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Caulerpa taxifolia - 2009 surveys of current distribution and high risk areas



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EXECUTIVE SUMMARY

Despite eradication attempts the marine pest *Caulerpa taxifolia* has substantially expanded its range in South Australia and cannot be eradicated with current technology. Ongoing monitoring of its distribution has become critical to the management of the alga, with annual surveys taking place since 2003. The pattern of distribution of *C. taxifolia* in the Port River/Barker Inlet system has shown little change over the past four years, with higher densities found in areas impacted by thermal effluent from the Torrens Island Power Station and high nutrients from industrial runoff into the area. The 2009 surveys, however, found fewer sites where *C. taxifolia* occurred in Barker Inlet and outer sections of the Port River, and decreased density in some infested areas compared with the 2008 survey.

Surveys of the Bolivar coast as well as St Kilda, West Beach and O'Sullivan's Beach boat ramps did not find any *C. taxifolia*, but, as in previous surveys, *Caulerpa racemosa* var *cylindracea* was found at St Kilda and O'Sullivan's Beach boat ramps. *Caulerpa racemosa* was also present at Bolivar. Regular surveys of North Haven boat ramp and marina by PIRSA Marine Biosecurity show that *C. racemosa* is present, and, while *C. taxifolia* disappeared following treatment in 2008, some patches were observed there over the summer immediately after the treatment, and monitoring of these patches is continuing.

1. INTRODUCTION

The circumtropical alga *Caulerpa taxifolia* (Vahl) C. Agardh has formed invasive populations in numerous areas outside its native range, including large areas of the Mediterranean (de Villèle and Verlaque 1995) and southern California, USA (Tippets 2002; Williams and Grosholz 2002). Within Australia, invasive populations have been reported in New South Wales (Glasby *et al.* 2005) and South Australia (Cheshire *et al.* 2002). Invasive *C. taxifolia* can form large monospecific stands that smother competitors and offer little compensation as a food source (Meinesz *et al.* 2001). *Caulerpa taxifolia* is particularly successful in colonising and expanding in areas exposed to wastewater pollution (Jaubert *et al.* 2003). Many of these areas were once occupied by seagrass, which has been replaced by expanding *C. taxifolia* meadows (Meinesz *et al.* 2001). Seagrass habitats are regarded as important ecologically and support high faunal abundances and diversity (Williams 2007). Faunal populations in *C. taxifolia* meadows have been shown to be different to those in seagrass habitats in the Mediterranean (Williams 2007), California (Tippets 2002) and South Australia (Tanner 2008), with *C. taxifolia* supporting a lower abundance of epifauna (Tippets 2002) and decreased species richness and abundance of infauna (Tanner 2008). These changes are likely to have negative flow-on effects to higher trophic levels (Tippets 2002; Williams 2007).

The distribution of *C. taxifolia* in South Australia has substantially expanded such that the alga cannot be eradicated from South Australia with current technology (see Manning, 2008). The approach to the alga has thus shifted to one of management of the existing population with the hope of slowing or stopping its future spread, and to determining the impact of the alga on local environments and industries. Ongoing monitoring of the population is thus critical to the management of the alga.

Adelaide metropolitan boat ramps are believed to be at high risk for *C. taxifolia* invasion due to having suitable conditions for algae growth, coupled with the risk of translocation by anchors and other boating gear. Equipment associated with recreational vessels (in particular anchors) has been identified as a high-risk vector for *C. taxifolia* (see West *et al.* 2007). The belief that boat ramps are at high risk is also supported by the findings of a risk assessment (Deveney *et al.* 2008), which also identified the Bolivar coast as a high risk area due to elevated nutrient levels and suitable substrate. Fragmentation is the primary means of natural spread of invasive

C. taxifolia, and healthy fragments of the alga have been discovered drifting off the coast of Adelaide (Largs Beach) outside the Port River/Barker Inlet region (Westphalen and Rowling 2005). Therefore, it is probable that the next areas to be infected will be either boat ramps or locations adjacent to the region where *C. taxifolia* occurs.

