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Habitat mapping of riverine fish by means of hydromorphological tools

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Abstract

Hydromorphological features of rivers, such as flow depth, flow velocity, and the composition of bed material play a crucial role in the habitat selection of fish. Although these basic hydromorphological parameters can be determined with high spatial and temporal resolution using state-of-the-art investigation methods, only few studies deal with the connection of habitat parameters and abundance of fishes (i.e., habitat modelling) in large rivers. The aim of this study is to fill this gap by introducing the so-called habitat maps connecting the results of 3D hydrodynamic simulations and results of offshore fish ecological surveys. The steps of habitat modelling are introduced through the case study of the Danube River focusing on evaluating the habitat use and suitability of two fish species representative to this section of the river (i.e., the round goby *Neogobius melanostomus* and the Danube streber *Zingel streber*). A novel method for mapping the bed material composition, playing a crucial role in the habitat assessment, is also presented along the numerical modelling.

KEYWORDS

bed material mapping, Danube, habitat suitability, hydromorphology, numerical modelling

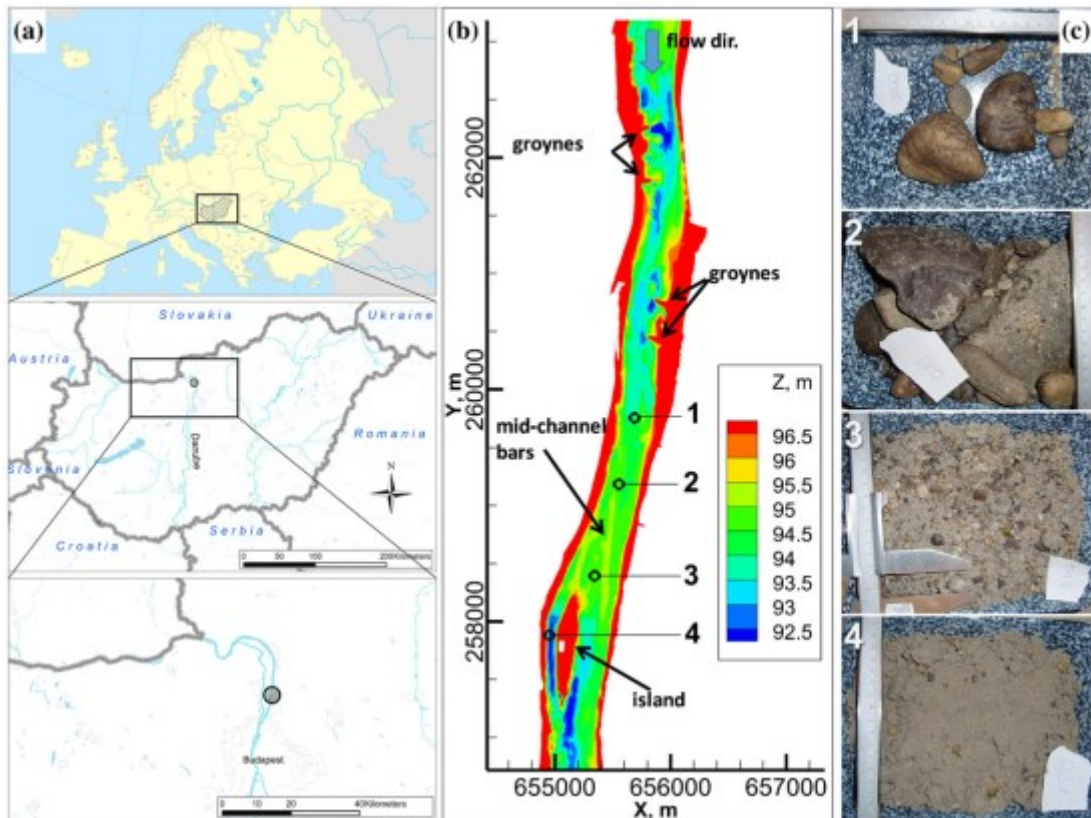


FIGURE 1 (a) Location of the study area; (b) digital elevation model of the study reach; (c) dried bed material samples (from the locations marked in b)

