Intertidal Monitoring

Autumn/Winter Report

2009

[This document contains the preliminary report for the Autumn and Winter seasons of the Adelaide Desalination Plant Intertidal Monitoring Program undertaken by Flinders University.]

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Intertidal Baseline Monitoring for the Adelaide Desalination Plant

Preliminary Report September 2009

Introduction

The coastline along the Fleurieu Peninsula S.A. is comprised of rocky intertidal reef habitats that support complex algal and invertebrate communities (Benkendorff and Thomas 2007; Benkendorff *et al*., 2008). The intertidal reefs at Port Stanvac appear to be biologically significant on a regional scale with large populations of invertebrate predators indicating a healthy reef system (Dutton and Benkendorff, 2008). Preliminary surveys by Dutton and Benkendorff (2008) indicate that the fenced off reefs at Port Stanvac may be a biodiversity hotspot for intertidal molluscs and red algal species. Further, a recent review of Southern Australian herbarium collections by Scott *et al*. (2009) indicates that the Port Stanvac area is a hotspot for vulnerable macroalgal species, based primarily on the work of Prof. Brian Womersley (1998).

The intertidal shores are heterogeneous environments with a high level of connectivity to other coastal ecosystems. Therefore there is the potential for shifts in the community structure to occur as the result of anthropogenic impacts in surrounding marine and terrestrial habitats. Impacts on intertidal communities can also influence other larger scale ecosystem level process, such as primary productivity, detritus supply and water quality, in other communities (Thompson *et al.* 2002). The proposed development of a desalination plant at Port Stanvac has the potential to impact local intertidal reefs during the construction phase due to increased vehicles and human activities in the area and from possible silt plumes from the tunnelling process which could temporarily smother intertidal communities, thus causing anoxia and species die-off. In the longer term, during the desalination plant operation phase, intertidal reefs could be impacted by larval entrainment in the intake pipe reducing local recruitment of species with planktonic larvae and possibly by salinity stress if the dense brine plumes do not sufficiently flush from the outlet pipe.

Monitoring a major development like the Port Stanvac desalination plant requires well planned ecological studies that account for the natural spatial and temporal variability in marine communities. Underwood (1991, 1992) recommends replicated before/after, control/impact (beyond BACI) studies in order to detect anthropogenic effects over and above the natural variability in local communities. Suitable control locations should be situated at sites with similar intertidal habitat, at varying distances from the desalination plant. A series of marine biology surveys have been previously undertaken at two sites in Port Stanvac and several control locations in 1978-1981 by Womersely (1988). In addition, Pillar (1998) undertook baseline surveys at Port Stanvac and a number of other sites in the Adelaide metropolitan region to develop an intertidal monitoring program for Mobil, Port Stanvac. However, in both of these studies, control locations to the south of Port Stanvac were limestone reefs, whereas the reefs at Port Stanvac are composed of hard igneous rock with complex boulder fields, rock platforms, crevices and rock pools (Dutton and Benkendorff, 2008). Comparisons of intertidal communities along the Fleurieu Peninsula have revealed significant differences between limestone and hard rock reefs (Benkendorff and Thomas, 2007; Benkendorff *et al*., 2008), thus requiring careful selection of control locations for environmental monitoring.

Aims and Objectives

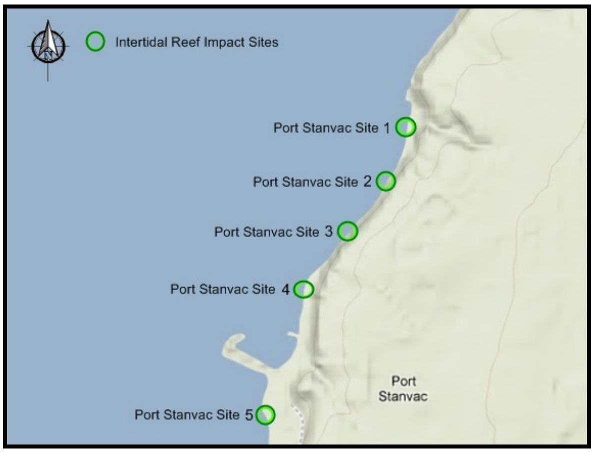
The intertidal assessment herein was undertaken as an initial sampling effort to obtain a 'before impact' dataset of the intertidal communities within the Port Stanvac Construction zone, as well as at northern and southern reference zones.

Methods

Sampling locations and sites

Sites along the Fleurieu Peninsula were selected according to comparable strata type and topography. Five locations within the Port Stanvac fenced area were sampled (Figure 1a) with reference locations located to the North at Marino Rocks and Hallett Cove (Figure 1b) and to the South at Carrickalinga, Second Valley, Fisheries Beach and Kings Beach (Figures 1c). Two 20 x 20 m plots were surveyed within the intertidal zone at each location, thus generating data from 22 specific sites. A GPS coordinate was taken from the middle of each plot. All sites were surveyed during low tides in May (Autumn) and August (Winter) 2009 (Table 1), using each of the methods outlined below.

1a)



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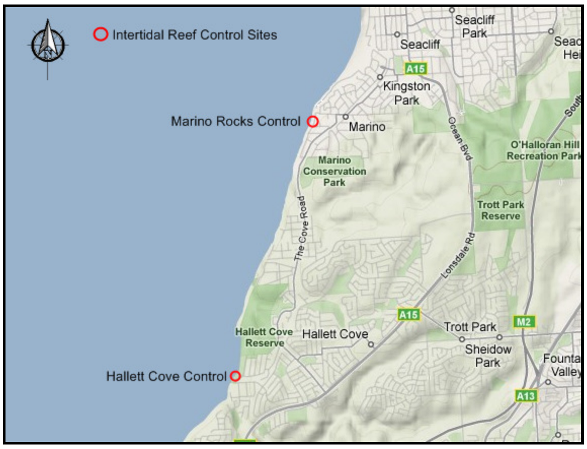

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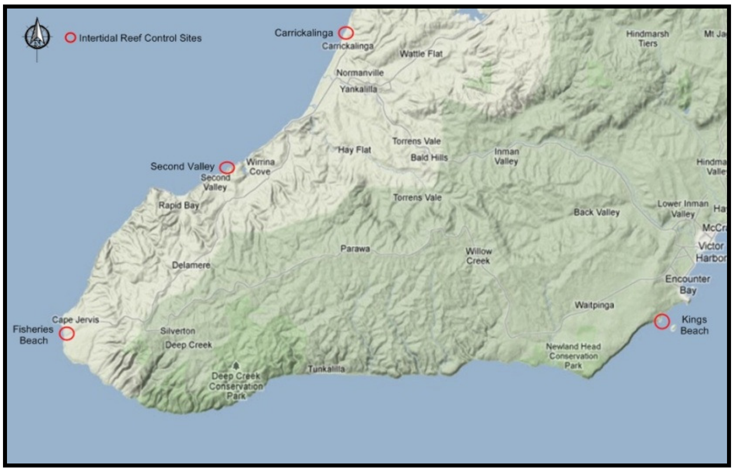


Figure 1: Intertidal sampling sites for (a) the Port Stanvac Construction zone within the Port Stanvac fenced area; (b) the Northern reference zone and; (c) the Southern reference zone.

Table 1: Sampling dates for the study sites for the Autumn and Winter surveys 2009.

