The effect of for

On river-bed surface structures and sediment mobility

Figure 1: *An example of a River Idle "ring cluster"*

Figure 2: *An example of an overlapping or "imbricated" gravel surface (flow direction left to right).*

Figure 3: *Gravel bar disturbance through "redd digging" by Pacific (Pink) Salmon in the Fraser River, British Columbia. Source: Prof. Mike Church*

The way that particles of sediment are arranged on a river bed is important because it can directly affect how easy it is for flows to transport bed material.

Sediment particles are rearranged by moderate flows, turning a bed with a random arrangement of grains into one where there is a distinct structure to the way sediments are positioned.

This new "structure" might consist of pebble clusters (Figure 1), or structures of overlapping stones (Figure 2). The newly structured surface will be more stable, rendering bed sediments less mobile during subsequent flood events and it is reasonable to assume that animals capable of disturbing or modifying these surface structures might directly influence the mobility of bed material, particularly under subsequent flood events.

If we consider existing "peer reviewed" academic literature, it becomes apparent that relatively few studies have considered the effects of freshwater fauna on river bed structures and "grain entrainment". Those interested in sediment transport and rates of erosion in rivers have historically almost entirely ignored the presence and potential effects of living organisms on physical processes.

A few studies have shown that animals are capable of modifying the environment in which they live and that exhibited behaviours can have significant effects on the mobility of sediments under subsequent flood events.

Redd-constructing by Pacific Salmon (Figure 3) and silk spinning by certain caddis flies (Figure 4) are two examples of species that have been studied- the caddis flies increase rather than decrease bed stability. However, the effects of foraging fish on bed sediment structures and thence, sediment dynamics remains almost entirely unstudied, despite there being an abundance of fish species worldwide that collectively expend significant amounts of time and energy foraging across river beds.

Within Europe, cyprinids dominate riverine fish communities and of specific interest is the barbel, being a large (when mature), shoaling, "bed-feeding specialist". It is likely that the barbel could have significant effects on bed surface structures and thence, sediment mobility whilst foraging, particularly when feeding in large shoals.

The research that I am

aging Cyprinids

Above left: ***Figure 4:*** *Hydropsychids create silk "nets" and retreats within gravel substrates. Through these activities, hydropsychids bind particles together, increasing bed stability. Source: Dr. Matthew Johnson.* **Above right:** ***Figure 5:*** *The picturesque River Idle in summer.*

conducting at Loughborough University as part of a 3 year PhD project, aims to understand how foraging barbel (*Barbus barbus)*, dismantle sediment surface structures, making particles less stable. Increases in available, transportable sediment will have implications for sediment transport fluxes, reach-scale sediment loads, channel morphology and aquatic habitat.

Furthermore, this research is relevant to river management strategies, fisheries management and engineering applications where knowledge of sediment transport is required.

I am now in the third and final year of my PhD at Loughborough University (Department of Geography), having previously gained Undergraduate and Masters degrees from the same establishment. Within the department, I am incredibly fortunate to be part of a research group, led by Professor Stephen Rice, who share a common focus in the study of freshwater fauna and more specifically, how animal behaviours influence earth-system processes. The team as a whole are working towards the exciting realisation that natural ecosystems consist of many thousands of as yet unrecognised faunal (and floral) species which may, cumulatively, have a significant impact on sediment dynamics within natural, riverine systems.

Whilst I enjoy the dynamic and stimulating environment in which I work, the primary motivation for my own research stems from a life-long "passion for angling" for which I have my parents and older brother to thank! Needless to say, I enjoy what I do and feel incredibly privileged to have been given the opportunity to conduct this research, which wouldn't have been possible without the support of friends, family and colleagues.

Equally, I would like to thank the Barbel Society and, in particular, Peter Reading and the Committee for providing financial (and personal) support throughout the project's duration. The society does a fantastic job in promoting barbel angling whilst maintaining a strong association with research, conservation and fish welfare.

So, to the research itself! I feel that in many ways I am preaching to the converted because for a long time, anglers have noted the effects of foraging fish on their environment. Many an angler has observed a feeding carp kicking up silt and fine sediment from a shallow lake bed, or the tell-tail signs of a foraging barbel, where discrete patches of scoured gravel can be seen in isolation on the riverbed. However, it is one thing to observe the signs of fish activity but it is another to understand how exhibited behaviours influence the fish's habitat and how these habitat changes might impact on physical processes. This is where my research comes in.

To date, my research has considered the effects of foraging cyprinids at a variety of scales, often using barbel as the subject species, due to their natural preference for gravel-bed rivers and coarse substrate types whilst foraging (for

Figure 6: *An underwater image of a substrate tray, installed in the River Idle*

mature specimens at least). Experiments have been conducted under both controlled, laboratory conditions and in natural field settings in the River Idle, Nottinghamshire. To date, the Barbel Society has kindly part funded field work within the River Idle and it is this component of the research that I will expand on here.

Before I start, it is important that I thank Ron Trevis and Derbyshire County Angling Club for giving me access to a stretch of the River Idle (Figure 5). It's a great stretch of river and I have four months worth of underwater video footage to prove it!

