FINAL REPORT

Feasibility survey for the installation of artificial rock pools at Staithes, North Yorkshire

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EXECUTIVE SUMMARY

The purpose of this project was to assess the feasibility of installation of saw-cut artificial rock pools in the existing granite rock armour at Staithes, North Yorkshire. Ecological surveys were conducted of the granite rock armour and adjacent natural bedrock to determine if additional habitat could be created by adding artificial rock pools as ecological enhancement to the existing structure.

The survey found that the rock armour at Staithes supported twenty-two species in total, which is significantly more than other granite rock armour in the region. The granite boulders were varied in size, morphology and colour and the areas which supported the highest numbers of species were the areas which had rough surfaces, cracks, crevices and holes. Several boulders had pools which had formed in depressions on the top face of the boulders; these pools were colonised by coralline algae and a variety of other species.

The presence of water retaining features on the rock armour demonstrates the potential benefit of installing artificial rock pools on the granite boulders at Staithes. The species richness of the boulders may not increase significantly as a result of rock pool installation; however, the amount of habitat available and the abundance of individuals would likely rise if the work was undertaken.

CONTENTS

1. INTRODUCTION

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 (Firth et al., 2014; Little et al., 2009; White et al., 2014). The majority of artificial structures have low surface textures and pools are absent, which inhibits colonisation of marine life (Coombes et al., 2015; Pomerat and Weiss, 1946).

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 (Hall et al., 2018a; ITRC, 2004). Previous ecological enhancement studies have shown that water retaining features and habitat heterogeneity are important to promote biodiversity on artificial structures (Browne and Chapman, 2014; Evans et al., 2015; Firth et al., 2013). Existing trials at Runswick Bay have shown how increased habitat heterogeneity and water retention can lead to increased species richness and diversity on granite boulders (Hall et al., 2020, 2018a, 2018b).

Granite is commonly used on coastal defence structures due to its strength and longevity. However, granite is typically a poor habitat for marine life, especially when quarried and used for artificial structures. The faces of the granite can be very smooth and angular which provides sparse suitable space for marine life to attach. Granite also has a low porosity which results in very little water retention when the tide goes out. Ecological enhancement techniques on granite structures have the potential to increase the suitable habitat available for marine life to colonise. For example, the coastal defence scheme at Runswick Bay successfully increased the species richness and diversity of the granite boulder rock armour through the installation of saw-cut artificial rock pools (Hall et al., 2020, 2018b).

The aim of the current survey was to determine if artificial rock pools could be incorporated into the existing rock armour at Staithes to enhance the ecological potential of the structure.

2. METHODS

2.1 Site description

The foreshore at Staithes comprises an exposed shoreline with large mudstone bedrock platforms (Figure 2.1). 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 harbour walls were reconstructed and reinforced with granite rock armour in 2002, with the granite being sourced from Norway.

Figure 2.1. Location of Staithes harbour and Staithes village - east harbour arm is on the left of the images and west harbour arm is on the right of the image (Source: North East Coastal Observatory).

2.2 Survey protocol

Surveys were conducted on a neap tide between 29th February and 1st March 2020 by Dr Sue Hull and Dr Alice Hall.

The relative abundance of fauna and flora were recorded using 0.25m^2 quadrats in-situ on the existing granite rock armour on the east and west harbour breakwater. All organisms were identified to the lowest taxonomic resolution possible and photographs were obtained. The Marine Nature Conservation Review (MNCR) SACFOR abundance scales were used as per Hiscock, (1996).

The adjacent natural bedrock platforms were also surveyed using the MNCR SACFOR abundance scales in order to determine the differences between natural and artificial communities.

In addition, areas were identified where the installation of artificial rock pools could be possible; this was determined by accessibility, shore height, boulder size and orientation.

3. RESULTS

3.1 Rock armour characteristics

The rock armour at Staithes is mixed in terms of morphology (Figure 3.1a), with some boulders being very smooth and others exhibiting varying levels of coarseness (Figure 3.1b). Several of the boulders have holes and groove marks which are created during the quarrying process; the holes, in particular, providing areas of water retention. Due to the natural positioning of the boulders, areas of water retention have been created on the top face of the boulders, forming small shallow rock pools (Figure 3.1c). The small shallow rock pools supported similar species to shallow rock pools on the adjacent natural bedrock. In addition, the rock armour was cast into concrete foundations which facilitated some species being able to colonise the concrete and move up onto the base of the granite boulders.

