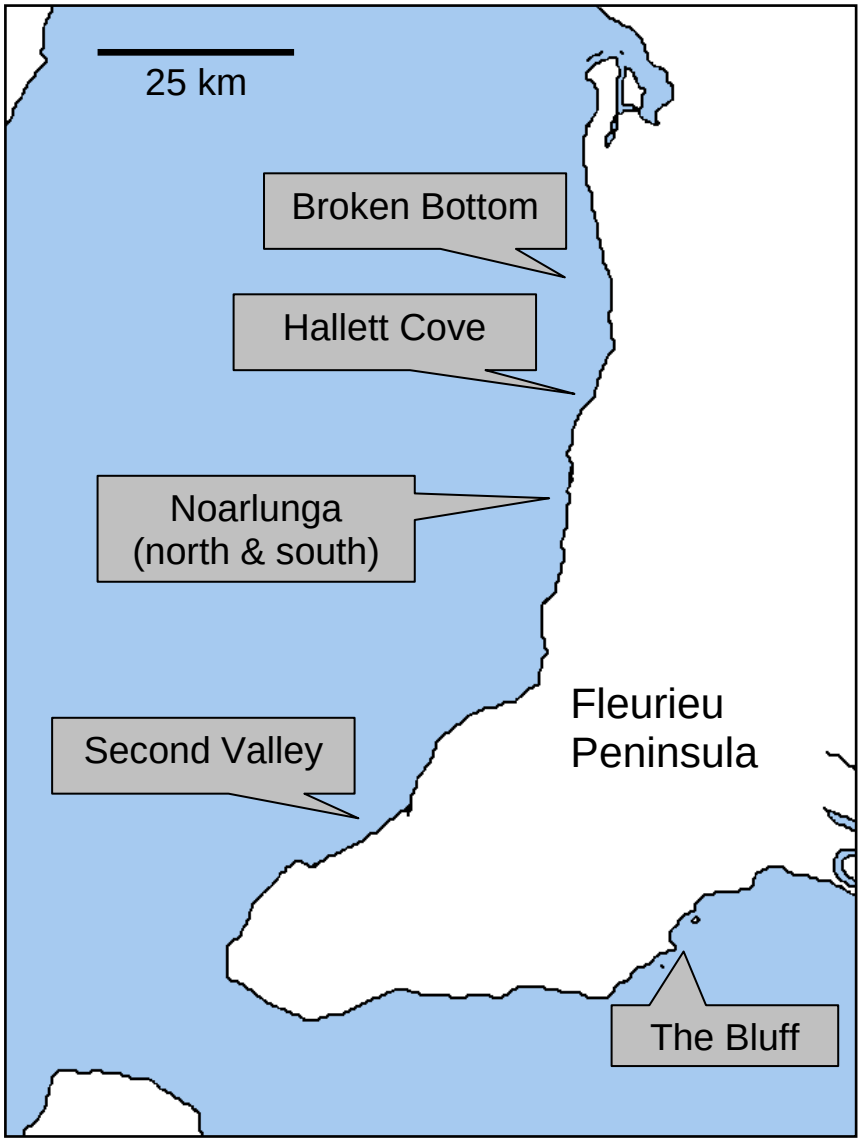


**Figure 1 - Map of Fleurieu Peninsula within the AMLR NRM region showing the locations of the reefs considered.**

## AIMS

The aims of this report are to:

1. Describe Reef Watch data obtained in the 2009-2010 period in light of recommendations from previous analyses.
2. Consider Reef Watch data through the approach provided by the Turner *et al.* (2007) indices.
3. Propose areas where sampling might be further improved.

## METHODS AND INDICES

Reef status (or "health") is based on observations from four reef community strata:

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

The methods employed in obtaining reef data are based on those used in Reef Health investigations, a full summary of which may be found in Turner *et al.* (2007), although note that the taxonomy employed within Line Intercept Transects (LITs), Fish and Invertebrate surveys have been substantially simplified (see Appendix A).

Feral or in Peril observations are not based on a structured sampling approach, but nonetheless form a useful additional data resource in this context (see Reef Watch; http://www.reefwatch.asn.au/fpreport.html, accessed July 2010).

The primary tools for analysing Reef Watch data are the 11 indices of reef status developed by Turner *et al.* (2007), although not all could be considered (Table 1). A full description of each index including their calculation as well as some of their limitations is found in Turner *et al.* (2007). For further interpretation and critiquing of the indices, see Collings *et al.* (2008), CCSA (2009) and Westphalen (2009). Additional interpretations of the data are based on the findings and recommendations from previous reporting for Reef Watch data (see Collings *et al.* 2008, CCSA 2009, Westphalen 2009).

**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 | As part of other 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 |

Index scores from the above can be averaged to develop an overall indicator of reef health for each observation, in this instance based around site and season (see below).

Given the substantial differences in the species considered between different reef surveys (Turner *et al.* 2007, Collings *et al.* 2008, CCSA 2009, Westphalen 2009), the species richness indices were not employed in this analysis.

The sedimentation index was also not employed as Reef Watch does not collect data.

## SURVEY DATA, INDEX RESULTS AND DISCUSSION

Reporting of Reef Watch data for 2009-2010 includes summaries of the index calculations based on formal surveys as well as the "Feral" aspect of Feral or in Peril reporting.

### INDEX DATA AVAILABILITY AND QUALITY

The Reef Watch surveys from August 2009 to May 2010 covered seven sites along the AMLR coast (Figure 1), with a total of 17 seasonal observations. Surveys were unevenly distributed across seasons but most sites included at least three (Table 2). Data were summarised to include continuous months within each season, meaning that observations undertaken within June 2010 will be included in 2010-11 reporting. Otherwise the summary data would use data that are actually split across two winters (i.e. June 2010 along with July and August 2009). This issue did not arise last year as there were no observations in winter (see Westphalen 2009).

One location, Noarlunga North Outside (NNO), only has LIT data from autumn (it was considered as part of the Marathon Dive event) and was not surveyed in 2008-2009 (Table 2; Westphalen 2009). This site therefore presents limited opportunities for comparison. Overall, the Reef Watch dataset for 2009-2010 is more comprehensive in terms of seasonal coverage across sites than previous years (see CCSA 2009, Westphalen 2009).

