Artificial reef and shellfish restoration project at Ardrossan

Final report for assessment of soft sediment benthic fauna

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Project background

Prior to the establishment of shellfish reefs, background data were obtained for benthic fauna and sediment properties. During May 2017 investigations were undertaken of the unvegetated sediments of a planned artificial reef location at Rogues Point, Ardrossan, in Gulf St. Vincent. Various works including assessment of bare soft sediments were part of the pre-planning before installation of the artificial reef structure which commenced in June/July 2017. This report provides findings from the first assessment of soft sediment macrofauna and sediment characteristics throughout the designated location for the artificial reef. Description of further field sampling of an adjacent southern control site is also presented, but the laboratory processing and discussion of this control site are subject to further funding and not included in this report. The assessment of soft sediments of the artificial reef location in this report includes macroinvertebrate species counts, sediment grain size and organic matter content of sediments.

Methods for field sampling and sample processing

Sampling of sediments for benthic fauna was undertaken at the proposed artificial reef location at Rogues Point, Ardrossan on 19th May 2017 (Table 1a) from the Flinders University boat "Tethys". Further sampling was also undertaken at a control location south of the proposed artificial reef location (Table 1b). Ten box corer samples (Wildco®, model: 191-A12, internal dimensions: 0.15 x 0.15 x 0.23 m, total weight: 30 kg) were haphazardly taken at the artificial reef and control locations (n = 20) surrounding the pre-determined baited remote underwater video (BRUV) sites as required by TNC. Sediment samples were obtained from depths between eight to ten metres across the artificial reef and control locations. Sediment samples were placed into a plastic container on the deck of the boat so that sub-samples could be obtained for sediment grain size (7-10 cm^3) and organic matter (9.12 cm^3), with the remaining sample rinsed through 500 µm mesh and preserved with ethanol (70 % concentration) for macrobenthic invertebrate assessment before being transported to Flinders University laboratories for processing.

Macrobenthic invertebrate samples were sorted in the laboratory to the finest taxonomic level possible and as morphospecies with consistencies checked by key criteria, before counts of each taxa were undertaken. All macroinvertebrates were kept in vials of 70 % ethanol in the laboratory as a reference collection.

Organic matter was assessed as % dry weight (d.w.), with sediment samples dried to constant weight using an Ohaus MB45 Moisture Balance. Sediment samples were homogenously distributed onto aluminium cups and dried using the standard drying protocol (controlling the temperature profile at 80ºC). The profile burn was automatically completed after all moisture content was dried and remained stabilised for 30 seconds. Samples were then burnt in a muffle furnace at 450ºC for 5 hrs. Organic matter is the weight loss after burning expressed as percent content within sediments.

Sediment grain size samples were thawed and macroinvertebrates were sorted and collected from the sediment and added to the rest of the matching macroinvertebrate samples. As marine sediment can contain particles of oblong shape with one dimension >2 mm, coarser particles have to be separated to avoid blockage of the laser grain size analyser. Sediments were thus wet sieved through 1 and 2 mm mesh sizes and the weights of the entire sample and the fractions > 1 mm and > 2 mm were recorded from weighing on an analytical balance (to 4 decimal places).

A representative homogenous sub-sample was taken from each sample to be measured using laser diffraction. Samples were run through a Malvern Mastersizer 2000 to analyse sand granulometry. Sediment data were then processed through a data analysis programme (Gradistat) to determine median grain size and sand sorting, and categorized according to the parameters of 'geometric method of moments' (Blott & Pye (2001).

Data analyses

Sediment and organic matter data were untransformed and analysed with one-way ANOVA of the site factor (Origin Pro 2015). The experimental design of Site as a fixed factor was used to test for differences between fourth root transformed data of benthic infauna which were analysed with univariate PERMANOVA based on Euclidean distances (PRIMER, PERMANOVA+ V7). Benthic infauna communities were visualised with non-metric multidimensional scaling (nMDS) and also analysed with SIMPROF tests on fourth root transformed data that were based on a Bray Curtis Similarity matrix.

Table 1. GPS positions and water depths for the ten sediment samples obtained at the (a) proposed artificial reef and (b) southern control locations at Rogues Point, Ardrossan during May 2017.