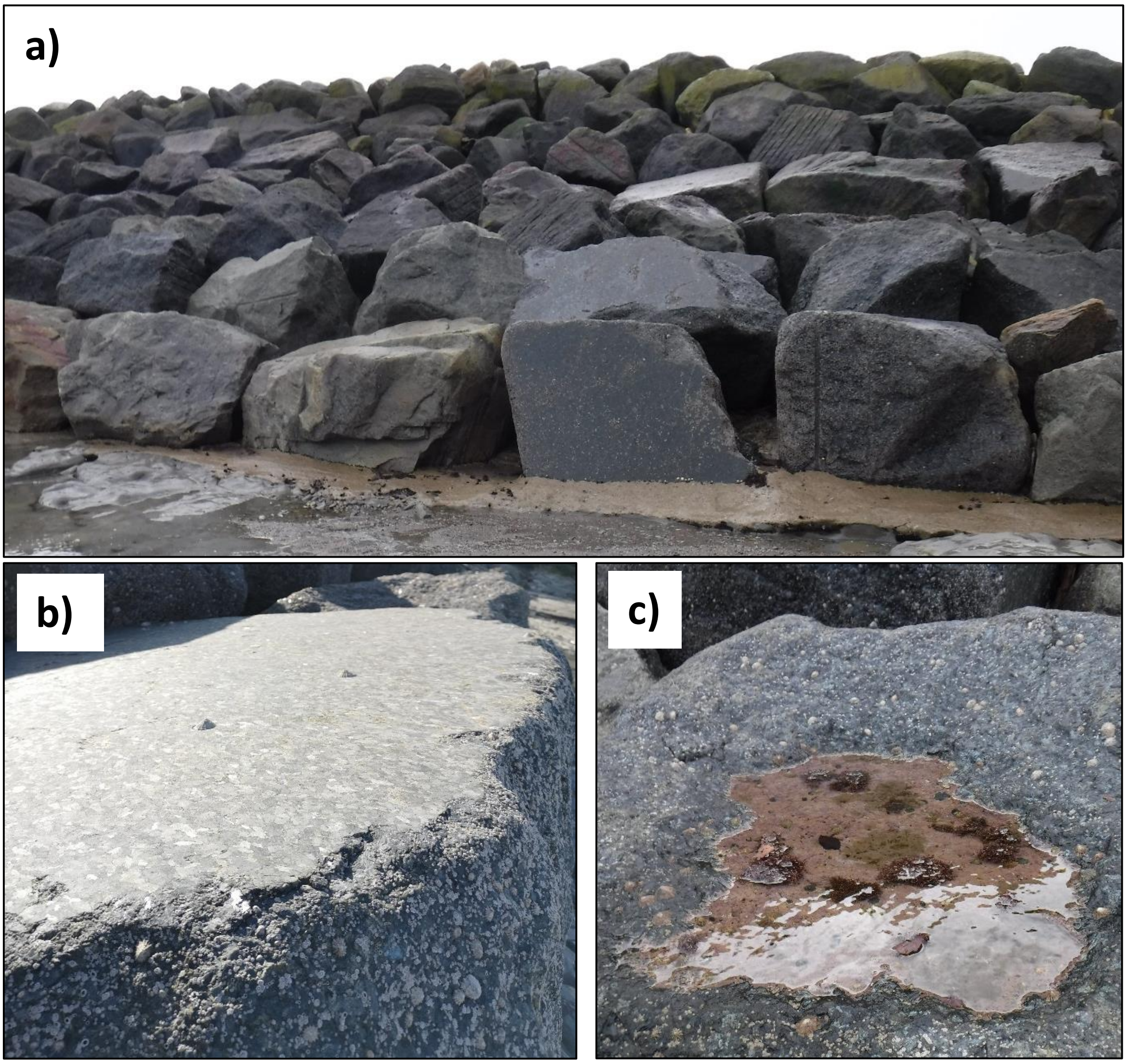

Figure 3.1. a) Overview of granite boulders, highlighting the variety of textures, b) boulder with smooth top and rough sides c) shallow rock pool on the top face of a boulder.

