Towards Understanding Fish Behavior Near an Angled Rack: An Approach for Fish Tracing Using Open-Source Software

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Establishing free fish migration is a key to improve and protect the good ecological status of running waters. Recent studies on downstream migration focus on the micro-movements of fish in the immediate vicinity of or within hydraulic structures, most commonly fish-bypass channels or trash racks. Knowledge gains related to these micro-movements are essential to improve hydraulic structure designs, especially to prevent fish injury and mortality. Accurate fish tracking in related laboratory experiments can therefore provide a large benefit when visualizing animal behavior as well as linking measured and simulated physical parameters to fish movement and behavior.

As part of the MeMo project (“Development of a Combined Measuring/Modelling System for the Design, Evaluation und Optimization of Facilities for the Downstream Migration of Fish at Hydropower Plants”), laboratory experiments with different cyprinid species were conducted to investigate fish behavior in front of two angled bar racks (30° and 55°). Together with conventional measurements of the flow using an Acoustic Doppler Velocimeter (ADV), and 2D and 3D hydrodynamic CFD modelling, the bioinspired fish-shaped fish sensory sonde (FSS) are used for the characterization of the environmental conditions upstream of the racks.

Fish movements were recorded with a set of top- and side-facing cameras. The challenge was to trace individual fish swimming within small swarms of about 10 to 20 animals in a relatively wide flume (2 m) under non-optimal light conditions. Instead of using commercial tracking systems that may require considerable efforts for supplementary corrections of automatically generated tracks, a manual tracking method has been developed and applied in MeMo. Since most fish in this study were bottom-oriented during the experiments, the fish body shadows on the flume floor were tracked using a customized version of the open-source software Kinovea. The flume floor had been rasterized with a 10x10 cm coordinate grid which allowed for the transformation of pixel coordinates from the video frames into the fish positions in the physical flume coordinate system. Fish shadows were recorded at 0.3 s time intervals, allowing for high resolution tracing and subsequent calculation of the fish movement speed. Additional modification of the Kinovea software allowed for the tracing of fish swarm shadows. For both static and time-lapsed video visualization of the fish tracks the QGIS software and its feature “Temporal controller” is used. The QGIS system allows for the overlay of fish positions with all measured and modelled physical variables as well as with the geometry of a flume.

A first analysis of fish positions shows a strong influence of the rack setting angle on fish behavior during downstream passage. Additionally, the flow blockage arising from the vertical rods supporting the racks has been identified as influencing the fish micro-movements. Future analysis is aimed at the assessment of general behavioral patterns in front of the angled racks and preferred areas for approaching the laterally located bypass channel.