Other than this additional site, there is a spatiotemporally aligned set of observations from across LIT, Fish transects and Invertebrate transects, meaning that reef status was based on the same potential number of indices in each instance. Again this approach forms a substantial improvement over previous surveys, building on the achievements of the 2008-2009 surveys (see Westphalen 2009).

**Table 2 – Reef Watch surveys on the AMLR NRM coast from August 2009 to May 2010 in terms of the total length of LIT within each site-season. Red numbers indicate where there was not enough LIT data for a summary to be considered (see CCSA 2009). Note that for the Noarlunga North Outside survey (shaded) there were only LIT data available.**

| Site Name | Code | Total transect distance (m) within each season | | | |
|---|---|---|---|---|---|
| | | Spring | Summer | Autumn | Winter |
| Broken Bottom | BRB | 34 | | 51 | |
| Hallett Cove | HAL | 48 | 94 | 47 | |
| Noarlunga North Inside | NNI | 17 | 11 | 19 | 14 |
| Noarlunga North Outside | NNO | | | 18 | |
| Noarlunga South Inside | NSI | 33 | 17 | | |
| Second Valley | SVA | 41 | 28 | 48 | |
| The Bluff | BLU | | 85 | | 6 |

Fish and invertebrate surveys use fixed length transects (50 m – see Turner *et al.* 2007), while LIT can vary in length, but nonetheless form the basis for four of the indices (Table 1). While LIT data prior to 2009 were accurately collected, the transects themselves were often very short, so much so that the representativeness of the observation was suspect (CCSA 2009). The majority of LITs in 2009-2010 (10 out of 17 site-season combinations) comprised a total of 20 m or more of LIT, which is the recommended minimum length. Two site-seasons, The Bluff in winter (BLU-Winter) and Noarlunga North Inside in summer (NNI-Summer) had total transect lengths of only 6 and 11 m of LIT respectively (Table 2). Based on the approach used in an earlier analysis (CCSA 2009) these site-seasons were not

included in the results. A further five site-seasons (NNI-Winter, NSI-Summer, NNI-Spring, NNI-Autumn and NNO-Autumn) included total LIT lengths from 14 – 19 m of LIT (Table 2) and are considered borderline in terms of inclusion. Otherwise LIT coverage ranged from 28 m at Second Valley in summer (SVA-Summer) to 94 m at Hallett Cove in summer (HAL-Summer; Table 2).

Rather than include additional site-seasons (such as Noarlunga North Outside in autumn), observations should focus on collecting a minimum of 20 m worth of LIT from each of the six core sites in each season. Developing views of the online database that indicate the total current LIT length collected relative to season would enable a quick check by field organisers to see where survey effort should be applied.

## FERAL OR IN PERIL - FERAL OBSERVATIONS 2009-2010

Feral or in Peril data were investigated for supporting information related to invasive species within the AMLR region. Data were broadly summarised relative to generalised locations (see Appendix B) that indicate where "Feral" species were observed at any time during the period from June 2009 to May 2010, even where subsequent observations at a site may not have found the pest in question. 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 or include similar observational intensity (i.e. number of divers × time spent searching). Observation of a pest through Feral or in Peril does not necessarily mean that the pest has become permanently established at 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.

Feral data comprise 41 observations across 17 summary locations around the AMLR NRM coast (Figure 2; Appendix B), although note that these sites do not entirely align with those of the broader reef surveys. Importantly, the Feral or in Peril data now includes data on surveys where no feral species were observed, a key deficiency in earlier surveys (CCSA 2009).

Two invasive species from the "Feral" list were observed. The most common was the Mediterranean fanworm (*Sabella spallanzanii*), which was found at most of the metropolitan jetties (Largs, Semaphore, Grange, Henley Beach, Glenelg, Brighton and Noarlunga; Figure 2) reflecting a possible preference for artificial substrates in sheltered areas (Boxall and Westphalen 2003). However, *S. spallanzanii* was also reported at Broken Bottom and, most disturbingly much further south at Wirrina (Figure 2). The Wirrina Marina is a popular stopover for recreational vessels (Boating Industry Association of South Australia 2005) and it is likely, but by no means proven, that *S. spallanzanii* probably arrived in this location as hull fouling.

The spread of *S. spallanzanii* has continued, with observations at Kingscote Jetty (Kangaroo Island) by a Reef Watch volunteer in February 2008 (http://www.reefwatch.asn.au/cgi-bin/database/fpview.pl, accessed July 2010).

Infestations of *S. spallanzanii* within the Kangaroo Island Natural Resource Management Region (KI NRM) have been subject to control efforts at Kingscote and the Bay of Shoals (Kinloch *et al.* 2010). These surveys have observed *S. spallanzanii* as hull fouling on recreational vessels that were traced to Wirrina as the main source (Kinloch *et al.* 2010). Although these conclusions were based on correlative evidence, this mechanism is entirely probable.

In spite of control measures, further spread of *S. spallanzanii* around Wirrina and Kangaroo Island is highly likely, if only via natural dispersal. Further monitoring of this pest by Reef Watch in partnership with the KI NRM has been organised with assistance from a Community NRM grant.