(a)

TNC site reference	TNC Waypoint reference	Flinders University replicate reference	Easting	Northing	Depth (m)
Impact 1	1177	AR1	137°54.071	34°30.439	9.4
		AR2	137°54.066	34°30.451	9.5
		AR3	137°54.096	34°30.438	9.6
Impact 2	1178	AR4	137°54.008	34°30.545	9.9
		AR5	137°53.983	34°30.544	9.7
		AR6	137°53.963	34°30.521	9.3
		AR7	137°53.944	34°30.572	9.6
Impact 3	1182	AR8	137°53.849	34°30.676	9.0
		AR9	137°53.904	34°30.685	9.6
		AR10	137°53.878	34°30.655	9.4

(b)

TNC site reference	TNC Waypoint reference	Flinders University replicate reference	Easting	Northing	Depth (m)
ContSth5	1180	SC1	137°54.054	34°32.108	8.7
		SC2	137°54.019	34°32.139	8.7
		SC3	137°54.012	34°32.112	8.6
ContSth6	1181	SC4	137°54.124	34°32.247	8.4
		SC5	137°54.151	34°32.314	8.7
ContSth7	1185	SC6	137°54.278	34°32.393	8.9
		SC7	137°54.227	34°32.422	8.7
		SC8	137°54.275	34°32.460	8.6
ContSth8	1184	SC9	137°54.433	34°32.564	8.7
		SC10	137°54.577	34°32.602	8.8