3.2 Granite rock armour

Overall the west arm of the harbour supported a higher number of species compared to the east arm of the harbour. In addition, the Mid shore sections of the rock armour arms supported the greatest number of species on both sides of the harbour (Figure 3.2). Four of the species recorded on the granite boulders were only found in areas of water retention, including the pink encrusting *Lithothamnion* sp. and the *Corallina officinalis*. The granite rock faces were dominated by the barnacle *Semibalanus balanoides* and the limpet *Patella vulgata.* In areas such as crevices the intertidal snail *Littorina littorea* were also superabundant.

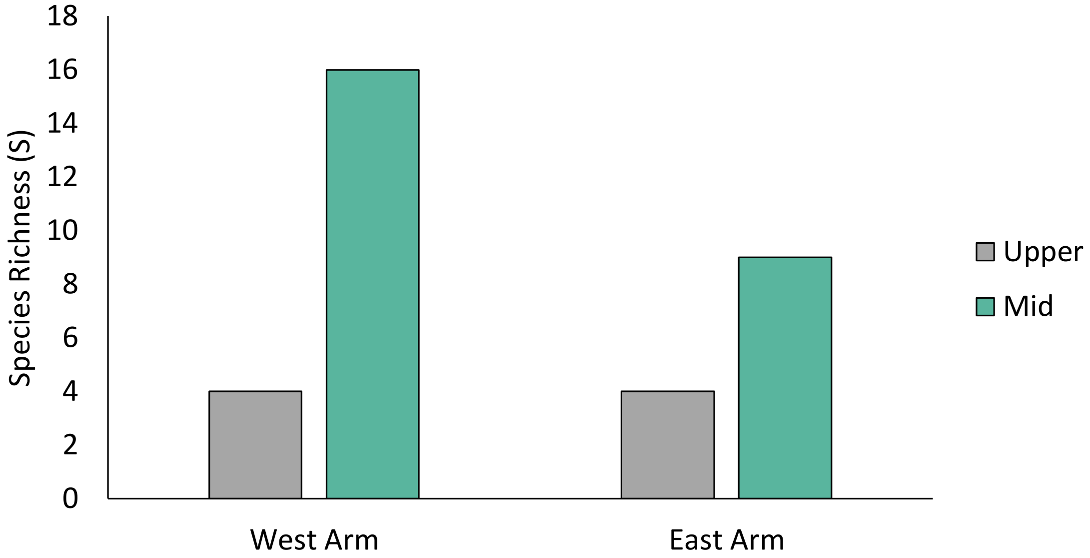

Figure 3.2. Species richness of the Upper & Mid shore heights on both the East and West harbour arms.

3.3 Granite rock armour compared to natural bedrock

A total of 22 species were record on the granite rock armour compared to 28 recorded on the natural bedrock (Figure 3.3, Table 3.1, Appendix A). A total of nine species were present on the natural bedrock, but were absent on the rock armour; five algal species (*Dumontia contorta, Fucus serratus, Fucus vesiculosus, Osmundea osmundea, Rhodochorton purpureum*), one worm species (*Spirobranchus triqueter*), two lichens (*Verrucaria maura* and *V. mucosa*) and one mollusc species (*Littorina obtusata*). Three species were recorded on the concrete overlapping onto the granite rock armour and were not found on the natural bedrock – the breadcrumb sponge (*Halichondria panacea),* the Ross worm (*Sabellaria spinulosa)* and the alga (*Lomentaria articularta)* (Figure 3.4).