The main objectives of this study are to document the current distribution of *C. taxifolia* in the Port River/Barker Inlet system and to establish if the alga has established in other areas described as high risk by Deveney *et al.* (2008). Given its proximity to the Port River/Barker Inlet, the high risk area around Bolivar was selected for monitoring, and surveys were conducted at Adelaide metropolitan boat ramps at St Kilda, West Beach and O'Sullivan's Beach. Since an eradication program was carried out on the North Haven outbreak, this location has been regularly surveyed by PIRSA Marine Biosecurity. The results of that monitoring program are also discussed here.

2. METHODS

The Port River, Barker Inlet and Bolivar coast surveys comprised of 40 km of 100 m snorkelling transects along the major channels and areas of likely accumulation (Figure 1). The Bolivar coast transects were conducted in the shallow subtidal zone (low tide water depth 0.5 to 2 m) along a 2 km stretch centred around the Bolivar outflow creek. Coverage of *C. taxifolia* was estimated in terms of a modified Braun-Blanquet scale (Table 1). The start and end point of each transect was referenced using a GPS (Garmin GPS60) from the tender vessel.

Table 1. Braun-Blanquet scale that was used to record coverage of *Caulerpa taxifolia* (and other major community types) during the survey (based on a method developed in Mueller-Dombois and Ellenberg 1974)

Scale	Percent Cover
0	Absent
1	< 5 %
2	5 – 25 %
3	25 – 50 %
4	50 – 75 %
5	75 – 95 %
6	> 95 %

There were also Braun-Blanquet estimates made of the cover of major community types (seagrasses, bare sand, etc) as well as other *Caulerpa* species (notably *C. racemosa* var. *cylindracea*) and any visible marine pests (*Sabella spallanzanii*, *Ciona intestinalis*, etc) noted for future reference. The surveys were completed between 6th April 2009 and 29th May 2009.

Three major boat ramps across the metropolitan coast were surveyed: St Kilda, West Beach and O'Sullivan's Beach. At each site, approximately 2 hours of SCUBA or snorkel surveys were conducted. No Braun-Blanquet cover data was collected, but the presence of marine pests was noted. Position fixing of the survey area was achieved using shore referenced GPS points and features. The surveys accounted for man-made structures (pontoons, pilings) and the adjacent soft substrate. The boat ramp surveys were undertaken on 20th May, 5th June and 10th June 2009.

Subsequent to an outbreak of *C. taxifolia* in North Haven in 2008 (Rowling 2008), PIRSA Marine Biosecurity implemented a treatment program and have since conducted bi-monthly surveys (J Gilliland, PIRSA Marine Biosecurity personal communication June 2009). *Caulerpa taxifolia* coverage was recorded from the area and approximate percentage cover was estimated.

The Geographic Information Systems (GIS) package ArcView (ver 9.3 ESRI California) was used to construct a map of the current distribution. Percent cover values from Table 1 were mapped as: 0 absent, from 1-25 % light cover, 26-74 % as medium cover and 76-100 % heavy cover.

3. RESULTS

The current distribution of *Caulerpa taxifolia* from this survey is shown in Figure 1. A map showing the distribution of the alga in 2005-2008 is shown for comparison (Figure 2). All surveys were conducted using the same methodology. Surveys from 2005 and 2006 were conducted at a similar time of year to the current survey (April-May), while the 2007 survey extended into July (Rowling 2007), and the 2008 survey was conducted earlier in the year, from February to early April (Rowling 2008).

