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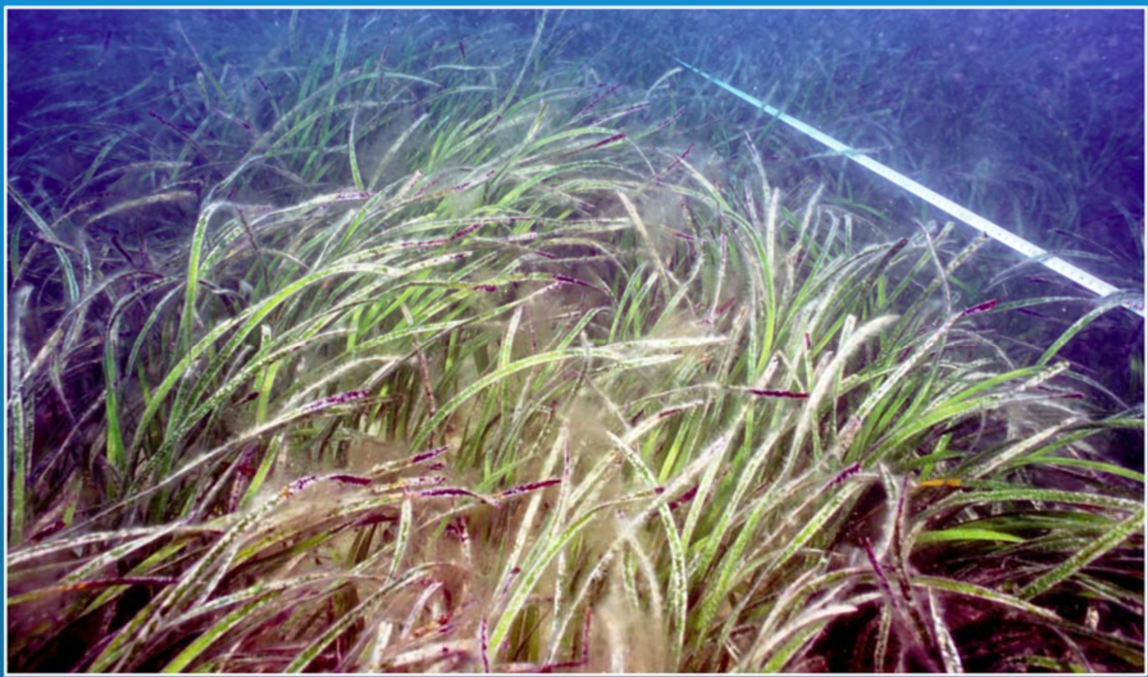
Re-assessment of sites potentially impacted by dredging in Outer Harbor, Port Adelaide: dredge spoil dump site and seagrass adjacent to dredged channel



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SARDI Aquatics Sciences
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December 2016

Report for KBR Pty Ltd and Flinders Ports

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EXECUTIVE SUMMARY

In 2006, Flinders Ports undertook a capital dredging program at Outer Harbor. Dredge spoil was dumped at an offshore site located approximately 38 km west of Outer Harbor. As part of the environmental impact assessment process, SARDI conducted video surveys of the spoil dump site. Two sets of 42 video transects of the spoil disposal site were taken prior to dredging, the first in 2002 to assess the presence and distribution of flora and fauna, and the second in 2005, subsequent to the discovery of the occurrence of invasive *Caulerpa* species in Port Adelaide, to specifically determine if *Caulerpa* species were present at the site prior to dredge spoil disposal. A third video survey was conducted of a subset of 15 transects in 2008, after completion of the major dredging operation, to determine whether any *Caulerpa* had been translocated to the dump site by the dredging operations.

Immediately after completion of the dredging operation in October 2006, seagrasses in the vicinity of the dredged channel were surveyed, and a clear gradient of increasing leaf density was found away from the dredge site. The seagrass survey was repeated in November 2007 and leaf density was found to have recovered, with no clear spatial pattern found in relation to distance from the dredged channel. Leaf length was also investigated but while this parameter varied with location and year, it did not show any consistent patterns.