Results

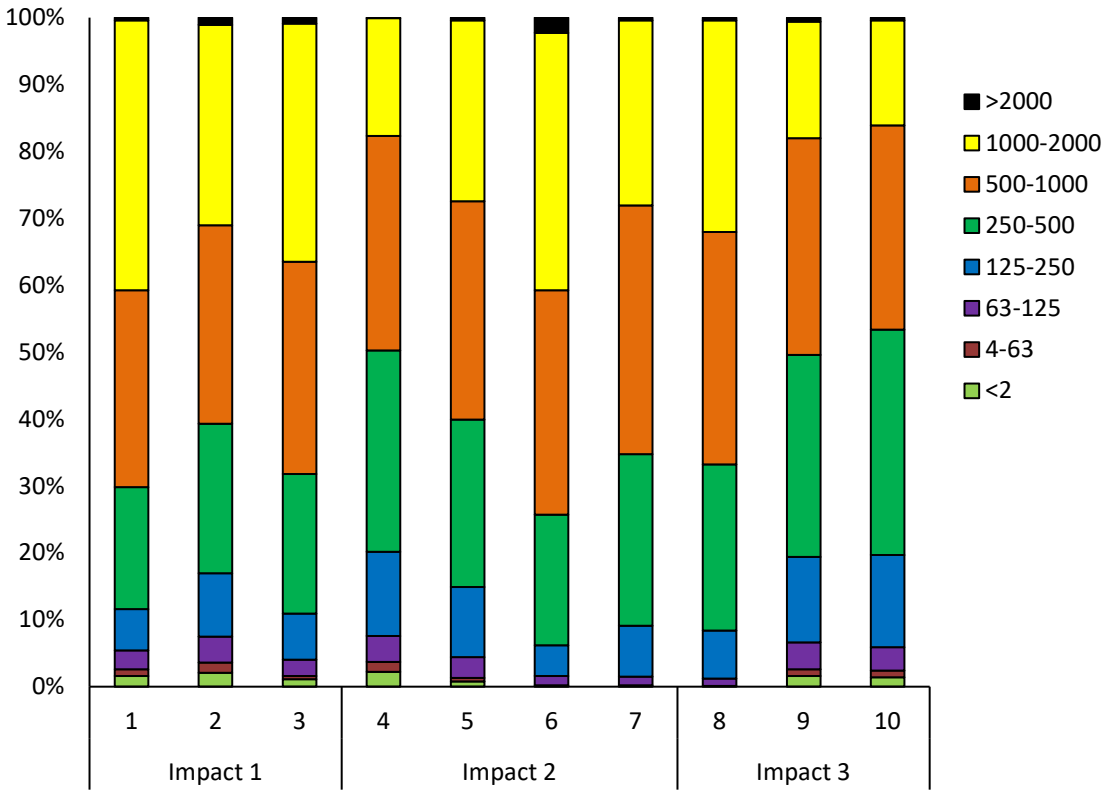
Sediments

Sediments from the three impact sites were all classed as coarse sands and poorly sorted, and similar across all of the sites (One-Way ANOVA, $P > 0.05$). Sediments contained on average, coarser sand and more clay in the north (Impact 1) while smaller sized sediment grain sizes were found at the southern site (Impact 3) (Table 2, Figure 1). Sediments in preliminary sampling at Rogues Point in October 2016 ranged from medium to very coarse sand across four replicate samples with some presence of clay in samples giving some indication of the variability of benthic sediments through time in this region (Figure 1, Dittmann et al. 2016). Two of the sediment samples taken in October 2016 (samples 3 and 4) were more similar in grains size distribution to the May 2017 sediment samples (Figure 1). Organic matter was not significantly different between the sites in May 2017 (One-Way ANOVA, $P > 0.05$) and moderately high with 3.5% mean dry weight across all sites (Table 2).

Table 2. Average organic matter (percent of dry weight ± standard deviation SD), median grain size, sorting coefficient, and sediment descriptions according to Blott & Pye (2001) using geometric methods of moments for each of the three sites sampled in May 2017.

Site	Organic Matter (% DW)	Grain size (μm)	Grain size description	Sorting	Sorting description
Impact 1	2.88 ± 0.44	729.44	Coarse sand	3.78	Poorly sorted
Impact 2	4.74 ± 4.72	651.57	Coarse sand	2.89	Poorly sorted
Impact 3	2.60 ± 0.51	556.09	Coarse sand	3.02	Poorly sorted

(a) May 2017



(b) October 2016

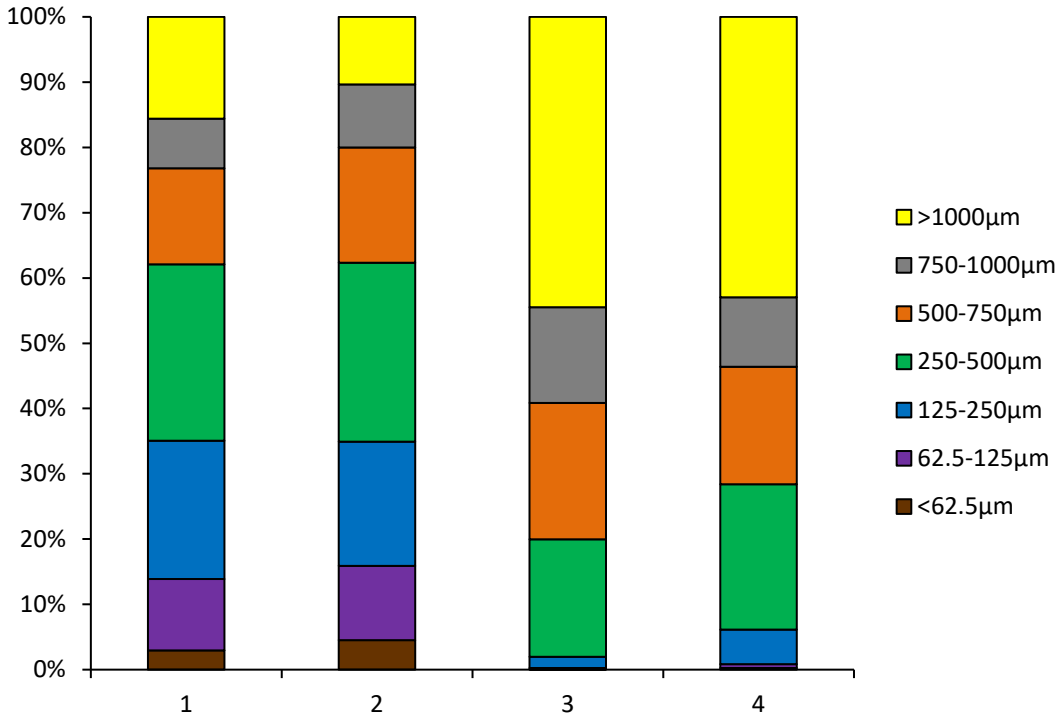


Figure 1. Mean percentage composition values of sediment grain sizes for (a) positions 1-10 for each of the three Impact sites in May 2017 and (b) for positions 1-4 from sampling in October 2016.