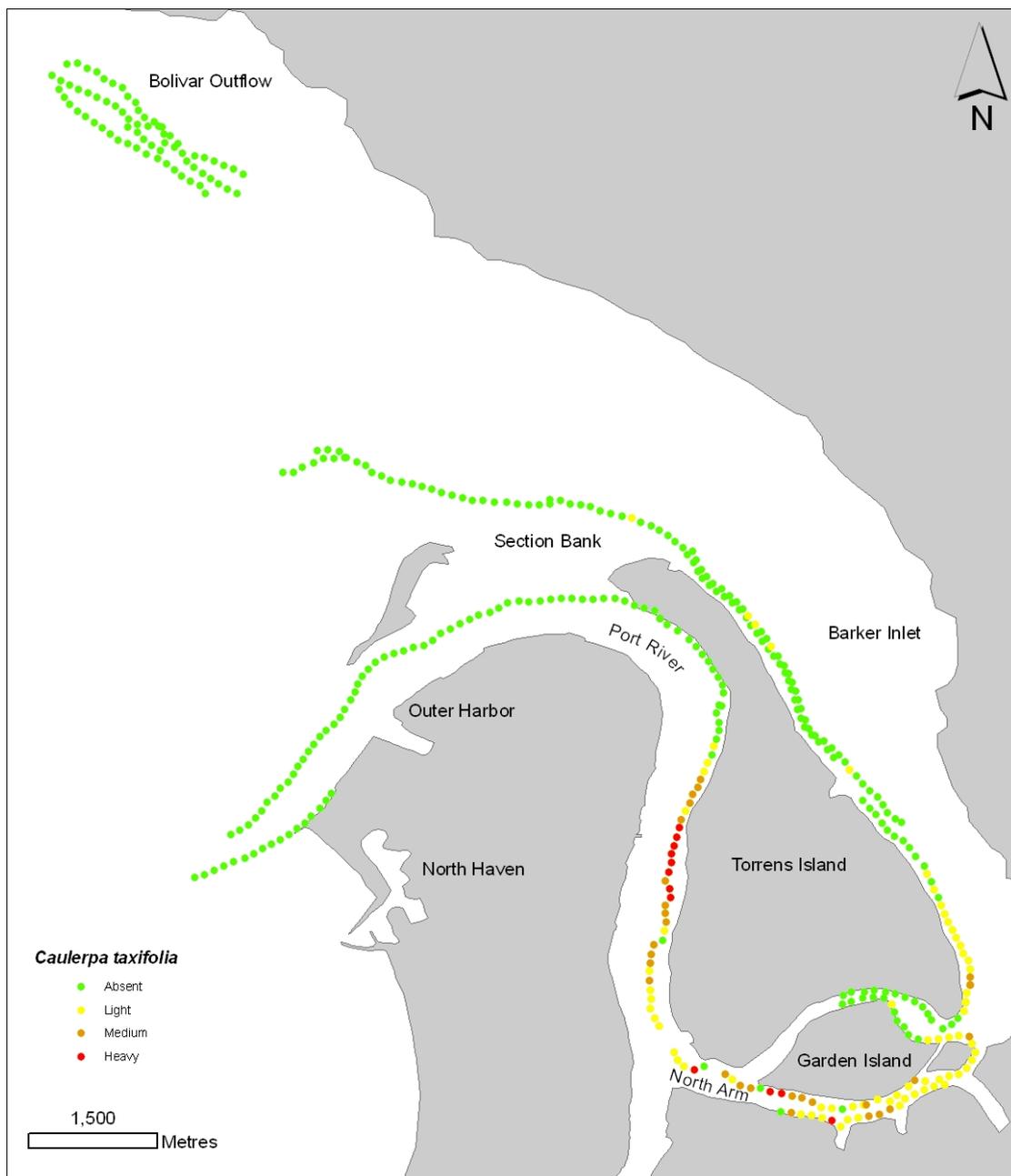


Figure 1. Location of 2009 Port River-Barker Inlet and Bolivar coast surveys, showing current distribution of *C. taxifolia*.

