

## Publication

Impact of hydraulic forces on the passage of round goby (*Neogobius melanostomus*), gudgeon (*Gobio gobio*) and bullhead (*Cottus gobio*) in a vertical slot fish pass

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Every fish migrating upstream through vertical slot fish passes must swim through slots, where the resistance force of flowing water could affect the passage success. We measured the hydraulic force acting on the body of preserved benthic fish in a vertical slot at different water discharge rates (80 and 130 L/s) to compare the hydraulic burden individual fish species (round goby *Neogobius melanostomus* Pallas, 1814, gudgeon *Gobio gobio* L. and bullhead *Cottus gobio* L.) must overcome. The forces measured in three spatial axes were then compared to acoustic Doppler velocity measurements and the passage probability of 39-45 live fish per species. Passage probability reduction of 28.26% for round goby and 39.29% for bullhead was observed at the higher water discharge. Gudgeon showed increased numbers of passages and approaches when larger hydraulic forces were experienced at 130 L/s compared to the lower water discharge. Gudgeon experienced significantly lower hydraulic forces (mean 0.27 N  $\pm$  0.12 standard deviation) compared to round goby (mean 0.32 N  $\pm$  0.12 SD) and bullhead (0.35 N  $\pm$  0.14 SD). Potentially, the increased hydraulic forces at the higher water discharge contributed to the reduction in passages in round goby and bullhead. That gudgeon behaved differently from the other species illustrates how fish species deal differently with flowing water and the hydraulic forces experienced. Our approach provides a species-oriented assessment of the flow field in ecologically relevant fish passes. These findings represent an important step towards the development of purposeful fish pass designs, which is essential for ecosystem-oriented river connectivity.

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