Future capital dredging of the Outer Harbor channel will be required. In order to inform options for dumping of future dredge spoil, the dump site was re-assessed in May 2016 using a video survey of 15 transects to assess the abundance of flora and fauna and specifically to determine presence or absence of *Caulerpa* species. As found in 2002, the area surveyed was predominantly bare sand, with no seagrass and low faunal abundance. No *Caulerpa* species were observed.

To determine the current status of seagrass in the area impacted by dredging, the survey of seagrasses near the channel was repeated in November 2016. All sites were found to have high leaf density, with some minor differences from those found in 2007, but no clear spatio-temporal patterns from 2007-2016. Leaf length also varied, but with no consistent pattern. Recovery of seagrass after dredging appears to have occurred rapidly, within the first year after cessation of dredging, and only minor changes in seagrass structure occurred between 2007 and 2016.

1. INTRODUCTION

1.1. Background

In 2006, Flinders Ports undertook a capital dredging program at Outer Harbor to provide a deep-sea port accessible to fully laden Panamax class ships. The project involved dredging a large area of the swing basin and existing approach channel to deepen them by 2 m, requiring the removal of ~2,700,000 m^3 of sediment, and dumping the spoil at an offshore site located approximately 38 km west of Outer Harbor in a water depth of 30-35 m (Figure 1). As with any major dredging operation, a substantial turbidity plume was created, with the potential for a negative impact to occur on surrounding marine communities.

As part of the environmental impact assessment process, SARDI conducted video surveys of the dredge spoil disposal site, and investigated benthic habitats in the vicinity of the dredging. Two sets of 42 video transects of the spoil disposal site were taken prior to dredging, the first in 2002 to assess the presence and distribution of flora and fauna (Marsh *et al.* 2002), and the second in 2005 (Rowling and Tanner 2005), to specifically determine if *Caulerpa* species were present at the site prior to dredge spoil disposal. This second survey was conducted subsequent to the discovery of two invasive *Caulerpa* species in Port Adelaide: *C. cylindracea* (formerly *C. racemosa* var. *cylindracea*), which was discovered growing around Outer Harbor in the area to be dredged, and *C. taxifolia*, which was found growing in West Lakes and the upper Port River, but with drift material also present in Outer Harbor (Rowling and Tanner 2005; Rowling *et al.* 2005). A third video survey was conducted of a subset of 15 transects in 2008, after completion of the major dredging operation, to determine whether any *Caulerpa* had been translocated to the dump site by the dredging operations (Rowling 2008). The video recorded from the 2005 and 2008 surveys was only examined for the presence of *Caulerpa* spp. and the presence of other benthic organisms was not assessed (Rowling and Tanner 2005; Rowling 2008).

Tanner (2004) mapped the distribution of benthic habitats around the area to be dredged prior to the commencement of dredging. This mapping identified that the inshore and offshore areas were dominated by bare sand with scattered macroalgae, *Halophila* seagrass, and a range of sessile invertebrates. At intermediate depths (about 7-12 m), however, there was a dense bed of *Posidonia* spp. seagrass, with relatively few invertebrates documented. Given that *Posidonia* is a photosynthetic plant, it relies on light to survive, and thus could potentially experience substantial mortality if the turbidity plume persisted for too great a period of time. These potential effects were also reviewed in Tanner (2004). *Posidonia* seagrass was therefore surveyed immediately after the cessation of dredging in 2006, and again 12 months later (November 2007) to assess recovery (Tanner and Rowling 2008). These surveys were conducted at four sites along a transect from 1 to 5.5 km south of the dredged channel (Figure 2).