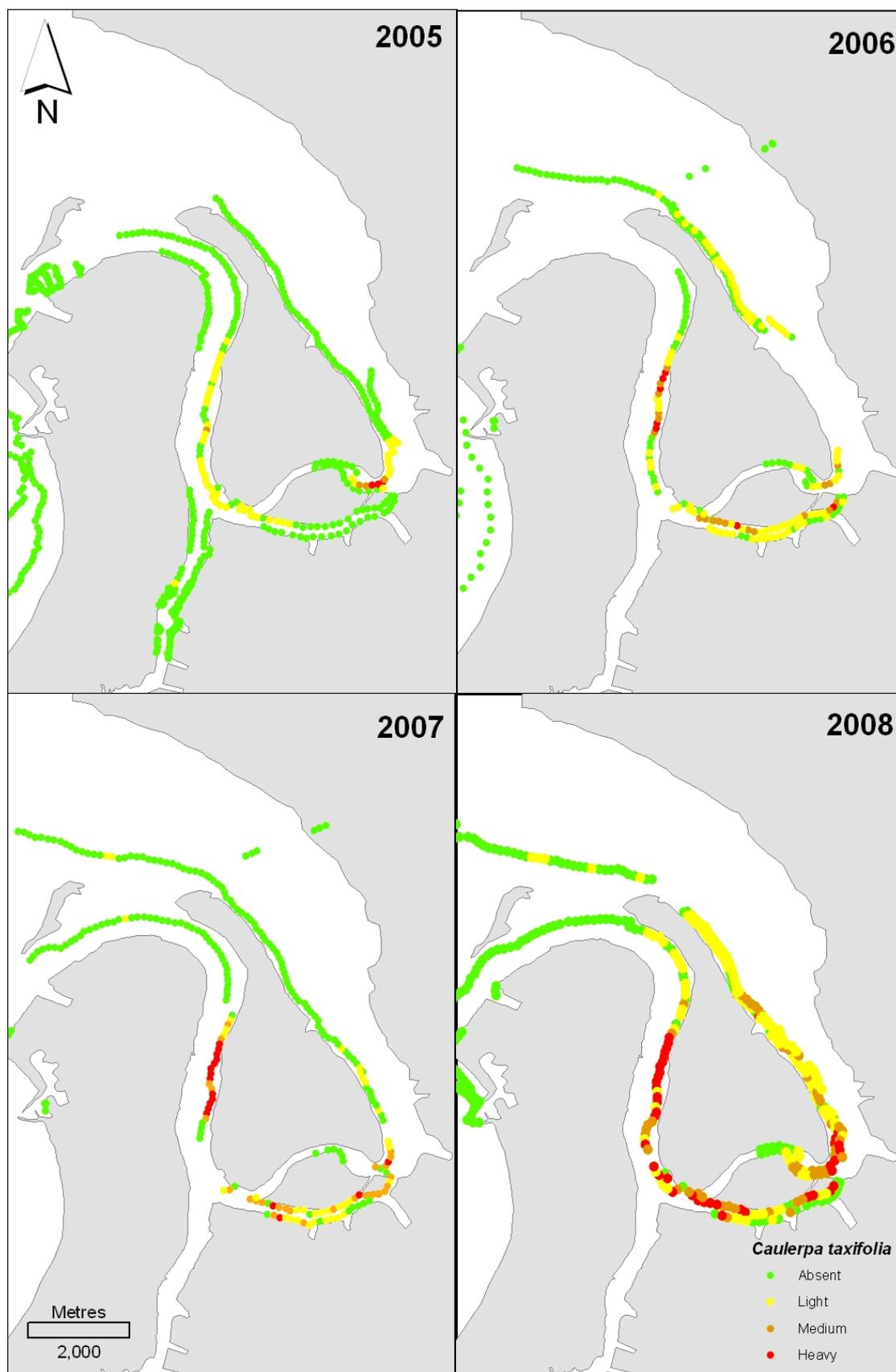


Figure 2. Comparative distribution of *C. taxifolia* from 2005-2008 surveys.

