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Assessment of the ecological impacts of macroroughness elements in stream flows

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The environmental suitability of flow release rules is often assessed for different fish species by modeling (e.g., CASiMir and PHABSIM) Weighted Usable Area (WUA) curves. However, these models are not able to resolve the hydrodynamic at small scales, e.g. that induced by the presence of macroroughness (e.g., single stones), which yet determine relatively large wakes that may contribute significantly in terms of habitat suitability. The presence of stones generates sheltered zones (i.e. the wake), which are typically temporary stationary points for many fish species. By resting in these low velocity regions, fishes minimize energy expenditure, and can quickly move to nearby fast water to feed (Hayes and Jowett, 1994).
Following the analytical model proposed by Negretti et al., (2006), we developed an analytical solution for the wake area behind the macroroughness elements. The total wake area in the river reach being monitored is a function of the streamflow, Q, and it is an actual Usable Area for fishes that can be used to correct the one computed by classic software such as PHABSIM or CASIMIR at each flow rate. By quantifying these wake areas we can therefore assess how the physical properties and number of such zones change in response to the changing hydrologic regime. In order to validate the concept, we selected a 400 meter reach from the Aare river in the center of Switzerland. The statistical distribution of macroroughness elements is obtained by taking orthorectified aerial photographs by drone surveys during low flow conditions. Then, the distribution of the wakes is obtained analytically as a derived distribution. This methodology allows to save computational costs and the time for detailed field surveys.