Linking changing grain size distributions with the development of shelter availability for fish in the bypass reach of a hydro power plant

Spyros Pritsis, Kordula Schwarzwälder, Wolfgang Szentkereszty and Nils Rüther
Department of Civil and Environmental Engineering
The Norwegian University of Science and Technology, Trondheim, Norway
Corresponding author: kordula.v.a.schwarzwalder@ntnu.no

INTRODUCTION

Aquatic biodiversity is highly under pressure due to anthropogenic changes of rivers such as hydraulic structures changing the diversity of flow and aquatic fauna as well as sediment continuity. This can have severe consequences on the fish population in the river reach. Fish are strongly depending on a certain substrate composition throughout all their life stages. Juveniles e.g. are depending on a certain availability of shelter in the substrate in order to survive their life stage. Therefore we investigate the effects of changes in the sediment composition at a Hydropower plant in Switzerland on the availability of potential shelter for juvenile fish.

CASE STUDY

The test site is a residual flow reach at a hydropower plant in the river Limmat. In this residual flow reach we defined several spots based on different criteria such as:

- Submergence/ wetted area
- Submergence/wetted area only during certain periods with higher discharge
- Upstream sediment inflow fluxes (via a vortex tube)
- Downstream sediment inflow fluxes
- Backwater areas

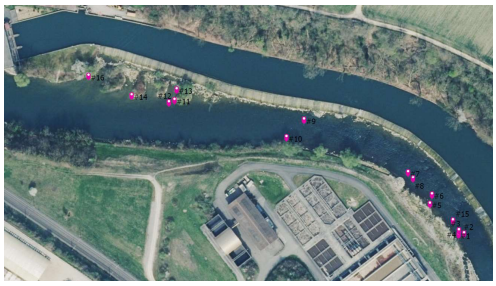

Figure 1: Sampling spots in the residual flow reach (the headrace channel can be seen in the upper part with the hydropowerplant in the left upper corner).

METHOD

At these different locations (fig. 1) in the bypass reach different sediment measurement techniques were conducted such as

- sieving
- photogrammetry (Basegrain)
- pebble count method

Further we measured the shelter availability in the corresponding locations, using the so called Finstad method (fig. 2). For this method a frame with a specific size (65 mm x 65 mm) is placed on the gravel. Then a tube with a certain diameter (in our experiments three with 5mm, 8mm and 12mm) are used to mimic the possible hidings of fishes between the stones.

The results are categorized into four different length classes. Based on the number of shelters available and the classes the shelter availability can be defined (tab. 1).

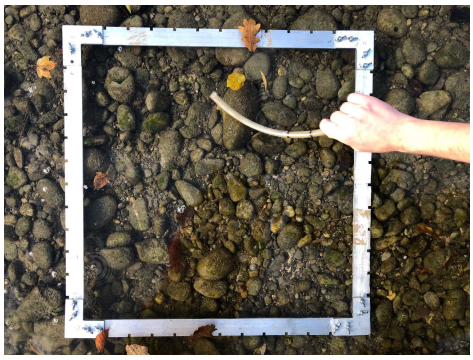

Figure 2: Frame and tube for the application of the Finstad method

This method was developed for Atlantic salmon in Norwegian rivers with very large gravel sizes. In the current study we are working to adapt this method to the needs of other spezies and smaller grain size distributions.

RESULTS

The results show quite good accordance in the areas with similar patterns (fig. 3) such as submergence, part-time submergence etc. .

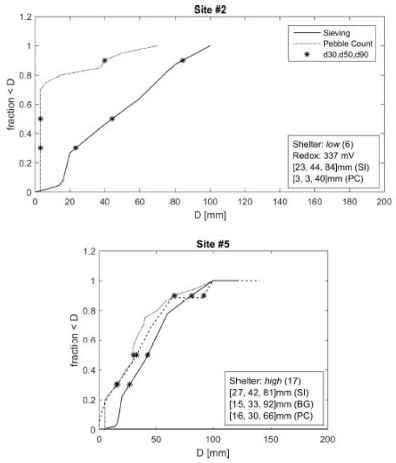

Figure 3: Results of the measurements of the grain size distribution using sieving, basegrain and pebble count at two different spots in the part-time submerged (#5) and submerged (#2) region

While the resulting grain size distribution shows a quite good correlation, with the potential shelter availability at different locations showed a fairly low dependency on D5 and D10 as found in earlier studies .

The shelter availability for spot #2 for instance is counted to 2, which results in a low availability, while spot #5 offers 17 shelters for class 1, which leads to a high availability (fig. 4). At the same time, the D5 is calculated with 14.2 mm (spot #2) vs 16.5 mm (spot #5) and the D10 with 16.5 mm (#2) vs 17.4 mm (#5), which would be close enough to assume a comparable number of shelter.

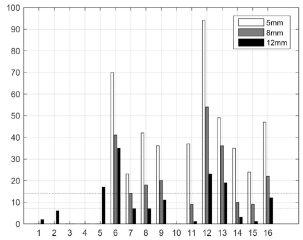

Figure 4: Shelter availability at different spots for class 1, for instance 6 at spot #2 and 17 at spot #5

CONCLUSION

The results show clearly that for the gravel present in the river Limmat no reliable correlation between the shelter availability and either D5 or D10 can be determined.

Further tests with other relevant grain related parameter are ongoing and appear promising. This equation can then be used in hydro-morphological models to estimate the spatial distribution of potential shelter availability for any given flow regime and grain size distribution. Further investigation at other sites will over time enlarge the database and therefore improve the correlation.

Figure 5: Numerical simulations of bed level changes in the residual flow reach

In addition numerical simulations are currently carried out to simulate the sediment movement throughout the residual flow reach. Figure 5 shows the bed changes in plus (red)/minus(black) 0.2 m after 24 hrs with a discharge of 100 m^3/s. The results show that even with such a high discharge, mass movement is little and only the fine fraction of the total size distribution is transported. Further post processing will show the rate of change of the individual fractions in the bed mixture, which will allow to determine possible shelter in the residual reach. The simulations are run using the software SSIIM.

FIThydro

Funded by the Horizon 2020 Framework Programme of the European Union under the Grant Agreement number 727830