The work itself has attempted to up-scale flume experiments (using single fish in isolation) to investigate and quantify the foraging effects of naturally occurring *cyprinid* populations on bed sediment structures and thence, erosion rates.

Figure 8: *Using the laser scanner to gain Digital Elevation Models (DEMs) of the tray surface.*

To achieve this, large trays of gravel (Figure 6) were installed in the River Idle for 5 days to develop a degree of water-worked structure (similar to those examples shown in Figures 1 and 2), and seeded with feed at typical densities. Due to the physical size and mass of these trays, a winch and tripod were used to extract them (Figure 7).

Figure 7: *Winching one of the sediment trays from the river bed*

"Small sections of the tray were transported back to the laboratory in Loughborough and placed in an artificial river channel"

Digital Elevation Models (DEMs) of the trays, derived from laser scanning measurements (Figure 8), were obtained before and after exposure to fish, in order to quantify the impact that foraging *cyprinids* have on bed surface structures. Examples of tray surfaces, scans and a Digital Elevation Model of Difference (one of the many techniques that I have used to quantify bed disturbance by fish) can be seen in Figure 9. Small sections of the tray were transported back to the laboratory in Loughborough and placed in an artificial river channel. Bed surface material was then entrained under simulated flood events and I was able to quantify the effects of foraging on the mobility of bed sediments.

The results of these experiments are currently being processed and will be published within my PhD thesis and as an academic paper. I am unable to publish any findings at this stage, but the work I have completed to date has already provided an improved knowledge of the effects of foraging fish on bed sediment structures and river bed erosion.

I have provided a brief outline and justification for research here but if you are interested in my work and would like to know more, please feel free to contact me by email: gyap@lboro.ac.uk.

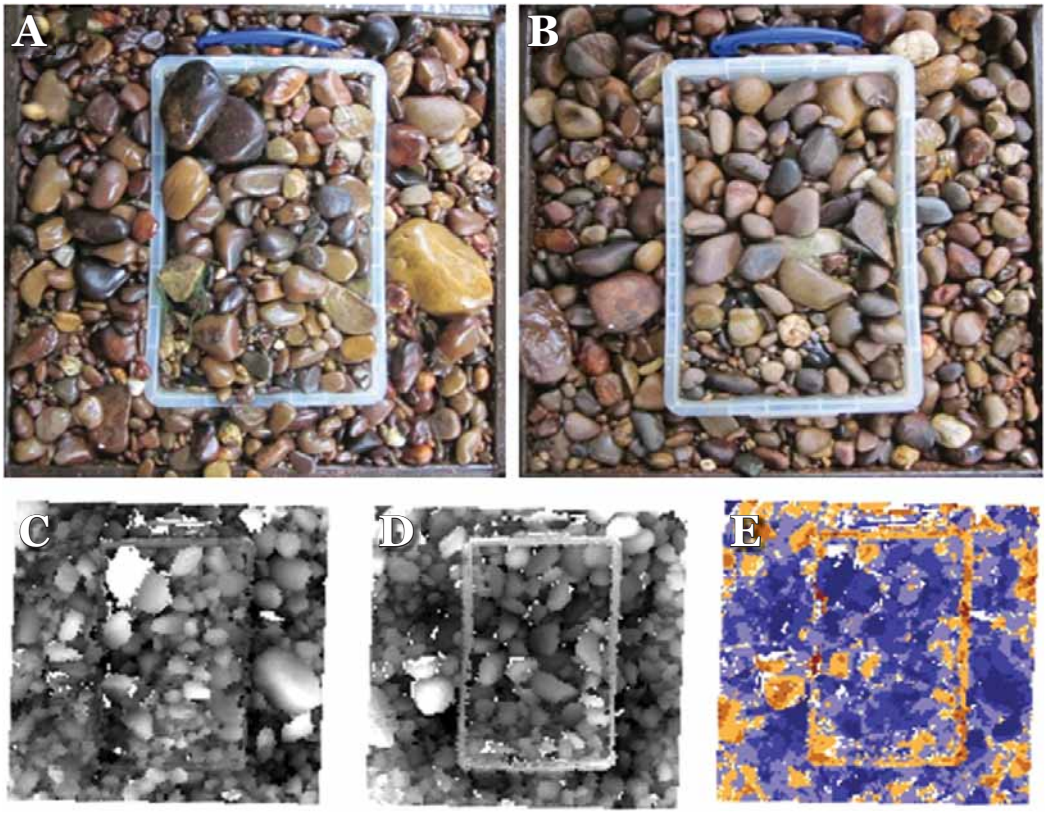

Figure 9: **A** *and* **B** *represent photographs of tray substrates before and after exposure to foraging cyprinids in the Idle.* **C** *represents the DEM equivalent of photo A.* **D** *represents the DEM equivalent of photo B.* **E** *represents the topographic difference between pre- (C) and post-fish (D) substrates; Blue indicates "pitting" whilst red/ orange indicates "mounding".*