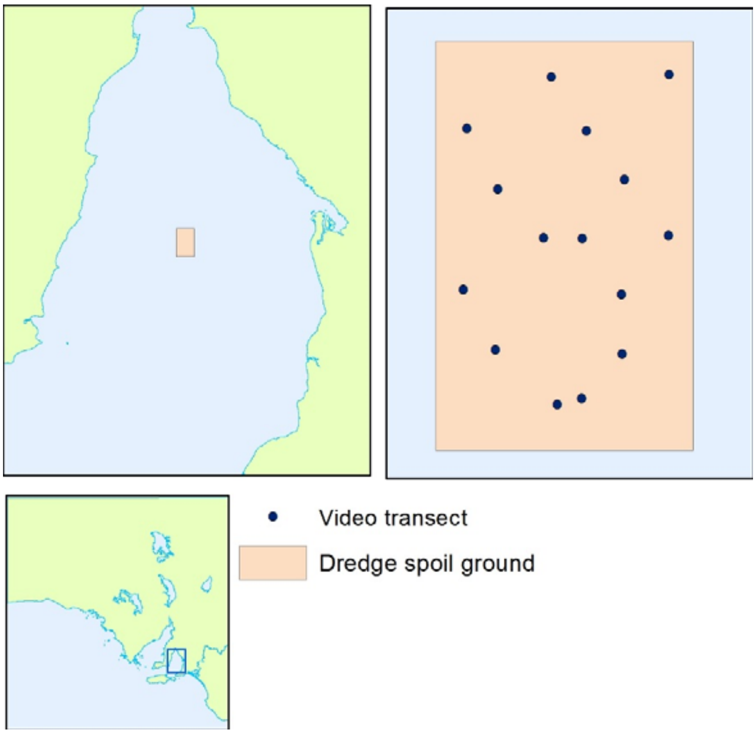

Figure 1. Location of the dredge spoil dump site in Gulf St Vincent and location of the 15 video transects recorded in May 2016 within the dump site area.

Future capital dredging of the Outer Harbor channel will be required. In order to inform options for dumping of future dredge spoil, the dump site was re-assessed in May 2016 to determine the presence or absence of *Caulerpa* species and obtain data on abundance of flora and fauna. The survey of *Posidonia* seagrass was also repeated to determine the current status of seagrass in the area and its longer-term recovery from dredging.

1.2. Objectives

Determine if *C. taxifolia* and/or *C. cylindracea* have colonised the vicinity of the 2006 dredge spoil disposal site and obtain data on the current benthic community at the disposal site.

Determine the status of seagrasses in the vicinity of the dredged Outer Harbor channel to assess current status and long-term recovery.

2. METHODS

2.1. Dredge spoil dump site survey

Remote video surveys by towed camera were conducted at the dredge spoil disposal site, consistent with the methodology used for the 2008 survey (Rowling 2008). The dump site was divided up into 42 1 km x 1 km blocks. A video transect was undertaken approximately through the centre of 15 of these blocks, ensuring that at least two transects were conducted through each of the seven rows and six columns of the dump site area (see Figure 1 for the locations of each transect recorded in 2016).

For each transect, a video camera (Scielex 0.01 lux colour camera), was lowered to 0.2 - 0.5 m off the bottom and the substrate filmed while the boat drifted or slowly motored for either 10 min or 500 m, whichever came first. A GPS (Garmin GPSmap78c) was used to record the start and end point of each transect. Footage was recorded on a digital video recorder (Lawmate 120 Gb), which incorporated a live feed display so that the location of the camera relative to the bottom, and quality of footage, could be monitored by an observer on board the boat in real time.

Video footage was played back and analysed visually in the laboratory by a trained observer to determine the presence or absence of both *Caulerpa* spp. along each transect. The abundance of other taxa along each transect was also recorded. Due to the difficulty in identifying many organisms, especially invertebrates, from video footage, identification was made only to broad morphological or taxonomic group, except for a few distinctive species. Counts were standardised to abundance per 500 m to allow comparison with abundances recorded in 2002 (Marsh *et al.* 2002), but formal statistical analysis was not performed due to the difference in sampling effort between surveys (42 c.f. 15 transects). Only 15 transects were recorded in the current survey since the primary aim was to repeat the 2008 survey to assess the presence/absence of *Caulerpa* spp. Data on abundance of other epibenthos was obtained from the recorded transects and gives indication of the current assemblage, but further data would be needed to adequately characterise the site and allow formal comparison with the 2002 survey data. To detect changes in epibenthos that may have been driven by dredge spoil dumping, data from the dump site would also need to be compared with that from multiple control sites (Underwood 1994). No comparison was made with the 2005 and 2008 surveys, as these recorded only presence/absence of *Caulerpa* spp. and did not enumerate other epibenthos (Rowling and Tanner 2005; Rowling 2008).

