The Role of Freshwater Mussels in River Bed Dynamics and Sediment Flux

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Introduction

Freshwater mussels may constitute up to 90% of the benthic biomass of a river[1] and can filter approximately 40 litres of water per individual per day, removing particulates such as algae, bacteria and suspended sediment[2] (Fig. 1). The critical role that they play in benthic-pelagic food webs[3] has led to general recognition of their status as "keystone species" and "ecosystem engineers." [4,5,6] Freshwater mussels have experienced significant declines in recent years, attributed primarily to anthropogenic influences, and as such are now considered globally threatened. [6,7,8] Improved understanding of the role that freshwater mussels play in fluvial sediment dynamics will enhance the modelling of fluvial systems and add further justification to the importance of conserving this group of animals.

Figure. 1: *Anodonta anatina* filter feeding in the flume at the University of Derby.

Experimental Design

A recirculating flume-based study using the unionid species *Anodonta anatina* (Fig. 1) investigated the impact of this species on a the sedimentological, water and flow conditions of a model fluvial environment (Fig. 2 & 3).

Figure 2: The flume tank containing the substrate mix and freshwater mussel *Anodonta anatina*.

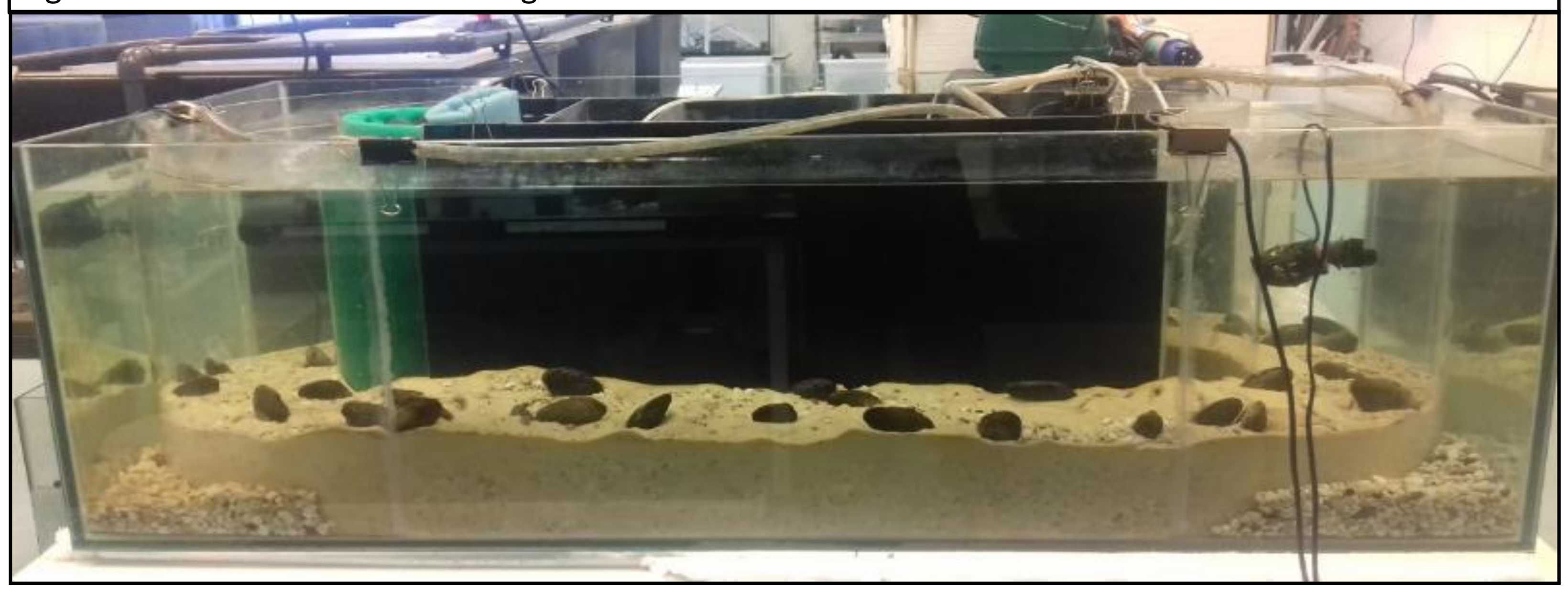
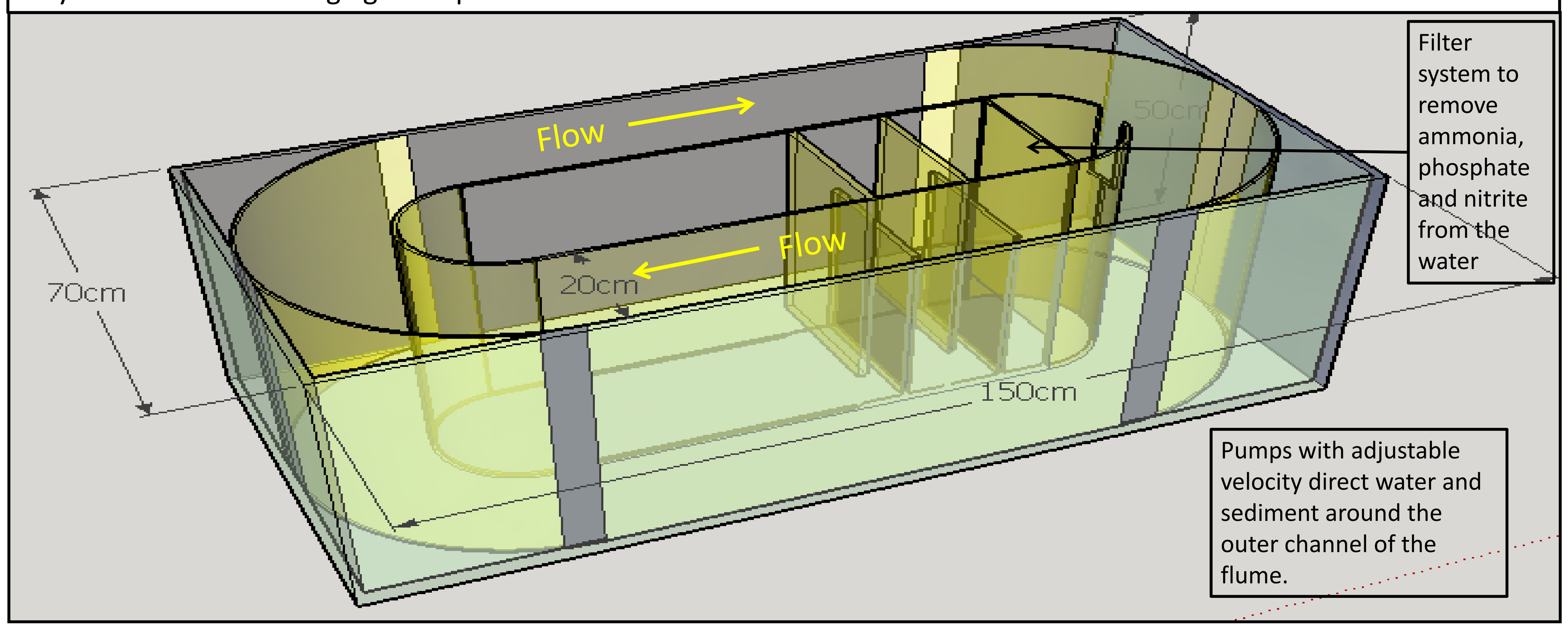


Figure 3: The dimensions and design of the recirculating flume tank at the University of Derby, which comprised an acrylic insert within a large glass aquarium tank.



Results

Figure 4: Graph to show the change in mean total dissolved solids (TDS) over the duration of the study. TDS was significantly lower when mussels were in the flume compared with when they were absent.