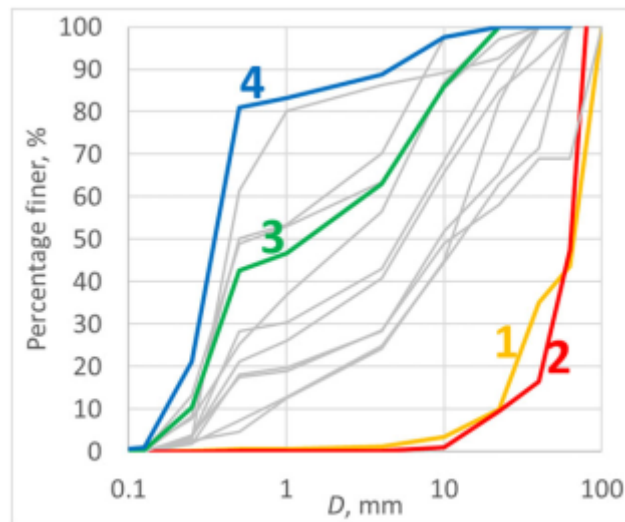


FIGURE 2 Grain size distribution curves of the bed material samples (the sampling locations of Samples 1-4 are indicated in Figure 1b)

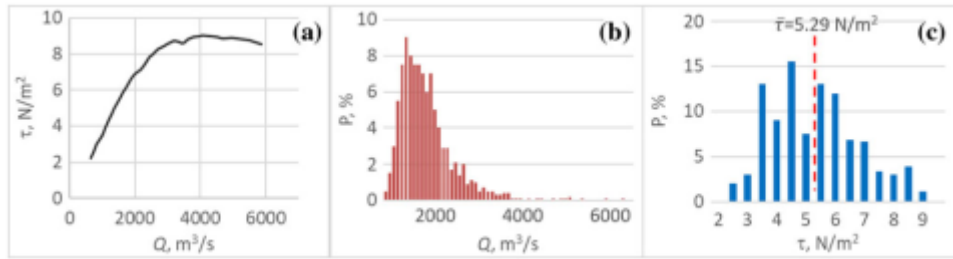


FIGURE 3 Determination of mean bed shear stress value for a computational cell: (a) simulated local bed shear stress versus flow discharge; (b) probability distribution of flow discharge; (c) derived probability distribution of bed shear stress and the estimated mean value

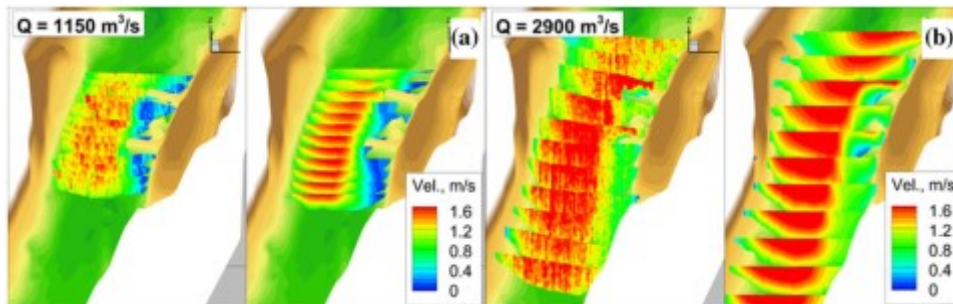


FIGURE 4 Measured (left) versus simulated cross-sectional flow velocity distributions for two flow regimes: (a) $Q_{low} = 1,150 \text{ m}^3/\text{s}$ and (b) $Q_{year} = 2,900 \text{ m}^3/\text{s}$ (perspective view from downstream)

