The influence of repeated hydropeaking events on early live stages of European grayling (*Thymallus thymallus*) and common nase (*Chondrostoma nasus*)

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ABSTRACT: Short-term water releases from hydropower plants, called hydropeaking, negatively affect river biota, such as fish. Much is already known about the responsible factors characterizing the ecological consequences. The current understanding of the ecological effects of ramping rates, time of day, or seasonality on fish stranding and drift is mainly based on research on single hydropeaks. There is a need to understand how peaking frequency affects fish drift and stranding risk in the longer term, subsequently, the population. Experimental studies can aid to fill this knowledge gap on multipeaking effects, constituting a profound basis for the improvement of mitigation measures.

This study investigated how recurring hydropeaking events during day and night affect the drift and stranding of young-of-the-year European grayling (*Thymallus thymallus*) and common nase (*Chondrostoma nasus*) in a semi-natural outdoor channel. Grayling multi-peaking experiments consisted of nine peak events within 24 hours, whereby the first three occurred during the day, the next three during the night, and the last three during the next day. Nase experiments consisted of five peak events, each starting 15 minutes after the preceding one; this series was conducted both during the day and night.

Our data show that drifting and stranding rates of nase were highest at the first hydropeak; the following 2-4 peaks showed reduced responses. This pattern was the same for day and night experiments. The results of grayling showed that drift was reduced after the first event, particularly the nighttime peak events exhibited lower drift and stranding rates compared to the data from single-peak experiments, indicating a behavioral change due to experience gained during previous peak events a few hours before. Fish drift and stranding were low for all peak events during three events on the second day.

To gain more information on this behavioral phenomenon, we tested two groups of juvenile grayling during another multi-peaking experiment, splitting fish into two groups. The first group consisted of individuals which neither drifted nor stranded during experimental hydropeaking events 24-48 hours prior to the start of this multipeak setup. The second group comprised individuals which had no hydropeaking experience during the previous few days. Group comparisons showed no clear difference in drift or stranding rates, except for stranding during the first nocturnal peak event, suggesting that most of the experience acquired by fish from the first group gained 24-48 hours prior seemed to have vanished.

The findings of this study show that extrapolating results from single peak experiments to frequent hydropeaking schemes may, under certain conditions, overestimate the cumulative drift and stranding rates of young-of-the-year fish. Our data suggest that reducing hydropeaking intensity is particularly important after a pause phase. We suggest that the notion of releasing a small 'warning peak' to prevent extensive drift and stranding should be investigated in future studies. Overall, this study contributes key knowledge regarding hydropeaking impacts and mitigation.