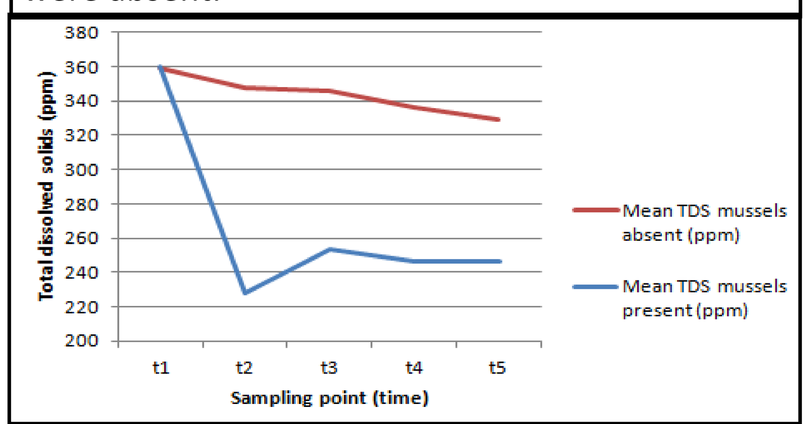


Figure 5: Graph to show the change in mean water turbidity over the duration of the study with a weekly addition of seston to the flume. When mussels were present their filter feeding maintained turbidity levels of less than 2 FNU.

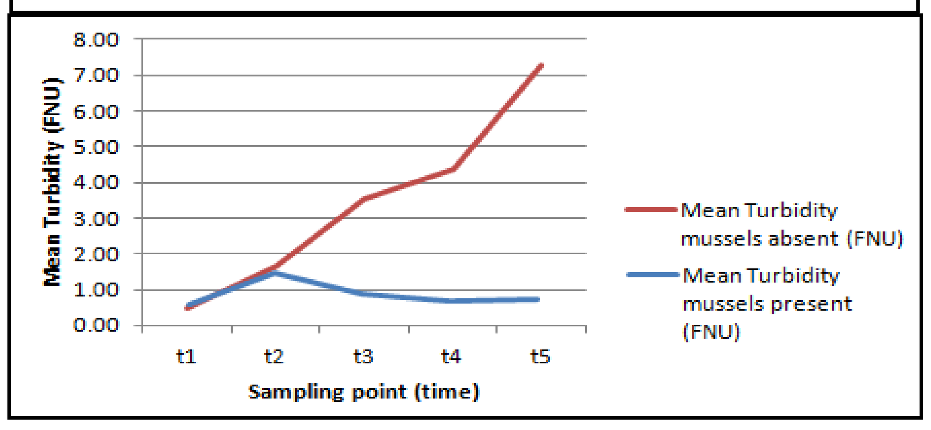


Figure 6: Graph to show the mean water velocities at four depth levels after eight weeks. The presence of mussels led to significantly reduced near-bed velocities. Near-surface velocities remained unaffected.

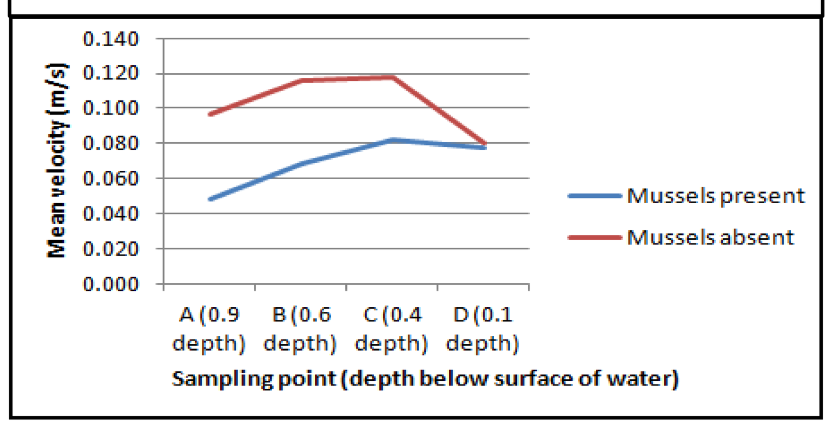
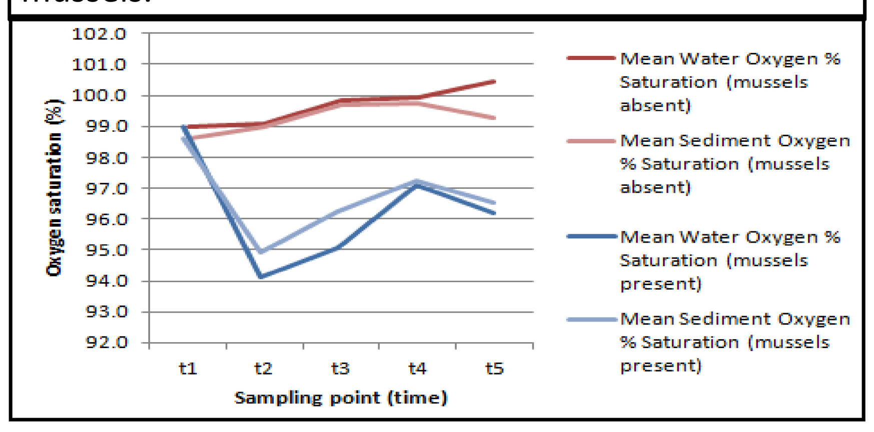