Location	GPS Co-ordinates South	GPS Co-ordinates East	Season	Date	Tidal Height (m)
Marino Rocks	S 35°02’45.6”	E 138°30’27.6”	Autumn	13/5/09	0.41
			Winter	11/8/09	0.56
Hallett Cove	S 35°05’06.2’’	E 138°29’31.5”	Autumn	13/5/09	0.41
			Winter	11/8/09	0.56
Port Stanvac 1	S 35°06’48.8”	E 138°28’13.5”	Autumn	15/5/09	0.74
			Winter	12/8/09	0.61
Port Stanvac 2	S 35°06’28.4”	E 138°28’20.0”	Autumn	15/5/09	0.74
			Winter	10/8/09	0.53
Port Stanvac 3	S 35°06’15.4”	E 138°28’31.8”	Autumn	26/5/09	0.77
			Winter	10/8/09	0.53
Port Stanvac 4	S 35°06’12.4”	E 138°28’34.4”	Autumn	14/5/09	0.67
			Winter	12/8/09	0.61
Port Stanvac 5	S 35°06’25.7”	E 138°28’20.7”	Autumn	14/5/09	0.67
			Winter	07/8/09	0.60
Carrickalinga	S 35°25’09.0”	E 138°19’25.2”	Autumn	27/5/09	0.38
			Winter	27/8/09	0.69
Second Valley	S 35°30’36.3”	E 138°12’54.2”	Autumn	27/5/09	0.38
			Winter	26/8/09	0.61
Fisheries Beach	S 35°37’58.5”	E 138°06’49.4”	Autumn	28/5/09	0.50
			Winter	27/8/09	0.69
Kings Beach	S 35°36’13.6”	E 138°34’56.1”	Autumn	25/5/09	0.77
			Winter	26/8/09	0.61

Invertebrate abundance

Photoquadrats were used to assess invertebrate abundance, species diversity and species richness as this method can be rapidly applied in the field and provide a permanent record for future reference. Ten replicate 0.25m^2 quadrats were randomly placed within each 20mx20m plot. Each quadrat was divided into quarters, with one photograph taken of each quarter, as well as one encompassing the whole quadrat, using an Olympus Model µ 1030SW / Tough8000 digital camera (see Dutton and Benkendorff, 2008). Photographs were later downloaded onto a computer and analysed using Paint.NET v3.36 image analysis software. All visible mobile fauna was identified and counted to a minimum of family level, with identification to species level where possible. Organisms which were unable to be identified to the family level (due to heavy erosion of the shell or algal/invertebrate encrustation etc.) were marked as unidentified species.

Percent cover of sessile organisms

The line intercept transect method (e.g. Benkendorff and Thomas, 2007; Dutton and Benkendorff, 2008) was used to assess the percent cover of sessile invertebrates (e.g. black mussels *Limnoperna pulex* (formerly *Xenostrobus pulex*) and tube worms *Galeolaria caespitosa*), as well as percent algal cover from the low to high tide zones. Video footage was taken of each replicate transect using an Olympus Model Tough8000 digital camera to ensure that transects were completed within the short time frame between low and high tides on the same day at each location. The transects were videoed by walking slowly along a tape measure, showing distance covered in centimetres. The camera was set at a rate of 30 frames per second and held approximately 10cm from the substrate to ensure that the footage was captured at a high resolution. Due to the difficulties in reliably identifying algae, these were grouped into broad morphological categories (e.g. foliose green, encrusting brown/red/green, brown turfing, red foliose etc.) such as those used in Reefwatch surveys. In regions where there was an overlap of sessile communities, 'mixed community' categories (e.g. mixed algal, mixed invertebrate) were established to represent and identify the presence of multiple species. Bare substrate and sediment cover was also recorded along these transects.

The video transects were downloaded and analysed using VLC Media software, with regular pausing along the transect to identify sessile organisms and accurate recording of distance intervals. At the start of each transect, the type of organism cover was recorded and then transition from one type of organism cover to another was recorded along each transect to a resolution of 1cm. Total percent cover for each category, organism or substrate was subsequently calculated from the summed total distance covered, divided by the total length (20m). Means and standard deviation were generated from 5 replicate transects in each plot. However, due to the seasonal influence of wind, swirl and wave exposure, transects of 20m were not always able to be obtained. In these cases percent cover was calculated by dividing the summed distance of organisms by the total distance covered by the transect, thus giving a proportional cover comparable to that of other shoreline transects.

Data analyses

To determine the diversity and evenness of invertebrate species composition at all sites, three different diversity indices were calculated (Shannon-Wiener index, Pielou's evenness and Simpson's index) based on the total number of individuals (*N*) from the number of each taxa (*S*).

The Shannon-Wiener index identifies greater species diversity with an index number closer to one. Pielou's index identifies the equitability of species presence at each site where a larger number indicates less evenness and Simpson's index is a measure of ecological diversity with infinite diversity decreasing from zero to one, indicating dominance of single species (Clarke and Warwick 2001).

Analyses of invertebrate community composition for autumn and winter were undertaken to determine if there were similarities between sites and zones. A square root transformation was performed on the abundance data for sites and zones. A Multi-Dimensional Scaling ordination (MDS) was employed to provide a visual pattern of invertebrate community structure. In addition, Two-Way Analysis of Similarities were undertaken to distinguish any dissimilarities of invertebrate community structure for sites nested within zones. The invertebrate community data was further examined using Similarity of Percentages (SIMPER) to determine the contribution of discriminating species if dissimilar zones were identified (Clarke and Gorley 2006). All multivariate analyses were performed using the PRIMER v6 programme.

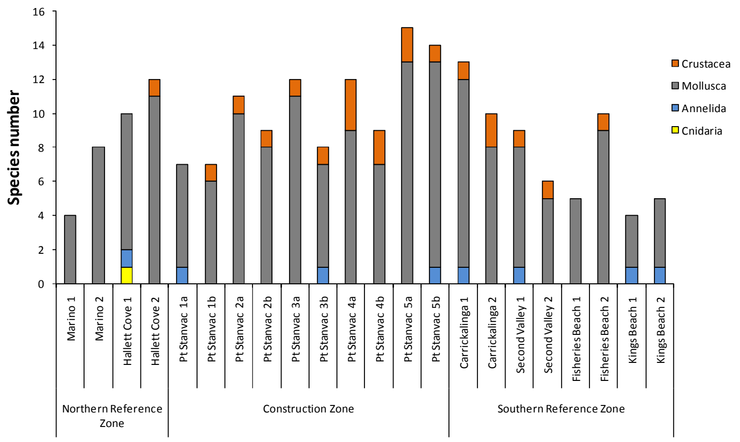
Results

Invertebrate species richness

In total, 40 invertebrate species were recorded in the quadrat surveys across all sites and seasons (Appendix 1). Some differences were found in the species list at each site from Autumn to Winter, with more species recorded overall in Winter (31 Appendix 1b), compared to Autumn (29; Appendix 1a). During Autumn, species richness was highest at the southern end of the Construction Zone at Port Stanvac (sites 5a and 5b) due to the greater number of mollusc species compared to all other sites (Figure 2a). The Subphylum Crustacea consisted solely of barnacles with the greatest species richness recorded at the southern end of Port Stanvac (site 4a). The lowest number of species overall was recorded at Marino (site 1) and Kings Beach (site 1) (Figure 2a). Annelids were represented by only one species (*Galeolaria caespitosa*) at eight sites and one cnidarian species (*Epiactis* sp.) was recorded at Hallett Cove.

Overall species richness in Winter was greatest at four of the Port Stanvac sites (sites 1a, 1b, 4a and 5b) due to the greater number of mollusc species compared to all other sites (Figure 2b). Crustacean species richness was greatest in Hallett Cove (site 1) with two species recorded and all other sites were represented by only one crustacean species. The most southern sites from Second Valley (site 2) through to Kings Beach (site 2) had the lowest overall species richness with no more than five species recorded at each site (Figure 2b). The species *G. caespitosa* was the only annelid recorded at most sites from Marino (site 2) through to Port Stanvac (site 5b) except one site at Port Stanvac (site 3a).

a)



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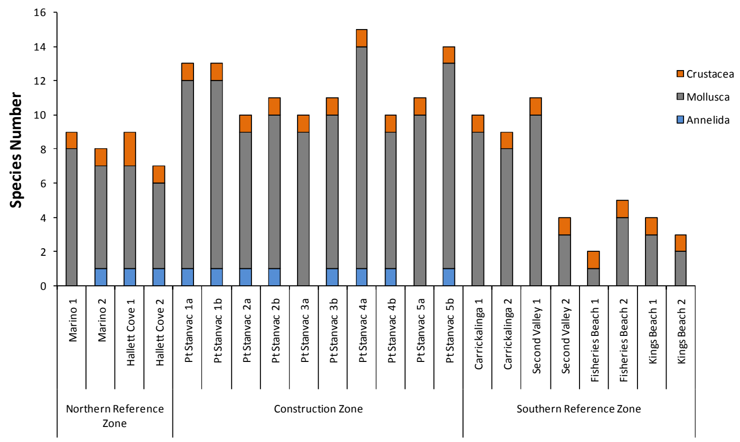


Figure 2: Total species number per phyla identified in quadrats during the (a) Autumn and (b) Winter 2009 intertidal survey for all sites encompassing three zones; Northern Reference Zone, Construction Zone and Southern Reference Zone.