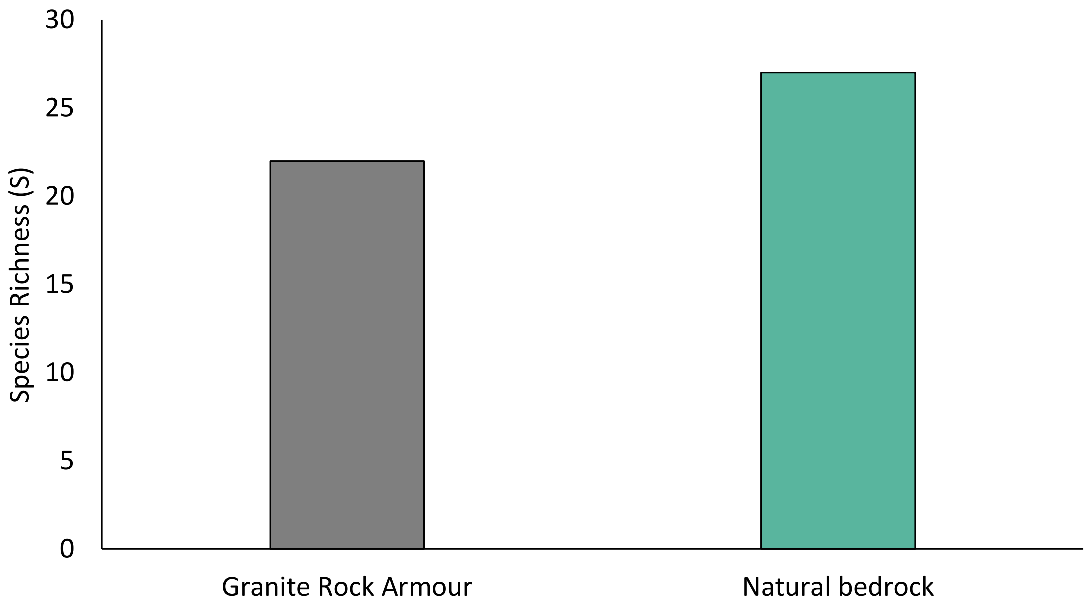

Figure 3.3. Species richness of the granite rock armour compared to natural bedrock at Staithes in Match 2020.

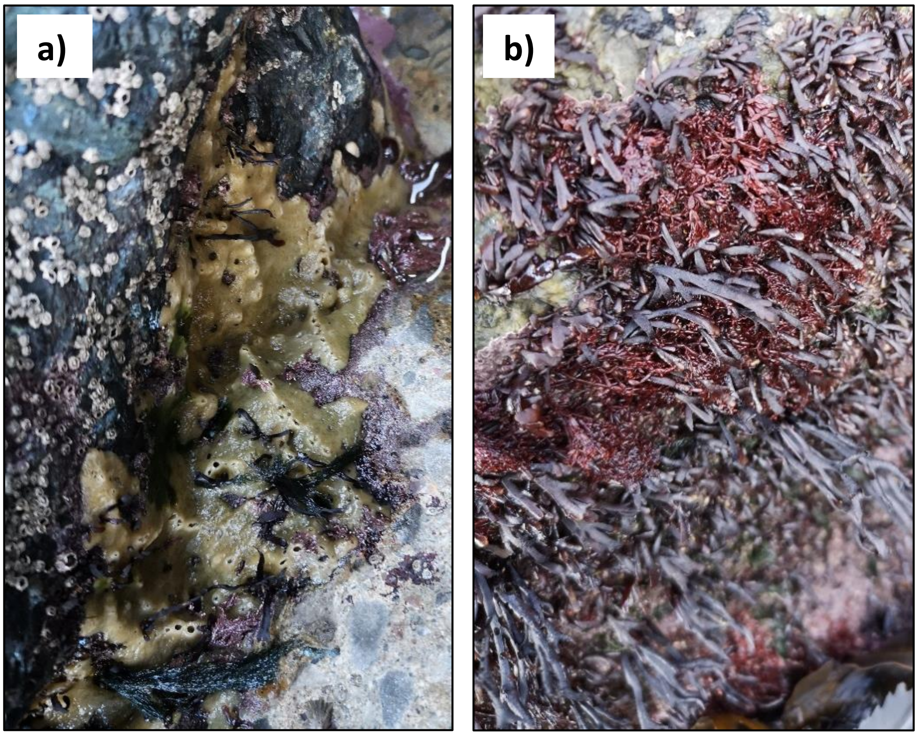

Figure 3.4. Two species found only on the granite rock armour, not recorded on the natural bedrock **a)** Breadcrumb sponge (*Halichondria panacea*) **b)** red algae (*Lomentaria articularta*)

Table 3.1 Species recorded at Staithes in March 2020 (* indicated present).