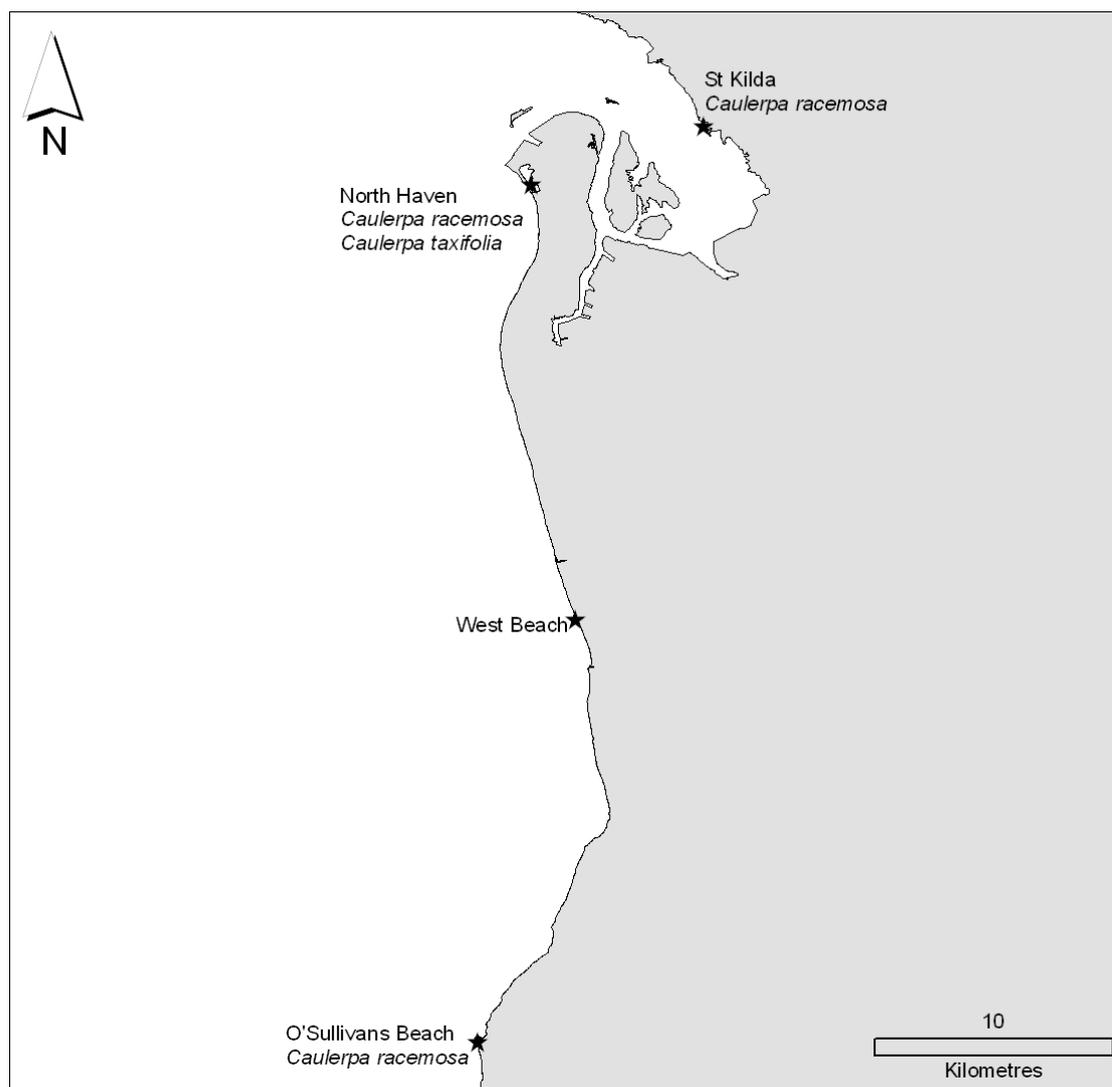


Figure 3. Location of Adelaide metropolitan boat ramps, showing presence of *Caulerpa* species.

No *C. taxifolia* was detected along the Bolivar coast or around the surveyed boat ramps. However, *C. racemosa* var. *cylindracea* was present at Bolivar, around the boat ramp at St Kilda, and within the marina at O'Sullivan's Beach (Figure 3). No *Caulerpa* species were found at West Beach.

Surveys by PIRSA Marine Biosecurity, carried out bi-monthly since the May 2008 outbreak, indicated that *C. taxifolia* had disappeared from North Haven boat ramp and marina following treatment by diver operated suction dredge. A small amount of the alga not removed by treatment did not survive over winter in 2008. However, some small patches have since re-appeared and continue to be monitored. *Caulerpa racemosa* var. *cylindracea* is present within both the marina and boat ramp area (J Gilliland, PIRSA Marine Biosecurity, personal communication, June 2009).

4. DISCUSSION

The pattern of *C. taxifolia* distribution in 2009 is similar to that found in previous surveys, with areas of greatest accumulation being North Arm, and along the Port River to the west of Torrens Island. However, the extent of the region in which medium to heavy cover was found was less than in the previous (2008) survey. The region to the east of Garden Island that has had medium-heavy cover previously was found only to have light to medium cover in the present survey.

