HABITAT USE OF CYPRINID SPECIES IN A SMALL HYDROPEAKING RIVER. ARE FISH USING LATERAL REFUGES?

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RESUMO

Hydropeaking, due to hydropower plant (HPP) operation, is seen as one of the major human impacts on rivers. The intensity, frequency and persistence of peak flows often place an intolerable stress on fish over all life-stages thus interfering with the population success. Rapid increases of flow velocity will induce fish to avoid unstable habitats and seek refuge to avoid energy expenditure. Structural mitigation measures (e.g. lateral refuges) have been proposed to contradict this impact, though only a few cases have been tested in rivers affected by hydropeaking. In the scope of the Horizon 2020 FIThydro (Fishfriendly Innovative Technologies for Hydropower) project, an assessment of fish habitat use downstream Bragado HPP in the North of Portugal took place by applying telemetry technology and image acquisition. In the river reach (c. 150 m) downstream the HPP 79 cyprinids (*Pseudochondrostoma duriense*, *Squalius carolitertii* and *Squalius alburnoides*) were PITtagged. Fish positions were recorded manually in two different seasons: Spring and late Summer. The riverbed topography of the river reach was surveyed and the river reach was modeled in two-dimension unsteady flow using the HEC-RAS model. The total detection rate was 59%. Fish species were distributed along the river reach with high density upstream the HPP tailrace for both seasons. A lateral refuge with a multispectral stereo underwater camera inside was installed in the riverbank where a high density of fish was found to occur. Preliminary vídeo analysis showed fish using the refuge c. 10 min after the turbines start operation.

Keywords: hydropeaking; cyprinids; habitat use; multispectral stereo camera; lateral refuge

1. INTRODUTION

In rivers subjected to hydropeaking, downstream of a hydropower plant (HPP) the base flow is periodically disrupted by extreme and short-duration fluctuations of discharge during daily peaks of energy demand, raising concerns as to the ability of fish to respond to the quickly changing environment, and the costs and time to react to constant changes (Young et al. 2011). Despite the growing awareness of hydropeaking impacts in the fish biota, it is still largely unknown how fish react under peak events. It is uncertain whether fish will move laterally to more suitable habitats, 'recolonizing' abandoned habitats after the flow has changed, or will move longer distances longitudinally to other habitats resulting in a major redistribution (Boavida et al. 2017).

Structural mitigation measures (SMM), such as lateral shelters are believed to improve fish habitat, helping fish to find escape from unsuitable habitats and recover from stress. However, very few studies assess the efficiency of those structures, either in under controlled conditions (i.e. an artificial flume) or in situ experiments (Ribi et al. 2014, Costa et al. 2018). Also, most of the studies focus in salmonid species, due to their economic value, leaving little knowledge on the behavior and habitat use of cyprinid species, an important biological component of Iberian fish assemblages with some of the species being at risk due to human-induced impacts. Without appropriate shelters, hydropeaking events can be energetically costly (Costa et al. 2019) and affect the over-summer survival of individuals. This points out to the need to overcome the problem by generating quantitative information over those impacts on species and promote SMM aiming the success of fish populations.

In the scope of the Horizon 2020 FIThydro (Fishfriendly Innovative Technologies for Hydropower) project (www.fithydro.eu), an assessment of fish habitat use downstream a HPP took place by applying telemetry technology and image acquisition with a multispectral stereo underwater camera. The main goal was to assess the effects of peak events on cyprinid fish movements and behavior to further propose guidelines to design useful SMM for a sustainable use of hydropower energy. Aditionally the hydropeaking tool developed in the FIThydro project was applied.

2. METHODS

This study was conducted in the Avelames River (Tâmega River basin), downstream the Bragado HPP (installed capacity 3.1 MW, turbined flow 2.2 m^3/s) located in North Portugal. Long term mean annual discharge amounts to 1.4 m^3/s (watershed area of 78.8 km^2 and a mean annual flow volume of 44.1 hm^3).

A 150-m long-reach representing a range of habitats was selected next to Bragado HPP tailrace. The river reach can be divided in two-sections: one section downstream (c. 100m) and another section upstream the HPP tailrace (c. 50 m). The riverbed topography was surveyed along the 150 m long-reach with an accuracy adequate to define every macro-irregularity of the riverbed. Flow velocity and depth were measured at a serie of points along different cross-sections. These data were then used to calculate the downstream discharge rating curve and to calibrate the hydrodynamic model.

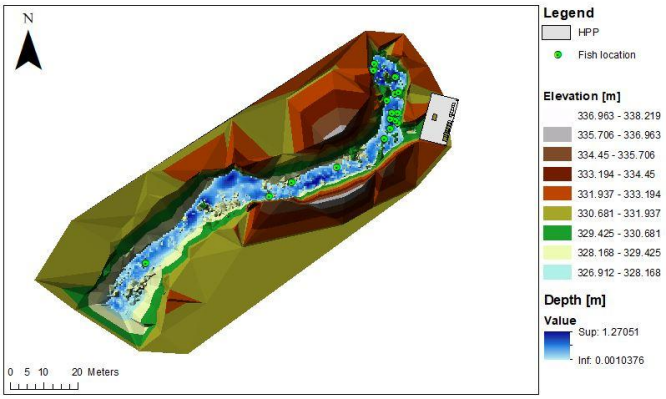
2D hydrodynamic simulations were performed with HEC-RAS. Upon calibration, the model was run for the surveyed discharges (i.e. 0.08, 0.5, and 1.5 m^3/s). Based on the simulations, spatial maps of habitat (depth and velocity) were developed. Results from the hydrodynamic modeling were then exported into a Geographic Information System (ArcGIS) for further analysis.