Group	Species	Granite Rock Armour	Natural bedrock
Algae	*Blidingia* sp.	*	*
	Ceramium sp.	*	*
	Cladophora rupestris	*	*
	Corallina officinalis	*	*
	Diatom film		*
	Dumontia contorta		*
	Fucus serratus		*
	Fucus spiralis	*	*
	Fucus vesiculosus		*
	Lithothamnion sp.	*	*
	Lomentaria articularta	*	
	Mastocarpus stellatus	*	*
	Osmundea osmundea		*
	Osmundea pinnatifida	*	*
	Polysiphonia sp.	*	*
	Porphyra linearis	*	*
	Rhodochorton purpureum		*
	Ulva spp.	*	*
Annalida	*Sabellaria spinulosa*	*	
	Spirobranchus triqueter		*
Cnidaria	*Actinia equina*	*	*
Crustacea	*Semibalanus balanoides*	*	*
Lichens	*Verrucaria maura*		*
	Verrucaria mucosa		*
Mollusca	*Littorina littorea*	*	*
	Littorina obtusata		*
	Littorina saxatilis	*	*
	Melarhaphe neritoides	*	*
	Nucella lapillus	*	*
	Patella vulgata	*	*
Porifora	*Halichondria panicea*	*	
Total number of species		**21**	**28**

3.4 Rock pools

The rock pools which had naturally formed on the granite rock armour were very similar to the natural bedrock rock pools; they were both dominated by pink encrusting algae and *C. officinialis* with *O.pinnatifida*, *P.vulgata* present (Figure 3.5).

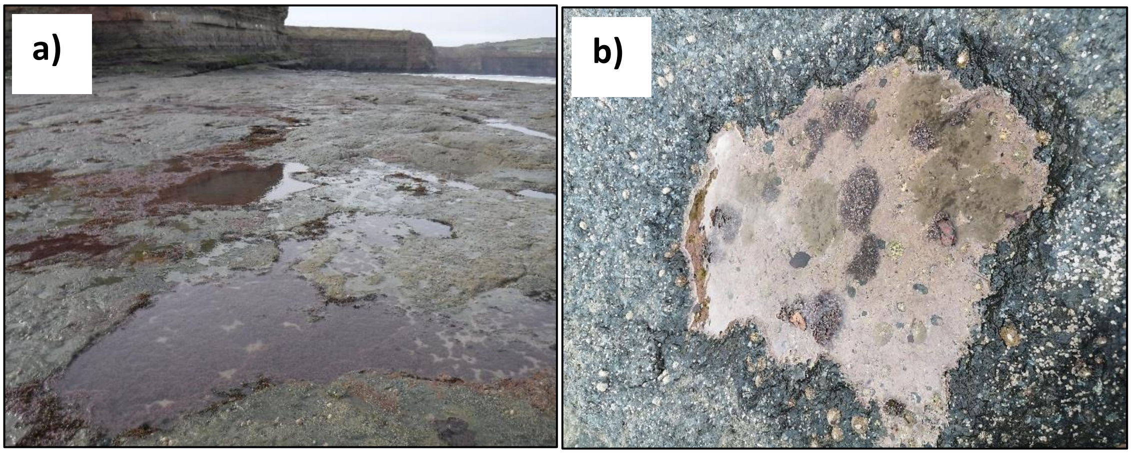

Figure 3.5. a) Natural shallow rock pool in bedrock, b) rock pool on granite rock armour.

3.5 Areas suitable for artificial rock pool creation

On the west harbour arm, 10 boulders on the lower layer were identified within the first 50 m which would be suitable for artificial rock pools (Figure 3.6a). These boulders were large enough in size and were orientated to retain water if a rock pool were created. These would all be accessible on a neap low tide; additional rock may be suitable on a lower spring tide, however the time available for working in that area may be limited.

On the east harbour arm only 30 m was accessible on a neap tide due to a deep channel at the base of the rock armour. Eight boulders were identified on the seaward side of the arm which would be accessible and safe to install artificial rock pools (Figure 3.7a).

