

***Global changes and spatial species distribution of stream fish in France:
methodological approach and synthesis of observed modifications***

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ABSTRACT

There is accumulating evidence that global climate change is currently affecting the spatial distribution of species all over the globe. Understanding the capacity of species to shift their distribution ranges in the face of climate change is crucial for conservation biologists and resources managers. However, although freshwater ecosystems contain among the most imperiled fauna worldwide, such range shifts have been poorly documented in streams and rivers. Based on national monitoring data, we examined distributional changes of 32 stream fish species in France, providing a unique opportunity to analyze range shifts over the last three decades of warming in freshwater environments. By using an ensemble approach, we compared the modelled spatial distribution of species across the whole hydrographic network between an historical (1980-1992) and a contemporary period (2003-2008). A multi-facet approach, operating on several range measures along climatic and environmental gradients, allowed us to rigorously quantify range shift across multiple species at large spatial scale. Our results highlighted systematic species upslope and upstream shifts, with a mean altitudinal shift of $13.7 \text{ m.decade}^{-1}$ and a mean upslope shift of $0.6 \text{ km.decade}^{-1}$, consistent with the recent changes in mean annual temperature. Fish species showed dispersal-driven expansions along the altitudinal gradient at their higher range limit while substantial range contractions at the lower limit were documented for most low- and mid-range species along the upstream-downstream gradient. These changes suggested that fish species could track their climatic niche through complex modifications of their spatial distributions. However, the majority of stream fish have not shifted at a pace sufficient to track changing climate conditions, in particular at their range centre where range shifts lag far behind expectation. Our study provides evidence that stream fish are currently responding to recent climate warming, and that their responses could be greater than those of many terrestrial and marine organisms, although they may be not sufficient to cope with future climate modifications.

KEY WORDS

Global changes, distribution shift, stream fish, France