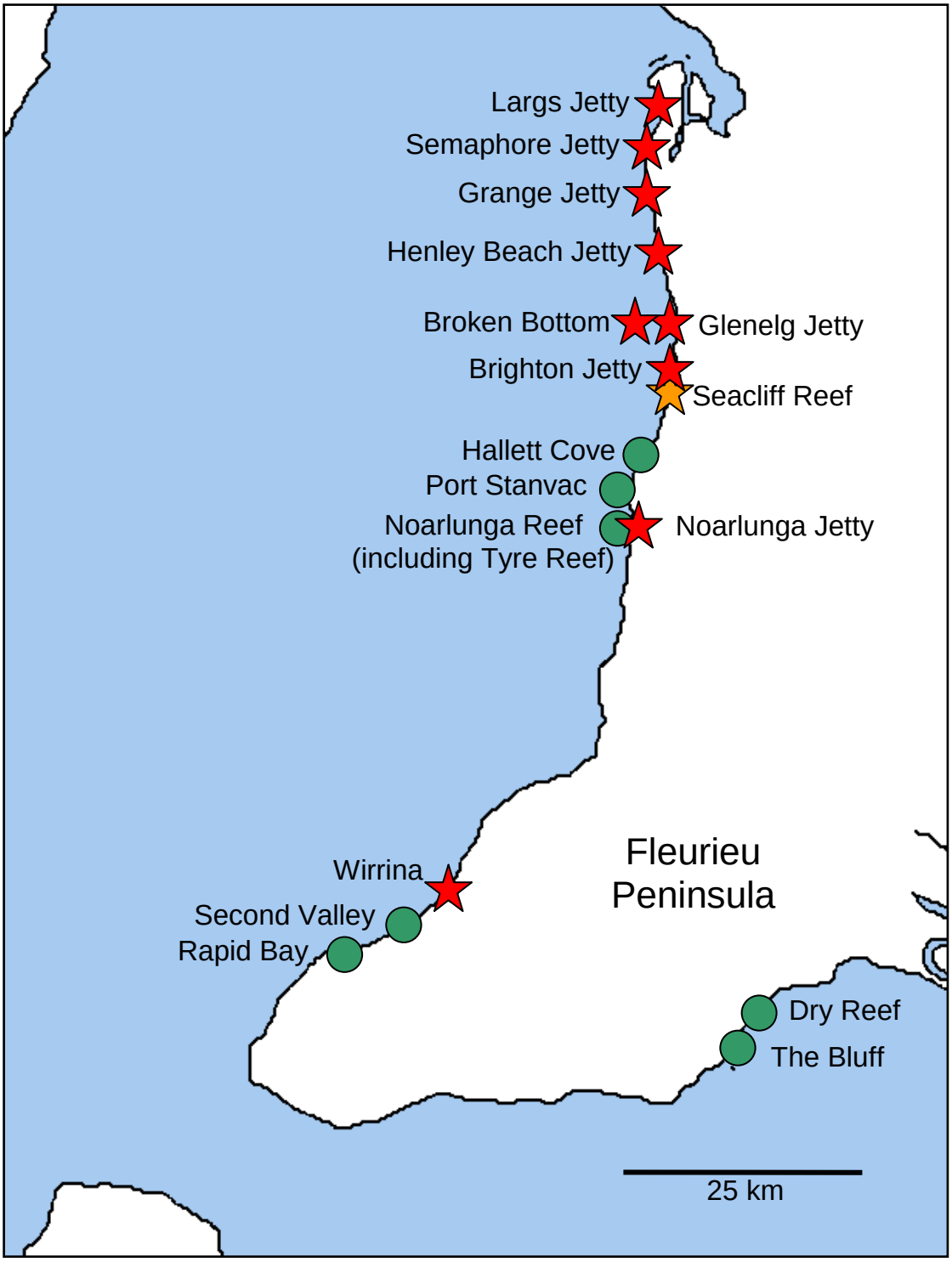


**Figure 2 - Map of the Fleurieu Coast showing the location of Feral observations from the Feral or in Peril dataset from June 2009 to May 2010. Green circles indicate where nothing was found, Red stars show where *Sabella spallanzanii* was observed at any stage during the reporting period, Orange star indicates where *Caulerpa racemosa* var. *cylindracea* was observed during the reporting period.**

Formal surveys of the spread of *S. spallanzanii* indicate that, as of 2002, this pest was as far south as Brighton (Boxall and Westphalen 2003). Further spread of *S. spallanzanii* is unfortunately inevitable, either naturally through distribution of its spores or through artificial vectors, most probably as hull fouling. Most of the locations where it has been found comprise artificial substrates in relatively sheltered locations, which this pest appears to favour (Boxall and Westphalen 2003). The lack of observations of *S. spallanzanii* on reefs adjacent to populations on jetty structures suggests that the former may be somewhat resistant to invasion, although this cannot be proven with the current data.

The other invasive species observed in Feral or in Peril observations was *Caulerpa racemosa* var. *cylindracea* at Seacliff Reef (Figure 2; Appendix B). Like its more widely known cousin, *Caulerpa taxifolia*, this species has been cause for concern elsewhere (see Collings *et al.* 2004), but its impact on southern Australian coasts is uncertain.

The 2009-2010 Feral or in Peril observations for the AMLR NRM region have included most, if not all of the Adelaide metropolitan jetties that might be considered primary points of establishment (seven jetties in 2009-2010 versus four in 2008-2009; Westphalen 2009). **This process should continue.**

The above results highlight the potential importance of Feral or in Peril observations as a tool for monitoring the spread of marine pests and the need to manage the likely vectors.

## INDEX RESULTS

As with previous reporting of Reef Watch data using the Turner *et al.* (2007) indices, only a subset of the collected data is employed, including seven of the 19 LIT lifeforms, 17 of the 34 fish species and only five of the 31 invertebrate species (Appendix A). Consideration should be given to simplifying data collection to consider a narrowly defined suite of taxa and/or making better use of the data that has been collected, the latter being beyond the scope of current reporting.

### COMPARISON BETWEEN REEF STATUS SURVEYS

Reef status across all site-season combinations reflects the north-south gradient of degraded to healthy reefs observed in previous surveys (Table 3; Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008, CCSA 2009, Westphalen 2009). Broken Bottom thus has a status of “Poor” or “Caution” depending on the season, while sites at Noarlunga (Noarlunga North Inside, Noarlunga North Outside and Noarlunga South Inside) have either “Caution” or even “Poor” (Table 3). Second Valley and The Bluff retained their overall “Good” status although with a seasonal dip in summer at the former (Table 3). However, there are some disturbing results from 2009-2010 Reef Watch observations.

Previous reporting has generally depicted Hallett Cove as being in “Good” condition (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008, Westphalen 2009). Results of Reef Watch surveys for 2009-2010 indicate a decline in reef status at Hallett Cove, which showed “Caution” (spring and autumn) and even “Poor” (summer) health (Table 3).

Noarlunga sites indicted “Caution” or “Poor” in 2009-2010 (Table 3). However, there are also a larger number of observations at Noarlunga in 2009-2010 relative to 2008-2009 (6 versus 2 respectively), which may give an impression of changes rather than simply having more information. Previous Reef Health observations at Noarlunga Inside have generally showed a status of “Good” or “Caution” (Cheshire *et al.* 1998, Cheshire and Westphalen

2000, Turner *et al.* 2007, Collings *et al.* 2008). It cannot be know if the decline observed at Hallett Cove includes the reefs at Noarlunga or if there is any loss of health further south (up to but not including Second Valley).

