Colonisation of stabilising mattresses and their impact on local invertebrate biodiversity - *A brief summary of work so far*

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Introduction

River restoration is increasingly being directed towards process based management whereby catchment scale management of processes such as sediment transport, flows and flow dynamics are considered prior to restoration projects. However, local scale erosion control and bank support will always be an essential part of many restoration activities, especially where there are conflicts of the river with human use (around bridges, preserving recreational or faming land, around abstraction pipes or outfalls). To minimise the ecological impact of bank support structures there has been a tendency away from hard engineering, such as steel piling or concrete. Gabions (rocks in square wire cages) and rip-rap (large rocks) are still commonly used for bank support but vegetation growth on such bank support structures appears to be poor.

Rock mattresses (rocks held in a polypropylene net) and rock rolls have been developed by Salix River & Wetland Services Ltd. These mould their shape into a natural bank form (unlike Gabions) and allow the establishment of vegetation to provide natural looking banks after several years, particularly if they have been planted with native bank species.

The SEACAMS (**S**ustainable **E**xpansion of the **A**pplied **C**oastal **A**nd **M**arine **S**ectors) group at Swansea University are currently investigating whether rock mattresses do sustain natural ecological communities (both plants and invertebrates), the speed of establishment of these communities, and comparing this to a widely used bank support material, rip-rap.

Method

Invertebrate Survey

A study site at Narberth Brook (located at 210401E 214166N) was chosen (Figure 1) because of the ease of access for both installation equipment and the ability of field workers to work in the stream, as well as having evident erosion problems whilst not having significant nutrient or chemical pollution.

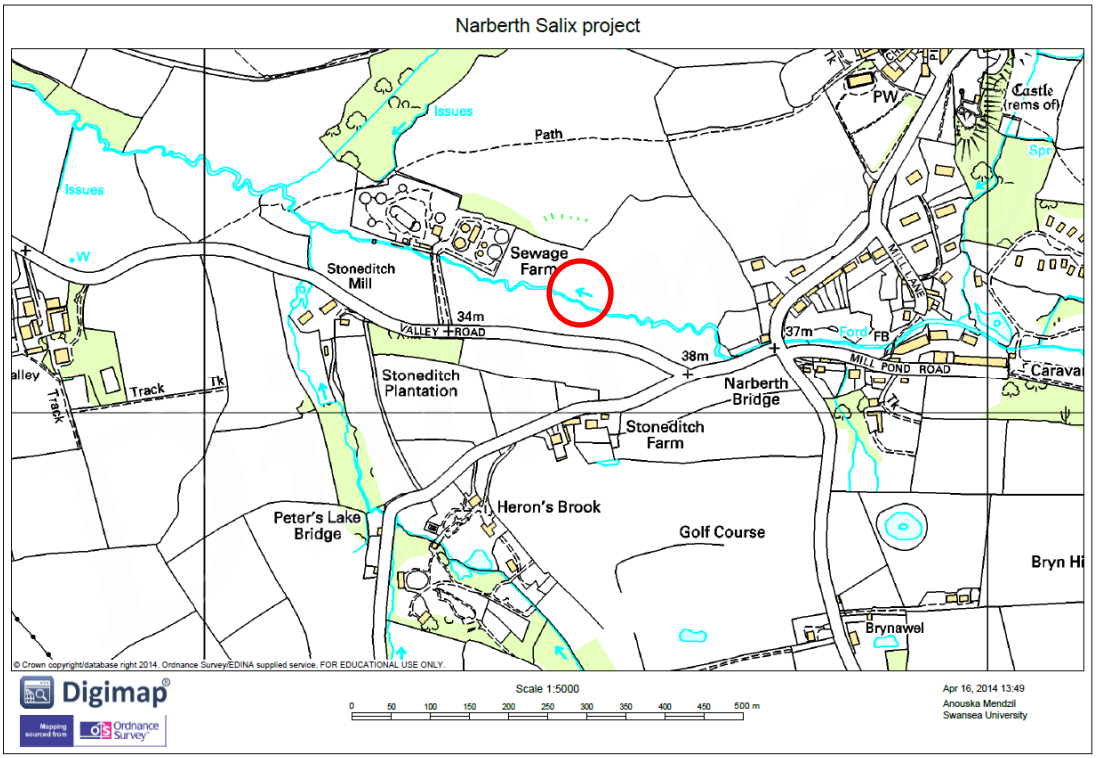

Figure 1. Location of study site (210401E 214166N) at Narberth Brook, near Narberth, Pembrokeshire.

