FINAL REPORT

Runswick Bay artificial rock pool monitoring: 2018 results

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EXECUTIVE SUMMARY

The purpose of this project is to assess the success of artificial rock pools as ecological enhancement interventions, which have been incorporated into the new coastal defence scheme at Runswick Bay, North Yorkshire in summer 2018.

During construction of the new rock armour defence at Runswick Bay, 70 saw cut artificial rock pools were installed on the granite boulders. This report details the findings from the first field survey which was conducted during August 2018. The survey compared the species richness, total abundance and species diversity of fauna and flora found both inside the artificial rock pools and on the adjacent granite rock faces. In addition, water parameters including water temperature, pH and salinity were collected to ascertain any variation between the water in the pools compared to the sea.

The survey found that all 70 artificial rock pools were retaining water effectively, with the depth of water varying between 5 cm and 19 cm. The water temperature, pH and conductivity did not differ significantly between the pools and the seawater; however, the salinity was found to be lower in the rock pools.

This study has shown that the construction of artificial rock pools on the granite rock armour has increased the species richness compared to the un-manipulated areas of the boulders. Ten species were observed in the rock pools which were absent from the adjacent rock surfaces, showing that the provision of water-retaining features and increased surface heterogeneity has enabled species to survive on the rock armour when the tide goes out. The majority of these new species were mobile fauna, including crabs and fish, and a high proportion of them were small juveniles.

These artificial rock pools will continue to be monitored over the next two years in order to observe community succession and development over time.

CONTENTS

1. INTRODUCTION

The Runswick Bay Coastal Protection Scheme was constructed in 2018 and included repairs to the existing concrete seawall and the placement of 9,500 tonnes of granite rock armour to protect 250 m of seawall frontage. Runswick Bay was designated a Marine Conservation Zone (MCZ) (Marine and Coastal Access Act 2009) in 2016 for low energy intertidal rock, moderate energy intertidal rock, high energy intertidal rock and intertidal sand and muddy sand biotopes. To limit the damage potentially caused to the protected features of the MCZ by the construction of the new sea defence, various measures were put in place, including designated access routes for machinery, protection of existing colonised boulders and ecological enhancement techniques. The ecological enhancement techniques which were incorporated into the new coastal defence scheme at Runswick Bay included the construction of 70 artificial rock pools which were saw-cut into the boulders.

Artificial structures typically lack optimal habitats for intertidal species due to the absence of habitat heterogeneity and water retaining features. On natural rocky shores, rock pools provide intertidal organisms with a refuge from biotic and abiotic stresses such as predation and desiccation (Little *et al*. 2009, Firth *et al*. 2014, White *et al*. 2014).

Ecological enhancement integrates ecology and engineering to create multifunctional structures which provide both protection from coastal erosion and also a suitable habitat for intertidal organisms (ITRC 2004, Hall *et al*. 2018). Previous ecological enhancement studies have shown that water retaining features and habitat heterogeneity are important to promote biodiversity on artificial structures (Firth *et al*. 2013, Browne and Chapman 2014, Evans *et al*. 2015). Existing trials at Runswick Bay have shown how increased habitat heterogeneity can lead to increased species richness and diversity on granite boulders (Hall *et al*. 2018).

The aim of this survey it to determine if the artificial rock pools have increased species richness, total abundance and species diversity compared to the control rock faces in the first 3 months since installation.

2. METHODS

2.1 Site description

Runswick Bay is a moderately exposed sandy shore with large shale bedrock platforms. It has an easterly prevailing wind direction and the tidal range is 5.6 m during spring tides and 4.2 m during neap tides. The new rock armour was placed on top of the shale bedrock at the foot of the seawall (Figure 2.1). Existing boulders were moved during construction and replaced in front of the granite rock armour to test if "seeding" would increase colonisation rates.

Figure 2.1. Location of new granite rock armour at the foot of the seawall, note the green (colonised) natural boulders which have been placed in front of the granite rock (August 2018).