Macroinvertebrates

The total number of taxa found across the three Reef Impact Sites was 95 from eight phyla (see Appendix 1). Species numbers were similar across all three of the sites in the May 2017 survey (Fig. 2). The most commonly found phyla at all three sites were annelids, arthropods and molluscs, representing more than 90% of taxa found (Figure 1). Species diversity and evenness of species distribution were also similar across the three sites (Table 3). Notable species found at the artificial reef location were; Nephtyidae polychaetes, crustaceans in the Tanaidae family and Gammaridea order, molluscs in the Veneridae, and Mactridae families and the introduced Asian mussel *Arcuatula senhousia* (i.e. particularly at Impact 1 and 3 sites) (Appendix 1). The Asian mussel *A. senhousia* has also been found in recent surveys conducted close to the metropolitan Adelaide coastline (Dittmann et al. 2017).

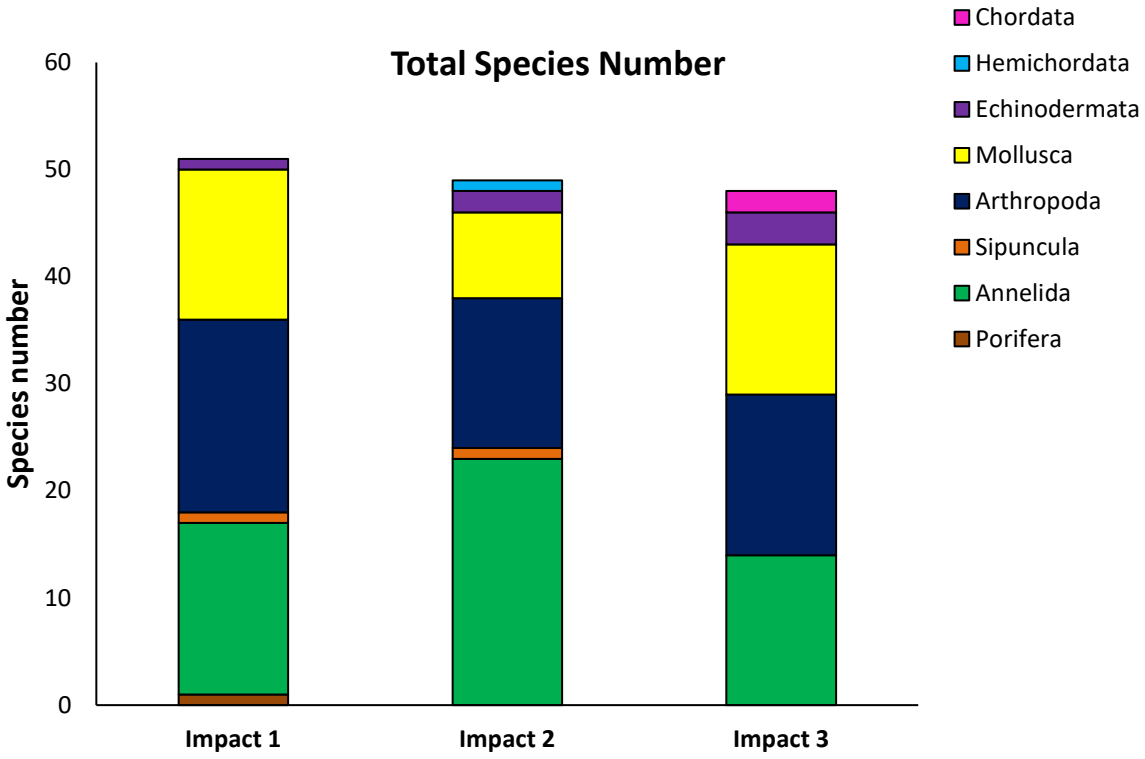


Figure 2: Total species number per phyla (x-axis) for the three sites at the Ardrossan artificial reef site.

Table 3: Species diversity indices (Shannon-Wiener & Simpsons) and evenness of species distribution (Pielou's) for infauna at all three sites in May 2017.