2.2. Seagrass survey

Seagrasses were surveyed in November 2016 at the same sites as in 2006 and 2007 (Figure 2), using methods consistent with those of previous surveys (Tanner and Rowling 2008). The sites were all at ~8 m of depth along a transect of potential impact, with the nearest site to the dredging 1 km south (patchy *P. sinuosa*) and another three sites at 2.5 km (*P. sinuosa* amongst *Amphibolis antarctica*), 4 km (*P. sinuosa* amongst *A. antarctica*) and 5.5 km (dense *P. sinuosa*) from the dredged channel. In 2006, it had been planned to locate the first site within 20 m of the channel, but seagrass was not located closer than 1 km from the edge at that time (Tanner and Rowling 2008).

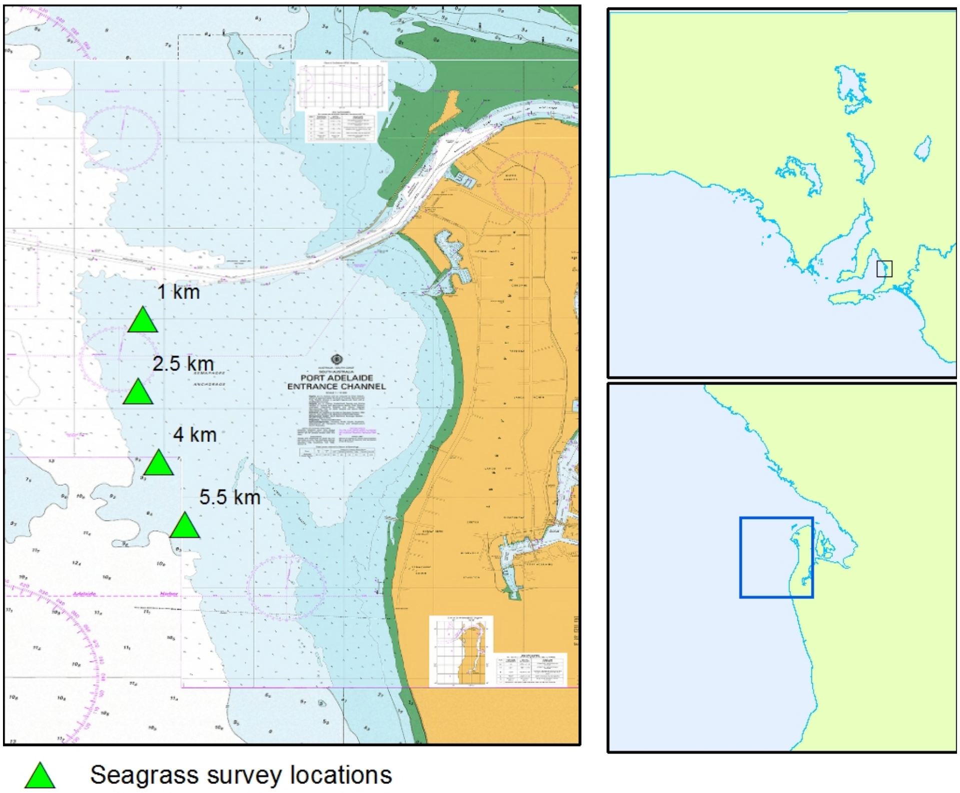

Figure 2. Location of seagrass survey sites. Sites were located along a depth contour at ~8 m depth, between 1 and 5.5 km south from the edge of the Outer Harbor approach channel.

At each location, ten quadrats of 0.0625 m^2 (250x250 mm) were haphazardly placed within the seagrass bed. All aboveground material within each quadrat was harvested at the level of the substrate and placed in separate labelled plastic bags, drained, sealed and frozen at –20°C until analysis. The samples were thawed and processed in the laboratory. Leaf counts were conducted of the entire quadrat sample based on the number of intact leaf sections with meristematic tissue at the base. The maximum leaf length was also taken by measuring the longest leaf from each quadrat. These parameters were recommended by Wear *et al.* (2006) as being the most appropriate and cost effective for monitoring the health of *Posidonia*.