Invertebrate species diversity

The diversity indices calculated for Autumn indicated that two sites at Port Stanvac (sites 2 and 3) had high Shannon-Wiener diversity and an uneven distribution according to Pielou's index (Table 2a). Simpson's index for the two sites at Port Stanvac (sites 2 and 3) were also high, indicating dominance of single species (the barnacle *Chtalamus antennatus*, Appendix 1a) at both sites. The Kings Beach site had the lowest Shannon-Wiener diversity and an even distribution across five invertebrate taxa according to Pielou's index (Table 2a). Low Shannon-Wiener diversity and low Pielou's evennness was identified at the most southern site of Port Stanvac (site 5) due to a large number of individuals distributed evenly over a low number of taxa.

Winter diversity indices revealed that two sites at Port Stanvac (sites 1 and 3) had the greatest Shannon-Wiener diversity and an uneven distribution according to Pielou's evenness (Table 2b). A large Simpson's index recorded at both sites in Port Stanvac (sites 1 and 3) indicated that there was a high dominance of the barnacle *C. antennatus* again (Appendix 1b). The lowest Shannon-Wiener diversity was identified at Kings Beach, which also had an even distribution due to the low number of individuals recorded across two invertebrate taxa (Table 2b). Similar to the Autumn survey, site five at Port Stanvac had low Shannon-Wiener diversity with an even distribution during Winter due to a large number of individuals spread equally across a low number of taxa.

Table 2: Diversity Indices for the (a) Autumn and (b) Winter 2009 intertidal survey. *S* = number of taxa; *N* = total number of individuals. All values are means and include Standard Deviation (SD) from the two replicate plots per site.

a)

Site	*S*	*N*	Shannon-Wiener	Pielou's evenness	Simpson
Marino	6 (2.8)	61.5 (30.4)	1.06 (0.39)	0.61 (0.06)	0.53 (0.16)
Hallett Cove	10.5 (2.1)	122 (72.1)	1.36 (0.14)	0.58 (0.01)	0.65 (0.05)
Port Stanvac 1	6.5 (0.7)	53.5 (7.8)	1.14 (0.08)	0.61 (0.01)	0.60 (0.00)
Port Stanvac 2	10 (1.4)	136 (52.3)	1.78 (0.05)	0.77 (0.03)	0.79 (0.00)
Port Stanvac 3	9.5 (3.5)	163 (89.1)	1.64 (0.02)	0.75 (0.14)	0.77 (0.04)
Port Stanvac 4	10.5 (2.1)	979 (1176.6)	1.25 (0.61)	0.55 (0.31)	0.59 (0.25)
Port Stanvac 5	13.5 (2.1)	1791.5 (878.9)	0.57 (0.11)	0.22 (0.06)	0.25 (0.03)
Carrickalinga	10.5 (0.7)	190.5 (72.8)	1.28 (0.28)	0.54 (0.10)	0.59 (0.12)
Second Valley	7 (1.4)	139 (151.3)	0.90 (0.50)	0.48 (0.31)	0.42 (0.31)
Fisheries Beach	7 (2.8)	71 (58)	1.29 (0.24)	0.68 (0.02)	0.66 (0.04)
Kings Beach	3.5 (0.7)	93 (14.1)	0.22 (0.10)	0.17 (0.05)	0.09 (0.04)

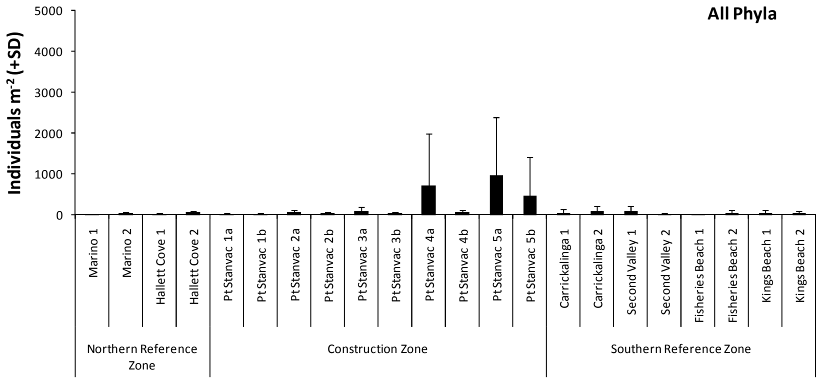
b)

Site	*S*	*N*	Shannon-Wiener	Pielou's evenness	Simpson
Marino	12 (1.4)	125 (5.7)	1.93 (0.14)	0.82 (0.02)	0.84 (0.03)
Hallett Cove	11 (0)	124.5 (9.1)	1.99 (0.30)	0.74 (0.12)	0.78 (0.07)
Port Stanvac 1	18 (1.4)	321 (22.6)	2.13 (0.05)	0.74 (0.00)	0.82 (0.00)
Port Stanvac 2	13 (0)	353 (2.8)	1.34 (0.17)	0.52 (0.07)	0.56 (0.09)
Port Stanvac 3	15.5 (3.5)	147.5 (40.3)	2.07 (0.28)	0.76 (0.04)	0.82 (0.05)
Port Stanvac 4	16 (1.4)	914.5 (115.3)	1.27 (0.22)	0.46 (0.06)	0.62 (0.09)
Port Stanvac 5	13.5 (2.1)	2097.5 (1539.4)	0.82 (0.16)	0.31 (0.04)	0.37 (0.03)
Carrickalinga	8 (0)	191.5 (186)	1.06 (0.19)	0.51 (0.09)	0.51 (0.11)
Second Valley	8.5 (6.4)	162 (162.6)	0.96 (0.08)	0.52 (0.18)	0.47 (0.07)
Fisheries Beach	3.5 (2.1)	86 (118.8)	0.50 (0.27)	0.60 (0.57)	0.56 (0.62)
Kings Beach	2 (1.4)	356 (123)	0.02 (0.03)	0.02 (0.03)	0.01 (0.01)

Invertebrate abundance

In Autumn the total mean abundances for all phyla in quadrat samples were greatest at the southern end of Port Stanvac at three sites (site 4a, 5a and 5b), while all other sites were comparable with an average of less than 100 individuals per square metre (Figure 5a). At two of the southern sites at Port Stanvac (site 4a and 5a) molluscs were more abundant than all other sites (Figure 5b). However, the abundance of crustaceans (barnacles) contributed most to the greater total abundance levels at the three southern Port Stanvac sites (site 4a, 5a and 5b) (Figure 5c).

a)



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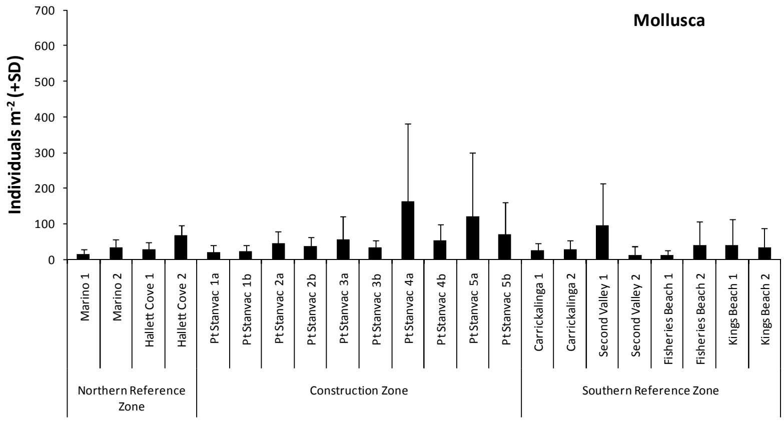