**Table 3 - Overall reef status index results (see Turner *et al.* 2007) for Reef Watch observations for 2009-2010. Note that a summary table of results of Reef Watch 2008-2009 surveys (Westphalen 2009) is included in Appendix C.**

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

All site-season combinations with "Caution" or "Poor" health status are characterised by relatively low canopy cover (Table 4), except Second Valley in summer, where there would appear to be fewer site attached fish, invertebrate predators and no blue-throated wrasse (Table 4). Previous investigations of Reef Watch data (notably the CCSA 2009 report), suggest that site attached fish, blue-throated wrasse and the mobile invertebrate predators are not as strong as LIT-based indices in determining reef status, in part because the species suites considered for fish and invertebrates is substantially different from those used in Turner *et al.* (2007) and because blue-throated wrasse were not widespread enough to be consistently applied (CCSA 2009, Westphalen 2009). These difficulties still apply to 2009-2010 data, although the number of blue-throated wrasse observations was relatively higher in 2009-2010 than in 2008-2009 (57% of sites versus 36% respectively). Notwithstanding this improvement, the blue-throated wrasse index is still considered to be relatively weak as an indicator as it is still not able to be applied universally and Reef Watch does not collect the length data required in calculation (see Turner *et al.* 2007), meaning that a global average (20.75 cm length) has to be employed.

It also needs to be noted that these indices were not employed until the 2007 observations (e.g. Turner *et al.* 2007) and comparisons with these earlier surveys (Cheshire *et al.* 1998, Cheshire and Westphalen 2000) are arguably subjective. Even comparing index results across surveys needs to be undertaken with a degree of care given that not all of them are employed in Reef Watch reporting (see Table 1). Similarly, the Noarlunga North Outside site surveyed in autumn as part of the Marathon Dive, only has LIT data, and its status as "Caution" (Table 4) relative to other sites needs to be viewed with some circumspection, although its status is consistent with other Noarlunga sites in this season. Finally, Cheshire *et al.* (1998), Cheshire and Westphalen (2000) and Turner *et al.* (2007) surveyed from summer-autumn 2005, while Collings *et al.* (2008) surveyed from autumn-winter 2007 and comparisons with these studies may be confounded by seasonal differences.

Conversely, the improvement to Reef Watch data collection and management means that, regardless of the various above caveats, comparisons can be undertaken and hypothesis regarding both seasonal and inter-annual differences in reef status can be developed.

Degraded reefs on the Adelaide coast typically lack large robust canopy-forming, brown macroalgae, but are otherwise dominated by bare substrate and/or turfing/filamentous red macroalgal species (Cheshire and Westphalen 2000, Turner *et al.* 2007). High mussel cover

has also been observed at Horseshoe Reef and may be either a cause or response to reef decline (Smith 2000). High cover of mussels (39% - data not shown) was observed at Hallett Cove in summer (note this translated to 0 index score in Table 4), although none were seen in the previous winter and spring (data not shown). Given that there is no change or even an increase in canopy coverage over the same period, this suggests a very rapid expansion of mussels at Hallett Cove. Given that there is a marker buoy at this site to direct surveys, there is greater certainty that the same patch of reef is being monitored unlike previous surveys.

**Table 4 - Reef status indices for each site-season considered by Reef Watch in the 2009-2010. 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". Note that a summary table of results of Reef Watch 2008-2009 surveys (Westphalen 2009) is included in Appendix C.**

| Site and Season | Status | Overall Score | Canopy | Turf | Mussels | Bare | Site attached fish | Mobile invertebrate predators | Wrasse | Invasive |
|---|---|---|---|---|---|---|---|---|---|---|
| BRB_Autumn | Caution | 50 | 0 | | | | 100 | 100 | 0 | |
| BRB_Spring | Poor | 29 | 0 | 37.3 | | 0 | 100 | 23 | 11 | |
| HAL_Autumn | Caution | 53 | 0 | | | 46 | 100 | 100 | 17 | |
| HAL_Spring | Caution | 57 | 12 | | | | 100 | 100 | 16 | |
| HAL_Summer | Poor | 32 | 1 | | 0 | | 100 | 28 | 33 | |
| NNI_Autumn | Caution | 55 | 44 | | | 31 | 100 | 100 | 0 | |
| NNI_Spring | Caution | 62 | 26 | | | | 100 | 100 | 22 | |
| NNI_Winter | Caution | 45 | 29 | | | | 52 | 100 | 0 | |
| NNO_Autumn | Caution | 52 | 52 | | | | | | | |
| NSI_Spring | Caution | 52 | 6 | | | | 100 | 100 | 0 | |
| NSI_Summer | Poor | 6 | 30 | | | 0 | 0 | 0 | 0 | |
| SVA_Autumn | Good | 83 | 100 | | | | 100 | 100 | 33 | |
| SVA_Spring | Good | 71 | 46 | | | | 100 | 100 | 37 | |
| SVA_Summer | Caution | 64 | 100 | | | | 70 | 85 | 0 | |
| BLU_Summer | Good | 74 | 100 | | | | 100 | 85 | 11 | |

## POTENTIAL FACTORS FOR INTER-ANNUAL DIFFERENCES

Changes in reef status can be related to seasonal factors (see below), but given the lack of "Good" status and that the within year differences relate to shifts from "Caution" to "Poor", it would appear that Hallett Cove has joined Noarlunga as well as Horseshoe Reef (see Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008) in showing signs of decline. This result would seem to be at odds with Collings *et al.* (2008) and the 2008-2009 Reef Watch report (Westphalen 2009) that suggested some degraded reefs (specifically Broken Bottom) were showing signs of improvement.

Given that sedimentation is increasingly considered to be a cause for reef decline (Cheshire and Westphalen 2000, Greig 2000, Smith 2000, Airoldi 2003, Turner 2004), it may be that dry/drought periods are actually helpful to reef status as there is less terrigenous runoff, particularly on urban coasts. Conversely wetter years may be detrimental to reef status as

more sediment is flushed into near shore waters from rivers, streams and stormwater systems. Wet periods that immediately follow a drought may be particularly high in sediments and turbidity as drought affected landscapes are swept clean by water runoff.

As part of investigations into seagrass decline on the Adelaide coast (the Adelaide Coastal Waters Study - ACWS), Collings *et al.* (2006) demonstrated that there was substantial light attenuation within shallow nearshore areas that was strongly related to terrigenous inputs. Irving and Connell (2002) found that the effect of sedimentation on reef systems increased under low light conditions, which suggests that the effect of increased sediment loads should not be considered in isolation from turbidity. However, while there is greater capacity to gather data on sediments loads from stormwater entering gulf waters, there is limited long term data on sedimentation and turbidity levels within nearshore systems on the Adelaide coast (or elsewhere for that matter).