It would also be possible to install artificial rock pools on the cliff facing side of the rock armour toe (Figure 3.7b). Care would need to be taken not to damage any of the existing rock pools which have formed naturally on the granite boulders.

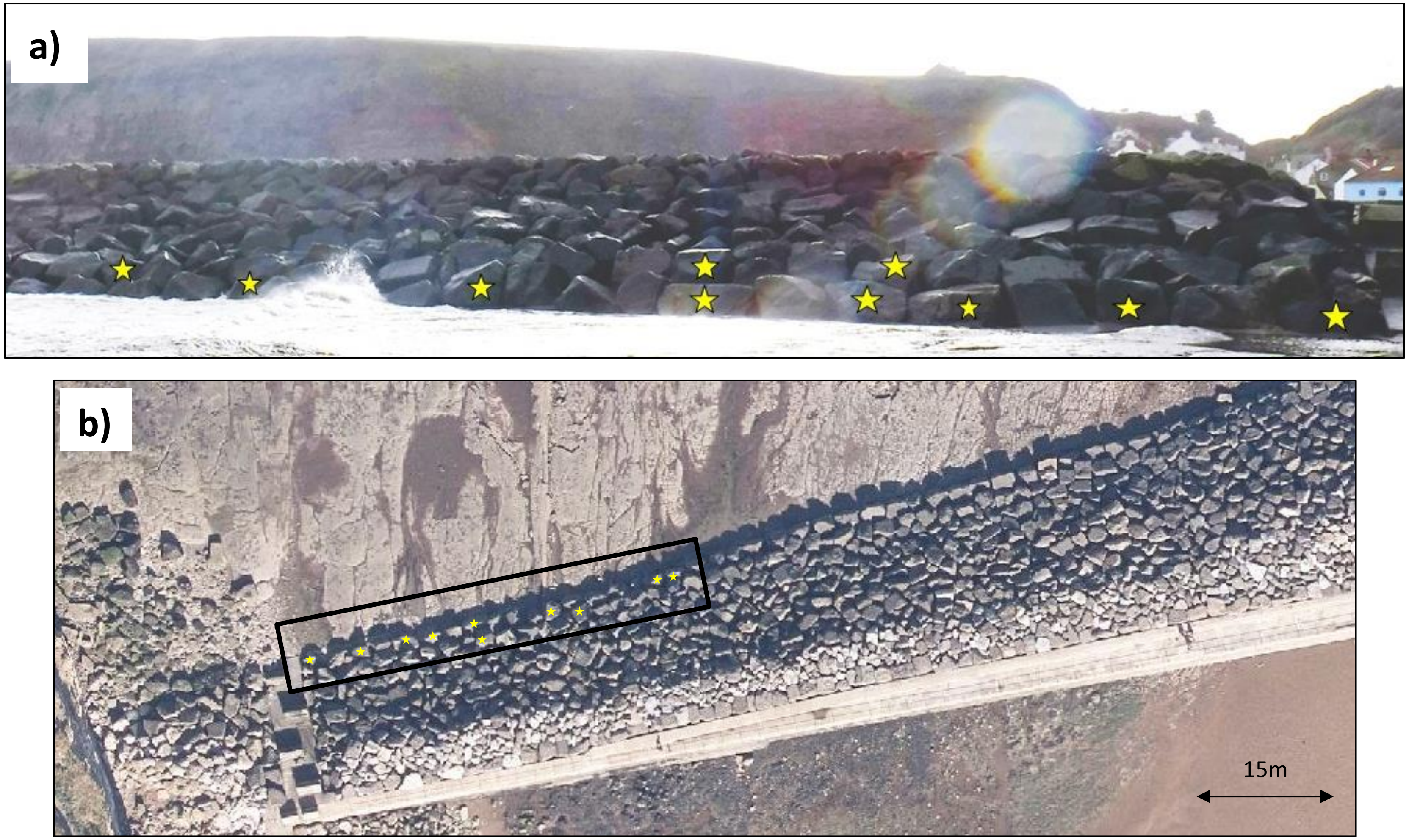

Figure 3.6. Suitable boulders for artificial rock pool creation on west arm of harbour indicated with yellow star, a) site photo b) North East Coastal Observatory aerial image. Black box donates where site image was taken.

