Managing Ecological, Community and Bathing Water Quality Aspects in Construction: Runswick Bay Coastal Protection Scheme, UK

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Abstract

The Runswick Bay Coastal Protection Scheme comprised repairs and installation of concrete toe protection to the existing seawall and the placement of approximately 9,500 tonnes of imported rock armour to form a new revetment totaling 250m length. The historic concrete seawall had reached the end of its serviceable life with a predicted failure within the next ten years. The newly constructed scheme offers an enhanced standard of protection to 96 residential and 17 non-residential properties including 6 listed buildings and infrastructure such as access roads and utilities, from coastal erosion for the next 100 years. Tourism, the foremost revenue stream of the community has also been safeguarded by the works. The effects of sea level rise and increased storminess predicted as a result of climate change have been factored into the design.

The scheme was achieved through collaboration across a wide project team with a focus on long term coastal protection alongside consideration for minimising the impact to the multitude of designated sites of the surrounding area. An emphasis during both the design and construction work was given to reducing disruption to the local community and visitors along with seeking opportunities for ecological enhancement. The scheme received financial contributions from local community via the Runswick Bay Coastal Protection Trust (the only scheme on the Yorkshire Coast to date to achieve such partnership funding) and an in-kind contribution from Yorkshire Water, through the execution of enabling works. The project involved the local community as much as possible to help steer the project's design and construction.

The programme for the construction phase was developed to minimise disruption to the area during peak visitor periods. Construction works commenced in February 2018 and the programme included a two-week suspension of activity over the school Easter holiday period, with completion scheduled for the end of June 2018, prior to the start of the school Summer holidays. During construction, water quality was monitored through regular sampling and laboratory testing to ensure the works did not adversely affect the bathing water quality. A sampling regime was developed which incorporated eleven sampling points across the wider bay to determine potential pollution sources, augmenting the existing information collected by the Environment Agency and providing useful verification for future intertidal rock offloading and stockpiling operations. In order to mitigate any environmental impact from the works the following mitigation measures were implemented in agreement with Natural England and The Marine Management Organisation:

- Workforce and machinery movements were limited to designated access routes and working areas to avoid ecologically sensitive areas of the foreshore, specifically the existing rockpool biotopes.
- Existing boulders on the foreshore which were heavily colonised with vegetation / fauna were carefully set aside as required during construction. On completion of rock armour placement,

the exiting rocks were placed against the toe rocks of the new structure to allow seeding of the new rock armour and to encourage fast colonisation of the new material.

University of Hull in partnership with Scarborough Borough Council had previously demonstrated that engineered rock armour structures tend to lack optimal habitat conditions for intertidal species, with surface heterogeneity and water retention the principal negative factors resulting in low diversity. To address this;

- The position and orientation of rock armour blocks was determined where possible to enable retention of water to mimic natural rock pools.
- The textural complexity of the granite rock armour blocks was increased by cutting artificial rock pools and grooves into selected rocks to encourage the colonisation and survival of intertidal species. Over 70 artificial rock pools (typically 300mm in diameter and 150mm deep) were created along with over 130 grooved sections. Trials were undertaken on site to establish a practical methodology to create the desired ecological characteristics.

The ecological enhancement aspects of the scheme are the largest of their type in the UK and represent leading-edge coastal engineering practice which will be monitored through links between public and private sectors and academia. Results will be shared with the coastal engineering community via conference presentations and journal publications; thus, raising the profiles of the organisations involved and the area in general amongst a global audience. Bournemouth University has been commissioned to monitor the evolution of the habitats created by the works, over the next three years.

Introduction

Background

Runswick Bay is a picturesque village set within a conservation area on the North Yorkshire Coast, approximately eight miles north of the town of Whitby. The village lies within the North York Moors National Park. Runswick Bay was designated as a Marine Conservation Zone (MCZ) in January 2016 to reflect the variety of habitats across the intertidal areas and sea bed, including rocky seashores, reefs, boulders, pools and sandy beaches. The bay is also designated under the Bathing Water Directive, achieving the highest category of Excellent, in 2015, 2016, 2017 and 2018, Figure 1.