The above hypothesis is broadly supported through correlation of reef status with the 2006-2007 drought that gradually eased in 2008 and 2009 (see http://www.bom.gov.au/climate/current/annual/sa/archive/, accessed July 2010) but otherwise remains speculation. A more localised factor for the decline at Hallett Cove cannot be discounted. There is limited empirical data on terrigenous inputs in terms of volumes and water quality to the coastal nearshore of Gulf St Vincent in particular relative to stormwater drains as well as creeks and streams south of Adelaide (see Wilkinson *et al.* 2005). However, there are programs aimed at addressing these issues following on from the results of the ACWS (see Fox *et al.* 2007), notably the Adelaide and Mount Lofty Ranges Natural Resource Management Boards (AMLR NRM) Stormwater Monitoring Network (http://www.amlrnrm.sa.gov.au/MonitoringEvaluation/WaterMonitoring/StormwaterQuantityMonitoringNetwork.aspx, accessed July 2010).

**It is highly recommended that formal surveys of Adelaide metropolitan reefs along the lines of Turner *et al.* (2007), Collings *et al.* (2008) are undertaken within the next twelve months**, preferably prior to commissioning of the Adelaide Desalination Project[1] at Pt Stanvac. These surveys should consider sites from previous Reef Health surveys (Cheshire *et al.* 1998, Cheshire and Westphalen 2000, Turner *et al.* 2007, Collings *et al.* 2008) but possibly include observations at the Stanvac Dump and Seacliff Reef or some other reef(s) in relative proximity to the plant outfall. This survey should look to confirm Reef Watch observations for decline in the Hallett Cove area and re-establish a baseline for reef status in the vicinity of the desalination plant (notably Hallett Cove, Horseshoe Reef and possibly the Stanvac Dump).

Importantly, there is a substantial distance (and quite a lot of reef) between Noarlunga Reef and Second Valley (~ 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 reef decline has encroached south of Noarlunga. While The Bluff is a good example of a healthy reef within the AMLR NRM region, its location makes it a poor indicator of processes within Gulf St Vincent.

[1] Note that the author has undertaken consulting work for the Adelaide Desalination Project related to monitoring of dredging operations.

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

The need for care in interpreting reef status indices is demonstrated in the seasonal differences observed within sites, notably Second Valley, where there was a dip in status from Good in spring to Caution in summer and then Good again in autumn (Table 3). Similar changes were observed at Second Valley and The Bluff in 2008-2009 (Westphalen 2009). However, while there may be substantial seasonal changes in macroalgae, particularly amongst canopy-forming species of *Cystophora* and *Sargassum* (Edgar 1983, Edgar *et al.* 2004, Collings 1996, Collings *et al.* 2008), the change observed at Second Valley in 2009-2010 would appear to be a response to altered site attached fish and invertebrates (Table 4).

While site attached fish implies a fixed residency, for some species of fish this status may change according to life cycle imperatives and/or external factors, both natural (e.g. predators, competitors and/or storm events) or anthropogenic (e.g. fishing, boating and/or diving disturbance). Similarly, mobile invertebrate predators may undergo changes due to species-specific or external influences. For example, giant cuttlefish (*Sepia apama*) will die soon after spawning (Australian Museum; http://www.australianmuseum.net.au/Giant-Cuttlefish, accessed July 2010), which may lead to substantial change in the mobile invertebrate index that is not related to the health of the system.

There is some capacity to observe the effect of season on reef status, although an in-depth consideration of differences between sites and/or seasons would be best achieved via a multivariate analytical approach that makes comprehensive use of the available data.

## 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). However, it needs to be pointed out that reassessment/improvement to reef status indices is not a job for Reef Watch, although it may form an excellent forum within which modified approaches can be tested.

For the immediate future, some rationalisation of the indices should be considered. In particular there are the indices for which Reef Watch collects no data (sedimentation, macroalgal diversity and invertebrate diversity) as well as indices where the data are inconsistent and/or incomplete (blue-throated wrasse).

LIT data are critical to understanding reef status and it is important that both the quantity and quality of these data are maintained. While the majority of site-season observations were sufficient, two sites (NNI-Summer and BLU-Winter) were still too short (6 m and 11 m) to be included in reporting, bearing in mind the minimum of 20 m (although note that the preferred minimum distance in Reef Health observations is actually 40 m).

A functional-form approach to site attached fish and mobile invertebrate predators should also be considered, although the broader reliability of these indices in their current form should also be considered. Current data collection by Reef Watch has only a subset of the site attached fish and mobile invertebrate predators considered by Turner *et al.* (2007).

Development of a tightly defined group of indicators would streamline data collection and reporting.

Consideration could be given to expanding the notion of reef "health" through collection of additional/alternative data, in particular some measure of marine litter as well as observations of rare/endangered species, specifically those listed by the Environment Protection and Biodiversity Conservation (EPBC) Act as well as those listed in the South Australian National Park and Wildlife Service (NP &WS) Act. While there is a small degree of overlap with Feral or in Peril within the current reporting, the "Peril" component is not currently reported within the current framework as it may expose the location of species targeted by collectors (seadragons and cowries - see http://www.reefwatch.asn.au/cgi-bin/database/fpview.pl

## CONCLUSIONS AND RECOMMENDATIONS

There is strong evidence for a decline in the status of the Hallett Cove site relative to previous years, which may be related to longer term climate factors (specifically drought) but a localised factor cannot be discounted. Otherwise reef index scores for Reef Watch surveys in 2009-2010 are in line with those of earlier Reef Health surveys for 2005 (Turner *et al.* 2007) and 2007 (Collings *et al.* (2008) as well as Reef Watch reporting for 2008-2009 (Westphalen 2009).

Improvements to Reef Watch data observed in the 2008-2009 report have been maintained and augmented in 2009-2010, with more comprehensive coverage of site-season combinations without any apparent loss in data quality. Sampling has become more fixed at Hallett Cove with the deployment of a marker buoy, meaning that there is greater certainty that the same patch of reef is being compared between seasons/years. Note that other sites considered by Reef Watch (in particular Noarlunga and probably The Bluff) were never a problem in this respect.