A linear model was used to assess effects of location and year on maximum leaf length, after checking assumptions of normality and heterogeneity using normal probability plots and Levene's test. Leaf density data was found to be heteroscedastic, as is common for count data; effects of location and year on number of leaves per quadrat were therefore assessed using a Poisson generalised linear model (Zuur *et al.* 2007). Where significant effects were found, post-hoc tests were conducted, with Bonferroni corrections applied. Post-hoc comparisons were conducted within levels of interacting factors as appropriate. All analyses were conducted in R (R Core Team 2016) with α of 0.5, using the 'lm' and 'glm' functions (Chambers and Hastie 1992), Levene's test from the 'car' package (Fox and Weisberg 2011), and 'glht' function from the 'multcomp' package (Hothorn *et al.* 2008) to perform post-hoc tests.

3. RESULTS

3.1. Dredge spoil dump site benthos

The transects recorded at the dredge spoil disposal site comprised predominantly bare sand with low faunal abundance (Table 1). Sponges (phylum Porifera) were the most common organism observed, followed by razorfish (*Pinna bicolor*) and scallops (Bivalvia: Pectinidae), with other observed taxa having an abundance of <1 per 500 m. Sponges were also the most common organism recorded at the site prior to dredge spoil disposal (Marsh *et al.* 2002), but neither razorfish or scallops were observed at that time. However, bryozoa, which were the second most common organism in 2002, were not observed in the current study. Other taxa recorded in 2002 but not in the current study were pencil urchins and Holothuria, while other organisms observed in the current study but not in 2002 were soft coral (Zoanthidae) and the red macroalga *Osmundaria prolifera*. Solitary ascidians and seastars were observed in both studies, but with generally lower abundances in the current study than in 2002. Abundances from both surveys are shown in Table 1. Fauna was not enumerated from either the 2005 or 2008 surveys (Rowling and Tanner 2005; Rowling 2008). Average faunal abundance from the current study was 0.07 organisms m^{-2}, compared with 0.6 m^{-2} in 2002.

Table 1. Average abundance per 500 m of benthic organisms recorded on video transects from 2002 (Marsh *et al.* 2002) and 2016 (this study).

Taxon	**Abundance per 500 m (± s.e., n=15)**	
	2002	**2016**
Sponge (Porifera)	99 ± 6.5	57.3 ± 6.2
Razorfish (*Pinna bicolor*)	-	8.1 ± 3.1
Scallop (Pectinidae)	-	1.1 ± 0.5
Seastars (Asteroidae)	1.2 ± 0.22	0.2 ± 0.1
Osmundaria prolifera	-	0.9 ± 0.5
Ascidiacea	9.0 ± 0.84	0.5 ± 0.3
Zoanthidae	-	0.2 ± 0.1
Bryozoa	38 ± 6.5	-
Pencil urchin	1.4 ± 0.37	-
Holothuria	0.11 ± 0.09	-

No *Caulerpa* species were observed on the recorded transects.

3.2. Seagrass structure

Interactive effects of location and year on both seagrass leaf density and maximum leaf length were found (p<0.001). Post-hoc tests showed that leaf density was significantly different between years at all locations, with leaf density in 2007 and 2016 being consistently higher than in 2006 (Figure 3). At distances of 1 and 2.5 km from the channel edge, leaf density in 2016 was slightly lower than that found in 2007, while there was no significant difference in leaf density from 2007 to 2016 at distances of 4 or 5.5 km. In 2006 there was a clear pattern of increasing leaf density away from the channel edge, while in both 2007 and the current (2016) survey, there were only minor differences in leaf density between locations, with no clear spatial trends (Figure 3).