The section of Narberth Brook chosen has a mobile and eroding channel. It is located in a field used for cattle grazing. Although there is some poaching due to cattle access to the stream, most of the erosion appears to be occurring due to undercutting of the bank, causing slippage of chunks of bank material into the channel (Figure 3 and 5a). The banks are a mixture of clay, earth and sand. The specific section that was used in the study was straight, having similar water velocities along all points and thus enabling a fair comparison between study sites (Figure 2).

Figure 2. Section of channel chosen for the study within Narberth Brook

Twenty-four erosion pins were placed in a separate eroding section about 100m upstream on the 17 April 2014 and erosion (protrusion of the pins) was measured on 6 June 2014, 11 July 2014 and 31 October 2014. These were placed in 6 vertical columns of pins, with four different heights on the bank, the first 2cm below the water surface (on 17 April 14) then 8, 16, and 46 cm above water surface (Figure 3).

Figure 3. Twenty four erosion pins placed in an eroding section between April and October 2014

Experimental design

Starting on 11 and finishing on 12 June 2014, rock-rolls and rip-rap were installed on the section of eroding bank (Figure 5a). The different treatments were:

1. Rip-rap
2. Rock rolls with large rocks (30-50mm length of secondary axis)
3. Rocks rolls with small rocks (50-100mm length of secondary axis)

The rip-rap was placed between the small and large rock roll sections of the bank to ensure that the experiment wasn't biased by differences in water velocity, erosion of other conditions due to an up or downstream trend. Rock rolls were of standard size (2m long), but four shorter rock rolls (½ m long) were placed in the lower row of rock rolls in each of the rock roll treatments. These had handles on, and were sewn on to the other rock rolls. This enabled them to be easily cut out from the other rock rolls and lifted, without

disturbing the structure, and taken for invertebrate sampling. The whole bottom row was pushed slightly into the sediment and was about 1/3rd covered by water in the summer. Figure 4 shows the experimental design and Figure 6b, the rocks rolls directly after installation.

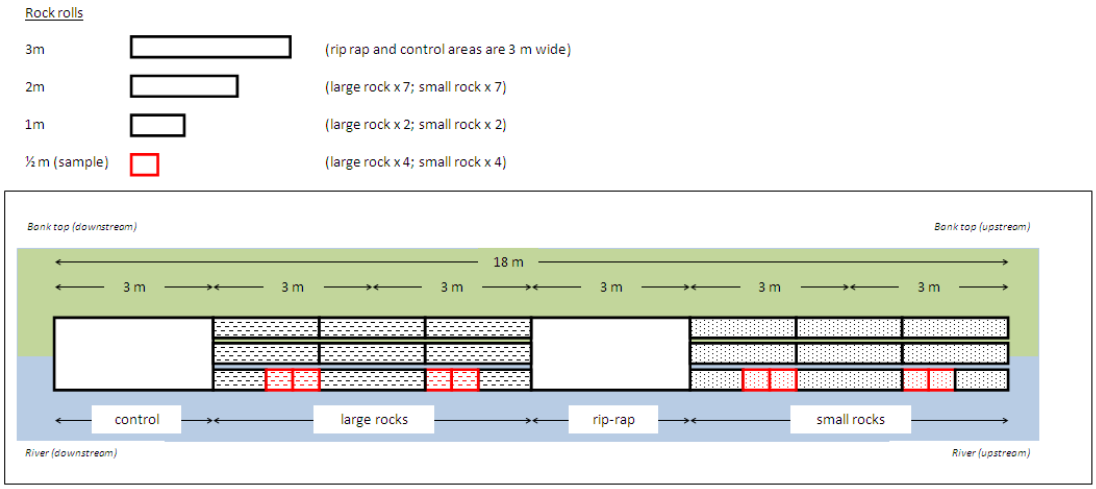

Figure 4. Arrangement of the rock rolls and rip-rap along the eroding bank. There are four 'treatments' on the bank at site 3 & 4 (see previous river plan for Narberth Brook).