Figure 7: Graph to show the change in mean water and sediment dissolved oxygen saturation over the duration of the study. Water and sediment oxygen saturation levels were lower in the presence of the mussels.



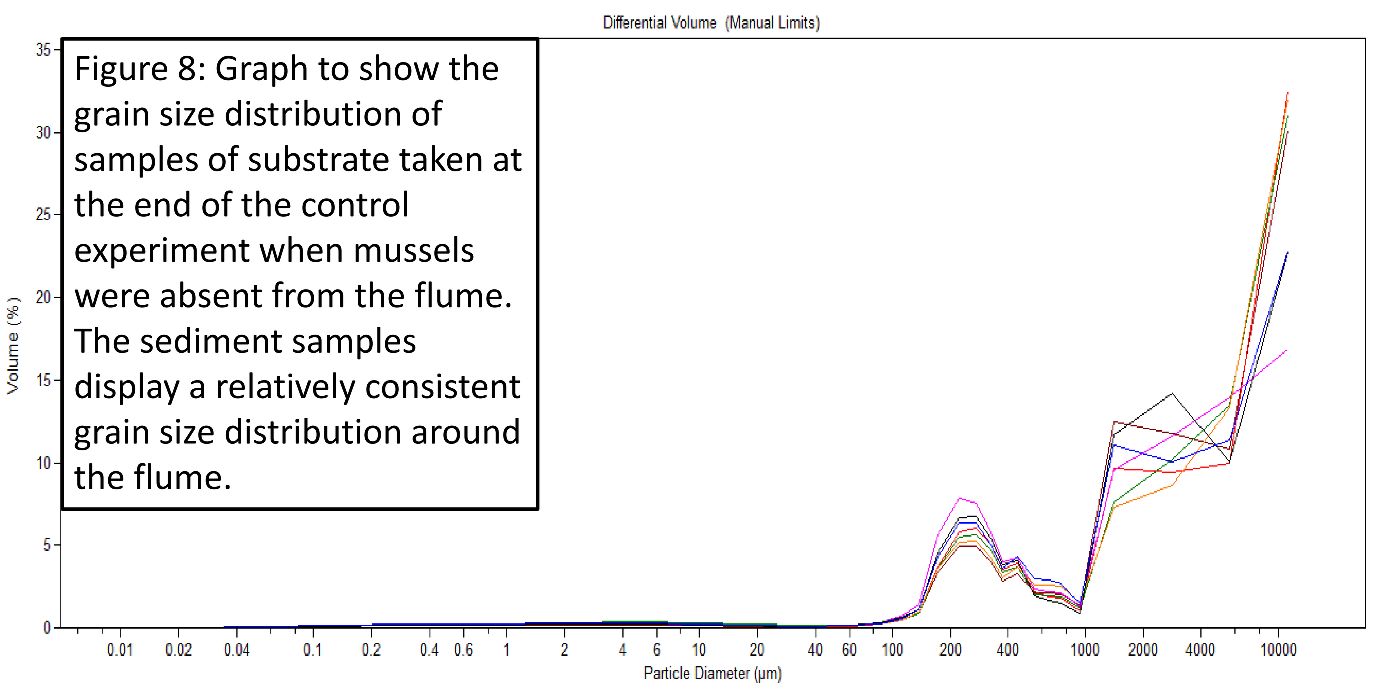


Figure 8: Graph to show the grain size distribution of samples of substrate taken at the end of the control experiment when mussels were absent from the flume. The sediment samples display a relatively consistent grain size distribution around the flume.