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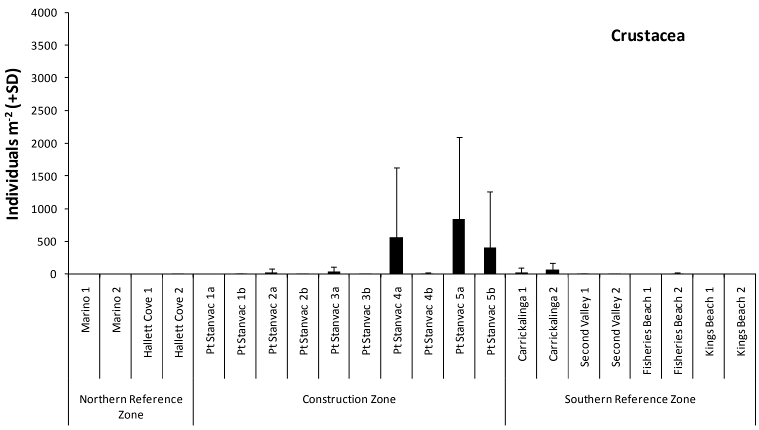
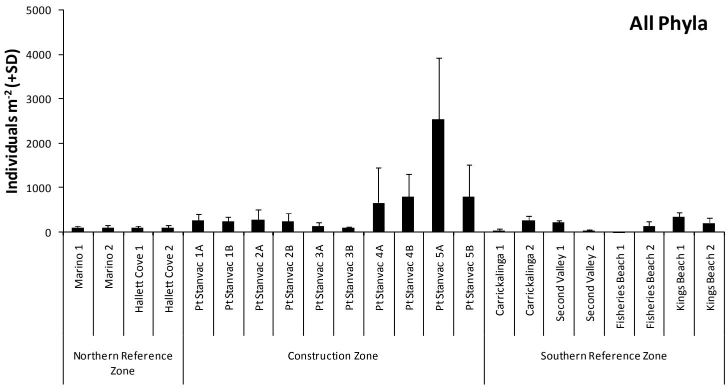


Figure 5: Mean abundances and standard deviations (SD) for the Autumn 2009 survey of (a) All Phyla, (b) Molluscs and (c) Crustaceans identified in quadrats (n=10) at all sites encompassing three zones; Northern Reference Zone, Impact Zone and Southern Reference Zone.

During Winter the total mean abundances for all phyla were greatest at one of the Port Stanvac sites (site 5a), followed by three other sites at the southern end of Port Stanvac (sites 4a, 4b and 5b) (Figure 6a). All of the other sites were comparable with abundances of all phyla under 400 individuals per square metre. Two of the sites at the southern end of Port Stanvac (site 5a); and one of the Kings Beach sites (site 1) had greater abundances of molluscs compared to all other sites, which revealed individual abundances no greater than 250 individuals per square meter (Figure 6b). Crustaceans were abundant at one of the Port Stanvac sites (site 5a) all of the other sites had abundances under 650 individuals per square metre (Figure 6c). No crustaceans were recorded at the sites in Hallett Cove or from the second site at Second Valley through to Kings Beach.

a)



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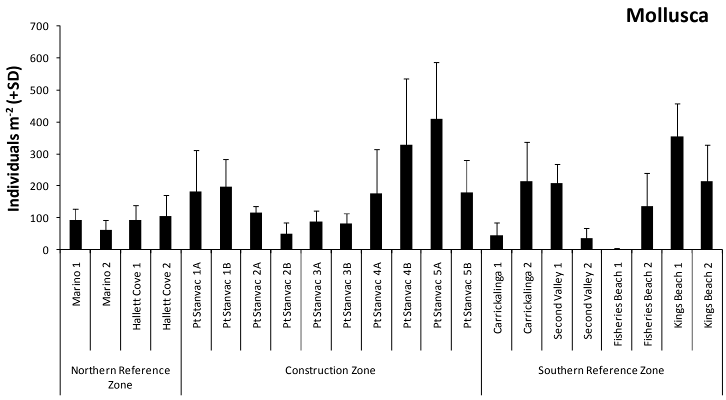

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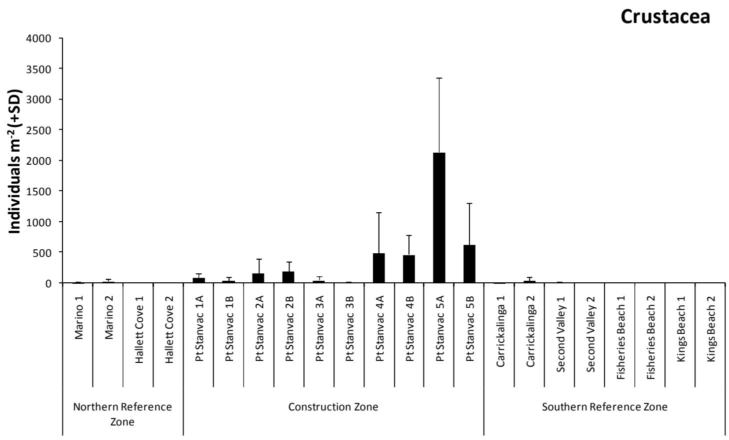


Figure 6: Mean abundances and standard deviations (SD) for the Winter 2009 survey of (a) All Phyla, (b) Molluscs and (c) Crustaceans identified in quadrats (n=10) at all sites encompassing three zones; Northern Reference Zone, Impact Zone and Southern Reference Zone.

Invertebrate communities

The MDS ordination of sites in Autumn revealed high variability within and between sites (Figure 7). A number of outlying samples were detected, mainly from sites within the Southern Reference Zone (Figure 7a). However, most site samples were clustered within the centre ellipse shown on the MDS plot in Figure 7a. Magnification of the centre ellipse indicated an interspersion of samples from Port Stanvac and the reference sites, although some within site clustering was observed (Figure 7b). Further analysis using ANOSIM identified a significant difference between sites (p = 0.001), yet samples within sites were also highly variable (Global R = 0.12). The reference sites were observed to generally cover the range in community variability observed at Port Stanvac (Figure 7).

The MDS ordination of sites group according to zones (i.e. Port Stanvac vs. North and South reference zones) in Autumn revealed no clear grouping of samples within zones, thus indicating similar community structures across all regions (Figure 7c). Further analysis using ANOSIM confirmed that invertebrate communities were similar, with no significant difference between Port Stanvac and the Northern or Southern reference zones (p = 0.34, Global R = 0.037).