Figure 1: Runswick Bay, North Yorkshire. Figure 1: Runswick Bay, North Yorkshire (courtesy of The North East Coastal Observatory)

Runswick Bay area has a history of coastal instability with risk of landslips and coastal erosion to the village and local community, due to the deterioration of the existing seawall, toe erosion and wave overtopping. The Shoreline Management Plan Review (2007) recommended a 'Hold the Line' policy. The Runswick Bay Coastal Strategy (CH2M HILL 2015) was developed to confirm the policy and determine the preferred coastal defence option. The process was undertaken in two stages comprising a preliminary assessment of a long list of options and a more detailed assessment of short-listed options. The preferred option was selected as a rock armour fillet again existing seawall.

The existing concrete seawall had reached the end of its serviceable life with a predicted failure within ten years. The Runswick Bay Coastal Protection Scheme comprised of repairs and installation of concrete toe protection to the existing seawall and the placement of approximately 9,500 tonnes of imported high density rock armour to form a new revetment totaling 250m length. This preferred coastal defence option was delivered through a Design and Build contract using a BIM (Building Information Modeling) approach.

Consenting and permissions

The local planning authority was the North York Moors National Park Authority, the scheme was also regulated by the Marine Management Organisation (MMO). AN Environmental Impact Assessment (EIA) screening was completed in 2015. Due to the size and nature of the proposal and the significance of the predicted environmental impacts it was determined that the proposal fell under Schedule 2, Part 10 (Infrastructure Projects) Town and Country Planning (Environmental Impact Assessment) Regulations 2011. An EIA was also required under the Marine Works (Environmental Impact Assessment) (Amendment) Regulations 2011. A formal scoping opinion was obtained from the North York Moors National Park Authority and MMO. Following consultation after award of the D&B Contract, it was confirmed that the North York Moors National Park Authority would act as the single determining authority. This approach provided significant benefits in costs and programme and more effectively managed the consultation with statutory bodies. During the period 2015 and 2017 the EIA regulations were replaced, however given that EIA Scoping had been completed under the previous 2011 regulations, NYMNP confirmed that the application could be progressed under these regulations, through the transitional arrangements of the 2017 regulations.

Planning Permission was granted in November 2017 and construction started in March 2018. A Marine Licence, issued under the Marine and Coastal Access Act 2009, was also submitted to cover the proposed scheme.

Design considerations and application

Ecological Baseline

Runswick Bay became a Marine Conservation Zone (MCZ) in January 2016. 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. The site may also be described by the zones illustrated in Figure 2, although only a relatively small part of the site is classified intertidal sediment.

An intertidal biotope survey was conducted following guidance from the Marine Monitoring Handbook (Davies *et al*., 2001) in April 2017. The methodology is a standard technique for classifying and mapping littoral habitats and species, where the dominant species are recorded and the biotopes assigned according to the JNCC's National Marine Habitat Classification for Britain and Ireland: Version 04.05 (Connor *et al*., 2004). Biotopes are the basic mapping units for intertidal surveys and consist of the dominant plants or algae and animals, in combination with the principal physical characteristics of the habitat, including:

- Substratum;
- Wave exposure;
- Tidal stream;
- Modifiers such as sand scour and freshwater runoff (Hiscock, 1996).

The survey was undertaken during a window of five hours (i.e. three hours before and two hours after low tide), with the surveyors working down the shore on the ebbing tide and up the shore on the flood tide to identify, differentiate and map the extent of biotopes. Low water was 1.5m at 15:45h. The survey area contains the broad-scale habitats (BSH) low energy intertidal rock and Intertidal sand and muddy sand.

Figure 2: Habitat zones, Runswick Bay (University of Hull, 2014).

