Multidecadal trends in brown trout (*Salmo trutta*) populations in regulated and unregulated river

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ABSTRACT: Most studies that have examined temporal trends in freshwater fish populations have rarely focused on headwater streams. In the present study, we jointly examined sections regulated and unregulated by dams to investigate shared or divergent temporal patterns in (i) a panel of stream-dwelling brown trout (*Salmo trutta*) populations and (ii) environmental variables known as environmental drivers of trout population dynamics (water temperature, stream flow, current velocity and habitat suitability). We conducted trend analyses of brown trout populations in 36 stream reaches spanning a diversity of French geographic areas (lowland and mountain streams). Of these reaches, 19 are located in a bypass section, with part of the stream flow diverted by a dam and are subject to a minimum flow (or residual flow). These reaches were regularly sampled over the period 1990-2020 for a total of 752 fish samplings.

General temporal trends in environmental variables and densities of three trout cohorts (i.e. young-of-the-year, juveniles and adults) were assessed using a meta-analysis framework. This method consists in a weighted meta-analysis performed on each environmental and trout variable using Mann-Kendall trend statistics (S) computed on each time series as “effect sizes”. This non-parametric method is used to statistically assess if there is a general monotonic upward or downward trend in the studied variable over time and over the entire dataset, without this necessarily being linear.

We found that the average annual temperature of these streams has significantly increased by a median of +0.21°C per decade. This upward trend was observed in most of the studied reaches, indicating that global drivers are probably involved. Spring, summer and fall water temperatures also showed a general significant increase. Analyses of stream flow revealed only a few significant trends, including a general increase in median values in spring and a general decrease in fall. Trends in current velocity were stronger and more significant than those found for stream flow.

A significant general decline in adult trout densities was observed, although disparities between geographic areas were found. No significant trend was found in the densities of the younger

cohorts. The trends in trout densities found in bypass sections and in reaches without hydrological modifications were not significantly different. The general decline in adult densities is likely due to multifactorial effects, in relation with the environmental changes observed during the study period, but also probably in relation to other factors not assessed in this study (e.g., predation, disease, water quality…).

Our results highlight the need to maintain long-term monitoring of trout populations, which should ideally be combined with extensive environmental monitoring. This would allow appropriate and efficient management measures to be taken in both regulated and unregulated sections to improve the living conditions of trout populations in a context of global change.