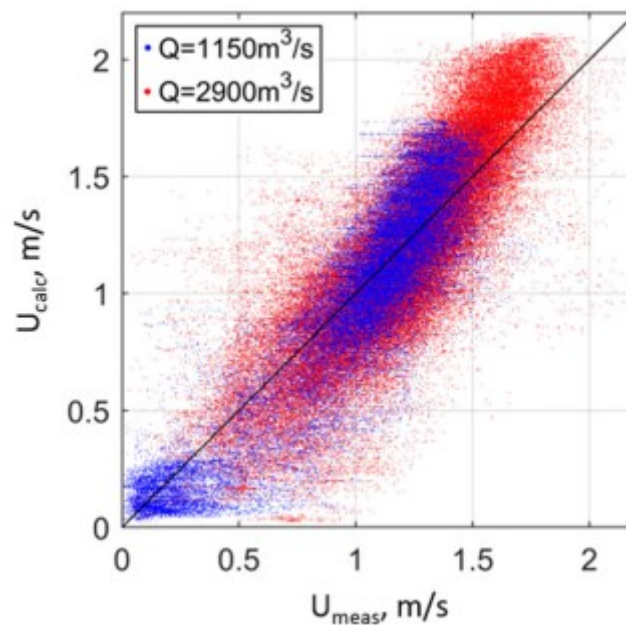


FIGURE 5 Measured versus simulated flow velocities for each ADCP cell

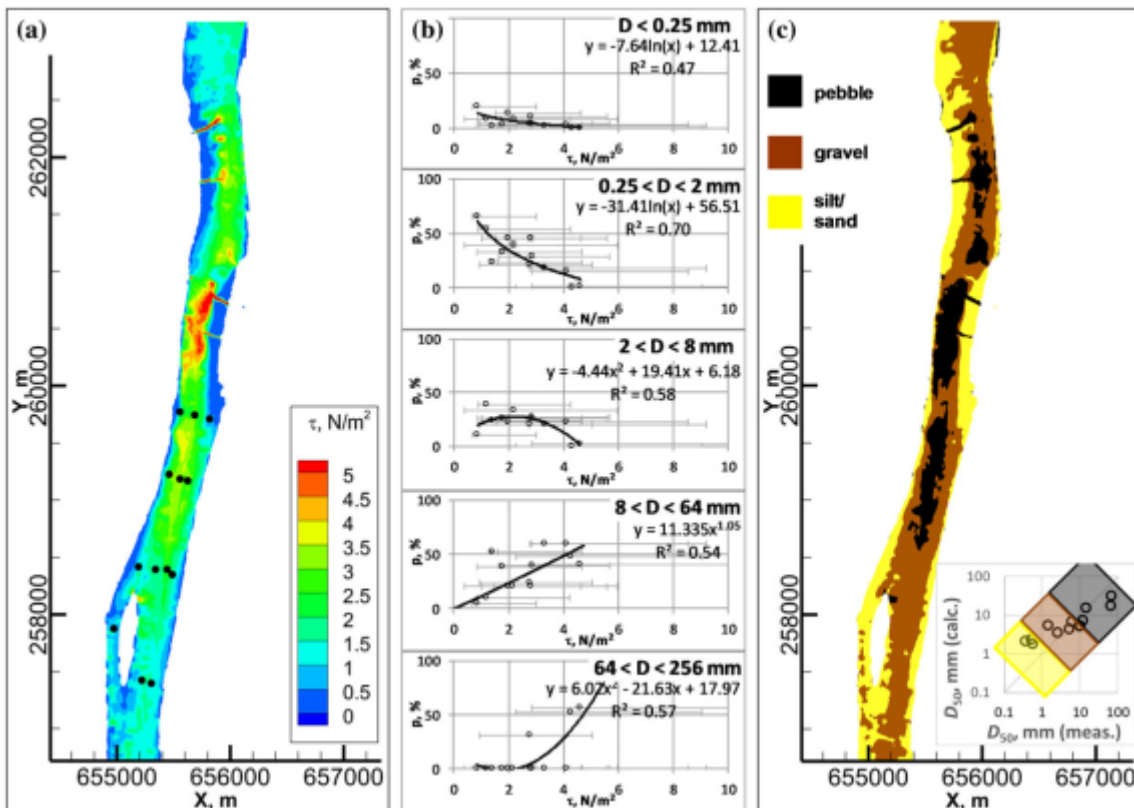


FIGURE 6 (a) Simulated mean bed shear stress field in the main channel (black dots indicate the location of bed material samplings); (b) relationships between grain-size fractions and simulated mean bed shear stress values at the bed material sampling points (error bars indicate the range of the simulated bed shear stress values); (c) simulated bed material map (small graph: comparison of measured and simulated D_{50} values; rectangles show the three bed material categories)