Isolated *C. taxifolia* plants were found in Barker Inlet to the north-east of Torrens Island, but with considerably lower frequency than the 2008 survey. Plants were also not found as far downstream as in either 2007 or 2008, but the distribution did extend to the north of Torrens Island adjacent to Section Bank. In the western reach of the Port River, the alga displayed a similar distribution to that seen in 2007; again, the extent of the distribution downstream and abundance was less than in 2008.

Winter senescence of the alga is well documented (Meinesz *et al.* 1995; Gacia *et al.* 1996; Thibaut *et al.* 2004) and was proposed as a possible explanation for the scarcity of *C. taxifolia* in Barker Inlet in the 2007 survey (Rowling 2007). However, although the present survey was completed slightly later in the year than the 2008 survey, it did not extend into winter as did the 2007 survey. *Caulerpa taxifolia* was found to increase in cover in quadrats located adjacent to Section Bank from March-May 2007 before disappearing by July 2007 (Wiltshire and Collings 2008), indicating that the growing season in the area may extend into late autumn. Climatic factors may cause senescence of the alga to occur earlier or later in different years, but other factors cannot be ruled out as causes for the decreased abundance in this survey.

Caulerpa taxifolia continues to co-exist with *C. racemosa* var. *cylindracea* in several areas, including North Arm and the western reach of the Port River. *Caulerpa racemosa* var. *cylindracea* extends further downstream in the western reach than *C. taxifolia* and has appreciable cover on the revetments of Outer Harbour. This species was also found at boat ramp facilities at North Haven, St Kilda, and O'Sullivan's Beach and is present along the Bolivar coast where it was commonly found growing on dead seagrass rhizomes, particularly adjacent to and south of the outfall creek. The presence of *C. racemosa* var. *cylindracea* at these locations further indicates their suitability as a possible habitat for *C. taxifolia*. Although the *C. taxifolia* that

occurred in North Haven disappeared following treatment, re-occurrence of plants over summer indicates that this area remains at high risk for further outbreaks.

A comprehensive data set of *C. taxifolia* coverage has been compiled by the annual surveys since 2003. Analysis of these data should allow improved survey methodology to be developed by identifying key areas that can characterise trends in the population. Such targeted survey methodology should indicate if critical areas of biomass are in decline or increasing, and whether the infestation is spreading to previously uninvaded areas, at a lower cost than the current methodology of surveying the entire population.

REFERENCES

- Cheshire A, Westphalen G, Boxall V, Marsh R, Gilliland J, Collings G, Seddon S, Loo M (2002) *Caulerpa taxifolia* in West Lakes and the Port River, South Australia: distribution, eradication options and consequences. A report to the PIRSA Fisheries, Marine Habitat Program. South Australian Research and Development Institute (Aquatic Sciences), SARDI Aquatic Sciences Publication Number RD02/0161, Adelaide.
- de Villèle X, Verlaque M (1995) Changes and degradation in a *Posidonia oceanica* bed invaded by the introduced tropical alga *Caulerpa taxifolia* in the North Western Mediterranean. *Botanica Marina* 38, 79-87.
- Deveney MR, Rowling K, Tanner J (2008) *Caulerpa taxifolia* spatial risk assessment. In '*Caulerpa taxifolia* (M. Vahl) C. Agardh: environmental risk assessment. Prepared for PIRSA Marine Biosecurity.' (Eds MR Deveney, KP Rowling, KH Wiltshire, CE Manning, MB Fernandes, GJ Collings and JE Tanner) pp. 126-153. (SARDI Aquatic Sciences: Adelaide)
- Gacia E, Rodríguez-Prieto C, Delgado O, Ballesteros E (1996) Seasonal light and temperature responses of *Caulerpa taxifolia* from the northwestern Mediterranean. *Aquatic Botany* 53, 215-225.
- Glasby TM, Creese RG, Gibson PT (2005) Experimental use of salt to control the invasive marine alga *Caulerpa taxifolia* in New South Wales, Australia. *Biological Conservation* 122, 573-580.
- Jaubert JM, Chisholm JRM, Minghelli-Roman A, Marchioretti M, Morrow JH, Ripley HT (2003) Re-evaluation of the extent of *Caulerpa taxifolia* development in the northern Mediterranean using airborne spectrographic sensing. *Marine Ecology Progress Series* 263, 75-82.
- Manning CE, Deveney MR (2008) *Caulerpa taxifolia* as an invasive species: a critical review. In '*Caulerpa taxifolia* (M. Vahl) C. Agardh: environmental risk assessment. Prepared for PIRSA Marine Biosecurity.' (Eds MR Deveney, KP Rowling, KH Wiltshire, CE Manning, MB Fernandes, GJ Collings and JE Tanner) pp. 1-56. (SARDI Aquatic Sciences: Adelaide)
- Meinesz A, Belsher T, Thibaut T, Antolic B, Mustapha KB, Boudouresque C-F, Chiaverini D, Cinelli F, Cottalorda J-M, Djellouli A, El Abed A, Orestano C, Grau AM, Ivesa L, Jaklin A, Langar H, Massuti-Pascual E, Peirano A, Tunesi L, de Vaugelas J, Zavodnil N, Zuljevic A (2001) The introduced marine alga *Caulerpa taxifolia* continues to spread in the Mediterranean. *Biological Invasions* 3, 201-210.
- Meinesz A, Benichou L, Blachier J, Komatsu T, Lem,e R, Molenaar H, Mari X (1995) Variations in the Structure, Morphology and Biomass of *Caulerpa taxifolia* in the Mediterranean Sea. *Botanica Marina* 38, 499-508.
- Mueller-Dombois D, Ellenberg H (1974) Aims and Methods of Vegetation Ecology. (Wiley: New York)