2.2 Installation of artificial rock pools

The 70 artificial rock pools were installed using a circular saw and breaker. The circular saw was used to make two sets of parallel cuts which were perpendicular to each other to form a cross shape. A breaker was then used to break up the cuts and form pools of approximately 300 mm diameter and 150 mm depth (Figure 2.2).

Figure 2.2. Examples of saw cut artificial rock pools roughly 300 mm diameter x 150 mm deep.

2.3 Survey protocol

Surveys were conducted between 13th and 15th August 2018 by Dr Sue Hull and Dr Alice Hall.

The abundance of fauna and flora were recorded in-situ inside the rock pools and compared to the adjacent rock face to determine if the artificial rock pools had a positive effect on increasing biodiversity on the rock armour.

The percentage cover of algae and count data for barnacles and mobile species such as fish and crabs were recorded to measure species abundance. All organisms were identified to the lowest taxonomic resolution possible. Photographs of all rock pool and control areas were taken to illustrate changes in assemblages over time. Water parameters, including temperature, pH and salinity were recorded inside the rock pools and compared to a sample of seawater. In addition, measurements of rock pool width and depth were also obtained to determine physical rock pool characteristics.

3. RESULTS

3.1 Artificial rock pool characteristics

Of the 70 artificial rock pools, 26 were located within the splash zone, three at the splash/upper height (MHWN), 38 at the upper tidal height (MHW) and one at the exteme upper tidal height (MHWS) (Table A1). Rock pool diameter ranged between 36 cm and 56 cm and water depth ranged from 5 cm to 19 cm (Figure 3.1, Appendix A, Table A.1).

