Effects of spatio-temporal variability of hydropeaking on juvenile fish

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ABSTRACT: Storage hydropower plants buffer volatile energy production by renewable energy sources. Generating energy flexibly, however, causes artificial flood waves (hydropeaking), which can negatively affect the river ecosystem. Fish are among the groups of organisms most affected by hydropeaking. The early life stages of fish are particularly endangered by rapidly changing water levels as they have lower swimming abilities than more mature fish. Also, their preference for near-bank habitats puts them at increased risk. In the up-ramping phase of a hydropeaking wave, fish may be displaced downstream and laterally, while in the drawdown phase, riverbank dewatering may cause stranding and trapping on previously wetted areas. Therefore, research has aimed to understand hydro-ecological relationships related to hydropeaking wave criteria (e.g., ramping rate, amplitude) and identify flow thresholds. However, most studies are either experimental or, if involving fieldwork, only consider single rivers and selected species (e.g. brown trout, grayling, rheophilic cyprinids). Here, we conducted a field study integrating multiple rivers and species, considering a longitudinal gradient for each river. This work integrates various hydrological aspects, aiming to better understand the ecological effects of hydropeaking frequency. A hydropeaking event is defined as exceeding a threshold related to the intensity of natural flow fluctuations under consideration of the respective river size used as a benchmark. This enables a standardized hydrological monitoring, which can then be linked to ecological measurements. In order to take legacy effects into account, hydrological conditions before sampling related to distinct life cycle periods (spawning, incubation, larval and juvenile stage) are included to allow identification of the most critical periods for fish. A better understanding of the impacts of hydropeaking can be gained by looking at the critical hydrological thresholds and the most influential periods/life stages. This also results in implications for mitigation measures and the operation of hydropower plants.