A total of ten biotopes were recorded across the survey area during the including intertidal biotope survey:

- *Ascophyllum nodosum* on full salinity mid eulittoral mixed substrata (LR.LLR.F.Asc.X);
- Oligochaetes in full salinity littoral mobile sand (LS.LSa.MoSa.Ol.FS);
- Littoral mixed sediment (LS.LMx);
- *Fucus serratus* on full salinity lower eulittoral mixed substrata (LR.LLR.F.Fserr.X);
- Low energy littoral rock (LR.LLR);
- *Fucus vesiculosus* on full salinity moderately exposed to sheltered mid eulittoral rock (LR.LLR.F.Fves.FS);
- *Fucus serratus* on full salinity sheltered lower eulittoral rock (LR.LLR.F.Fserr.FS);
- Seaweeds in sediment-floored eulittoral rockpools (LR.FLR.Rkp.SwSed);
- Coralline crust-dominated shallow eulittoral rockpools (LR.FLR.Rkp.Cor.Cor); and
- Green seaweeds (*Ulva* spp. and *Cladophora* spp.) in shallow upper shore rockpools (LR.FLR.Rkp.G).

Key biotopes are mapped in Figure 3. The survey was commissioned to support the design development and survey data formed part of the technical information included within the Environmental Statement (ES) and Marine Licence.