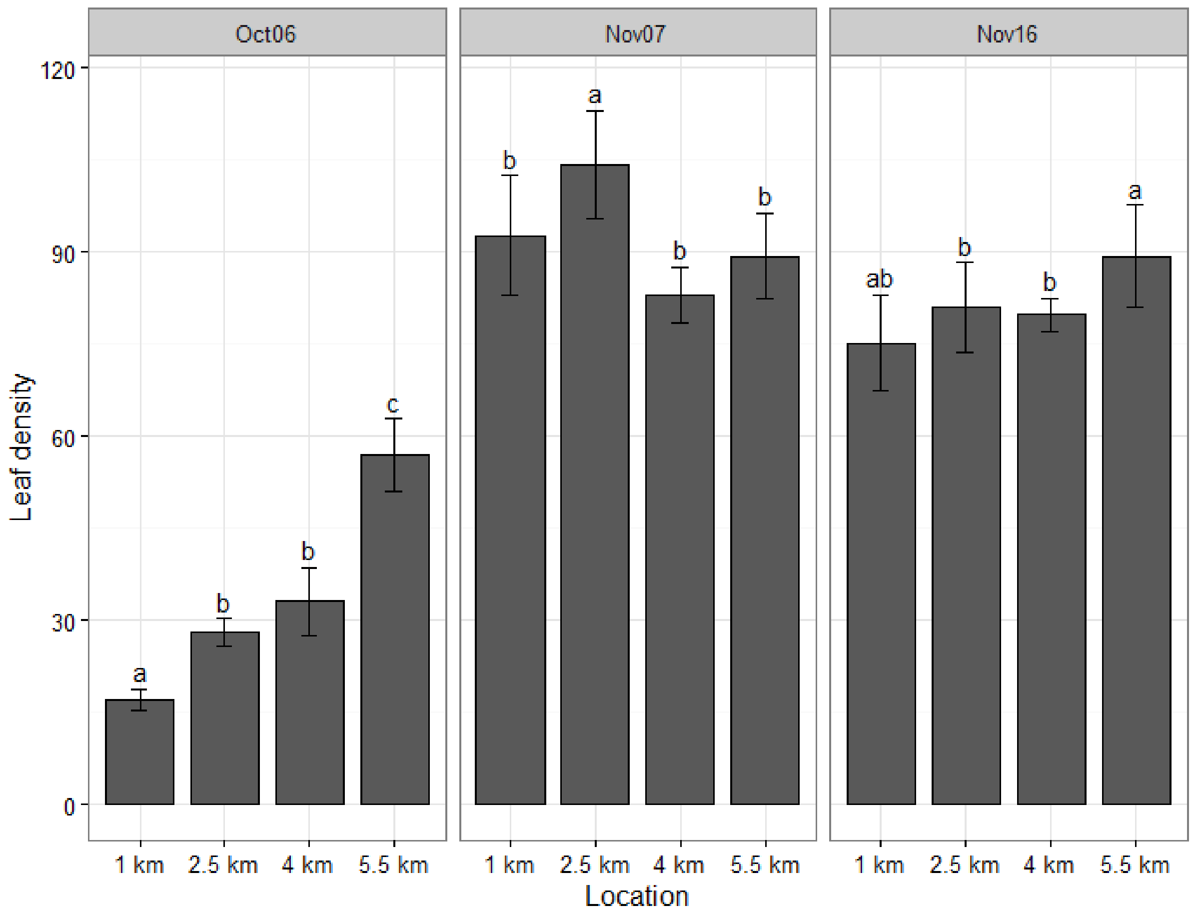

Figure 3. Average number of leaves per quadrat ± s.e. (n=10) from surveys in 2006, 2007 (Tanner and Rowling 2008) and 2016 (current report). Locations having the same letter within each sample period were not significantly different in that year.

Maximum leaf length varied between locations within each year, and between years at all locations except for 5.5 km, where there was no significant difference in maximum leaf length between surveys. The differences in maximum leaf length found showed no consistent patterns with either year or distance from the channel edge (Figure 4).