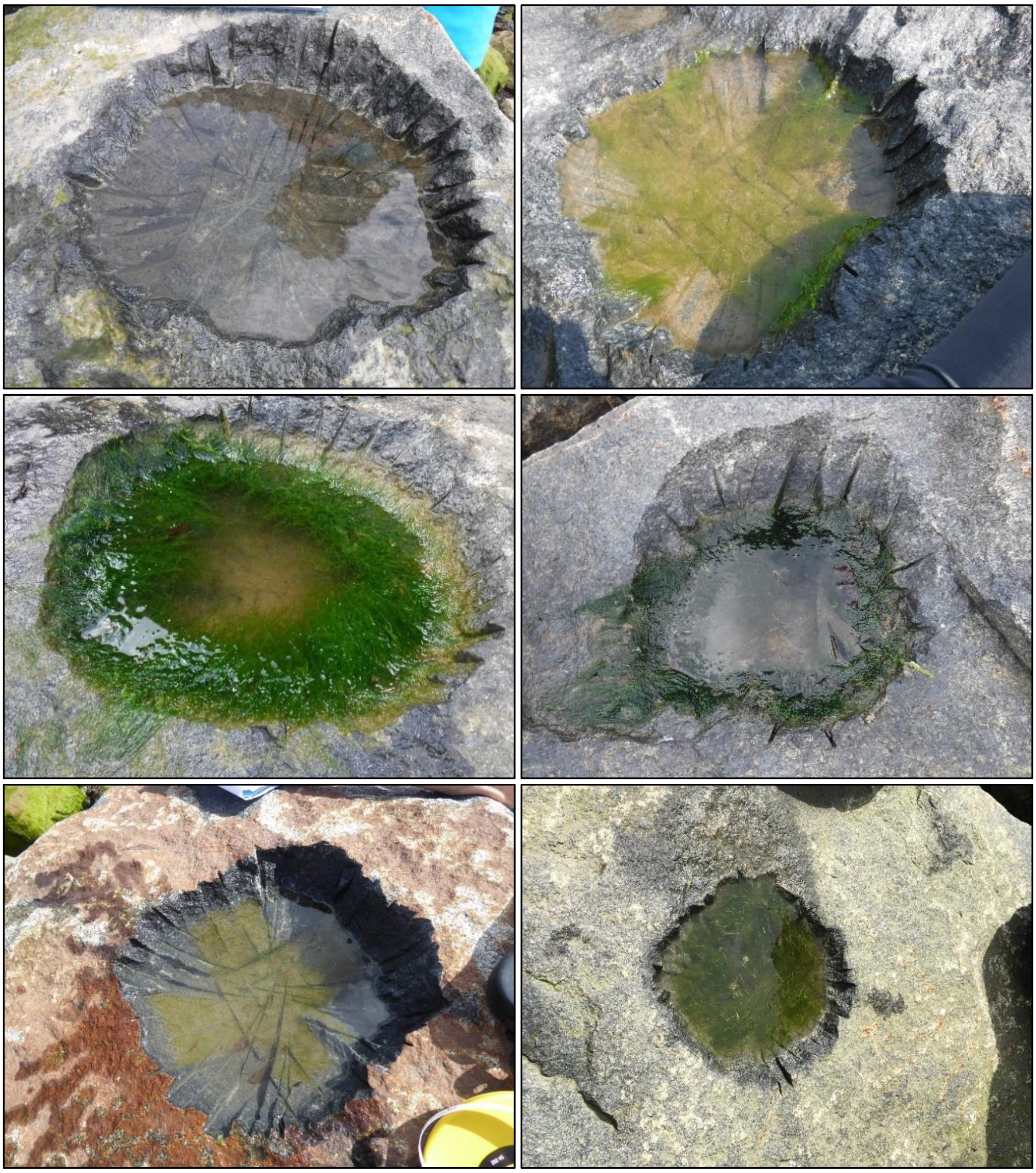

Figure 3.1. A selection of artificial rock pools cut into the granite rock armour at Runswick Bay.

3.2 Community assemblages

A total of thirteen species were record within the artificial rock pools and only three species were recorded on the adjacent control rock faces. Nine of the additional species present within the rock pools were mobile species, including the intertidal fish Shanny (*Lipophrys pholis*), two intertidal crabs (*Carcinus maenas*, *Necora puber*) and two intertidal snail species (*Littorina littorea, Littorina obtusata*) (Figure 3.2). Results indicate that the artificial rock pools supported significantly greater species richness, species diversity and total abundance than the adjacent rock face controls (Figure 3.3, Table 3.1).