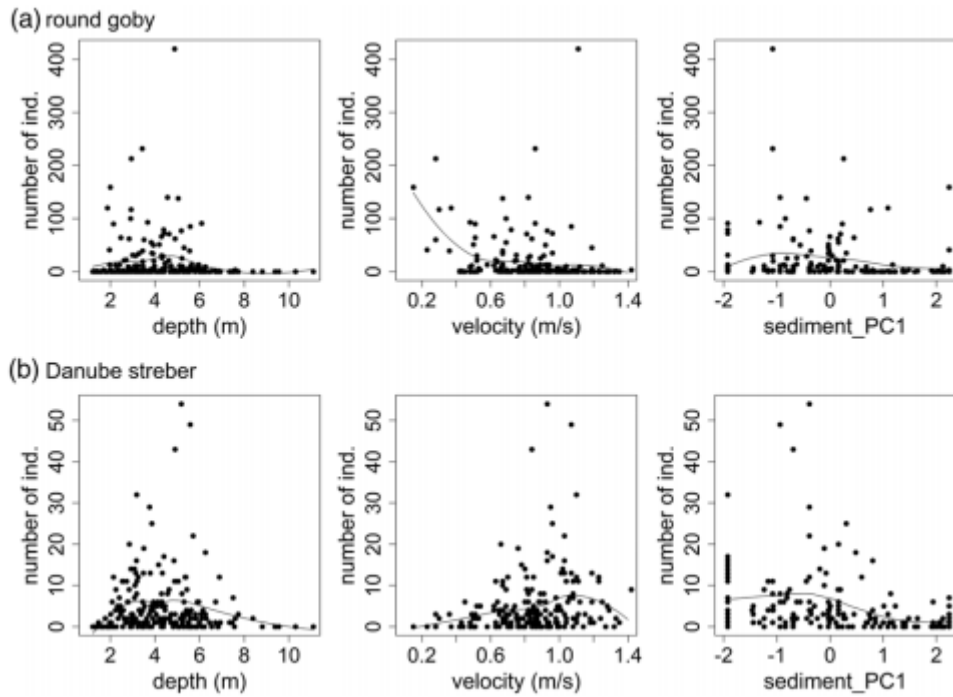


FIGURE 7 Relationships between fish abundance (i.e., CPUE: number of individuals per 500- m sample length) and physical habitat variables (depth, velocity, and bed material) for the (a) round goby, and for the (b) Danube streber. The response curves were fitted using the smoothing function of generalized additive models

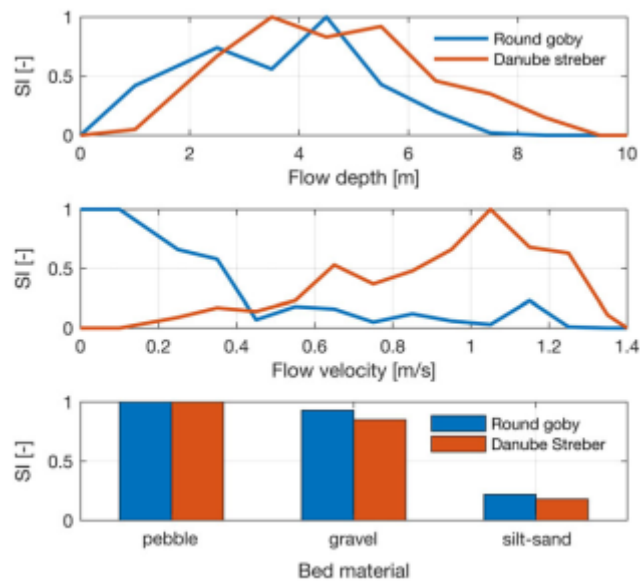


FIGURE 8 Flow depth, flow velocity, and bed material composition based SI functions for the round goby (*Neogobius melanostomus*; blue) and for the Danube streber (*Zingel streber*; red)