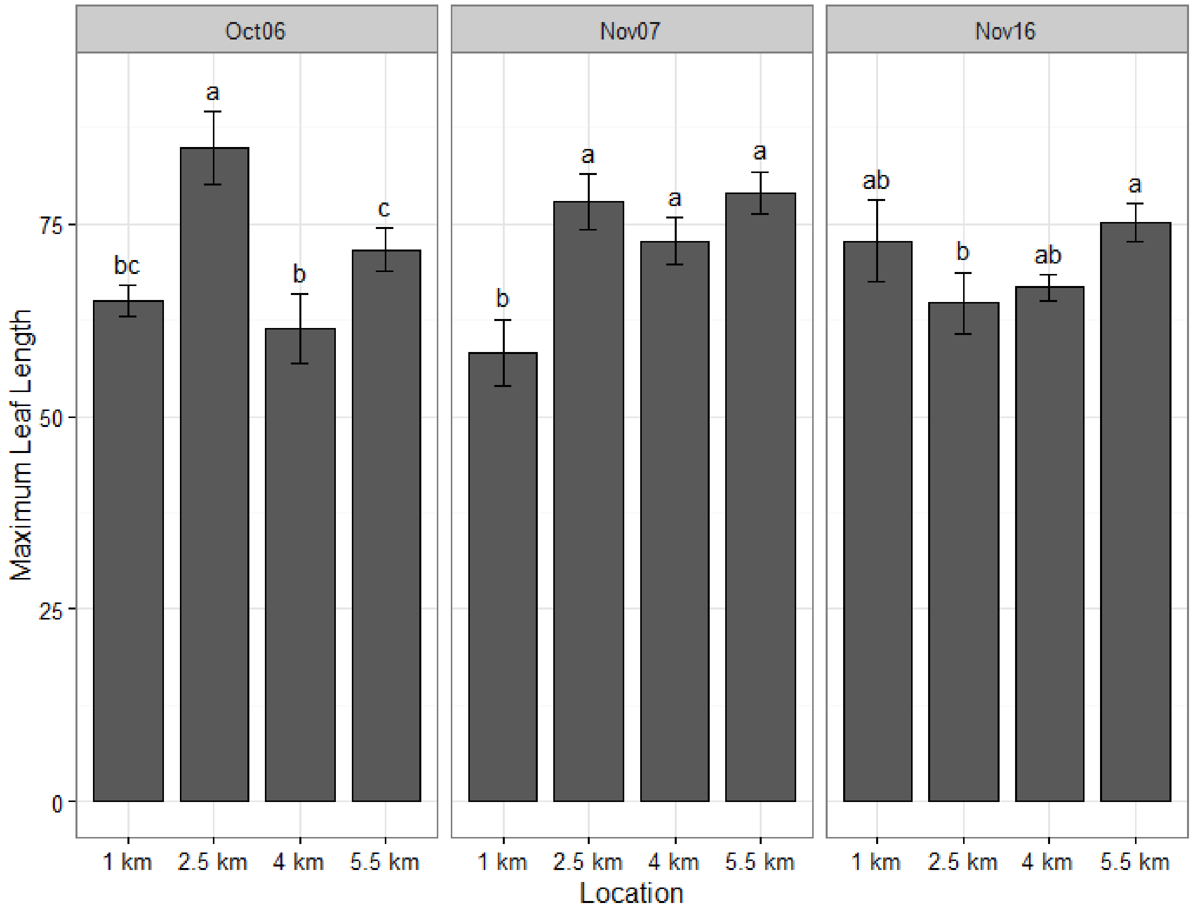

Figure 4. Average maximum leaf length ± s.e. (n=10) from surveys in 2006, 2007 (Tanner and Rowling 2008) and 2016 (current report). Locations having the same letter within each sample period were not significantly different in that year.

4. CONCLUSIONS

The 2016 survey of the dredge disposal site found this to be predominantly bare sand, with a lower faunal abundance than recorded in 2002, prior to dredge spoil disposal. It should be noted, however, that the lesser sampling effort employed for the current study means the site is less well characterised than in 2002. The primary aim of the current survey was to repeat the 2008 survey to assess whether *Caulerpa* spp. had established at the spoil dump site, and a more comprehensive survey would be required to adequately characterise the current benthic assemblage and allow for formal comparison with the 2002 survey data. The differences observed also cannot be ascribed confidently to any impacts of dredge spoil disposal without knowledge of broader-scale changes in the benthic communities of Gulf St Vincent between 2002 and 2016, which would also require investigation of sites not impacted by dredge spoil disposal.

The transects recorded covered only a small area relative to the size of the dredge disposal site, but no *Caulerpa* species were observed on the recorded footage. In previous surveys no macroalgae were recorded, but in the current survey a few plants of the red macroalga *Osmundaria prolifera* were observed. This is a common species in south-western Australia that may be found in deeper water (Womersley 2003). It should be emphasised that while *Caulerpa taxifolia* and *C. cylindracea* were not found in this survey, there is still a possibility that they are present in in areas that were not surveyed, but, given the paucity of macroalgae recorded over several surveys at the site, it appears unlikely that conditions at the site are conducive to algal growth and it is therefore unlikely that *Caulerpa* species have colonised this site.