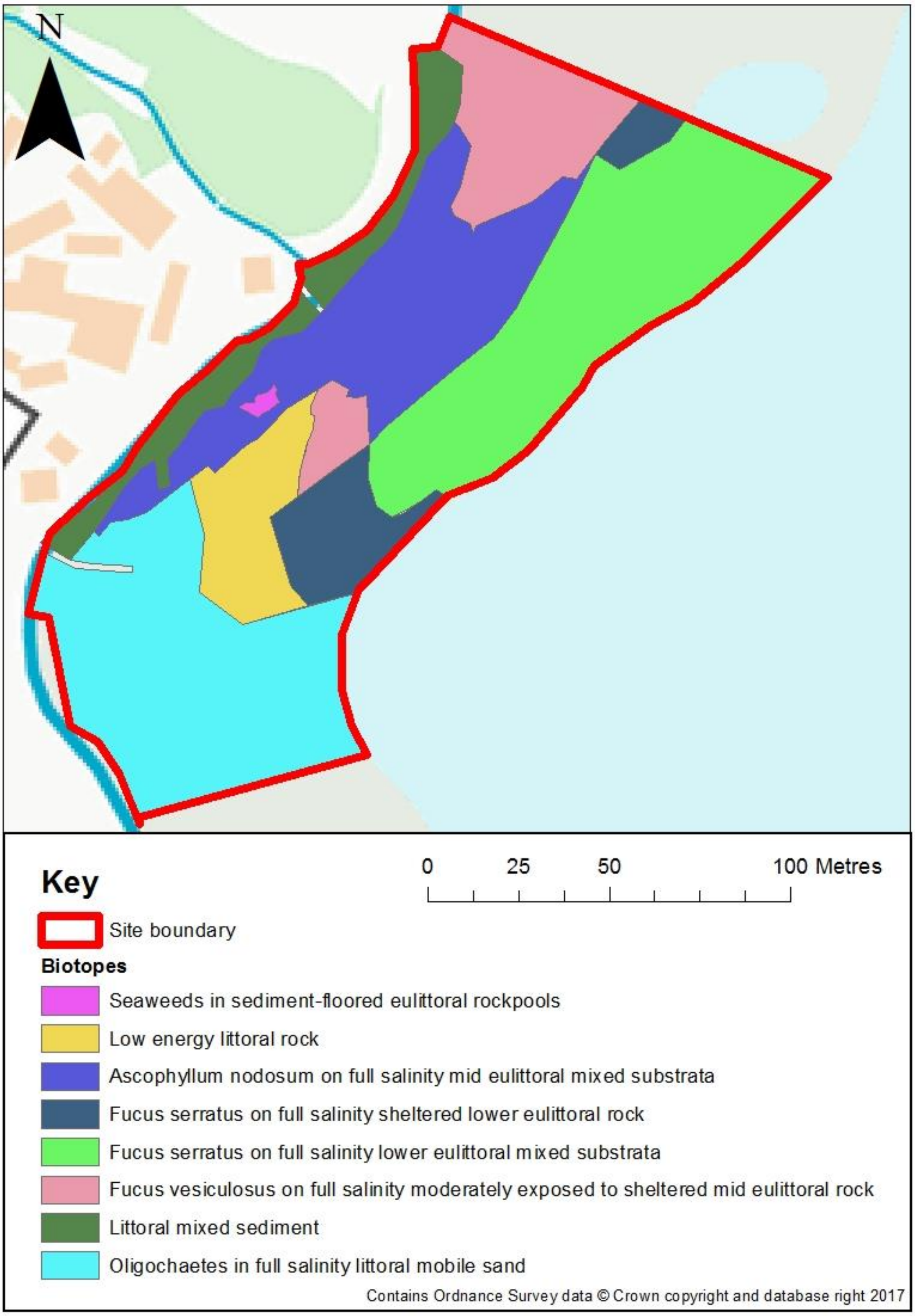

Figure 3: Marine Biotope Map, Inter-tidal habitat survey March 2017 (source JBA 2017).

Assessment of the survey made several important recommendations. First, it was important to retain the mapped rockpool biotope LR.FLR.Rkp.SwSed (~18m from the existing sea wall), as this was considered to contain a diverse range of species for its height in the intertidal zone. Also, it was recommended to avoid excessive trampling of the lower portion of the mid eulittoral to the low eulittoral (approximately 30m from the sea wall to low tide line), with specific care to avoid rockpool biotopes in these zones. The location of existing rock pools and heavily colonised rocks were mapped. These features were to be protected during works or returned to original location if moved to necessitate construction.

Ecological Enchancement

During the scoping phase the MCZ did not include the intertidal zone, which meant that the preferred option did not directly affect the MCZ. However, at designation the final alignment of the MCZ was located against the toe of the existing seawall meaning the rock fillet was situated within the MCZ. The 250m long rock armour fillet is approximately 2.5 metres high and rises approximately two thirds up the height of the sea wall. The rock armour was placed with a slope of 1 in 3 towards the beach, creating an overall width at the base of approximately 8 metres. The fillet comprised 2 layers of 6-10 tonne rocks with a median diameter of 1.5 metres. The fillet causes the loss of 10-13m of intertidal habitat along the length of the existing wall, representing approximately 2600m^2 in total. It was assessed that the intertidal habitats would also be affected during the construction as a result of the installation of the rock armour fillet. It was also noted that disturbance would be created as a consequence of the delivery of the rock by boat, workforce movements across the intertidal zone, temporary storage of the rock on the intertidal area and movement of the rock into place by machinery. During the EIA, discussions with Natural England were undertaken to develop measures to mitigate for the permanent habitat loss and the temporary disturbance as a consequence of rock movements and installation. This included 'distressing' boulders and placement of seed boulders to encourage colonisation by marine invertebrates. The distressing of the imported granite armour stones new granite boulders included the cutting/drilling of rock pool features and thin horizontal grooves (approx. 60cm long x 1cm deep) and thicker, coarser grooves (approx. 60cm long x 2cm wide) cut into the rock using an angle grinder, Figure 4.

Figure 4: Creation of the distressed features on the granite rock armour.

Some of the existing rocks along the intertidal areas needed to be relocated to allow for the placing of the new rock armour. These were retained and placed within the new rock armour to act as 'seed blocks' within the new material to aid colonisation. Creation of rock pools was proposed within several armour stones, along with the concept of considerate placement of armour stones in a manner that allowed the natural retention of water creating natural pools.

Trials had demonstrated that it was particularly important to have a rough surface to allow colonisation by intertidal organisms. Scratch grooves provide a vital refuge for marine organisms from environmental conditions and predation (Hall *et al* 2018). Over 130 groove sections have been cut into the armour stones. The project team worked with Bournemouth University and University of Hull to determine the success of the ecological designs. Monitoring was undertaken to provide a baseline and control areas were established for comparison (Hall, Hull and Herbert 2019).

Seventy artificial rock pools were installed using an innovate method utilising 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 with a rough surface. Rock pool diameter ranged between 36 cm and 56 cm and water depth ranged from 5 cm to 19 cm. The rock pools were created largely *in situ*. An additional 20+ pools were generated through the considerate placing/orientation of armour stones. 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 extreme upper tidal height (MHWS).