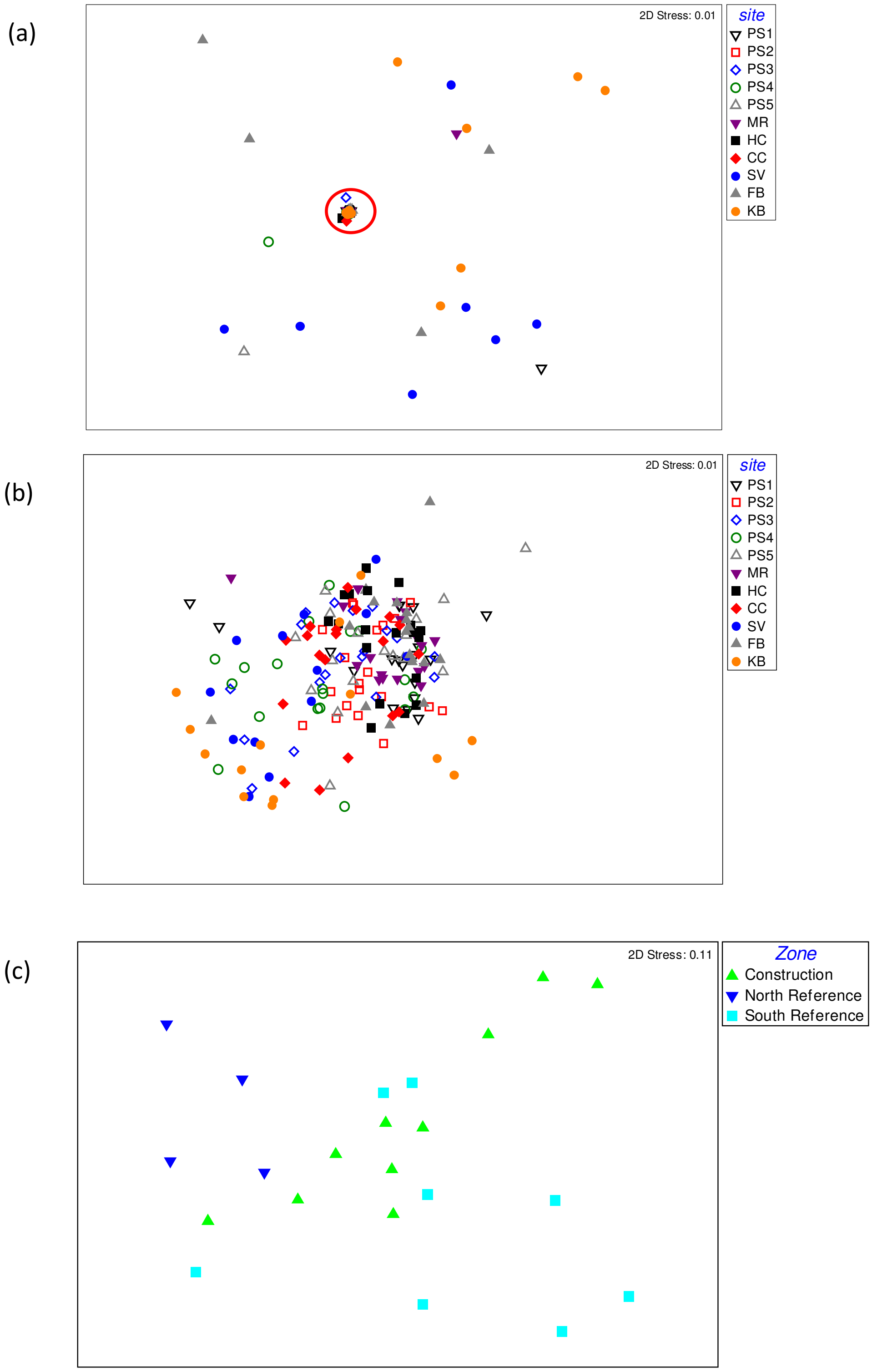


Figure 7: MDS ordination of invertebrate communities in Autumn for (a) sites (central cluster ellipse highlighted), (b) central cluster ellipse magnified and (c) zones. Note; zone ordination calculated from the mean data in each site. Abbreviations; CC, Carrickalinga; FB, Fisheries Beach; HC, Hallett Cove; KB, Kings Beach; MR, Marino Rocks; PS, Port Stanvac; SV, Second Valley.

The MDS ordination of sites in Winter revealed outlying samples, which again were mostly from sites within the Southern Reference Zone, particularly Fisheries Beach (Figure 8a). The majority of samples from all sites (excluding Fisheries Beach) clustered together within the central ellipse of Figure 8a.

Magnification of the ellipse area indicated that there was a high amount of interspersion of points within and between sites (Figure 8b). Further analysis using ANOSIM identified a significant difference between sites and high variability within sites (p = 0.001, Global R = 0.148).

The MDS ordination of zones in Winter revealed separate clustering of data points for the Construction Zone and South Reference Zone (Figure 8c). In comparison, the North Reference Zone data points were spread between the Construction and Southern Reference Zone clusters. ANOSIM identified a significant difference between zones (p = 0.01, Global R = 0.529). The significant difference between zones was distinguished by the dissimilar invertebrate communities of the Construction and Southern Reference Zones (p = 0.016, R = 0.644). A dissimilarity percentage of 89% between the Construction and Southern Reference Zones from SIMPER analysis was mostly driven by the greater abundance of the mollusc *Austrolittorina unifasciata* in the Southern Reference Zone, and the greater abundance of the mollusc *Nerita atramentosa* and the crustacean *Chthamalus antennatus* in the Construction Zone.

(a)

(b)

(c)

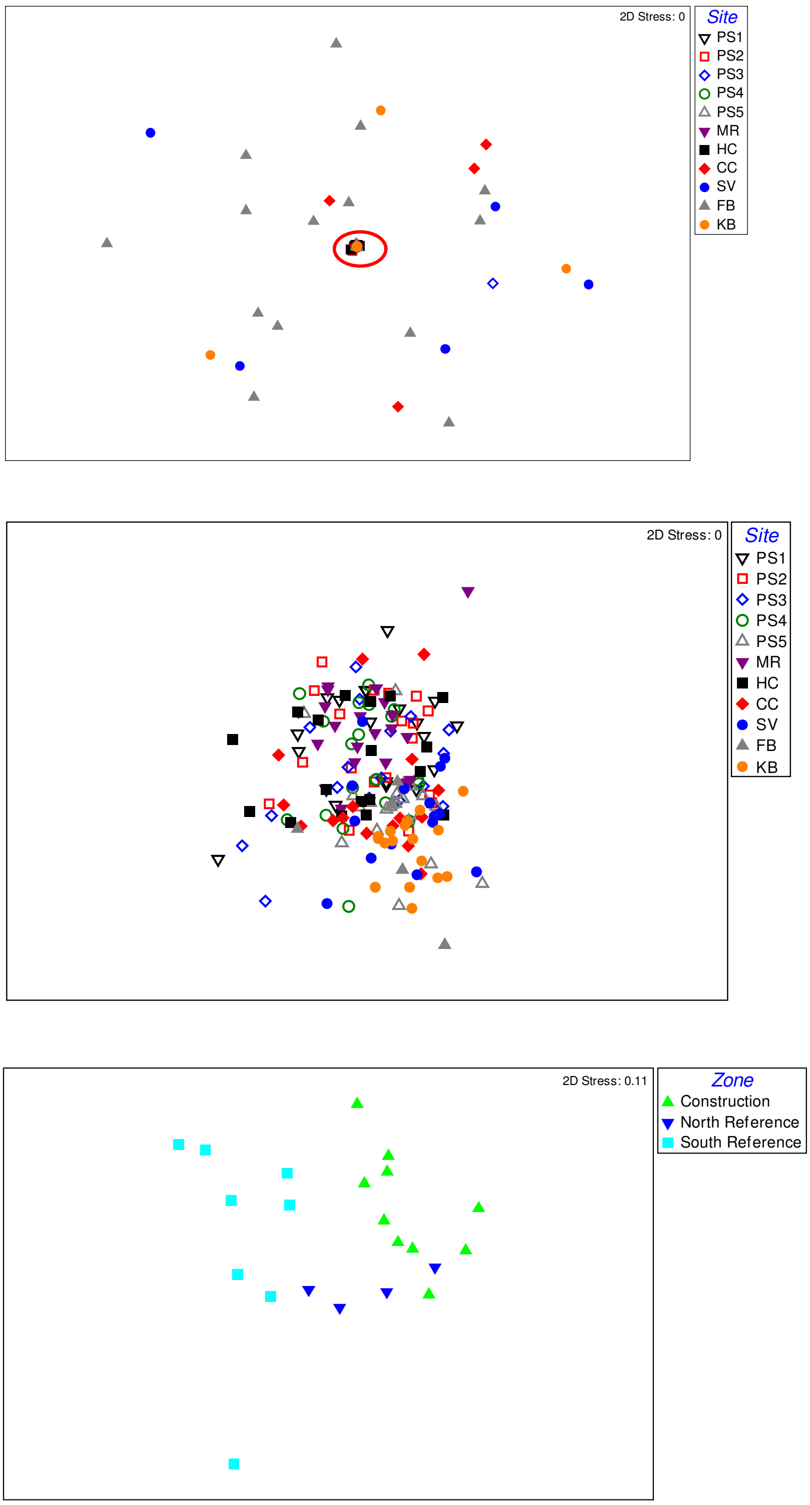
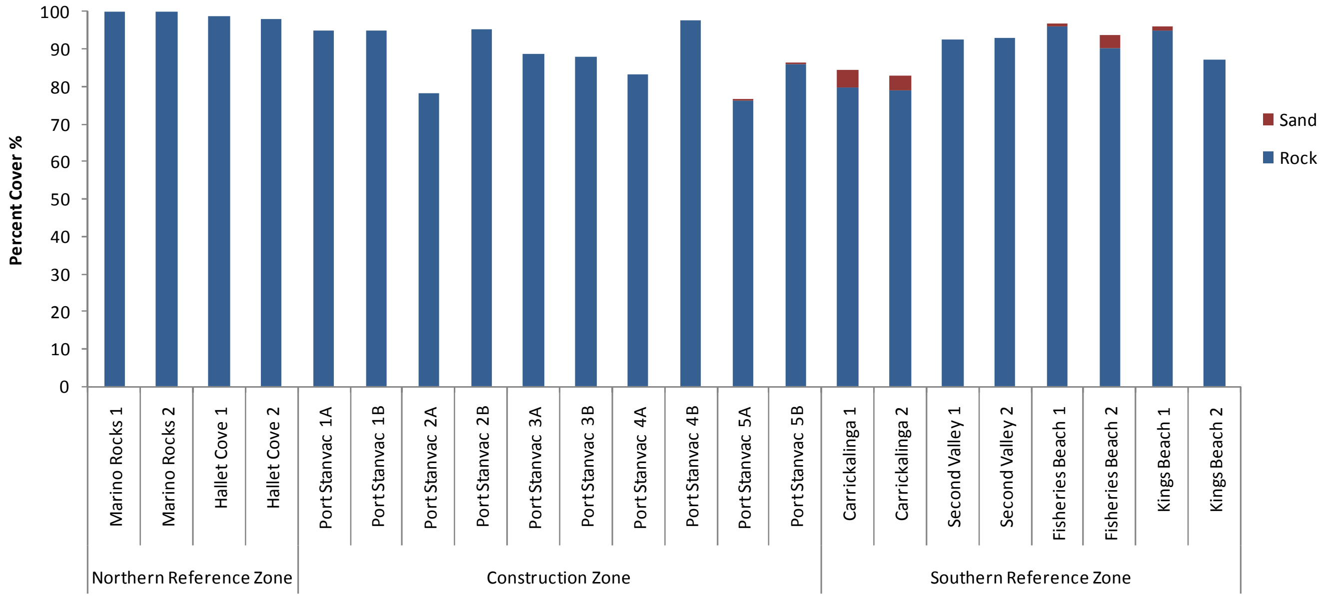