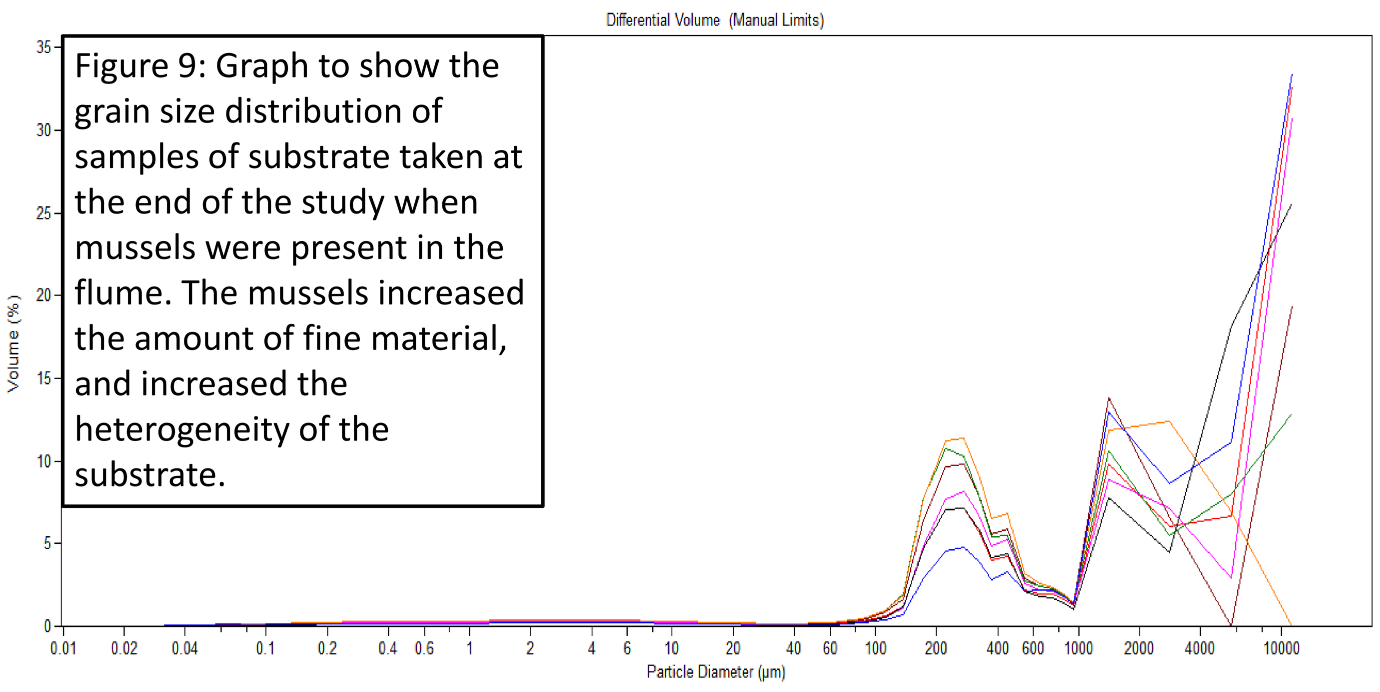
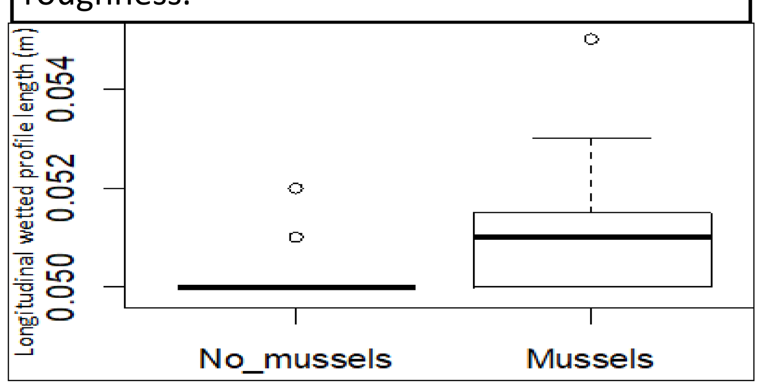