Seagrass structure along a transect from 1 to 5.5 km south from the dredged channel was similar in 2016 to that found in 2007, 12 months after cessation of dredging. Immediately after dredging was completed in 2006, there was a clear gradient of increasing seagrass leaf density away from the channel edge. This gradient cannot be unambiguously attributed to the dredging operation, but it seems that this would be the likely cause, as no other major disturbances are known to have occurred in the area over the relevant time period. Further evidence comes from the observation by Tanner (2004) that dense *Posidonia* seagrass occurred up to the channel edge ~2 years prior to the dredging operation, but that the closest seagrass found shortly after dredging was 1 km from the channel (Tanner and Rowling 2008). Thus it appears that there was a substantial area of seagrass decline associated with the dredging. Recovery of seagrass at the surveyed sites was, however, relatively rapid, with uniformly high leaf densities found in 2007. It is unknown whether these leaf densities reflect those that occurred prior to dredging, since pre-dredging seagrass structure was not investigated. The similar leaf densities found in 2016 to 2007 suggest that seagrass leaf density had recovered to levels typical for the area by 2007, although further detail on inter-annual averages and variability would be needed to ascertain this with confidence. However, it was beyond the scope of either the 2007 or current study to map seagrass distribution, and thus whether seagrasses have recovered up to the channel edge, and the rate of any such recovery are unknown. It is also not known if there was a longer term impact at the deep limit of the seagrass bed, where plants are likely to be stressed without additional decreases in light availability.

REFERENCES

Chambers JM, Hastie TJ (1992) Statistical models in S. (Wadsworth and Brooks/Cole Computer Science Series: Pacific Grove)

Fox J, Weisberg S (2011) An {R} Companion to Applied Regression, Second Edition. (Sage: Thousand Oaks, California)

Hothorn T, Bretz F, Westfall P (2008) Simultaneous Inference in General Parametric Models. *Biometrical Journal* 50, 346-363.

Marsh R, Tanner J, Fairhead A (2002) Environmental Assessment of the dredge spoil dump site in Gulf St. Vincent for dredging of Outer Harbor. Prepared for Egis Consulting SA. SARDI Aquatic Sciences, RD145.

R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rowling K (2008) Re-assessment of the presence or absence of *Caulerpa taxifolia* and *Caulerpa racemosa* var. *cylindracea* at the dredge spoil dump site for the Outer Harbor dredging. Prepared for KBR and Flinders Ports Pty Ltd. SARDI Aquatic Sciences

Rowling K, Tanner J (2005) Assessment of the presence or absence of *Caulerpa taxifolia* and *Caulerpa racemosa* var. *cylindracea* at the proposed dredge spoil dump site for the Outer Harbor dredging. Prepared for KBR and Flinders Ports Pty Ltd. SARDI Aquatic Sciences RD02/0161-15

Rowling K, Westphalen G, Tanner J (2005) *Caulerpa racemosa* var. *cylindracea* surveys of Outer Harbor. Prepared for KBR and Flinders Ports Pty Ltd. SARDI Aquatic Sciences, RD04-0090-2.

Tanner JE (2004) Environmental assessment for proposed dredging of the Outer Harbour approach channel. Prepared for the KBR and Flinders Ports. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Tanner JE, Rowling KP (2008) Monitoring of seagrass health following dredging of the Outer Harbour approach channel in 2006. Prepared for KBR Pty Ltd. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Underwood AJ (1994) On Beyond BACI: Sampling Designs that Might Reliably Detect Environmental Disturbances. *Ecological Applications* 4, 4-15.

Wear RJ, Eaton A, Tanner JE, Murray-Jones S (2006) The impact of drain discharges on seagrass beds in the South East of South Australia. Final Report Prepared for the South East Natural Resource Consultative Committee and the South East Catchment Water Management Board. South Australian Research and Development Institute (Aquatic Sciences) and the Department of Environment and Heritage, Coast Protection Branch, Adelaide.

Womersley HBS (2003) The marine benthic flora of southern Australia Rhodophyta Part IIID Ceramiales - Delesseriaceae, Sarcomeniaceae, Rhodomelaceae. (Australian Biological Resources Study, Canberra, and the State Herbarium of South Australia, Adelaide)

Zuur AF, Ieno EN, Smith GM (2007) Analysing ecological data. (Springer Science + Business Media, LLC: New York)