From upstream to downstream this is: small rocks; rip-rap; large rocks; control (left without any bank amendment). The large rock and small rock treatments have two replicates (adjacent). For each replicate there are two sample bags under the water level, whereas the control and rip-rap sections are just 3 m wide. There are three levels of rock rolls (the sample rolls being within the river, with the other two layers stacked further up the bank).

Figure 5. Section of eroding bank before installation of the bank support material (rock rolls and rip-rap) and at subsequent periods after installation. Red letters in (5B.) represent the locations where rock rolls or rip-rap was sampled. Apparent curvature of the straight channel is because each image is a panoramic composite of photos.

A. 14 March 2014
Pre-installation

B. 14 June 2014
Post-installation

C. 11 July 2014
Site visit

D. 31 October 2014
First sampling

Sampling

Four sampling periods between winter (2014) and spring (2015) are to be done. The first sample was completed on the 31st October, 141 days after installation. On each sample occasion two replicates of each treatment are taken i.e. 2 rocks rolls with small rocks, 2 rock rolls with large rocks, 2 rip-rap sections. A single kick sample is also taken.

The sampling protocol is:

Kick sample

1. Take a 30 second kick sample in a riffle (similar sized rocks) immediately downstream of the survey site. Sample sieved (500µm) and washed into sample bottle and 70% ethanol added until the sample covered, to kill and preserve the invertebrates.

Rock rolls

2. Cut out a ½ m rock roll from the lower rock roll section
3. Two people lift the rock roll section and place into a 64 litre plastic box whilst another person holds a net in the stream to catch invertebrates disturbed from the sediment. The net sample is preserved in the field as in (1).
4. A fresh rock-roll of the same type is sewn into the gap with polypropylene cord and kicked into place so it is flush with the existing rock rolls. Removed rock rolls are taken back to the lab.

Rip-rap

5. An area of bank identical to that covered by the rock rolls is selected and the rip-rap removed to large trays where they are scrubbed to remove invertebrates. During removal a net is again used to catch disturbed invertebrates, and the underlying sediment is agitated with the hand for 10 seconds to displace invertebrates that may be in the sediments underlying the rip-rap (since the rip-rap is not slightly buried , as the rock rolls are). Both samples are preserved with 70% ethanol and returned to the lab.

Lab

6. On the same day of sampling rock rolls are taken to the lab and the bag cut open whilst within the plastic box, then rocks are removed and scrubbed to remove invertebrates.
7. All the sediment and net remaining in the plastic box, and the material from the scrubbed rocks, is sieved with two stacked sieves (1mm at the top and 500µm underneath). The upper seize helps to immediate prevent blocking of the lower sieve. The samples are then preserved in 70% ethanol for later identification, but the invertebrate removal and preservation are done the same day as the field visit to ensure that the predation between invertebrates is minimised.

Invertebrate Identification

8. A sample from the rock roll, rip-rap or kick sample is placed in a white tray, and leaves are rinsed and removed. Invertebrates are then picked out and placed in petri-dishes for identification. Additional sieving and dividing of samples is sometimes necessary to find all of the invertebrates. A dissection microscope (x10 magnification) is finally used to scan the tray to find invertebrates not initially found.
9. Invertebrate samples are identified to family level, but the samples are also retained (preserved in 70% ethanol).