Figure 9: Graph to show the grain size distribution of samples of substrate taken at the end of the study when mussels were present in the flume. The mussels increased the amount of fine material, and increased the heterogeneity of the substrate.

Figure 10: The longitudinal wetted profile lengths were longer on average when mussels were present compared with when absent, indicating that the mussels increased bed roughness.



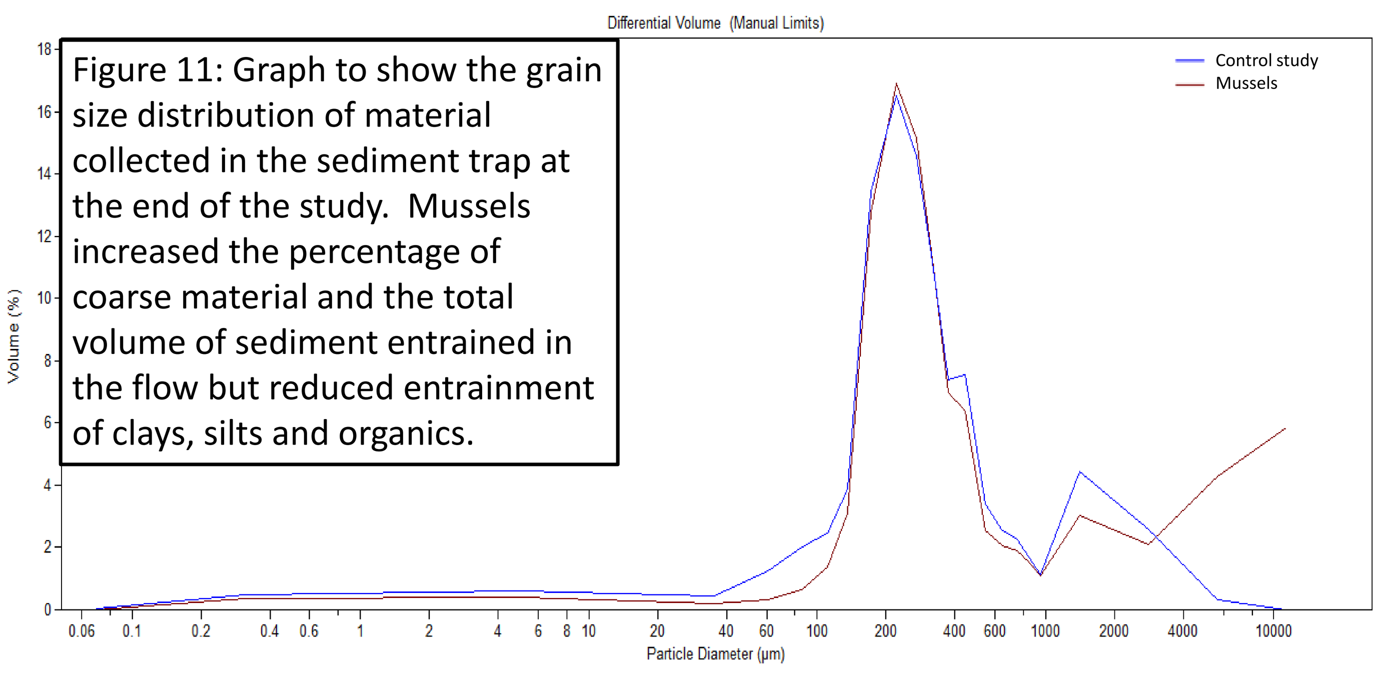
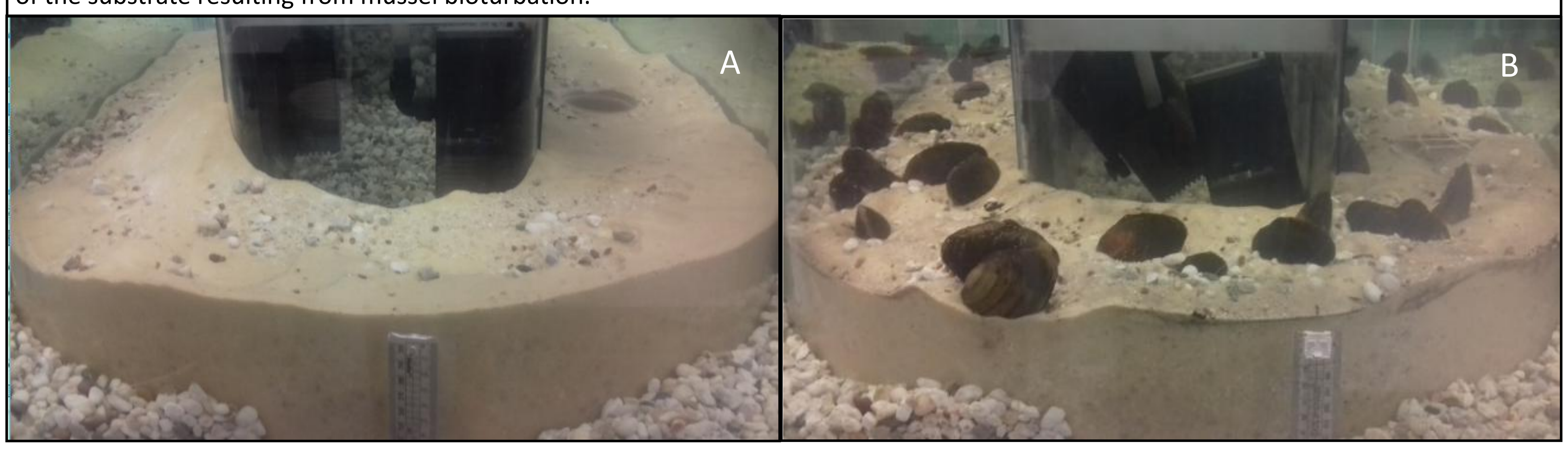