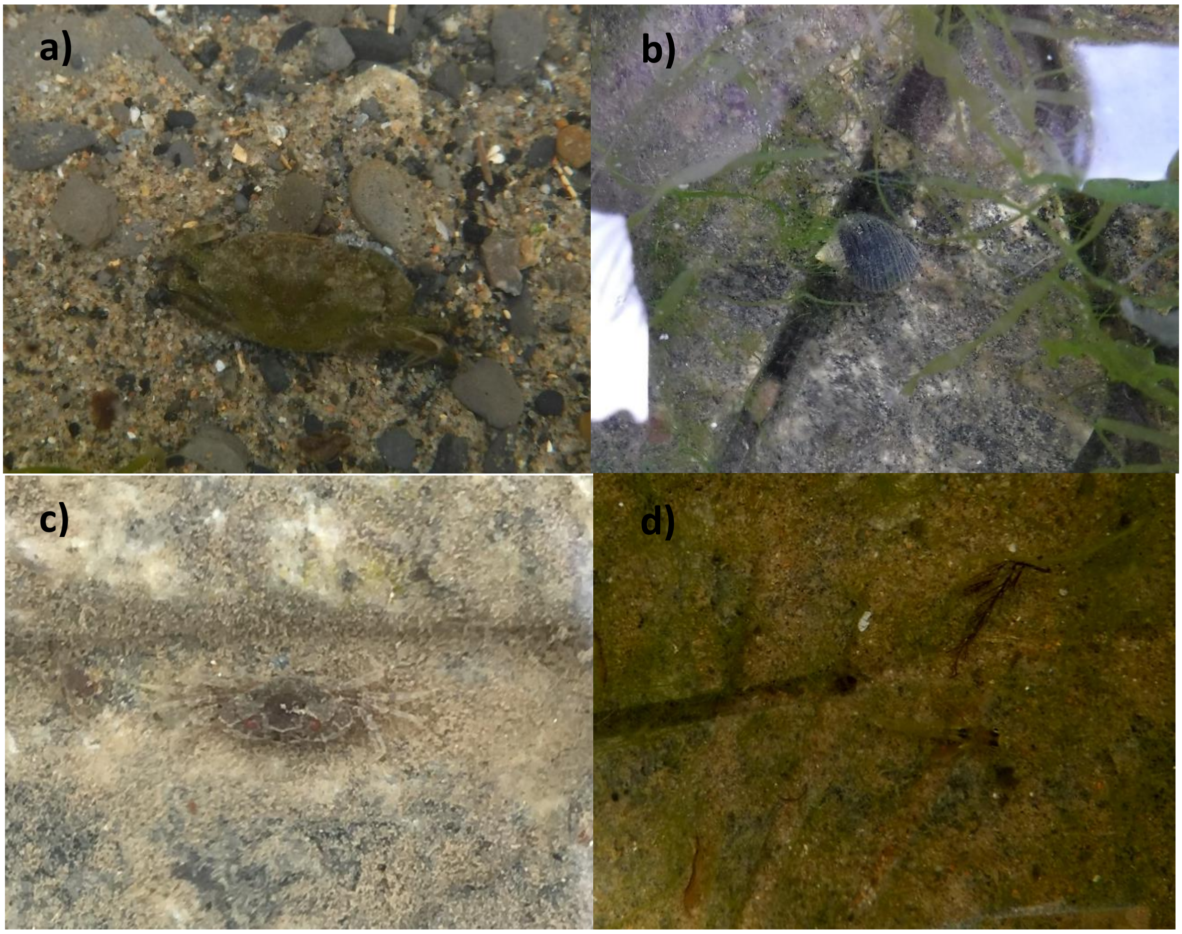

Figure 3.2. a) Green shore crab (Carcinus maenas), b) Edible periwinkle (Littorina littorea), c) juvenile Green shore crab (Carcinus maenas), d) Shanny (*Lipophrys pholis).*

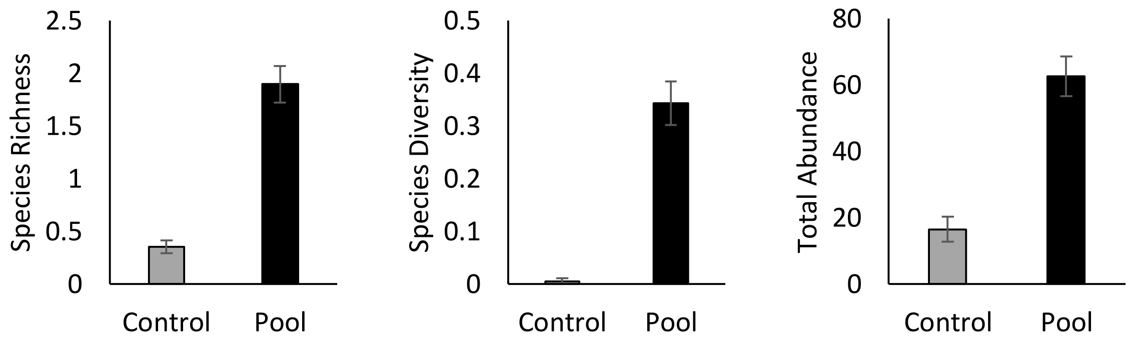

Figure 3.3. Mean species richness, species diversity (Shannon Wiener) and total abundance of flora and fauna found in the controls and rock pools after 3 months (+/- SE).

Table 3.1. Analysis of variance (ANOVA) results for comparison of species richness, species diversity and total abundance between pools (artificial rock pools) and control (adjacent rock face) * = highly significant.**

	Species Richness			Species Diversity			Total Abundance		
	df	*f*	*p*	*df*	*f*	*p*	*df*	*f*	*p*
Pool/Control	1	70.50	<0.001 ***	1	62.94	<0.001 ***	1	42.07	<0.001 ***

The multidimensional scaling plot (MDS) in Figure 3.4 illustrates the distinct separation in communities between artificial rock pools and the control rock face. Each individual triangular symbol represents a sample rock pool, the closer together the points the more similar the communities are. The similarity percentage analysis (SIMPER) found that 99.44 % of the overall 99.48 % dissimilarity between communities found in pools and controls was attributed to seven taxa; Brown filamentous algae, *Ulva* sp., unidentified green algae, green filamentous algae, *Carcinus maenas*, Amphipoda and *Liophrys pholis*. Table 3.2illustrates the species abundance in the artificial rock pools compared to the control rock face.

