Biogeomorphic effects of the renaturalization of an urban river: the Manzanares River in the city of Madrid (Spain)

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Along the 20th century, the Manzanres River section that flows through the city of Madrid (Spain), was channelized with rip-rap and stone walls to allow for intensive urban development. Furthermore, two large dams were built upstream from the city for water supply and flood control, and nine small control dams were located in the urban section with the sole objective of creating an artificial view of a deep large river. At the ecological level, margins were disconnected from the channel by artificial structures, and the longitudinal connection of flows, sediments and species between upper and lower sections virtually disappeared. As part of the Renaturalization initiative by the Madrid City Council, the urban dam gates were opened at the beginning of 2016, with the following effects: (i) water depths have lowered, on average, from 4 m to 0.3 m, (ii) water flow presents different velocities within the channel, (iii) sands are being deposited in the channelized section in the form of bars and islands, and (iv) vegetation and fauna is colonizing the new habitats. The present study aims at evaluating this initial natural dynamics recovery through biogeomorphic metrics that allow for the association of better natural habitat conditions with the recovery of natural in-channel vegetation and fish fauna. Results show that there has been a remarkable increase in number, area and shoreline length of islands and bars straight after the gate opening (spring 2016) and a few months later (autumn 2016). The rapid creation of bars and islands entails an increase in natural zones of terrestrial/aquatic transition (shoreline length) that can be temporarily colonized by different types of animals and plants. In this regard, surveys on fish fauna have shown an increase in the number and biomass of autochtonous species (mainly barbel), at the expense of alochtonous species (especially catfish). This case study of the Manzanares River shows how an urban river can evolve with a non-intensive intervention focused on self-forming dynamics recovery.

Measuring flow complexity from fish perspective: Challenges and opportunities to impact assessment

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Fish have evolved in water and unlike terrestrial species have developed an external sensory system which responds to the water's hydrodynamic characteristics. This crucial physiological adaptation is called the mechanosensory lateral line (octavolateralis afferent system). The lateral line provides critical sensory input which drives many common behaviors in fish, such as prey and predator detection, obstacle avoidance, rheotaxis and schooling among others. Specifically, the lateral line encodes spatial flow stimuli, gathering data from the environment and translates it via the peripheral nervous system into useful information. Currently, the in-situ analysis of fish preferences is usually based in point measurements of the physical environment (e.g. time average velocity, water depth, substrate type and underwater vegetation presence). We believe that this discretization may lead to a grave oversimplification of the hydrodynamic characteristics of the aquatic environment, primarily because these metrics ignore the physical interactions between variables and fundamentally lack the temporal rate at which fish experience, and react to hydrodynamic stimuli. To try to address this complex problem, we have developed a new measuring device based in the sensing principles of fish: the artificial lateral line probe. Artificial lateral lines probes provide a new technology for understanding aquatic ecosystems, and are fundamentally based on the fluid-body interaction between the sensor and the flow. Thus, they provide a new type of bio-inspired sensing device for ecohydraulic flow measurement and classification. This is achieved by using a time-synchronized array of rapid pressure sensors installed over a probe body. The benefits of this sensing system are multiple. For instance, in contrast to point measurements devices (e.g. acoustic Doppler velocimeter or propellers), the lateral line probe provides a source of simultaneous data in both space and time. This approach provides ecohydraulics researchers and managers with new sources of flow information as 1) the fluid-body interactions are considered, and 2) the sampling rate is higher than any other field tool (tested and validated up to 200 Hz), bringing the potential of measuring closer to the "fish's perspective". In this work, we summarize and analyze the results from over five years of continuous development and application, beginning with the fundamental working principles and concluding with a critical evaluation of our latest results in data-driven fish preference assessment. We discuss the opportunities of the technology for the in-situ and objective assessment and classification of the environments as well as the challenges to be faced in next years. Considering our results, artificial lateral line probes can become a multipurpose tool with the ability of monitoring the complex aquatic ecosystem experienced by fish.