The capacity to make recommendations related to both the nature of the systems (i.e. the apparent decline at Hallett Cove) as well as form related hypotheses is a reflection of the improvements to Reef Watch observations.

## RESULTS OF SURVEYS

**Recommendations for further action include:**

- A formal survey of Adelaide metropolitan reefs along the lines of Turner *et al.* (2007), Collings *et al.* (2008) aimed at establishing the nature of the decline at Hallett Cove and verifying if there is any degradation south of Noarlunga. These surveys would also form an important baseline prior to the commissioning of the desalination plant and should engage the skills available at DEH, SARDI Aquatic Sciences, and the Universities or similar with a view to determining the status of reefs independently of Reef Watch.

- In conjunction with the above, the available data on sedimentation and turbidity within the Adelaide metropolitan coast as well as related inputs from rivers, creeks and stormwater drains should be analysed to see if water quality correlates with reef status. Specifically, this should aim to determine whether there is an overall increase in sedimentation and turbidity along the Adelaide nearshore or if there is a localised factor at Hallett Cove.

- In light of the above investigations, the availability of water quality data from the Adelaide nearshore environment should be reviewed.

- More research into causal linkages between sediment/turbidity inputs and reef decline is required with specific reference to southern temperate reef systems.

**Recommendations for Reef Watch to consider:**

- While seasonal comparisons between reefs can be undertaken using the Reef Health indices, consideration of differences between sites and/or seasons may require more comprehensive use of the available data rather than the subset currently used in index calculation.

- Reef Watch observations should focus on collecting a minimum of 20 m worth of Line Intercept Transects (LIT) from each of the six core sites in each season. Development of summary views of the online database that indicate to the total current LIT length collected relative to season would enable a quick check by field organisers to track survey effort and where it should be applied.

## INDICES

Investigations of fish and invertebrate abundances as well as the presence of marine pests, canopy cover, bare substrate, mussel cover, turfing macroalgae cover and the presence of sediments form the basis of the indices of reef health developed by Turner *et al.* (2007). However, while this approach has been used in other Reef Health observations (Turner *et al.* 2007, Collings *et al.* 2008) as well as Reef Watch data (CCSA 2009), these indices are still open to substantial debate as to their parameterisation, calculation and even validity as a measure of reef status. It is **strongly recommended that use of these indices be considered in light of the need for further research and development in this area**, although these issues are not necessarily the responsibility of Reef Watch to deliver.

**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.

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

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

    - Consideration of marine debris,

    - Consideration of EPBC/NP&WS listed species.

## REFERENCES


Airoldi, L. (2003) The effects of sedimentation on rocky coast assemblages. *Oceanography and Marine Biology Annual Review* 41: 161-236.

Boating Industry Association of South Australia (2005). *South Australian Waters: an atlas and guide.* Boating Industry Association and the South Australian Tourism Commission. Wakefield Press.

Boxall, V. and Westphalen, G. (2003) *An education key for community monitoring of exotic marine pests*. A report to the Natural Heritage Trust. Project Number 012186. SARDI Aquatic Sciences Publication Number RD03/0041.

Cheshire, A.C. and Westphalen, G. (2000) *Assessing the status of reefs in Gulf St Vincent IV: Results of the 1999 survey.* A report to the Environment Protection Agency of South Australia. Pp 16.

Cheshire, A.C., Havenhand, J., Hall, S.J., Matsumoto, G. and Butler, A.J. (1998) *Assessing the status of temperate reefs in Gulf St Vincent I: Background and methodology for assessments*. A report to the Environment Protection Authority of South Australia. Pp. 43.

Conservation Council of South Australia (CCSA) (2009) *Reef Watch. The First Decade of Community Reef Monitoring.* Conservation Council of South Australia Inc.

Collings, G., Westphalen, G., Rowling, K. and Eglinton, Y. (2004) *Caulerpa racemosa var. cylindracea occurrence in western South Australia.* Report to PIRSA Marine Habitat Program. South Australian Research and Development Institute (Aquatic Sciences) Report Number RD04/0169.

Collings, G., Miller, D., O'Loughlin, E., Cheshire, A., and Bryars, S. (2006) *Turbidity and reduced light responses of the meadow forming seagrasses Amphibolis and Posidonia, from the Adelaide metropolitan coastline*. ACWS Technical Report No. 12 prepared for the Adelaide Coastal Waters Study Steering Committee. South Australian Research and Development Institute (Aquatic Sciences) Publication No. RD01/0208-17, Adelaide.

Collings, G., Bryars, S., Turner, D., Brook, J. and Theil, M. (2008) *Examining the health of subtidal reef environments in South Australia, Part 4: Assessment of community reef monitoring and status of selected South Australian reefs based on the results of the 2007 surveys.* SARDI Publication Number RD. F2008/000511-1 South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Collings, G.J. (1996) *Spatiotemporal variation of macroalgal communities of southern Fleurieu Peninsula, South Australia.* PhD Thesis, Department of Botany, University of Adelaide, Adelaide, Australia.

Connell, S.D., Russell, B.D., Turner, D.J., Shepherd, S.A., Kildea, T., Miller, D., Airoldi, L. and Cheshire, D. (2008) Recovering a lost baseline: missing kelp forests from a metropolitan coast. *Marine Ecology Progress Series* 360, 63-72.

Edgar, G.J. (1983) The ecology of southeast Tasmanian phytal animal communities: 2. Seasonal change in plant and animal populations. *Journal of Experimental Marine Biology and Ecology* 70: 159-180.

Edgar, G.J., Barrett, N.S., Morton, A.J. and Sampson, C.R. (2004) Effects of canopy clearance on plant, fish and macroinvertebrate communities on eastern Tasmanian reefs. *Journal of Experimental Marine Biology and Ecology* 312: 67-87.

Fox, D.R., Batley, G.E., Blackburn, D., Bone, Y., Bryars, S., Cheshire, A., Collings, G., Ellis, D., Fairweather, P., Fallowfield, H., Harris, G., Henderson, B., Kämpf, J., Nayar, S., Pattiaratchi, C., Petrusevics, P., Townsend, M., Westphalen, G. and Wilkinson, J. (2007) *The Adelaide Coastal Water Study Final Report, Volume 1.* Prepared for the South Australian Environment Protection Authority. CSIRO Marine and Atmospheric Research.