Figure 8: MDS ordination of invertebrate communities in Winter for (a) sites (central cluster ellipse highlighted), (b) central cluster ellipse magnified and (c) zones. Note; zone ordination calculated from the mean data in each site. Abbreviations; CC, Carrickalinga; FB, Fisheries Beach; HC, Hallett Cove; KB, Kings Beach; MR, Marino Rocks; PS, Port Stanvac; SV, Second Valley.

Substrate Cover

Autumn Video Transects

The data obtained from video transects revealed a high percent cover of bare substrate at all sites, particularly within the North and South Reference Zones, with the exception of Carrickalinga and Port Stanvac 2a and 5b (Figure 8a). The substrate was predominantly rock, but with a small amount of sand at some of the southern sites. Percent cover of various algae and invertebrate species were greatest at three sites within Port Stanvac (site 2a, 4a and 5a) and both sites at Carrickalinga (Figure 8b). Excluding bare substrate, algal cover was dominant at most sites, while invertebrates had the greatest percent cover at four sites (Hallett Cove 1, Port Stanvac 3b and 4b, Kings Beach 2; Figure 8b). In addition, relatively large quantities of wrack were recorded at Second Valley (site 2) and Kings Beach (site 2) (Figure 8b).



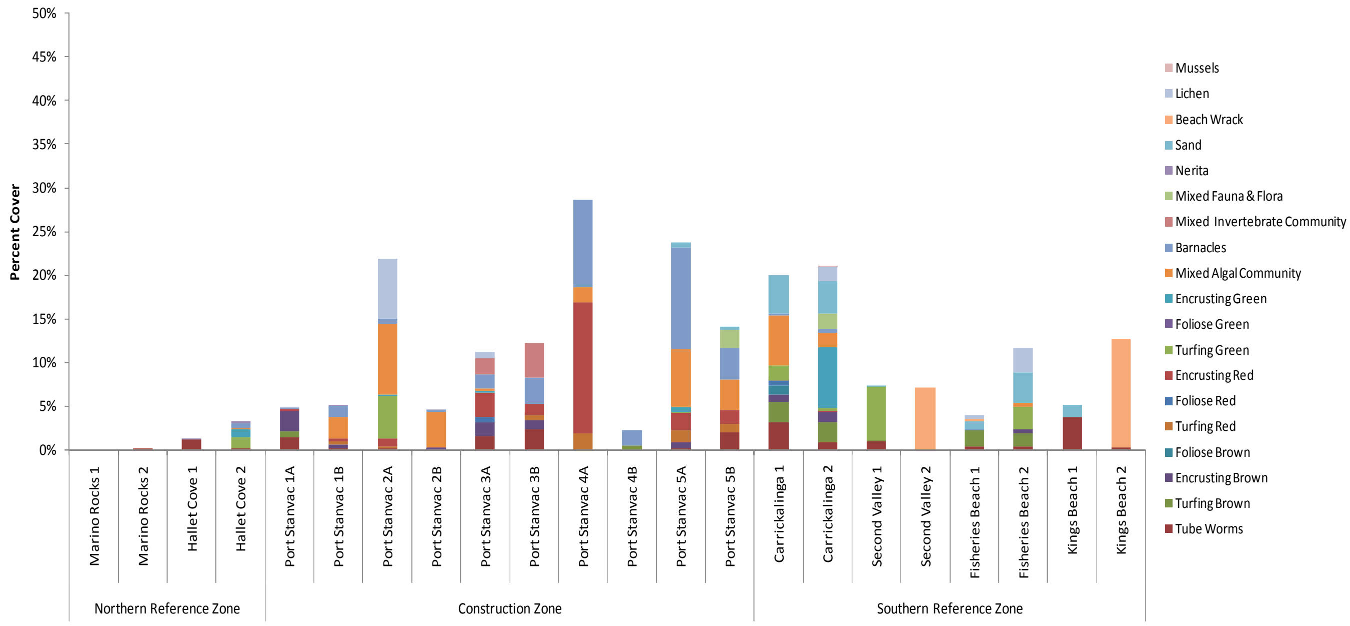
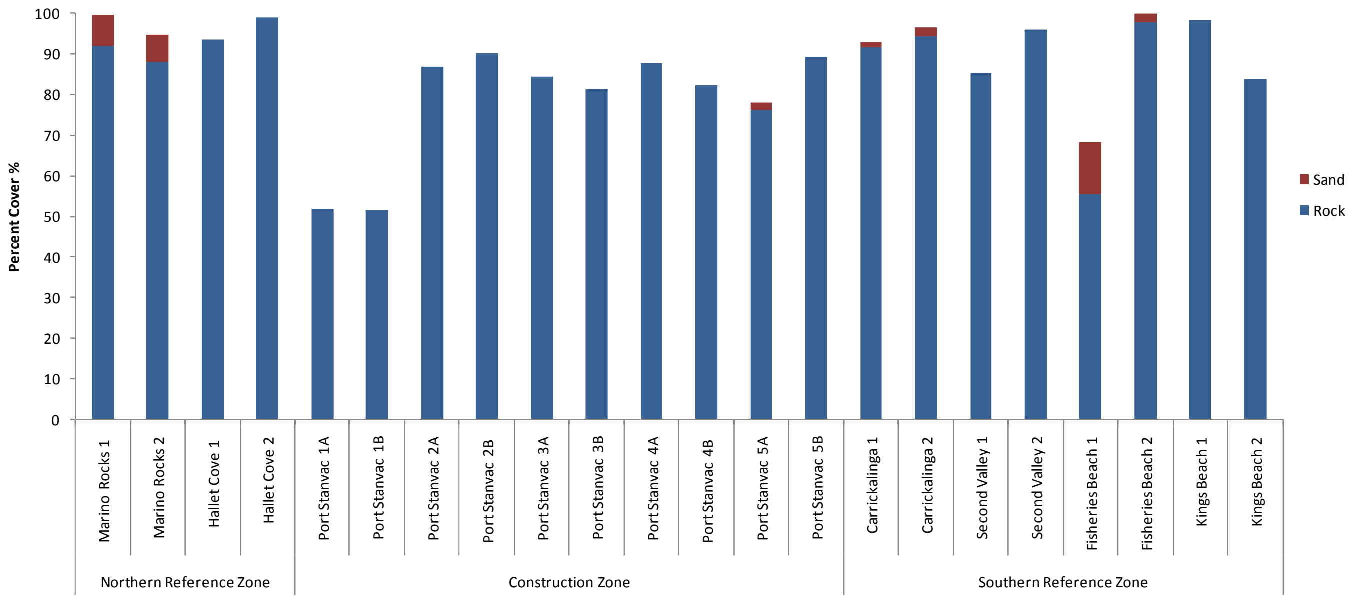