Site	Species number	Pielou's evenness	Shannon Wiener	Simpsons
Impact 1	51	0.79	3.11	0.90
Impact 2	49	0.74	2.89	0.85
Impact 3	48	0.76	2.95	0.88

The abundances of benthic invertebrates as catch per unit effort (CPUE) varied according to Phyla. Annelid and arthropod abundances were similar across the three sites and more variable at the southern site (Annelida *P* = >0.05, Pseudo-F 0.06[2, 7]; Arthropoda *P* = >0.05, Pseudo-F 0.07[2, 7]; Figure 2). Mollusc abundances were similar across all sites and more variable at the Impact 1 site (*P* = >0.05, Pseudo-F 0.84[2, 7], Figure 2). Total abundances of all benthic infauna were similar across the three sites and more variable at the Impact 3 site (*P* = >0.05, Pseudo-F 0.33[2, 7], Figure 2).

Community structure at the three sites were similar to each other with the Impact 3 site having a slight separation in community structure (Figure 3), although a SIMPROF test showed this not to be significantly different from the other two sites (SIMPROF >0.05).

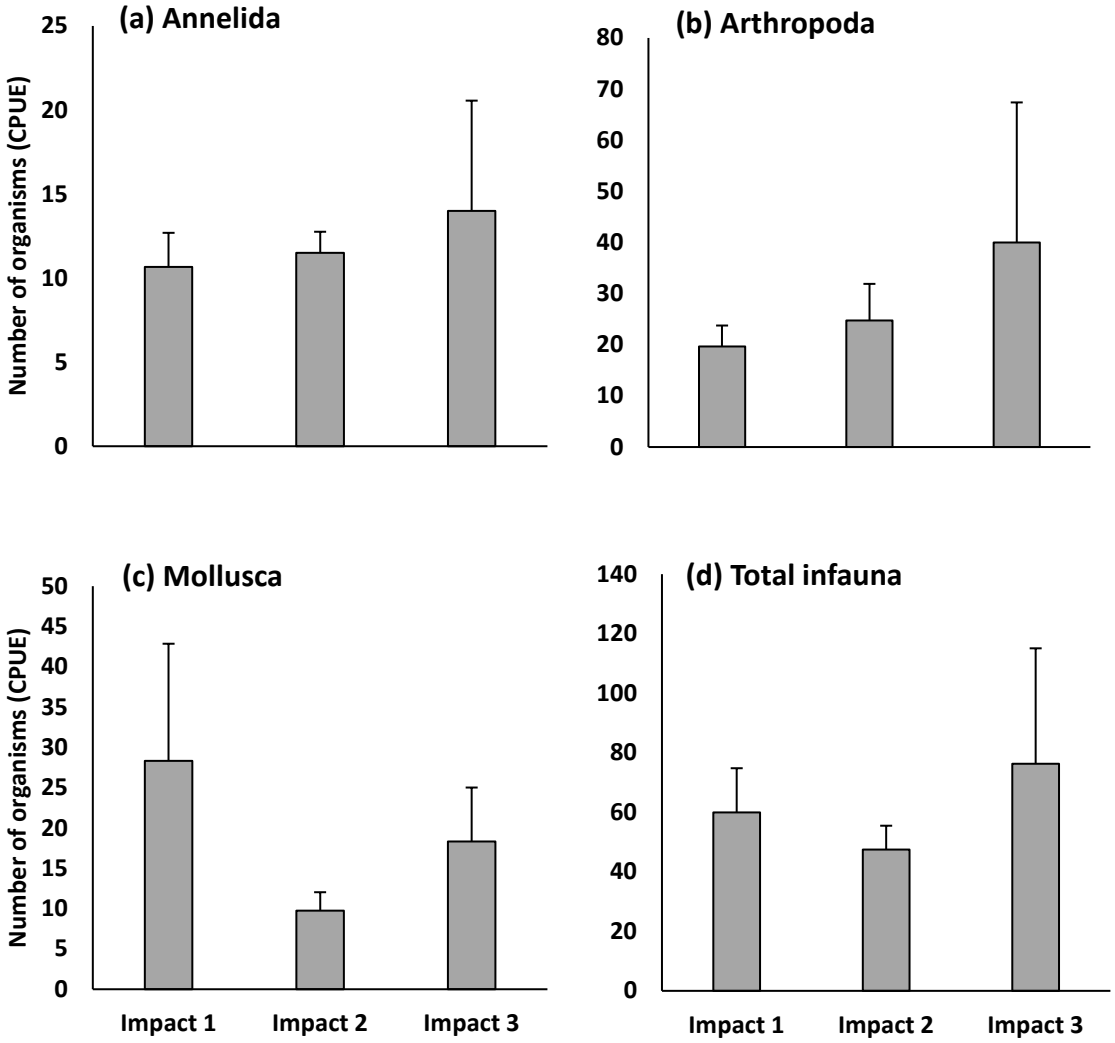