Gorgula, S.K. and Connell, S.D. (2004) Expansive covers of turf-forming algae on human-dominated coast: the relative effects of increasing nutrient and sediment loads. *Marine Biology* 145: 613-619.

Greig, T.J. (2000) *Investigating the effects of substrate texture on the recruitment of sessile marine organisms: an experimental approach.* Honours Thesis, Department of Environmental Biology, University of Adelaide, Adelaide, Australia.

Irving, A. and Connell, S. (2002) Sedimentation and light penetration interact to maintain heterogeneity of subtidal habitats: algal versus invertebrate dominated assemblages. *Marine Ecology Progress Series* 245: 83-91.

Kinloch, M., Brock, D. and Lashmar, K. (2010) *Kangaroo Island marine pest surveys 2010 summary report.* Prepared for PIRSA Biosecurity by the Coast and Marine Program, Kangaroo Island Natural Resource Management Board.

Smith, N. (2000) *The impacts of the mussel, Xenostrobus pulex (Mytilidae) on subtidal South Australian macroalgal systems.* Honours Thesis, Department of Environmental Biology, University of Adelaide, Adelaide, Australia.

Turner, D.J. (2004) *Effects of sedimentation on the structure of a phaeophycean dominated macroalgal community.* PhD Thesis, Department of Environmental Biology, University of Adelaide, Adelaide, Australia.

Turner, D.J., Kildea T.N. and Murray-Jones, S. (2006) *Examining the health of subtidal reef environments in South Australia, Part 1: Background review and rationale for development of the monitoring program.* South Australian Research and Development Institute (Aquatic Sciences), Adelaide, 62 pp. SARDI Publication Number RD03/0252-3.

Turner, D.J., Kildea T.N. and Westphalen G. (2007) *Examining the health of subtidal reef environments in South Australia, Part 2: Status of selected South Australian reefs based on the results of the 2005 surveys.* South Australian Research and Development Institute (Aquatic Sciences), Adelaide, 97 pp. SARDI Publication Number RD03/0252-6.

Westphalen, G. (2009) *Surveys across six reefs in the Adelaide Mt and Lofty Ranges Natural Resource Management region. A report to the Conservation Council of South Australia Inc.* Conservation Council of South Australia Inc. and Westphalen Consulting.

Wilkinson, J., Hutson, J., Bestland, E. and Fallowfield, H. (2005) *"Audit of contemporary and historical quality and quantity data of stormwater discharging into the marine environment, and field work programme".* ACWS Technical Report No.3 prepared for the Adelaide Coastal Waters Study Steering Committee, July 2005. Department of Environmental Health, Flinders University of South Australia.

# 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

| Common | Species | Site Attached | Blue-Throated Wrasse |
|---|---|---|---|
| Blue Groper | *Achoerodus gouldii* | YES | NO |
| Blue-Throated Wrasse | *Notolabrus tetricus* | YES | YES |
| Bullseye | *Pempheris* | YES | NO |
| Cuttlefish | *Sepia apama* | NO | NO |
| Drummer | *Kyphosus sydneyanus* | NO | NO |
| Dusky Morwong | *Dactylophora nigricans* | NO | NO |
| Goat Fish | *Upeneichthys vlamingii* | NO | NO |
| Gurnard | | NO | NO |
| Herring Cale | *Odax cyanomelas* | YES | NO |
| Horseshoe Leatherjacket | *Meuschenia hippocrepis* | YES | NO |
| Hulafish | *Trachinops* | NO | NO |
| Long-finned Pike | *Dinolestes lewini* | NO | NO |
| Magpie Perch | *Cheilodactylus nigripes* | YES | NO |
| Moonlighter | *Tilodon sexfasciatus* | YES | NO |
| Old Wife | *Enoplosus armatus* | YES | NO |
| Ornate Cowfish | *Aracana ornata* | YES | NO |
| Other Leatherjacket | | NO | NO |
| Other Wrasse | | YES | NO |
| Pygmy Leatherjacket | *Brachaluteres jacksonianus* | NO | NO |
| Rainbow Cale | *Odax acroptilus* | YES | NO |
| Scalyfin | *Parma victoriae* | YES | NO |
| Senator Wrasse | *Pictilabrus laticlavius* | YES | NO |
| Shaws Cowfish | *Aracana aurita* | YES | NO |
| Silverbelly | | NO | NO |

| Common | Species | Site Attached | Blue-Throated Wrasse |
|---|---|---|---|
| Small fish | | NO | NO |
| Squid | | NO | NO |
| Sweep | *Scorpis* | NO | NO |
| Trevally | *Pseudocaranx* | NO | NO |
| Weed whiting | *Siphonognathus* | NO | NO |
| Western talma | *Chelmonops curiosus* | YES | NO |
| Yellow-Headed hulafish | *Trachinops noarlungae* | YES | NO |
| Yellow-striped leatherjacket | *Meuschenia flaviolineata* | YES | NO |
| Zebra fish | *Girella zebra* | NO | NO |

## INVERTEBRATE SPECIES OBSERVED IN REEF WATCH SURVEYS

| Common | *Species* | Index |
|---|---|---|
| Amblypneustes | *Amblypneustes* spp. | NO |
| Blacklipped abalone | *Haliotis* spp. | NO |
| Bullseye | *Pempheris* | FISH |
| Cenolia (feather star) | *Cenolia* spp. | NO |
| Centrostephanus | *Centrostephanus tenuispinus* | NO |
| Coscinasterias (11 arm star) | *Coscinasterias muricata* | YES |
| Cartrut shell | *Dicathais orbita* | YES |
| Goniocidaris | *Goniocidaris tubaria* | NO |
| Heliocidaris | *Heliocidaris erythrogramma* | NO |
| Hermit crab | | NO |
| Holopneustes | *Holopneustes* spp. | NO |
| Holothurian (sea cucumber) | *Stichopus* spp. | NO |
| Moonlighter | *Tilodon sexfasciatus* | FISH |
| Nectocarcinus | *Nectocarcinus* spp. | NO |
| Nepanthia | *Nepanthia troughtoni* | NO |
| Patiriella brevispina | *Patiriella brevispina* | NO |
| Patiriella calcar | *Patiriella calcar* | NO |
| Pentagonaster (firebrick star) | *Pentagonaster dubeni* | NO |
| Petricia | *Petricia vernicina* | NO |
| Phasianella | *Phasianella* spp. | NO |
| Phyllacanthus | *Phyllacanthus irregularis* | NO |
| Plagusia (red bait crab) | *Plagusia chabrus* | NO |
| Queen scallop | *Equichlamys bifrons* | NO |
| Rock lobster | *Jasus edwardsii* | YES |
| Small fish | | FISH |
| Biscuit star | *Tosia* spp. | NO |
| Turbo torquatus | *Turbo torquatus* | NO |
| Turbo undulatus | *Turbo undulatus* | NO |
| Uniophora | *Uniophora granifera* | YES |
| Western Talma | *Chelmonops curiosus* | FISH |
| Whelk/triton complex | | YES |