Figure 8: Mean percent cover of a) bare substrate (sand and rock) and b) flora and fauna quantified from video transects at all sites; Northern Reference Zone, Impact Zone and Southern Reference Zone during autumn surveys.

Winter video transects

Similar to the results of the autumn survey, the winter video transect data also revealed a high percentage of bare substrate at all sites. A small amount of sand was recorded on the rock platform at Mario Rocks, in addition to some of the southern sites in during the winter surveys. Bare substrate was dominant at all sites with the exception of Port Stanvac 1A and 1B, in which greater than 50% of the substrate was covered by sessile organisms (Figure 9a). At these two sites, mixed algal communities accounted for approximately 40% of substrate cover (Figure 9b). Bare substrate cover also occurred in lower proportions at Fisheries Beach 1, in which beach wrack and sand occurred at a high percentage (Figure 9b).

Excluding bare substrate, algal cover was dominant at all sites within the Construction zone and was present at most sites (with the exception of Kings Beach 1, Fisheries Beach 1 and Marino Rocks 1). Invertebrates has the greatest percentage cover at Port Stanvac 3A/3B and Marino Rocks 2. Beach wrack also occurred in Second Valley 1/2, Fisheries Beach 1 and Kings Beach 1/2.



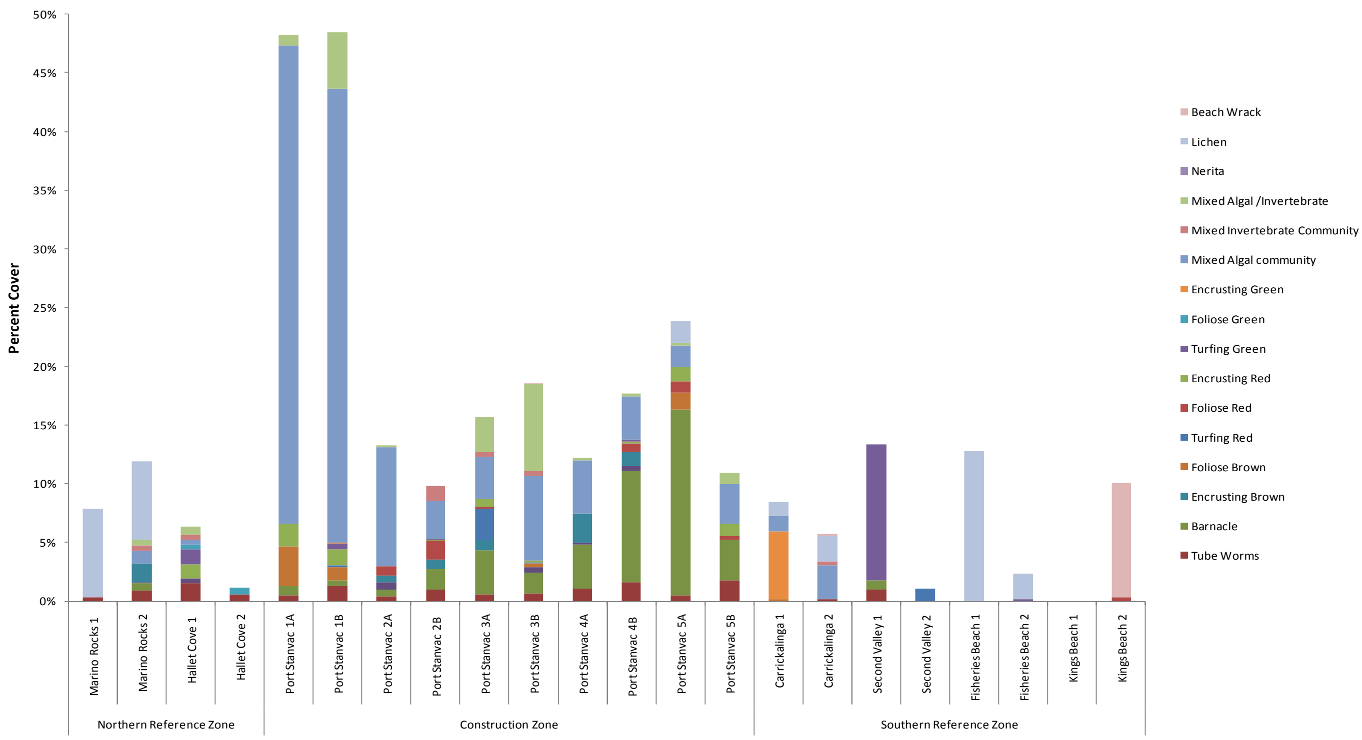


Figure 9: Mean percent cover of a) bare substrate (rock and sand) and b) sessile flora and fauna quantified from video transects at all sites; Northern Reference Zone, Impact Zone and Southern Reference Zone, during winter surveys.

Discussion and Conclusion

Intertidal monitoring of the Port Stanvac Construction Zone, and the North and South Reference Zones in autumn, revealed greater species diversity and abundances in quadrats at the most southern sites of Port Stanvac. The results of the winter survey revealed a similar trend, with species diversity and abundance being greatest within Port Stanvac sites when compared to that of the reference locations. ANOSIM analysis on the autumn dataset identified no significant difference between zones, indicating that the northern and southern zones are suitable regions to be used as controls for Port Stanvac. In comparison to this, ANOSIM analysis on the winter data revealed a significant difference between the construction and southern reference zones indicating a change to initial baseline dataset which at this stage can be explained by seasonal variation and tidal height. A further SIMPER analysis identified that the significant difference was being driven by a high presence of *A. unifasciata* in the southern zones and both *N. atramentosa* and *C. antennatus* in the construction zone.

A reason for this significant difference in the invertebrate communities at the Southern reference zone may be due to the positioning of transects which was limited by the lack of good low tides (<0.5m) in Autumn compared to Winter (Table 1). During low tides it was possible to position the transect further down the shoreline resulting in the transects ending before continuing on into the upper littoral zone. Nevertheless, due to seasonal variation in abiotic factors the reference locations should not be discounted as appropriate controls. Furthermore, the MDS ordinations show that the range in community composition is generally encompassed by the variability across all reference sites. The high level of variability between sites within Port Stanvac requires a large number of reference sites to the North and South of the construction zone.