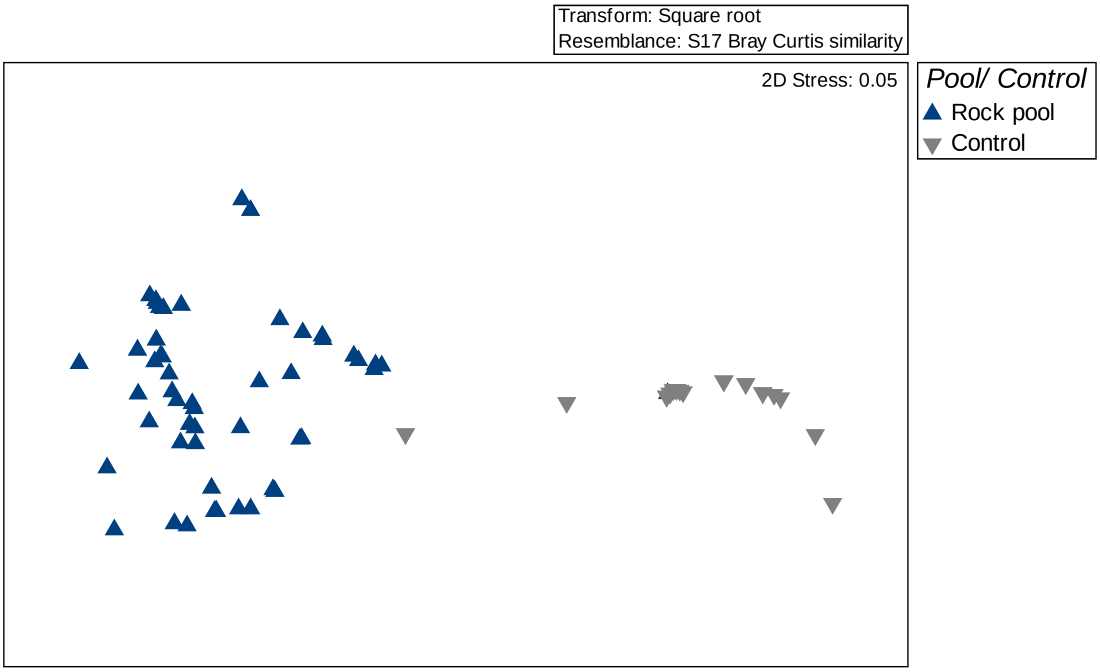

Figure 3.4. Multidimensional scaling plot of the samples in the rock pools and control areas on the rock armour (August 2018)

Table 3.2. SIMPER analysis on community similarity between artificial rock pools and adjacent control rock faces on the granite rock armour in August 2018.

Species	Pool Average Abundance	Control Average Abundance	Average. Dissimilarity	Dissimilarity /SD	Contribution %
Brown filamentous algae	23.65	0	30.66	0.86	30.82
Ulva sp.	21.4	0	25.61	0.78	25.75
Unidentified green algae	1.32	16.13	19.82	0.6	19.92
Green filamentous algae	14.51	0.44	16.69	0.55	16.78
Carcinus maenas	1.46	0	3.87	0.35	3.89
Amphipod	0.01	0	1.17	0.11	1.18
Lipophrys pholis	0.26	0	1.09	0.19	1.1
Ligia oceanica	0	0.01	0.4	0.07	0.4
Palaemon sp.	0.04	0	0.06	0.18	0.06
Necora puber	0.03	0	0.04	0.18	0.04
Littorina littorea	0.03	0	0.04	0.16	0.04
Littorina obtusata	0.01	0	0.01	0.13	0.01
Annelidia	0.01	0	0.01	0.13	0.01

3.3 Water parameters

There were no significant differences in temperature, pH and conductivity between the artificial rock pools and the seawater. There was a significant difference in salinity between groups, with the rock pools having a slightly lower salinity compared to the seawater (Figure 3.5).