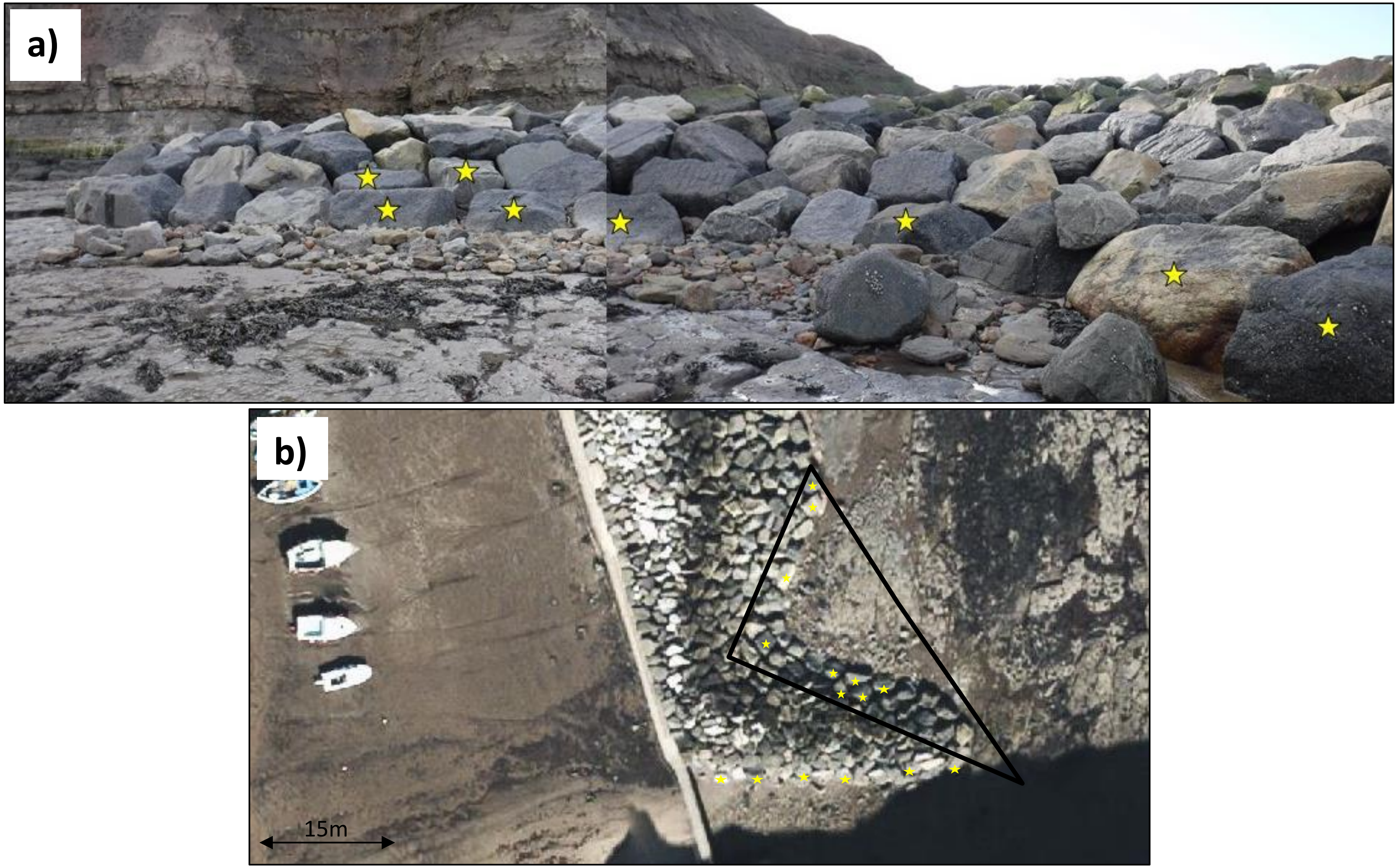

Figure 3.7 Suitable boulders for artificial rock pool creation on east arm of harbour indicated with yellow star, a) site photo b) North East Coastal Observatory aerial image. Black triangle donates where site image was taken.