High Shannon-Wiener values occurred within the Port Stanvac construction zone for both the autumn and winter surveys, indicating that this site is more biologically diverse than its neighbouring regions. For these sites, Simpson’s diversity value was also high indicating the presence of a dominant species. Percent cover of organisms obtained from video transects revealed that greater diversity of sessile organisms was found within Port Stanvac and the Southern Reference Zone at Carrickalinga. The high percentage of sessile organisms at Port Stanvac consisted primarily of algal and invertebrate species, while at Carrickalinga algal species were dominant. This is consistent with the relatively high barnacle abundances observed in quadrat surveys at Port Stanvac. A high proportion of bare substrate was observed at all sites and this was predominately bare rock. Very little sand deposition was recorded on the rocky reefs within the Port Stanvac area during these baseline monitoring surveys.

Overall, the autumn and winter monitoring effort has provided a dataset of species diversity and abundances, along with percent cover of organisms. The surveys initiate a baseline of ‘before construction’ data of the intertidal zone for the Port Stanvac Construction Zone as well as the North and South Reference Zones as a required environmental monitoring effort for the construction of the Adelaide Desalination Plant. Further monitoring efforts will be undertaken in the upcoming seasons (spring 2009/summer 2010) to gain data for a complete overview of seasons for a year period.

This preliminary report indicates a need for a continuation of collection of baseline data encompassing all seasons which will allow for monitoring of any abiotic or anthropogenic changes across zones.

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Appendix 1

Table 1: Species list of summed total of individuals for each location according to zone for (a) Autumn and (b) Winter 2009.

(a)

		Northern Reference Zone		Construction Zone					Southern Reference Zone			
Phylum	**Species**	**Marino**	**Hallett Cove**	**Port Stanvac 1**	**Port Stanvac 2**	**Port Stanvac 3**	**Port Stanvac 4**	**Port Stanvac 5**	**Carrickalinga**	**Second Valley**	**Fisheries Beach**	**Kings Beach**
Cnidaria	*Epiactis sp.*	0	1	0	0	0	0	0	0	0	0	0
Annelida	*Galeolaria caespitosa**	-	+	+	+	+	+	+	+	+	+	+
Mollusca	*Notoacmea flammea*	6	22	0	2	0	5	17	1	3	1	0
	Notoacmea petterdi	0	3	0	0	0	0	1	0	0	0	0
	Patelloida latistrigata	0	0	0	0	0	5	1	0	0	0	0
	Cellana tramoserica	1	2	0	0	0	2	0	4	0	2	0
	Cellana solida	0	0	0	0	0	2	5	1	7	3	0
	Nerita atramentosa	76	125	60	77	53	62	80	73	12	43	3
	Montfortula rugosa	0	1	0	0	3	4	0	0	0	0	0
	Diloma concamerata	9	45	32	24	30	8	6	2	0	16	3
	Austrocochlea rudis	0	1	0	2	0	0	0	0	0	0	0
	Austrocochlea constricta	0	18	0	2	2	0	0	0	0	8	0
	Austrocochlea porcata	7	7	1	0	1	1	1	0	0	0	1
	Herpetopoma aspersa	0	0	0	0	0	0	1	0	0	0	0
	Turbo undulatus	0	0	1	0	0	0	0	0	0	0	0
	Afrolittorina praetermissa	1	0	0	0	0	0	0	0	0	0	0
	Austrolittorina unifasciata	2	0	2	35	102	385	339	28	237	55	178
	Bembicium nanum	0	0	0	1	0	5	8	8	0	0	1
	Bembicium vittatum	19	5	3	31	21	59	11	18	9	1	0
	Neogastropoda sp.	0	0	0	0	0	0	2	0	0	0	0
	Dicathais orbita	0	0	0	0	0	0	0	0	2	0	0
	Onchidella nigricans	0	0	0	0	1	0	0	0	0	0	0
	Siphonaria diemenensis	0	10	1	17	9	2	3	1	1	0	0
	Siphonaria zelandica	0	1	0	3	1	0	3	1	0	1	0
	*Limnoperna pulex**	-	-	-	-	-	-	-	+	-	-	-
	Unidentified gastrodpod	2	2	3	8	5	1	3	5	2	2	0
Arthropoda	*Chtalamus antennatus*	0	1	4	70	98	1349	3097	237	5	10	0
	Chamaesipho tasmanica	0	0	0	0	0	62	0	0	0	0	0
	Eliminus modestus	0	0	0	0	0	6	5	0	0	0	0
	Balanus trigonus	0	0	0	0	0	0	0	2	0	0	0

*Data for *G. caespitosa* and *L. pulex* calculated to percent, therefore +/- denotes presence or absence of species at specific site

NB: Unidentified gastropod refers to organisms which could not be identified to family level due to shell erosion/encrustation etc.

(b)

		Northern Reference Zone		Construction Zone					Southern Reference Zone			
Phylum	**Species**	**Marino**	**Hallett Cove**	**Port Stanvac 1**	**Port Stanvac 2**	**Port Stanvac 3**	**Port Stanvac 4**	**Port Stanvac 5**	**Carrickalinga**	**Second Valley**	**Fisheries Beach**	**Kings Beach**
Annelida	*Eulalia* sp.	0	2	0	0	0	0	0	0	0	0	0
	*Galeolaria caespitosa**	+	+	+	+	+	+	+	-	+	-	-
Mollusca	*Notoacmea flammea*	43	18	4	21	10	3	3	0	2	0	0
	Notacmea sp.	20	14	6	2	6	8	3	0	0	0	0
	Patelloida alticostata	9	0	41	1	12	18	10	0	1	1	0
	Patelloida latistrigata	0	2	2	19	7	8	11	0	0	0	0
	Patelloida sp.	0	0	3	0	2	0	0	0	0	0	0
	Cellana tramoserica	7	3	14	10	1	6	0	0	0	0	0
	Cellana solida	20	0	19	4	4	23	16	1	0	0	0
	Nerita atramentosa	47	49	40	82	59	20	105	46	31	8	1
	Montfortula rugosa	3	1	0	0	0	0	0	0	0	0	0
	Chlorodiloma adelaidae	0	0	0	0	1	0	0	0	0	0	0
	Diloma concamerata	1	10	6	9	6	1	0	0	5	0	0
	Austrocochlea rudis	0	12	14	15	11	22	0	0	1	1	0
	Austrocochlea constricta	0	6	1	0	14	1	0	1	0	0	0
	Austrocochlea porcata	1	1	12	0	0	1	2	0	1	0	0
	Herpetopoma aspersa	0	0	1	0	0	0	0	2	0	0	0
	Phasianellidae sp.	0	0	124	0	0	0	0	0	0	0	0
	Rissoina fasciata	0	1	6	0	0	0	0	0	0	0	0
	Austrolittorina unifasciata	7	80	0	31	2	460	543	254	239	159	709
	Bembicium auratum	0	0	1	0	0	0	0	0	1	0	0
	Bembicium nanum	0	0	1	6	4	1	1	6	0	0	0
	Bembicium vittatum	29	50	31	39	48	33	23	12	21	2	0
	Onchidella nigricans	0	0	2	0	0	1	0	0	0	0	0
	Siphonaria diemenensis	7	0	130	8	22	18	7	1	0	1	0
	Siphonaria zelandica	0	0	0	1	1	0	0	0	1	0	0
	*Limnoperna pulex**	-	-	-	+	-	+	+	-	-	-	-
	Unidentified gastrodpod	3	0	16	3	2	8	10	1	3	0	2
Arthropoda	*Tetraclitella purpurascens*	0	0	0	0	5	0	157	0	0	0	0
	Chtalamus antennatus	50	0	74	455	78	970	3297	50	3	0	0
	Eliminus modestus	0	0	94	0	0	226	7	9	15	0	0
	Catomerus polymerus	3	0	0	0	0	1	0	0	0	0	0

*Data for *G. caespitosa* and *L. pulex* calculated to percent, therefore +/- denotes presence or absence of species at specific site

NB: Unidentified gastropod refers to organisms which could not be identified to family level due to shell erosion/encrustation etc.