Figure 2: Mean abundance as catch per unit effort (CPUE) of macroinvertebrates for (a) Annelida, (b) Arthropoda, (c) Mollusca, and (d) total infauna for all three sites at the Ardrossan artificial reef location.

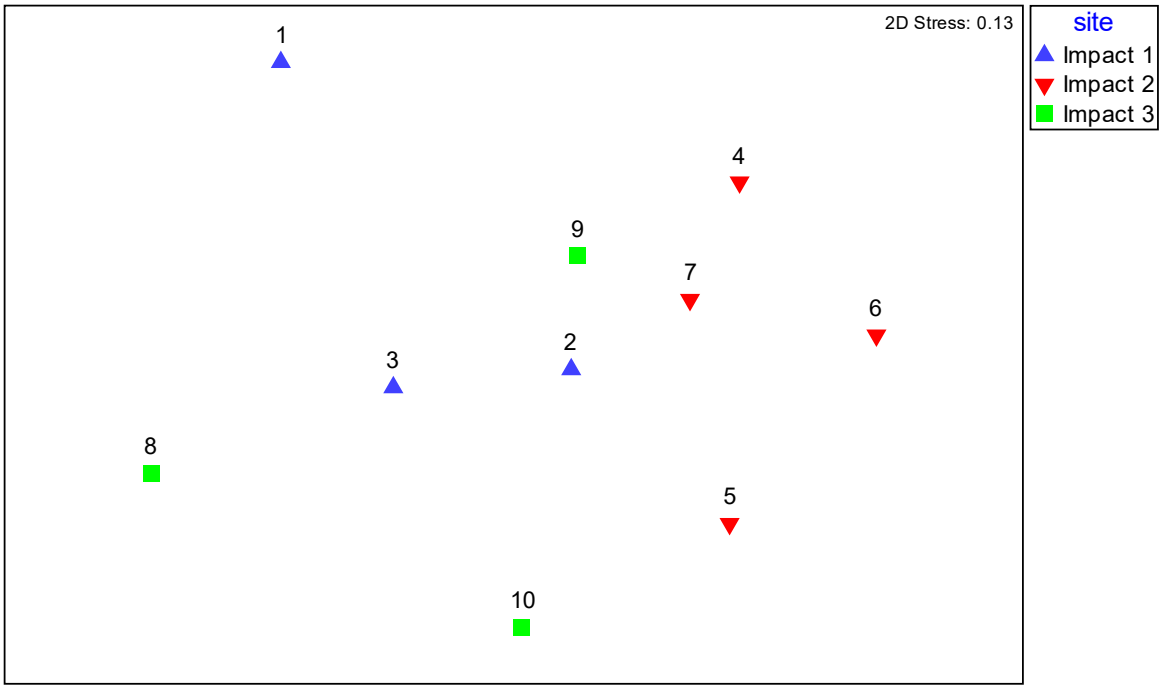


Figure 3: Multidimensional scaling (MDS) of macroinvertebrate communities (fourth root transformed using Bray-Curtis similarities) at all three Ardrossan artificial reef sites.

Discussion

The assessment of benthic macroinvertebrates, sediment condition and organic matter within sediments is provided as a baseline in this report for the Rogues Point, Ardrossan artificial reef location before deployment of reef structures in mid-2017. Overall, the sediment grain sizes were mainly coarse sands and compared to previous sampling in October 2016, variable through time. The macroinvertebrates found in the baseline survey in May 2017 had similar types of species and species abundances to previous sampling in other projects undertaken in Gulf St Vincent (Loo and Drabsch 2008; Ramsdale et al. 2011).