Figure 11: Graph to show the grain size distribution of material collected in the sediment trap at the end of the study. Mussels increased the percentage of coarse material and the total volume of sediment entrained in the flow but reduced entrainment of clays, silts and organics.

Figure 12: Flume substrate after 8 weeks with mussels absent from the flume (A) and after 8 weeks with mussels present (B). Note the greater quantity of organic matter in photograph B from mussel biodeposits, and the increased topographic roughness and heterogeneity of the substrate resulting from mussel bioturbation.



Conclusions

Compared with the control study, the presence of *A. anatina:*

1) Reduced the amount of total dissolved solids in the water; p <.001 (Fig. 4).
2) Reduced, the mean water turbidity; p <.001 (Fig. 5).
3) Reduced mean near-bed velocities; p <.001 (Fig. 6) and boundary shear stress.
4) Reduced the water and sediment % oxygen saturation; p <.001 (Fig. 7).
5) Increased, through bioturbation the heterogeneity of the substrate (Fig. 8, 9 & 12).
6) Increased longitudinal wetted-profile length, indicating an increase in bed roughness (Fig. 10 & 12).
7) Reduced the entrainment of fine and organic material to the sediment trap, and increased the percentage of fine and organic material in the substrate (Fig. 8, 9 & 11).
8) Increased, through bioturbation the amount of sand and gravel in the sediment trap (Fig. 11).

Given that freshwater mussels can exist at very high densities within rivers,[6] increased mixing and mobilisation of bedload, improved habitat heterogeneity and the transferral of material from the water to the substrate by mussels implies they constitute a critical element in the sediment dynamics of fluvial systems.

References:

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All photos taken by Andrea Leng, University of Derby.

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