Results

Erosion

During the summer, when water levels were low, there was little erosion above the water level. However, slippage of the bank material rather than gradual erosion by water action did occur (Table 1). During the autumn, water levels rose and there was more erosion higher up the bank, but many pins were also lost (Table 2). These pins were likely pulled out by the action of the turbulent water pulling at protruding pins, and not due to complete erosion at these locations.

Erosion per day averaged 240µm/day in summer, and 210µm/day in autumn. Lost pins were not counted in mean calculations, and even in the columns where there were no lost pins, the summer erosion still seemed high compared to autumn. This is probably due to undercutting of the bank causing slipping of large chunks of bank (e.g. column 3 in the summer erosion) whereas in the autumn higher and more varied water levels likely produced a more even erosion across the whole surface.

Mean erosion per day over the whole time period (197 days) is 250µm/day or 9cm/yr. This is the linear amount the bank gets cut back, so we can expect about 90 000 cm^3 (0.09 m^3)of bank material eroded each year per m^2 of bank surface.

downstream						*upstream*	
HWL*	6	5	4	3	2	1	mean
46	0	0	0	0	0	0	0
16	0	0	86	0	0	lost	17
8	16	10	98	0	0	7	22
-2	43	16	48	35	80	30	42
mean	13	6	47	8	16	10	20

Table 1. Summer erosion (mm): 17 April 14 to 11 July 14; 85 days.

downstream						*upstream*	
HWL*	6	5	4	3	2	1	mean
46	lost	77	25	50	0	0	30
16	lost	lost	51	21	2	2	19
8	lost	-1	42	62	1	lost	26
-2	lost	lost	5	24	15	lost	15
mean	lost	38	31	39	5	1	24

Table 2. Autumn erosion (mm): 11 July 14 to 31 October 14; 112 days.

Invertebrate Diversity

Invertebrates were identified to family level. Table 3 shows the mean number of families and the (mean) total number of individuals found for a treatment (kick sample, small rock roll, large rock roll, rip-rip sample). Standard errors are very high since there are currently only two samples for each replicate. By spring next year there will be 8 samples for each replicate. Graphs of this data is presented in Figure 6 and 7.

A Bray-Curtis similarity analysis, with log x+1 transformation was calculated for the different treatments (Table 4) showing that, although the rock rolls had higher species diversity, the rip-rap was closer to a channel kick sample. Looking at individual replicates we can represent how similar the individual rock-rolls, rip-rap samples and the kick sample were (Bray-Curtis similarity after log x+1 transformation) in Multi-Dimensional Scaling (MDS; Figure 8).

Table 3. The mean number of families and number of individual invertebrates within different bank support material (and a channel kick sample).

		Rock roll		
	Kick sample	Small	Large	Rip-rap
Number of families	18	29	27	21
Standard error	*-*	*5*	*4*	*4*
Number of individuals	119	318	494	103
Standard error	*-*	*182*	*147*	*66*