A total of 79 cyprinids were caught downstream Bragado HPP by electrofishing. Fish were anaesthetized before being individually marked with a Passive Integrated Transponder (PIT) Tag. Fish were sorted by species and measured for total length and weighted. One hour following the insertion and after regaining equilibrium, fish were released at their capture location and left to acclimate for at least four days.

Fish positions were recorded manually with base flow and immediately after a peak flow was released, in Spring and late Summer, using a detection portable antenna. Water velocity and depth were measured at each fish location, and the substrate was characterized. Additionally, hydrodynamic conditions were measured with a lateral line probe (LLP) (Tuhtan et al. 2017). Three derived pressure variables were selected: mean front pressure, mean pressure fluctuations and mean pressure asymmetry.

3. RESULTS AND DISCUSSION

Fish community of the Avelames River is dominated by small sized native cyprinids, as it is typical of similar rivers in northern Portugal. Iberian chub (*Squalius carolitertii*) (mean total length (TL) 9.7 ± 1.8 cm; mean total weight (TW) 12.6 ± 9.6 g), calandino (*Squalius alburnoides*) (TL 9.9 ± 1.9 cm; TW 7.5 ± 1.0 g), and Iberian nase (*Pseudochondrostoma duriense*) (TL 9.9 ± 1.9 cm; TW 10.4 ± 7.0 g) were tagged downstream Bragado HPP with PIT tags. The total detection rate was 59%. Fish were distributed along the river reach with higher density upstream the HPP tailrace (Figure 1).



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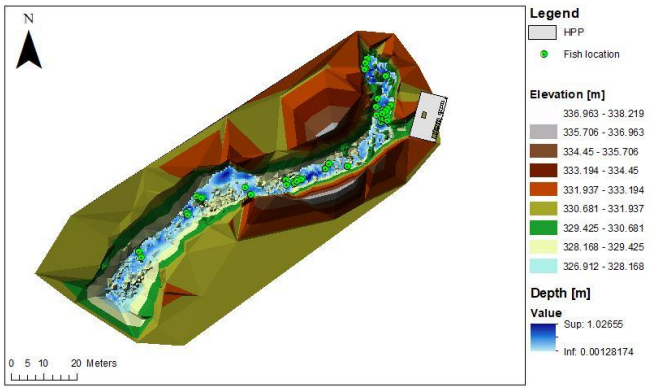
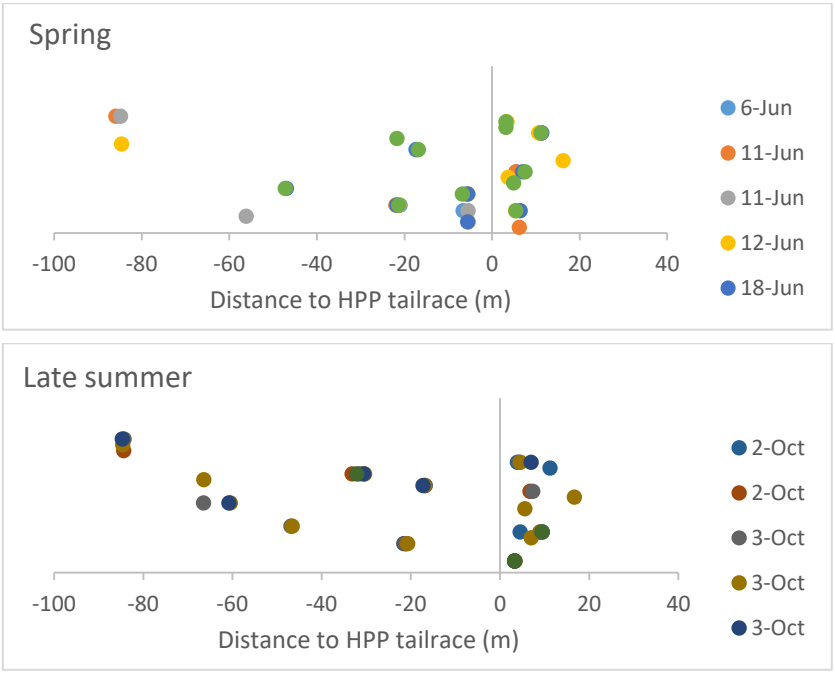


b)

Figure 1 – Fish locations during the survey in a) Spring for a discharge of 0.6 m^3/s; and b) late Summer for a discharge of 0.08 m^3/s, corresponding both to base flow (adapted from Ambrósio, 2019).