## APPENDIX B – FERAL OR IN PERIL – FERAL OBSERVATIONS

| General Location | Date | Observation | Map Location |
|---|---|---|---|
| Noarlunga Reef | 8/08/2009 | No Feral/In Peril species found | Noarlunga Reef |
| The Bluff | 15/08/2009 | No Feral/In Peril species found | The Bluff |
| Broken Bottom | 20/09/2009 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Broken Bottom |
| Noarlunga Jetty | 20/09/2009 | No Feral/In Peril species found | Noarlunga Jetty |
| Second Valley | 19/09/2009 | No Feral/In Peril species found | Second Valley |
| Hallett Cove | 10/10/2009 | No Feral/In Peril species found | Hallett Cove |
| Largs Bay Jetty | 24/10/2009 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Largs Bay Jetty |
| Noarlunga Jetty | 4/10/2009 | No Feral/In Peril species found | Noarlunga Jetty |
| Noarlunga Reef | 11/10/2009 | No Feral/In Peril species found | Noarlunga Reef |
| Rapid Bay Jetty | 2/10/2009 | No Feral/In Peril species found | Rapid Bay |
| Rapid Bay Jetty | 6/10/2009 | No Feral/In Peril species found | Rapid Bay |
| Semaphore Jetty | 24/10/2009 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Semaphore Jetty |
| Dry Reef | 8/11/2009 | No Feral/In Peril species found | Dry Reef |
| Dry Reef | 14/11/2009 | No Feral/In Peril species found | Dry Reef |
| Stanvac Mooring Blocks | 7/11/2009 | No Feral/In Peril species found | Port Stanvac |
| Stanvac Reef | 7/11/2009 | No Feral/In Peril species found | Port Stanvac |
| Hallett Cove | 13/12/2009 | No Feral/In Peril species found | Hallett Cove |
| Noarlunga Jetty | 13/12/2009 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Noarlunga Jetty |
| Noarlunga Reef | 5/12/2009 | No Feral/In Peril species found | Noarlunga Reef |
| Noarlunga Reef | 31/12/2009 | No Feral/In Peril species found | Noarlunga Reef |
| Noarlunga Tyre Reef | 20/12/2009 | No Feral/In Peril species found | Noarlunga Reef |
| Seacliff Reef | 6/12/2009 | *Caulerpa racemosa* var. *cylindracea* | Seacliff Reef |
| Grange Jetty | 7/02/2010 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Grange Jetty |
| Hallett Cove | 7/02/2010 | No Feral/In Peril species found | Hallett Cove |
| Henley Beach Jetty | 7/02/2010 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Henley Beach Jetty |
| Noarlunga Jetty | 7/02/2010 | No Feral/In Peril species found | Noarlunga Jetty |
| Noarlunga Reef | 6/02/2010 | No Feral/In Peril species found | Noarlunga Reef |
| Noarlunga Reef | 24/02/2010 | No Feral/In Peril species found | Noarlunga Reef |
| The Bluff | 21/02/2010 | No Feral/In Peril species found | The Bluff |
| Brighton Jetty | 7/03/2010 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Brighton Jetty |
| Broken Bottom | 27/03/2010 | No Feral/In Peril species found | Broken Bottom |
| Glenelg Jetty | 7/03/2010 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Glenelg Jetty |
| Stanvac Reef | 13/03/2010 | No Feral/In Peril species found | Port Stanvac |
| Noarlunga Reef | 18/04/2010 | No Feral/In Peril species found | Noarlunga Reef |
| Second Valley | 1/04/2010 | No Feral/In Peril species found | Second Valley |
| Second Valley | 3/04/2010 | No Feral/In Peril species found | Second Valley |
| Hallett Cove | 22/05/2010 | No Feral/In Peril species found | Hallett Cove |
| Wirrina Marina | 15/05/2010 | Mediterranean Fan Worm (*Sabella spallanzanii*) | Wirrina Marina |
| Wirrina Marina Outside | 15/05/2010 | No Feral/In Peril species found | Wirrina Marina |
| Broken Bottom | 6/06/2010 | No Feral/In Peril species found | Broken Bottom |
| Noarlunga Reef | 26/06/2010 | No Feral/In Peril species found | Noarlunga Reef |
| The Bluff | 27/06/2010 | No Feral/In Peril species found | The Bluff |

## APPENDIX C – REEF WATCH SUMMARY TABLES FROM 2008-2009

Overall reef status index results for Reef Watch observations for surveys conducted in 2008-2009

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

Reef status indices for each site-season considered by Reef Watch for surveys conducted in 2008-2009.

| Site and Season | Status | Overall Score | Canopy | Turf | Mussels | Bare | Site attached fish | Mobile invertebrate predators | Wrasse | Invasive |
|---|---|---|---|---|---|---|---|---|---|---|
| BRB_Autumn | Caution | 60 | 0 | | | 39 | 100 | 100 | | |
| HAL_Autumn | Good | 67 | 0 | | | | 100 | 100 | | |
| HAL_Spring | Good | 78 | 46 | | | | 88 | 100 | | |
| HAL_Summer | Good | 67 | 0 | | | | 100 | 100 | | |
| NNI_Spring | Caution | 38 | 34 | | | 0 | 58 | 100 | 0 | |
| NSI_Spring | Caution | 49 | 49 | | | | 47 | 100 | 0 | |
| SVA_Autumn | Good | 99 | 98 | | | | 100 | 100 | | |
| SVA_Spring | Good | 100 | 100 | | | | | 100 | | |
| SVA_Summer | Caution | 59 | 39 | | | 12 | 100 | 100 | 45 | |
| BLU_Spring | Good | 100 | 100 | | | | 100 | 100 | | |
| BLU_Summer | Caution | 51 | 81 | | | | 29 | 42 | | |