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Fish pass assessment by remote control: a novel framework for quantifying the hydraulics at fish pass entrances

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Fragmentation of aquatic habitats can lead to the extinction of migratory fish species with severe negative consequences at the ecosystem level and thus opposes the target of good ecological status of rivers defined in the EU Water Framework Directive (WFD). In the UK, the implementation of the EU WFD requires investments in fish pass facilities of estimated 532 million GBP (i.e. 639 million Euros) until 2027 to ensure fish passage at around 3,000 barriers considered critical. Hundreds of passes have been installed in the past. However, monitoring studies of fish passes around the world indicate that on average less than half of the fish attempting to pass such facilities are actually successful. There is a need for frameworks that allow the rapid identification of facilities that are biologically effective and those that require enhancement. Although there are many environmental characteristics that can affect fish passage success, past research suggests that variations in hydrodynamic conditions, reflected in water velocities, velocity gradients and turbulences, are the major cues that fish use to seek migration pathways in rivers. This paper presents the first steps taken in the development of a framework for the rapid field-based quantification of the hydraulic conditions downstream of fish passes and the assessment of the attractivity of fish passes for salmonids and coarse fish in UK rivers. For this purpose, a small-sized remote control platform carrying an acoustic Doppler current profiler (ADCP), a GPS unit, a stereo camera and an inertial measurement unit has been developed. The large amount of data on water velocities and depths measured by the ADCP within relatively short time is used to quantify the spatial and temporal distribution of water velocities. By matching these hydraulic features with known preferences of migratory fish, it is attempted to identify likely migration routes and aggregation areas at barriers as well as hydraulic features that may distract fish away from fish pass entrances. The initial steps of the framework development have focused on the challenge of precise spatial data referencing in areas with limited sky view to navigation satellites. Platform tracking with a motorised Total Station, various satellite-based positioning solutions and simultaneous localisation and mapping (SLAM) based on stereo images have been tested. The effect of errors in spatial data referencing on ADCP-derived maps of flow features and bathymetry will be quantified through simultaneous deployment of these navigation technologies and the ADCP. This will inform the selection of a cost-effective platform positioning system in practice. Further steps will cover the quantification of uncertainties in ADCP data caused by highly turbulent flows and the identification of suitable ADCP data sampling strategies at fish passes. The final framework for fish pass assessment can contribute to an improved understanding of the interaction of fish and the complex hydraulic river environment.