Figure 5: Artificial rock pools cut into the granite rock armour boulders.

The positioning of the rock pools adds to the intrinsic value of the depressions. The water retention and increased habitat heterogeneity created by artificial rock pools on the granite boulders has provided habitat for intertidal organisms to survive on the rock armour. Without these features these, organism would be absent, or the diversity of species is likely to be more restricted. The granite boulders are slow to weather and are smooth, therefore they do not provide conditions that promote rapid colonisation.

Bournemouth University have been commissioned to determine the success of the ecological designs. Monitoring was undertaken to provide a baseline and control areas were established for comparison (Hall, Hull and Herbert 2019).

The monitoring to date has shown that the rock pools have increased the species richness, species diversity and total abundance of the granite boulders compared to an un-manipulated control area. 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*). These results indicate that the artificial rock pools supported significantly greater species richness, species diversity and total abundance than the adjacent rock face controls (Hall, Hull and Herbert 2019).

Monitoring has shown that 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 (Hall, Hull and Herbert 2019). 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. Monitoring at Runswick Bay recorded multiple fish, crabs, prawns, gastropods utilising the artificial rock pools and not the adjacent unmodified rock faces. 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 refuge for these species. 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.

Water Quality

Bathing water at Runswick Bay was rated in 2017 with the best water quality (three stars - excellent bathing water quality). The Environment Agency requested specific action to monitor the impact of the construction activities on bathing water during the works. Construction works generally pose a risk to the water environment through excavation, fabrication of laying of concrete and storage of materials, exposure of bare ground, earth movement, stockpiling material, mobilising of sediment into surface water receptors through runoff from the site especially during the delivery and movement of material.

As part of the ES, the following mitigation measures were incorporated into the construction method and operation of the site:

- All work shall be undertaken in accordance with CIRIA Coastal and Marine Environmental Management Site Guide (CIRIA, 2003). The adoption of good practice means that all possible measures to limit the significance of a pollution incident will be implemented. With adherence to the above mitigation, there would be a residual impact of negligible significance on the surrounding environment.
- The contractor shall produce a site Bio-security Risk Assessment considering the source of the rock and the method of delivery. Bio-security aspects shall be incorporated into the site induction process and site procedures.

Bathing water quality was monitored during the coastal protection works as part of the Environmental Action Plan and Conditions 7 and 8 within the Planning Permission. Routine sampling during rock stockpiling commenced on 26/03/18 and was undertaken by PBA Applied Ecology on behalf of the site contractors. Samples were collected from a single monitoring point on each occasion. During construction, an early sample recorded a very high frequency of *Escherichia. coli*. The deterioration in water quality observed coincided with heavy rainfall within the catchment of Runswick Bay. High levels of bacteria were present within all inflows and across the entirety of the bay. This indicated that the primary source of pollution within the bay was likely to be entering via the multiple inflows.

During the second set of samples collected during the rock placement no rainfall was recorded at the Runswick Bay rainfall gauge station During this period elevated levels of bacteria were detected within Claymoor beck, Nettledale beck and Limekiln beck and the spring outflow, however, all samples collected within the intertidal area of the works area were of 'excellent' quality. Storm water sewer discharges, and potentially also contamination from the wider catchment, including point source discharges and diffuse pollution from agricultural land were deemed likely to be the cause of this pollution within the becks and across the bay.

It was found that although water quality does improve once rainfall ceases there was still elevated levels of pollution detected within multiple inflows and sample sites across the bay for the following two days. The implications of this are that following periods of heavy rainfall, deterioration to bathing water quality was to be expected for at least three days following independent of works being undertaken. The monitoring results demonstrated that the coastal protection scheme had no additional negative impacts on bathing water quality (PBA, 2018).

Community

This is the first major coastal defence project on the Yorkshire coast to receive financial support from the local community. The design and construction phases involved significant community engagement particularly during consultation events and via the project steering group. Local schools have been involved throughout the project and have a continued interest in the ecological enhancements.