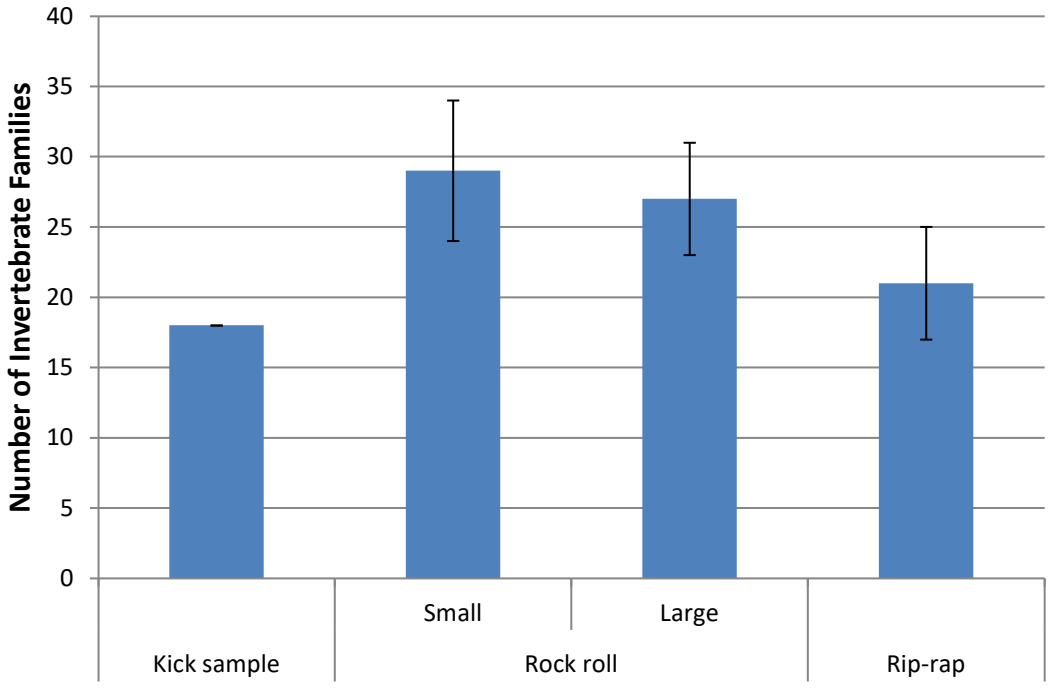

Figure 6. Number of invertebrate families found in the different bank support materials

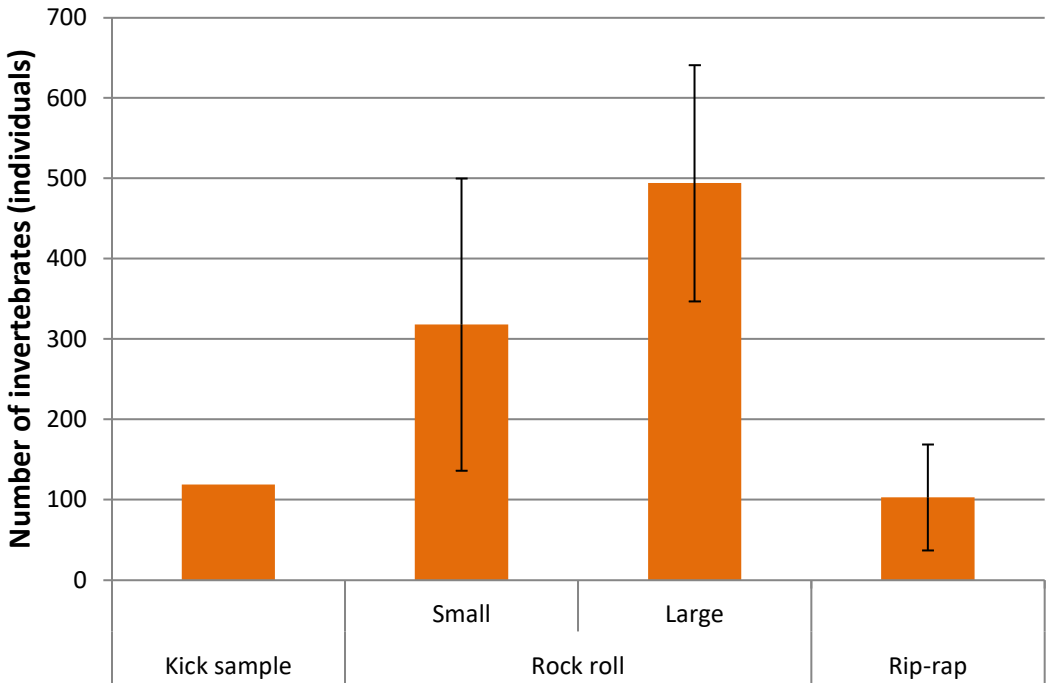

Figure 7. Number of invertebrate families found in the different bank support materials