Rowling K (2007) *Caulerpa taxifolia* - 2007 survey of current distribution and high risk areas. Prepared for PIRSA Biosecurity.

Rowling K (2008) Current distribution of *Caulerpa taxifolia* in South Australia. In '*Caulerpa taxifolia* (M. Vahl) C. Agardh: environmental risk assessment. Prepared for PIRSA Marine Biosecurity.' (Eds MR Deveney, KP Rowling, KH Wiltshire, CE Manning, MB Fernandes, GJ Collings and JE Tanner) pp. 57-67. (SARDI Aquatic Sciences: Adelaide)

Tanner J (2008) Utilisation of *Caulerpa taxifolia* as habitat by faunal assemblages in the Port River-Barker Inlet estuary. In '*Caulerpa taxifolia* (M. Vahl) C. Agardh: environmental risk assessment. Prepared for PIRSA Marine Biosecurity.' (Eds MR Deveney, KP Rowling, KH Wiltshire, CE Manning, MB Fernandes, GJ Collings and JE Tanner) pp. 68-81. (SARDI Aquatic Sciences: Adelaide)

Thibaut T, Meinesz A, Coquillard P (2004) Biomass seasonality of *Caulerpa taxifolia* in the Mediterranean Sea. *Aquatic Botany* 80, 291-297.

Tippets K (2002) The effects of *Caulerpa taxifolia* on invertebrate abundance in Agua Hedionda Lagoon, California.

West EJ, Barnes PB, Wright JT, Davis AR (2007) Anchors aweigh: Fragment generation of invasive *Caulerpa taxifolia* by boat anchors and its resistance to desiccation. *Aquatic Botany* 87, 196-202.

Westphalen G, Rowling K (2005) *Caulerpa taxifolia* surveys of the North Haven coast. A report for PIRSA Biosecurity. SARDI Aquatic Sciences, RD02/0161-16.

Williams SL (2007) Introduced species in seagrass ecosystems: Status and concerns. *Journal of Experimental Marine Biology and Ecology* 350, 89-110.

Williams SL, Grosholz ED (2002) Preliminary reports from the *Caulerpa taxifolia* invasion in southern California. *Marine Ecology Progress Series* 233, 307-310.

Wiltshire KH, Collings GJ (2008) Growth of *Caulerpa taxifolia* on bare sand and within seagrass beds - implications for invasion and competition. In '*Caulerpa taxifolia* (M. Vahl) C. Agardh: environmental risk assessment. Prepared for PIRSA Marine Biosecurity.' (Eds MR Deveney, KP Rowling, KH Wiltshire, CE Manning, MB Fernandes, GJ Collings and JE Tanner) pp. 96-108. (SARDI Aquatic Sciences: Adelaide)