RESPONSE OF TROUT POPULATIONS TO FLOODS IN NATURAL AND BYPASS REACHES

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Multiple abiotic and biotic processes structure trout population dynamics at different space and time scales [1], [2]. The key role of hydrological variability in structuring brown trout populations is well-established [3-5]; [6]; [7]. All age-stages were considered as potentially influenced by high spring floods because spates have a major impact on 0+ fish [8] [9] [10] and may be strong enough to influence the survival and dispersal of older stages [11]. Nevertheless, authors often failed to identify constraining abiotic conditions for juveniles and adults (e.g., [4]) except after exceptional events (e.g., a 50-year flood in [11]). For instance, discharge thresholds (e.g., maximum mean daily flood) have often been used, although they correspond to very different hydraulic constraints depending on rivers. Describing high flow based on standardized quantitative variables for the hydraulic habitat of brown trout (e.g., depth, velocity) might reduce these inconsistencies.

In this communication, we pointed out the results quantifying the effect of floods on trout densities obtained through three different approaches taking into account abiotic and biotic parameters [12, 13]. We used an extensive data set collected in 45 river reaches, including 22 reaches located downstream a hydropower facility. Electrofishing surveys and detailed physical habitat characteristics (e.g. hydraulics, water temperature, and cover) were available at all reaches.

First, we investigated the influence of discharge, hydraulics, water temperature and dispersal on density synchrony in three age-stages of resident brown trout (0+, 1+ and adults) in 40 stream reaches (Fig. 1). Results indicated that environmental synchrony strongly explained trout synchrony over distances less than 75km. This effect was partly due to a negative influence on 0+ trout of strong discharges during the emergence period and a more complex influence of substrate mobility during the spawning period [12].

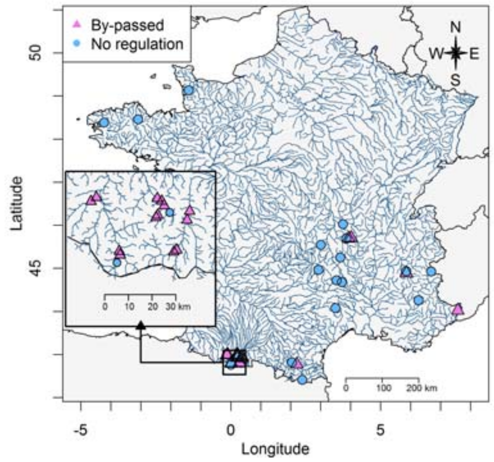

Figure 1: Location of the 40 reaches (19 below dams) [12]

Secondly, we identified the effect of floods with the help of a determinist population dynamics model, locally calibrated on nine bypass reaches showing well described environmental conditions [7]. Four drivers concerned hydrology. Two types of hydrological event induced mortality: (1) floods during spawning (for one bypass reach) or in spring (for the 9 bypass reaches) induced high mortality in 0+ trout, and (2) exceptional floods induced mortality in all age-stages (for two bypass reaches). Flood thresholds and minimum durations inducing 0+ mortality were variable according to reach and to year. Mortality rates could differ greatly depending on the intensity of the event (between 20% and 90%). Observed and simulated density fluctuations for 0+ in the BEY2 reach (Beyrede bypassed section in the Neste d'Aure river) are presented Fig. 2 to illustrate these results. In contrast, two other hydrological events induced positive effects on mortality: (3) overtopping was associated with better 1+ survival (when flooding exceeded 10 $m^3.s^{-1}$ during spring) and >1+ survival (whatever the flood value or time of year) in one bypassed reach, and (4) no floods during spring was associated with better 1+ survival in another bypassed reach.

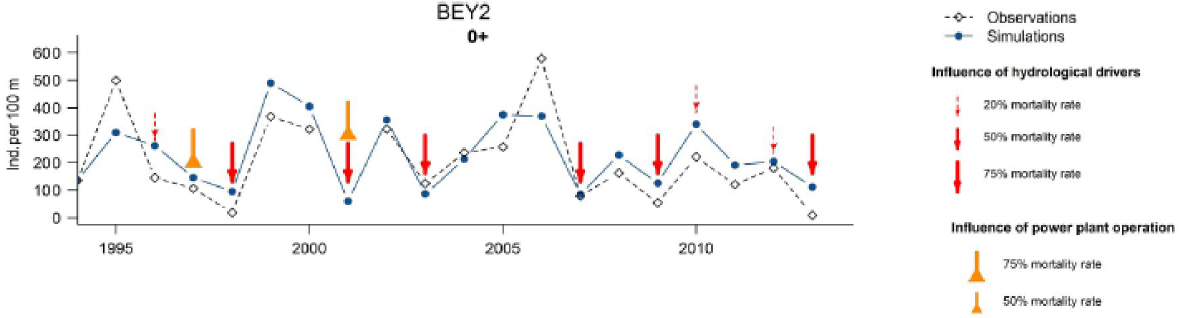

Figure 2: Observed and simulated density fluctuations for 0+ trout in the BEY2 reach [7]

Finally, a hierarchical Bayesian model for the resident brown trout life cycle was built to test if some common processes were shared by all the populations and assessed the relative influence of local and global determinants of mortality [13]. The model was fitted to an extensive data set collected in 40 river reaches, combining abundance and environmental data (hydraulics, water temperature). The influence of flow velocity was therefore modeled as an excess-mortality rate μ. This last one operated when daily flow velocity, exceeded more than 10% of the time during emergence V_{10E}, was higher than a threshold Z which had to be adjusted. The posterior distributions of parameters showing high flow influence on recruitment revealed very high mortality in emerging fry (94%; posterior mean of μ) for flow velocity >1.15 $m.s^{-1}$ (posterior mean of Z) (Figure 3). Extreme mortality was therefore modeled for only 8% of studied years.

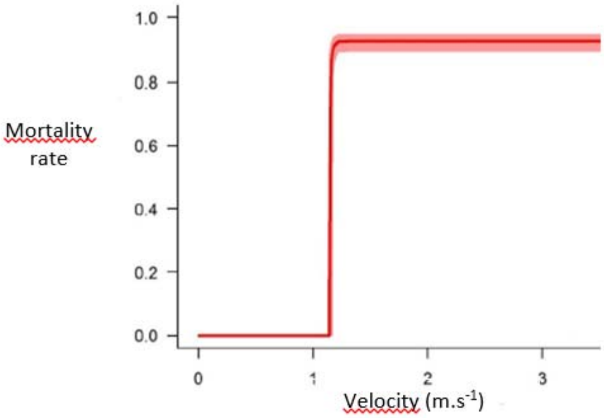

Figure 3: Fry mortality rate (during emergence) in function of flow velocity, exceeded more than 10% of the time during emergence V_{10E}

All these results confirmed and quantified the effect of floods on juveniles of trout i) by identifying the influence of strong discharge on synchrony of trout populations or on mortality of 0+ and ii) by determining threshold of limiting velocity inducing 0+ mortality. No difference in the responses of populations to floods were observed between bypass reaches and upstream dam reaches. The threshold value of flow velocity (1.15 m.s^{-1}) could be tested in hydropeaking reaches to determine if this threshold is often reach in these reaches and if the limiting effect on trout populations is confirmed. Analysis of temporal variation in 0+ density would likely be improved by modeling additional abiotic processes of direct mortality. Including frequency or duration of high or low flows ([14]) or streambed mobility [10]; [12] could improve modeling trout recruitment (of 0+ density).

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