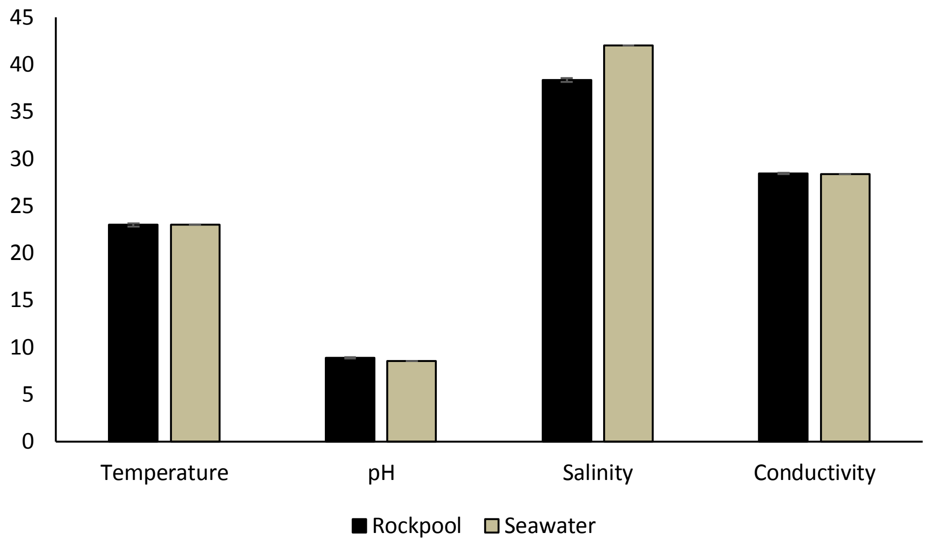

Figure 3.5. Comparison of water temperature, pH, salinity and conductivity between artificial rock pools and seawater (+/- S.E).

4. DISCUSSION

The water retention and increased habitat heterogeneity created by the saw cut artificial rock pools on the granite boulders at Runswick Bay has provided habitat for intertidal organisms to survive on the rock armour where otherwise they would be absent. The rock pools have increased the species richness, species diversity and total abundance of the granite boulders compared to an un-manipulated control area. All 70 artificial rock pools retained water effectively at low tide and provided areas of increased surface texture, cracks and crevices which is more characteristic of natural shores, supporting previous studies (Metaxas and Scheibling 1993, White *et al*. 2014).

Water retention is a vital feature on a natural rocky shore; it creates protection from desiccation and predation during periods of low water (Firth *et al*., 2013; White *et al*., 2014). Natural rock pools are known to extend the distribution of intertidal species and mobile fauna such as intertidal fish, which are known to use rock pools as important habitats (Bennett and Griffiths, 1984; Zander *et al*., 1999). Evidence has found that more complex rock pools with ledges and algal cover resulted in higher abundances and diversity of intertidal fish (White *et al*. 2014). This study supports this evidence, as multiple fish, crabs, prawns, gastropods were recorded utilising the rock pools and not the adjacent rock faces. In addition, the high proportion of juvenile mobile fauna including green shore crabs (*Carcinus maenas)*, velvet swimming crab (*Necora puber)* and shanny (*Lipophrys pholis*) demonstrate that the rock pools are providing a vital refuge for vulnerable species that are highly susceptible to predation and dislodgement. The deep fissures created by the saw blades have created an ideal refuge habitat for smaller organisms, including a variety of sized microhabitats which can be used by a diverse range of species. Ten additional taxa have been attracted to this novel habitat created on the rock armour; a habitat which is more representative of the natural shore which was found previously.

As Runswick Bay was designated an MCZ for its low energy, moderate energy and high energy intertidal rock with the conservation objectives to "maintain in favourable condition" (DEFRA 2016), these ecological enhancement measures were taken to prevent damage to the site. Additional research will be conducted into the long term success of the defence structure as a habitat for intertidal organisms.