Table 4. Bray-Curtis similarity between the treatments

	kick	small	large	riprap
kick				
small	53			
large	63	77		
riprap	74	63	70	

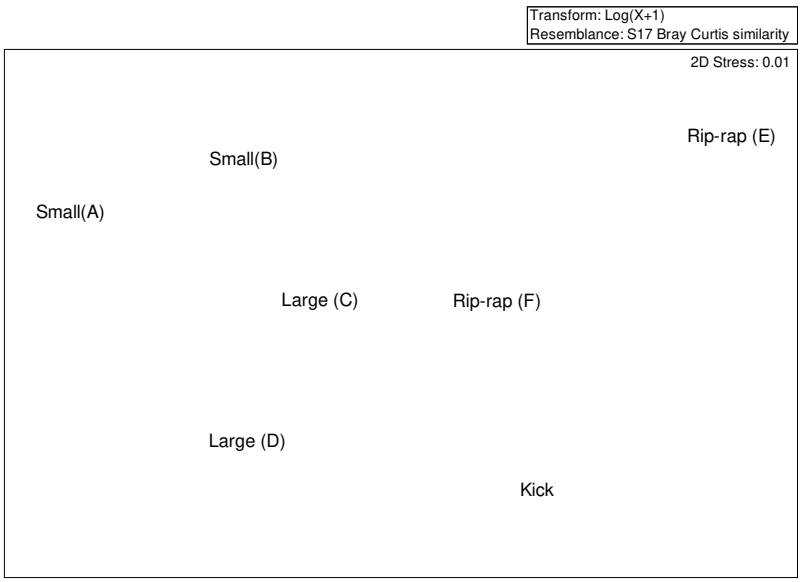

Figure 8. Multi Dimensional Scaling (MDS) diagram of Bray-Curtis similarity for the samples taken. Distance between samples in the diagram represent the dissimilarity, with closer samples being more similar.

Observations during the field work

During sampling it was noticed that the core of the rock rolls had already filled with deposited sediment. This is ideal for structures to reduce erosion since the flow speed in the interstitial spaces is sufficiently slow to capture sediment and allow the natural development of the bank. However, it also means that only burrowing invertebrates will occupy the core of the rock mattresses.

Many more rocks are present per unit area of rock roll, than per unit area of rip-rap, so the initial availability of interstitial spaces may be higher at the early stages, although as sediment gets deposited, this is likely to change.

The rock rolls accumulated a lot of leaves, which the rip-rap didn't seem to capture. Sediment deposition was also not evident around the rocks of the rip-rap. Sediment accumulation and organic matter accumulation will be calculated during the next field sampling period.

Conclusions

With only one sampling period complete, any conclusions must be considered tentative. The two replicates still give high standard error but this is expected to reduce as we get towards our intended 8 replicates.

The rock rolls had both higher diversity and higher abundances of invertebrates than either rip-rap or the kick samples. This is probably due to the large number of interstitial spaces that were still present within the rock rolls and the additional habitat created by sediment accumulation.

Small rock rolls appear to have a higher diversity of invertebrates than the large rock rolls, but lower abundance. It did appear that there was more sediment accumulation in the smaller rock rolls (to be confirmed by the next field mission). Thus, there is a smaller volume of interstitial spaces, yet the small interstitial spaces that are available may be more effective for predator avoidance. Differences in the representation of different invertebrate functional groups is currently being studied.

The MDS shows that the small and large rock rolls are somewhat distinct in their communities; a more obvious difference between these two types may occur when there are more samples. The larger rock rolls and the rip-rap, although slightly different to each other, are about equidistant (same dissimilarity) to the kick sample. The small rock rolls are more different than either of these to the kick sample, probably due to the increased sediment accumulation.

As a preliminary conclusion, it could be that the sediment is trapped more rapidly and more effectively by the small rock rolls than either the large rock rolls or rip-rap. This gives a slightly different community, and a higher diversity due to smaller interstitial spaces and more sediment accumulation. The rocks rolls certainly appear to be more diverse and have more invertebrates at this stage of establishment than rip-rap, though as they slowly become entrained with sediments diversity may actually reduce, matching that of a natural bank. The entrainment of sediments may assist with the rapid development of 'natural looking' banks, and thus eventually with the development of the bank vegetation.