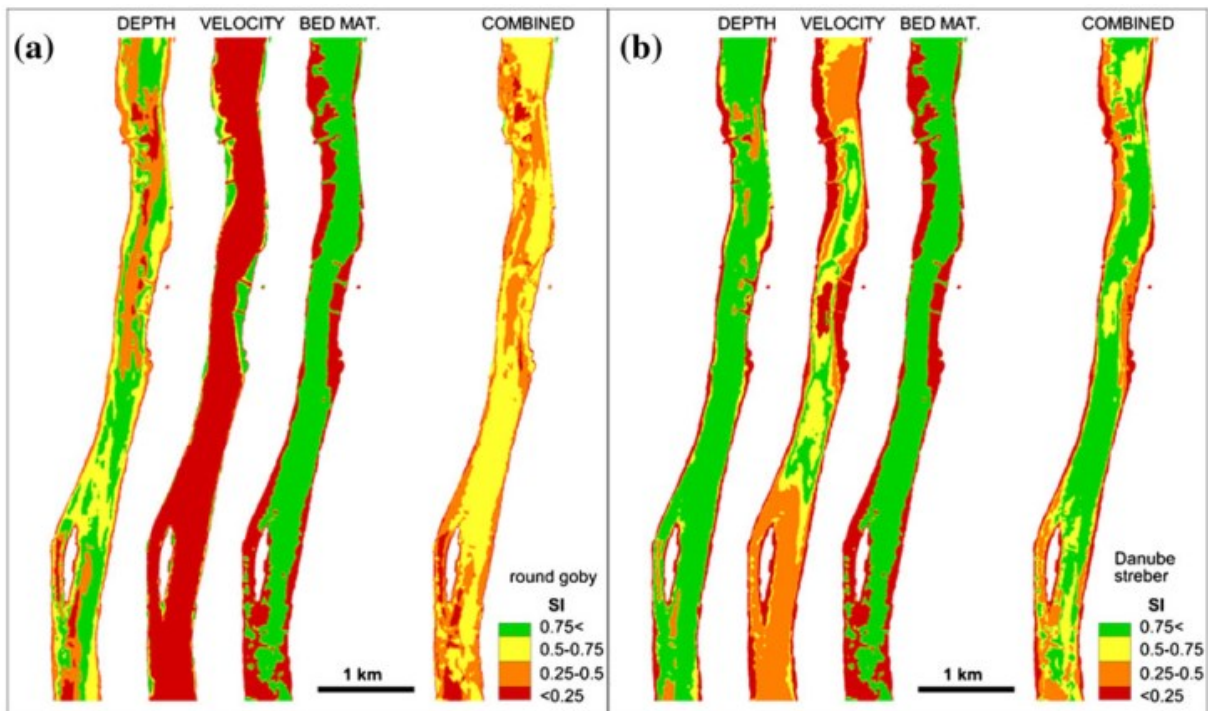


FIGURE 9 Habitat suitability maps at mean water ($Q_{\text{mean}} = 1,450 \text{ m}^3/\text{s}$) for (a) the round goby (*Neogobius melanostomus*) and for (b) the Danube streber (*Zingel streber*). Values close to zero (<0.25 SI values, red) indicate unsuitable habitat conditions, whereas values close to one ($0.75 < \text{SI}$ values, green) indicate preferred habitat conditions