Incorporating the artificial rock pools into the granite rock armour appears to have been successful to date; although, it should be noted that these surveys were conducted only two months post-installation. Continued monitoring of ecological community development will be undertaken using the same methodology in 2019 and 2020 to assess the longer-term success of this ecological enhancement technique.

5. REFERENCES

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Appendix A – Artificial rock pool parameters

Table A.1. Artificial rock pool location, tidal height, diameter (cm) and depth (cm).

Pool number	OS Grid Reference	Tidal Height	Rock pool Diameter (cm)	Water Depth (cm)
P1	NZ81120 16194	Upper	50	12
P2	NZ81118 16192	Splash	40	11
P3	NZ81116 16190	Splash	44	9
P4	NZ81116 16189	Splash	45	11.5
P5	NZ81119 16189	Splash	42	14
P6	NZ81119 16190	Splash/Upper	46	10
P7	NZ81120 16181	Splash/Upper	39	8.5
P8	NZ81119 16181	Upper	42	9
P9	NZ81117 16175	Splash	45	9
P10	NZ81117 16173	Upper	50	9
P11	NZ81117 16172	Extreme splash	43	12
P12	NZ81117 16170	Upper	49	13
P13	NZ81117 16165	Upper	50	8
P14	NZ81116 16164	Upper	56	11
P15	NZ81115 16157	Splash	42	12
P16	NZ81115 16157	Splash	43	12
P17	NZ81109 16152	Splash	48	13
P18	NZ81106 16150	Splash	45	11
P19	NZ81109 16144	Upper	47	11
P20	NZ81105 16149	Splash/upper	44	10
P21	NZ81103 16144	Splash	45	8
P22	NZ81101 16143	Splash	45	10
P23	NZ81096 16141	Upper	49	7
P24	NZ81097 16139	Splash	46	13
P25	NZ81096 16137	Upper	45	13
P26	NZ81092 16135	Splash	45	8.5
P27	NZ81092 16136	Upper	46	11
P28	NZ81092 16136	Upper	45	11
P29	NZ81086 16130	Splash	47	14
P30	NZ81086 16130	Splash	49	12
P31	NZ81077 16124	Splash	45	8
P32	NZ81078 16121	Upper	43	11
P33	NZ81075 16122	Upper	43	10
P34	NZ81075 16125	Splash	45	10

P35	NZ81075 16121	Upper	43	10
P36	NZ81074 16118	Upper	44	8
P37	NZ81070 16121	Upper	46	12
P38	NZ81066 16113	Upper	42	10
P39	NZ81064 16114	Upper	42	11
P40	NZ81064 16116	Splash	46	9
P41	NZ81064 16113	Upper	50	11
P42	NZ81062 16114	Splash	40	8
P43	NZ81061 16115	Splash	45	8.5
P44	NZ81061 16114	Splash	40	8
P45	NZ81064 16110	Upper	43	11
P46	NZ81058 16111	Splash	36	5
P47	NZ81057 16109	Upper	42	9
P48	NZ81058 16111	Splash	40	10
P49	NZ81053 16109	Splash	43	7
P50	NZ81049 16101	Upper	43	9
P51	NZ81047 16100	Upper	40	9
P52	NZ81047 16100	Upper	43	12.5
P53	NZ81044 16096	Splash	46	11
P54	NZ81045 10694	Upper	46	11
P55	NZ81039 10694	Upper	45	10
P56	NZ81037 16087	Splash	42	9
P57	NZ81036 16086	Upper	42	9
P58	NZ81036 16086	Upper	50	10
P59	NZ81035 16083	Upper	55	10
P60	NZ81034 16081	Upper	41	19
P61	NZ81032 16079	Upper	40	8
P62	NZ81031 16074	Upper	40	10
P63	NZ81031 16074	Upper	39	10
P64	NZ81025 16072	Upper	55	13
P65	NZ81021 16071	Upper	42	12
P66	NZ81016 16068	Upper	41	10
P67	NZ81017 16068	Upper	40	8
P68	NZ81017 16065	Upper	41	12
P69	NZ81018 16063	Upper	41	9
P70	NZ81018 16062	Upper	42	11