P. duriense tended to prefer higher depths and higher velocities when compared to *S. carolitertii*. Only the *P. duriense* was found immediately downstream the HPP tailrace in the most disturbed area (Figure 2). Furthermore, the preliminary results indicate that fish presence was associated with lower pressure fluctuations and asymmetry. The highest fluctuations and asymmetry were observed in areas where fish were not detected, whereas both presences and absences occurred in the whole range of mean front pressure.



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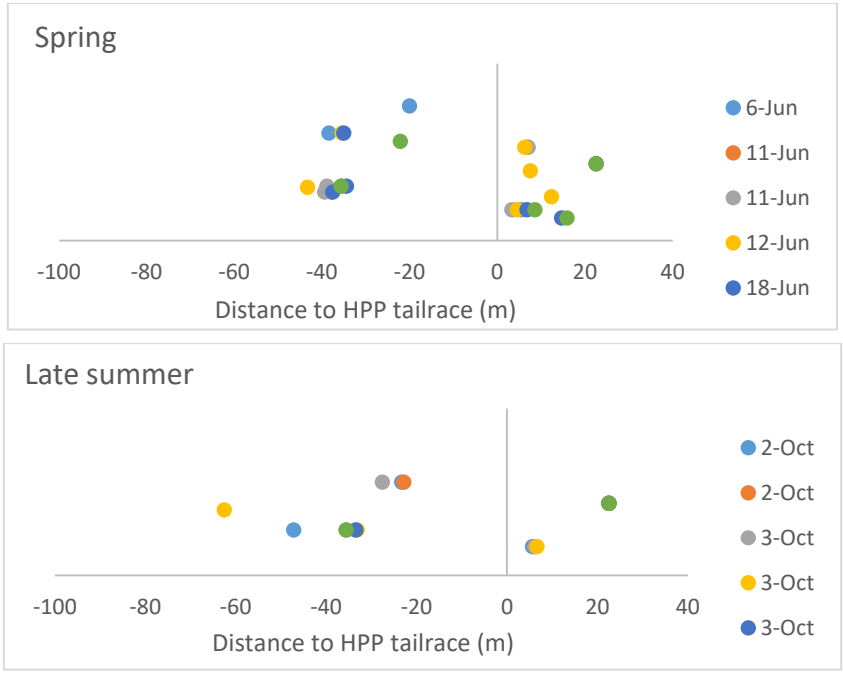

b)

Figure 2 – Fish locations relatively to the HPP tailrace for a) *P. duriense* and b) *S. carolitertii* (adapted from Ambrósio, 2019)

Based on the fish habitat use results, a lateral refuge (40 cm high; 40 cm wide and 50 cm long) was installed in the left riverbank c. 40 m downstream the tailrace where a high density of fish was found to occur. A multispectral stereo underwater camera was fixed inside the refuge to monitor refuge use under base and peak flow. Preliminary results indicate fish using the refuge c. 10 min after the turbines start operation. Larger adults tend to appear after the turbine discharge reached 1 m^3/s or more.

The hydropeaking assessment indicated a large impact for the effect factos and a low impact for the vulnerability factors, corresponding to a low impact. The final assessment, combining both the effect and vulnerability factors, resulted in an overall moderate hydropeaking impact of Bragado HPP.

ACKNOWLEDGMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727830, http://www.fithydro.eu/.

REFERÊNCIAS BIBLIOGRÁFICAS

Ambrósio F (2019) EcoPeak – Análise do impacto de diferentes cenários de operação de uma central mini-hídrica no habitat piscícola e na manutenção dos leitos de desova. MSc Thesis (in portuguese), IST/UL

Boavida I, Harby A, Clarke KD, Heggenes J (2017) Move or stay: habitat use and movements by Atlantic salmon parr (Salmo salar) during induced rapid flow variations. Hydrobiologia, 785(1): 261-275

Costa MJ, Pinheiro A, Boavida I (2019) Habitat Enhancement Solutions for Iberian Cyprinids Affected by Hydropeaking: Insights from Flume Research. Sustainability, 11(24): 6998

Ribi J-M, Boillat J-L, Peter A, Schleiss AJ (2014) Attractiveness of a lateral shelter in a channel as a refuge for juvenile brown trout during hydropeaking. Aquatic Sciences, 76: 527–541

Costa MJ, Boavida I, Almeida V, Cooke SJ, Pinheiro NA (2018) Do artificial velocity refuges mitigate the physiological and behavioural consequences of hydropeaking on a freshwater Iberian cyprinid? Ecohydrology, 11: e1983.

Tuhtan JA, Fuentes-Perez JF, Toming G, Kruusmaa M (2017) Flow velocity estimation using a fish-shaped lateral line probe with product-moment correlation features and a neural network. Flow Measurement and Instrumentation, 54: 1–8

Young PS, Cech JJ, Thompson LC (2011) Hydropower-related pulsed-flow impacts on stream fishes: a brief review, conceptual model, knowledge gaps, and research needs. Reviews in Fish Biology and Fisheries, 21: 713–731