Currently, samples from the southern control location adjacent to the artificial reef location are being held at Flinders University for later analysis of benthic macrofauna, sediment and organic matter when further funding becomes available. It is recommended that those samples are processed in the near future in order to obtain a control baseline dataset that will match the data within this report for more detailed analyses and reporting of results. Benthic assessments associated with instalment of artificial reefs have been undertaken elsewhere in the world to detect if they function in a similar way to a natural reef habitat (Barros et al. 2001; Fabi et al. 2002; Fukunaga and Bailey-Brock 2008, Guoshan et al. 2017). We also recommend that consideration should be given for future benthic condition assessments and more detailed investigation of benthic functioning at various stages over the time of the project to establish a better understanding of the habitat functioning and effects of the artificial reef on adjacent benthic fauna.

Acknowledgements

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Appendix 1: List of all taxa identified from three sites at the proposed artificial shellfish reef site, Rogues Point, Ardrossan in May 2017.

Phylum	Class/Order	Taxa
Porifera	Calcarea	Calcarea sp. 1
Annelida	Hirudinea	Hirudinea sp. 1
	Oligochaeta	Oligochaete sp. 1
	Polychaeta	Capitellidae sp. 1
		Cirratulidae sp. 1
		Dorvilleidae sp. 1
		Dorvilleidae sp. 2
		Eunicidae sp. 1
		Glyceridae sp. 1
		Glyceridae sp. 2
		Glyceridae sp. 3
		Lumbrineridae sp. 1
		Maldanidae sp. 1
		Nephtyidae sp. 1
		Nephtyidae sp. 2
		Nephtyidae sp. 3
		Nephtyidae sp. 4
		Nereididae sp. 1
		Opheliidae sp. 1
		Oweniidae sp. 1
		Oweniidae sp. 2
		Phyllodocidae sp. 1
		Polynoidae sp. 1
		Sabellidae sp. 1
		Scalibregmatidae sp.1
		Sphaerodoridae sp. 1
		Spionidae sp. 1
		Spionidae sp. 2
		Spionidae sp. 3
		Syllidae sp. 1
		Terebellidae sp. 1
		Terebellidae sp. 2
		Terebellidae sp. 3
		Unknown Polychaete sp. 1
Sipuncula	Sipuncula	Sipuncula sp. 1
		Sipuncula sp. 2
Arthropoda	Amphipoda	Ampeliscidae sp. 1
		Caprellidae sp. 1
		Caprellidae sp. 2
		Dexaminidae sp. 1
		Gammaridea sp. 1
		Gammaridea sp. 2

		Gammaridea sp. 3
		Gammaridea sp. 4
		Gammaridea sp. 5
		Lysianassidae sp. 1
		Lysianassidae sp. 2
	Decapoda	Caridea sp. 1
		Halocarcinus ovatus
		Halocarcinus rostratus
		Lophopagurus nanus
	Isopoda	Anthuridea sp. 1
		Cirolana cranchii australiense
	Leptostraca	*Nebalia sp. 1*
		Nebalia sp. 2
		Nebalia sp. 3
	Ostracoda	Ostracoda sp. 1
		Ostracoda sp. 2
		Ostracoda sp. 3
		Ostracoda sp. 4
		Ostracoda sp. 5
		Ostracoda sp. 6
		Ostracoda sp. 7
		Ostracoda sp. 8
	Tanaidacea	Tanaidacea sp. 1
		Tanaidacea sp. 2
		Tanaidacea sp. 3
		Tanaidacea sp. 4
Mollusca	Bivalvia	*Arcuatula senhousia*
		Clavagellidae sp. 1
		Electroma georgiana
		Limaria orientalis
		Mactridae sp.1
		Mesodesmatidae sp. 1
		Mytilidae sp. 1
		Semalangulus tenuilirata
		Tellina sp. 1
		Thraciidae sp. 1
		Veneridae sp. 1
		Veneridae sp. 2
		Veneridae sp. 3
	Gastropoda	Diodora sp. 1
		Emarginula gabensis
		Eulima lodderae
		Reticunassa paupera
		Naticidae sp. 1
		Rissoidae sp.1
		Trochidae sp. 1

	Scaphopoda	Scaphopoda sp. 1
Echinodermata	Asteroidea	Asteroidea sp. 1
		Ophiacantha sp. 1
	Holothuroidea	Holothuroidea sp. 1
Hemichordata		Hemichordata sp. 1
Chordata	Ascidiacea	Ascidiacea sp. 1
		Holozoidae sp. 1