Can We Protect Salmonid Spawning Habitats From Fine Sediment Intrusion?

Introduction

In the past centuries, 98 % of all streams in Denmark have been channelized in order to improve drainage of agricultural areas. The channelizations have left the streams void of natural spawning gravel and generated excessive sediment transport due to run off from fields and reduced stability of the river bed. As a consequence, natural salmonid fish stocks have been reduced in number and distribution. Spawning habitat rehabilitation projects have been conducted in many regulated streams by reintroducing spawning gravel following general guidelines.

A drawback to the positive effects of reintroducing spawning gravel is the amount of fine sediments in the regulated streams. Numerous studies have shown that the presence of high levels of fine sediment in the spawning gravel has a deleterious effect on survival of the incubating eggs [1].

To mitigate the effects of excessive sediment transport and thereby fine sediment intrusion, sediment traps are occasionally constructed upstream the spawning gravel areal by excavating a segment of the stream with an increased width and depth compared to the main channel. The reduced flow velocity through the sediment trap is intended to reduce both suspended sediment load and bed load by storing the sediment. These sediment traps are then excavated when filled.

Systematic monitoring of the effects of spawning habitat rehabilitation is not common [2]. In this study, the effects of a sediment trap on the fine sediment deposition rates and the grain sizes of fine sediment in reintroduced spawning gravel in a channelized stream is investigated. Furthermore, an investigation of the required dimensions of sediment traps is conducted based on laboratory data of fine sediments.

Methods

Infiltration baskets, used to monitor the deposition rates of fine sediment, were made of net with a mesh size of 6 mm. They were 25 cm deep and had a diameter of 24 cm. A total of 12 infiltration baskets were filled with clean gravel (D_{50} 29 mm, D_{15} 19 mm and D_{85} 62 mm) and buried flush with the bed surface in four areas of the stream Rakkeby Å, where spawning gravel has been reintroduced. One area was located 100 m upstream a sediment trap, while the remaining three areas were located 250 m, 1500 m and 1600 m downstream, respectively. The infiltration baskets were emptied of fine sediment (below 2 mm) and re-buried at monthly intervals during the incubation period, which is the period between spawning and emergence of fry, normally November to April, see fig. 6,7. Loss of fine sediment from the baskets during retrieval from the bed was avoided by pulling up a collapsible bag around the baskets. The content of the baskets was dried, weighed and sieved in laboratory. Along with the infiltration rates, the flow in the stream was continually measured using a HOBO preassure logger. Settling velocities of sediment grainsizes typically found in lowland streams were determined in the laboratory together with a relationship between resuspension of settled sediment and bottom shear stress.

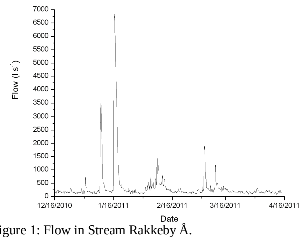

Figure 1: Flow in Stream Rakkeby Å.

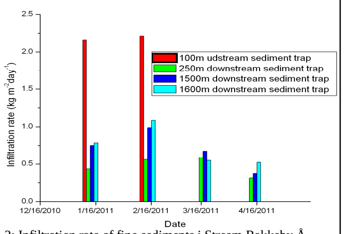

Figure 2: Infiltration rate of fine sediments i Stream Rakkeby Å.

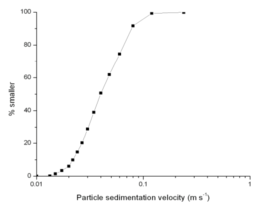

Figure 3: Particle sedimentation velocity.

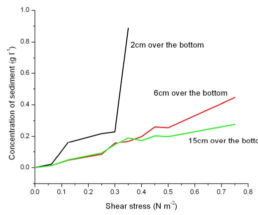

Figure 4: Data from bed erosion experiment.

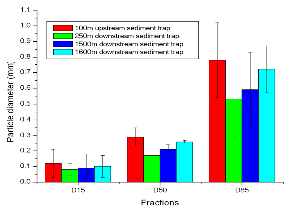

Figure 5: Size characteristics of infiltrated fine sediments.


Figure 6: Gravel with infiltrated fines.


Figure 7: Emptying of gravel basket, January 2011.

Results

Both bedload and suspended load is present in the accumulated fine sediment. Fine sediment expected to be in suspension is typically below 0.063 mm, while sediment transported at the bed typically is above 0.063 mm [3]. The measurements provide evidence of finer but lower levels of sediment 250 m downstream the sediment trap compared with the upstream area, see fig. 2 and 5. The sediment trap reduces the total amount of accumulated sediment, but only sediment larger than approximately 0.5 mm is retained leaving the finer fractions of the sediment to move further downstream. The finer fractions of the sediment are more critical due to a lower permeability. After 1600 m the effect of the sediment trap is negligible due to new sediment inputs.

These field observations together with the laboratory experiments concerning settling velocity and resuspension suggest that the sediment trap is under dimensioned, see fig. 1,3,4. The generally high rates of fine sediment deposition is probably due to the excessive sediment transport in the stream and the large difference in size between sediment in motion and spawning gravel and thus pore size. Sediment traps is not the solution to the problem of fine sediment accumulation in spawning gravel. Better management of the sediment sources in the catchment area is needed, especially considering the predictions of higher frequency of heavy rain and thereby sediment runoff events in future. In channelized streams with a high transport rate of fine sediments, sediment traps might be a cost effective temporary method to protect the salmonid spawning gravel from fine sediments.

The results in the study only suggest that the sediment trap is sorting the sediment in motion by removing the larger fractions. Differences in hydraulic variables (bottom shear stress, flow velocity, pressure gradient etc.) between the different spawning areas in the study may account for some of the differences in the measured deposition rates.

References

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