4. DISCUSSION

The granite rock armour located at Staithes has been installed since 2002 and in the 18 years it has been in the intertidal environment it has attracted a variety of marine fauna and flora. Compared to granite at other intertidal sites on the Yorkshire coast it supports a greater number of marine species (see results of Hall et al., 2018 for comparison). A unique habitat which has formed on the granite rock armour are the shallow coralline algae pools, which are not a common feature on granite rock armour. As the rock armour has been installed for 18 years it is not possible to say how long it took for coralline algae to colonise; however, this is something which should be investigated further. Due to the shallow areas of water retention on the granite boulders having formed coralline pools, this demonstrates that the creation of artificial rock pools at this site would likely be an effective ecological enhancement technique. The creation of artificial rock pools would create additional areas of water retention, and deeper pools may attract other mobile species, such as fish and crabs.

The natural bedrock on the eastern side of the harbour was colonised by serrated wrack (*Fucus serratus)* which was absent on the bedrock on the west side of the harbour. The rough surface interior of the artificial rock pools is suitable for fucoid species, as observed at Runswick Bay (Hall et al., 2020); therefore, the pools at Staithes could also result in colonisation by F. *serratus,* particularly on the east side.

Access for safe installation of artificial rock pools is important, as the contractors will need to use large heavy machinery. Access is possible for both the east and west sides of the harbour. These surveys were conducted on a neap tide; therefore, the area accessible on a spring tide would be much greater. The area on the western side of the pier provides a longer stretch of accessible rock armour than the east side due to the deep channel on the eastern side of the harbour. However, access would be time limited due to the rapid encroachment of the tide.

Overall, the granite rock armour at Staithes currently supports a range of species; however, most species are limited to areas of water retention or crevices. Creation of artificial rock pools would increase the amount of refuge provided for marine life at low tide through the provision of water retention areas and increased surface texture. In addition, it would be very interesting to monitor how long it takes for coralline algae pools to become established, and whether or not they provide habitat for additional species currently not observed.

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Appendix A: Species list and average abundance for fauna and flora recorded in the granite rock armour and on the natural bedrock in March 2020 (MNCR SACFOR abundance scales S=Superabundant, A=Abundant, C=Common, F=Frequent, O=Occasional, R=Rare).

	Species	North Natural Upper	North Natural Mid	North Granite Upper	North Granite Mid	South Natural Upper	South Natural Mid	South Granite Upper	South Granite Mid
Algae	*Blidingia* sp.	F		S		F		S	
	Ceramium sp.		R		R		R		
	Cladophora rupestris		R		R		R		R
	Corallina officinalis		S(Pools)		R (Hole)		R-F (Pools)		R (Pools)
	Diatom film	C				A			
	Dumontia contorta		R						
	Fucus serratus						C		
	Fucus spiralis	C		R-C		R-O		R-C	
	Fucus vesiculosus		R				R-F		
	Lithothamnion sp.		S (Pools)		R (Hole)		R-F (Pools)		R (Pools)
	Lomentaria articulata				R				
	Mastocarpus stellatus		O-R		R		R-F		
	Osmundea osmundea						R		
	Osmundea pinnatifida		C		R		R-F		R (Pools)
	Polysiphonia sp.				R		C		
	Porphyra linearis	R-C		C		R-C		C	
	Rhodochorton purpureum	R							
	Ulva spp.	F-A		C		F-A	R	C	
Annalida	*Sabellaria spinulosa*								R (Hole)
	Spirobranchus triqueter		R						
Cnidaria	*Actinia equina*		R		O		R		R
Crustacea	*Semibalanus balanoides*	R	C		C-S	R	O		O-C
Fungi	*Verrucaria maura*		R						
	Verrucaria mucosa		R						
Mollusca	*Littorina littorea*		S		R		R		R
	Littorina obtusata						R		
	Littorina saxatilis	R			R				
	Melarhaphe neritoides	R			R				
	Nucella lapillus		R-O		R				
	Patella vulgata	R-C	F-C		C-S	R-C	R-F		O-C
Porifora	*Halichondria panicea*				R				
Total number of species		**10**	**16**	**4**	**16**	**7**	**16**	**4**	**9**

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