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Modelling the effect of fine sediment on salmonid spawning habitat

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Diffuse fine sediment delivery to rivers is recognised as a widespread problem in the UK. Furthermore, projections suggest that sediment pressures may increase in the future due to both climate change and land use changes. This fine sediment infiltrates into the bed and clogs up salmonid spawning gravels. Fine sediment has been found to reduce survival rates of salmonid eggs in both field and laboratory experiments, with the main hypotheses used to explain this being (a) fine sediment reduces gravel permeability and intra-gravel flow velocities; (b) intra-gravel O_2 concentrations decrease due to reduced supply and increased consumption by organic sediments; and (c) clay particles block the exchange of O_2 across the egg membrane.

The SIDO (Sediment Intrusion and Dissolved Oxygen)-UK model is a physically based numerical model which stimulates the effect of fine sediment intrusion on the abiotic characteristics of the salmonid redd, along with the consequences for egg development and survival. The first 2 hypotheses above are represented, while the third is not yet included. Field observations from the River Ithon, Wales, have been used to calibrate the model using sediment accumulation data. The model was then used to assess the impact of varying sediment inputs upon the sediment intrusion rates, abiotic redd characteristics and fish egg survival rates.

Results indicate that egg survival is highly sensitive to the discharge and the suspended sediment concentrations, particularly to changes in the supply rate of sand particles, rather than silt and clay. This can be explained by the increased likelihood of blocking of intra-gravel pores by larger sand particles, which reduce intra-gravel flow velocities and the supply of oxygen rich water. A doubling of the sand concentration results in a 51% increase in red infilling, which causes a 24% reduction in the average intra-gravel flow velocity. A corresponding 20% decrease of the average O_2 concentration is evident which is a function of reduced supply of oxygen rich water and consumption by sediment within the redd. The results indicate that it is the former of these processes which is the most important, while the Sediment Oxygen Consumption (SOC), mainly associated with the silt and clay fractions, is considered to have a secondary effect on influencing the egg zone abiotic properties. These findings have implications for how we manage the sediment delivery problem.