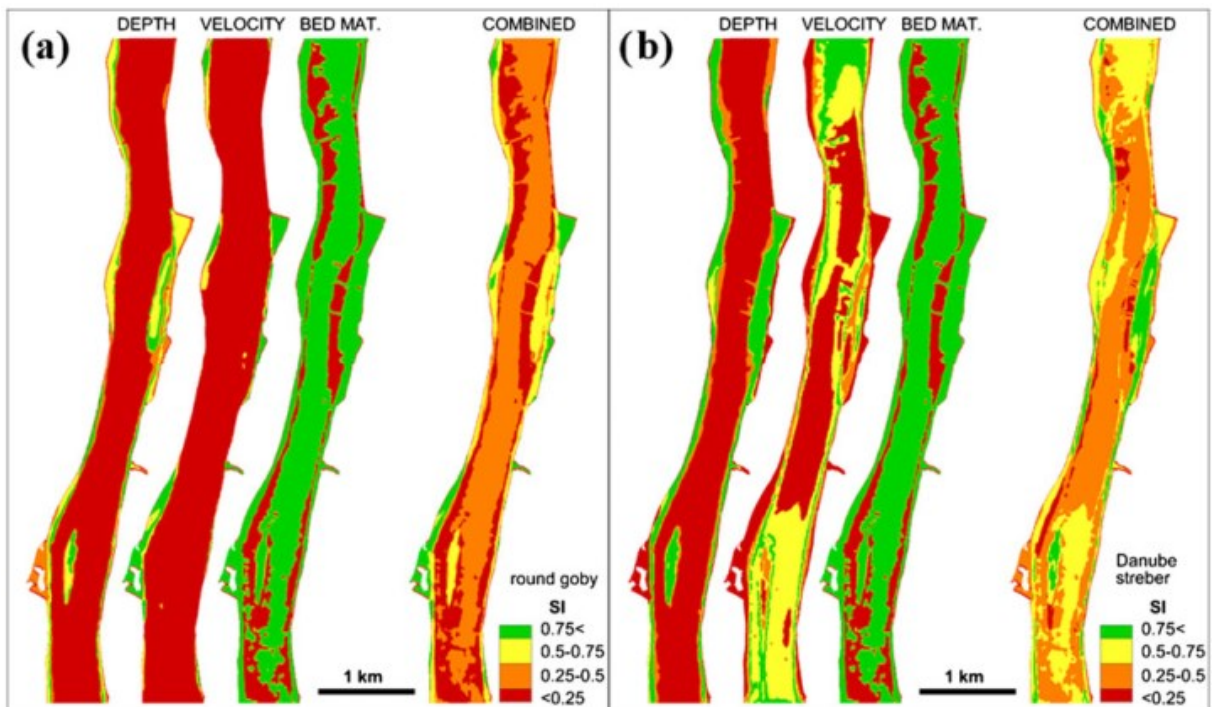


FIGURE 10 Habitat suitability maps during flood ($Q_{125\text{years}} = 6,100 \text{ m}^3/\text{s}$) for (a) the round goby (*Neogobius melanostomus*) and for (b) the Danube streber (*Zingel streber*). Values close to zero (<0.25 SI values, red) indicate unsuitable habitat conditions, whereas values close to one ($0.75 < \text{SI}$ values, green) indicate preferred habitat conditions

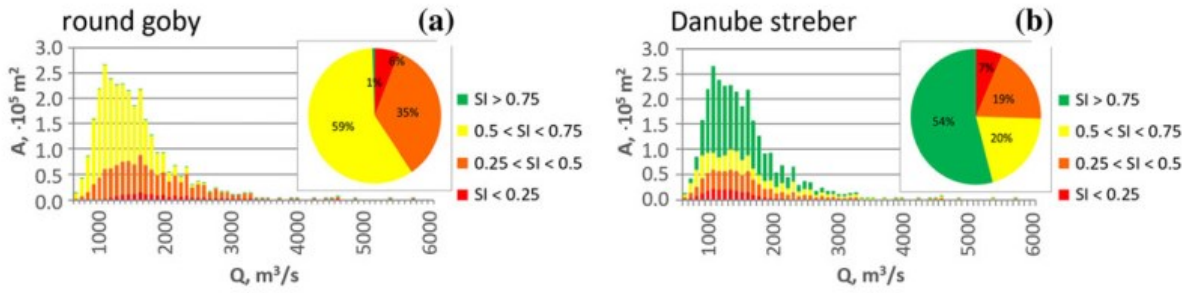


FIGURE 11 Frequency distribution of the areal representation of four SI classes for (a) the round goby (*Neogobius melanostomus*) and for (b) the Danube streber (*Zingel streber*)