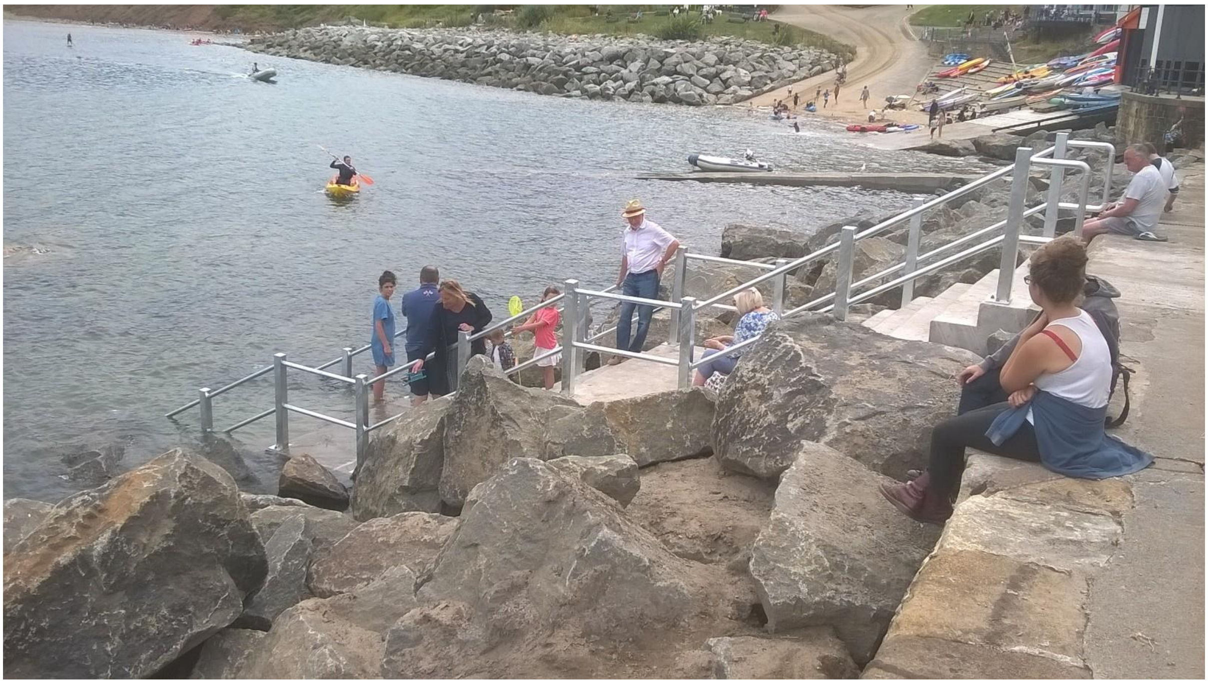

Figure 6: New steps and community ‘crabbing’. Runswick Bay summer 2018.

New steps were installed to provided improved access to the beach and is now proving a well-liked place to go crabbing. The natural rock pools are a popular feature at the Bay and enjoyed by the local community, especially during holiday periods. These features were protected during construction, some of the new manmade rock pools were installed close to the original pools and at the base of the stairs. A formal opening of the new defences was completed on 21st January 2019.

Conclusion

The ecological enhancement aspects of the scheme are the largest of their type in the UK and represent leading-edge coastal engineering practice. Engineers have worked closely with ecologists to gain the best outcomes in terms of coastal defence, environmental protection and environmental enhancement. The production of heterogeneous surfaces and rock pools has a low monetary cost to implement, relative to the overall costs of a coastal defence works, but is of high value in terms of creating and increasing habitat. Future coastal rock armour revetment schemes across the UK and elsewhere could benefit from incorporating ecological enhancement. It is hoped that the innovative method and technics developed during this case study and the lessons learnt will aid others in creating habitat on similar structures.

Two months after the installation of the artificial rockpools there were ten species present in the rockpools which were absent from the adjacent rock surfaces, these included two species of crab, intertidal fish, shrimps and marine snails. To observe such rapid success is a very encouraging sign in terms of future community development.

Incorporating the artificial rock pools into the granite rock armour appears to have been successful to date; although the surveys that have been completed are relatively soon after the 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.

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