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Qu'avons-nous appris ? - Le suivi à long terme des communautés de poissons et d'invertébrés lors de la restauration du fleuve Rhône.

What have we learnt? - A multi-year monitoring of invertebrates and fish in the Rhône River under restoration.

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RÉSUMÉ

Le Rhône français fait l'objet d'un programme de restauration hydraulique et écologique depuis 1998. Ce programme comporte essentiellement l'augmentation des débits réservés dans les tronçons court-circuités, la reconnexion au fleuve d'un ensemble d'annexes fluviales ou le recreusement de plans d'eau au sein de ces annexes. La présentation met en évidence quelques résultats obtenus à travers les études pré- et post-restauration des communautés de poissons et d'invertébrés dans le fleuve et ses annexes, menées dans quatre secteurs depuis 1995.

ABSTRACT

A long-term programme of hydrological and ecological restoration has been conducted on the French Rhone River since 1998. Its main components are i) the increase of the minimum flow in the river sections bypassed by an hydro-power plant, ii) the direct reconnection of cut-off channels to the river, iii) the dredging of isolated pools within the channels. The presentation highlights a selection of key findings from the pre- and post-restoration monitoring of fish and macroinvertebrate assemblages in the River and its floodplain, carried out in four different sectors since 1995.

KEY WORDS

Alien species; Floodplain; Long-term Monitoring; Species preference modelling; Species traits.

1 INTRODUCTION

Despite important investments dedicated to the physical restoration of rivers, assessing the ecological effects of such operations remains challenging. This is largely due to the difficulty of organizing long-term scientific surveys that anticipate restoration operations and allow comparisons of their effects over multiple years and multiple sites. It is even more difficult to assess how ecohydraulic models can predict biological responses to river restoration. The need to monitor community responses over the whole lateral dimension of the floodplain (i.e. from the main river channel to isolated cut-off channels), represents a further challenge.

As other large rivers in Europe, the Rhône River has been regulated for navigation, irrigation and hydroelectricity since the 19th century. A restoration programme of the river started in 1998 and involved i) the increase of minimum flow in bypassed sections, ii) the modifications of the connections of dozens of floodplain cut-off channels with the main river and iii) the dredging of their sediments. So far (i.e. in 2011), four bypassed sections and 26 floodplain cut-off channels were restored.

The aim of the presentation is to highlight key findings from the scientific survey of the Rhone restoration programme that would be of interest for other large-scale river restoration projects. They are based upon the monitoring of fish and macroinvertebrate assemblages in both the main river and the floodplain cut-off channels.

2 METHODS

We used the Rhône restoration project as a template for testing the predictive power of models relating species to those environmental conditions that are modified by restoration operations.

In the main river channel (bypassed sections), predictions were based upon hydraulic microhabitat models that predicted how observed microhabitat preference of fish and macroinvertebrate taxa could result in community changes after restoration (Lamouroux et al. 2006, Mérigoux et al. 2009). A multiple-trait based approach was also used to compare the effects of the increased minimum flow upon macroinvertebrate species composition and trait composition, using a priori hypotheses.

In the floodplain cut-off channels, models were based upon observed correlations between macroinvertebrate community structure and diversity and the connectivity of floodplain channels with the main river. An index based upon environmental variables known to be representative of the lateral connectivity was used as surrogate for the level of lateral connectivity of each floodplain site (Paillex et al. 2009).

The data considered here were collected on several sampling dates before and after restoration in four sectors of the French Rhône (Chautagne, Belley, Brégnier-Cordon, Pierre-Bénite) between 1995 and 2010. Pierre-Bénite was subject to an initial programme of restoration that started in 1995, while it started in 1998 for the three remaining sectors.

3 RESULTS & DISCUSSION

In the bypassed river sections where minimum flow was increased five to ten-fold, important changes in community composition were observed (e.g. the proportion of fish individuals belonging to species preferring fast-flowing and deep microhabitats increased two- and three-fold). The hydraulic habitat models partly predicted these changes, which were observed in all study reaches and involved several species. In contrast, in bypassed reaches for which flow was less modified, community changes were unrelated to model predictions. Results also revealed complex population dynamics and the establishment of alien taxa that were not considered in the models. The trait analysis of the macroinvertebrate assemblages showed that the minimum flow increase induced a functional response of communities associated to a selection of individuals with biological strategies known to be better adapted to higher hydraulic constraints (e.g. higher turn-over, streamlined shape, microphyte food).

In the restored floodplain cut-off channels, the modification of the lateral connectivity induced predictable changes in the taxonomic richness and composition of macroinvertebrates. Taxa such as lotic Ephemeroptera, Plecoptera and Trichoptera increased noticeably in the reconnected channels.

Richness of alien taxa reached a maximum in channels with a high lateral connectivity and was enhanced by restoration operations, but never represented more than 4% of the entire community. At the scale of the entire floodplain, the diversity of restoration measures, led to a post-restoration increase in the taxonomic diversity of macroinvertebrate assemblages in the cut-off channels (Figure 1).

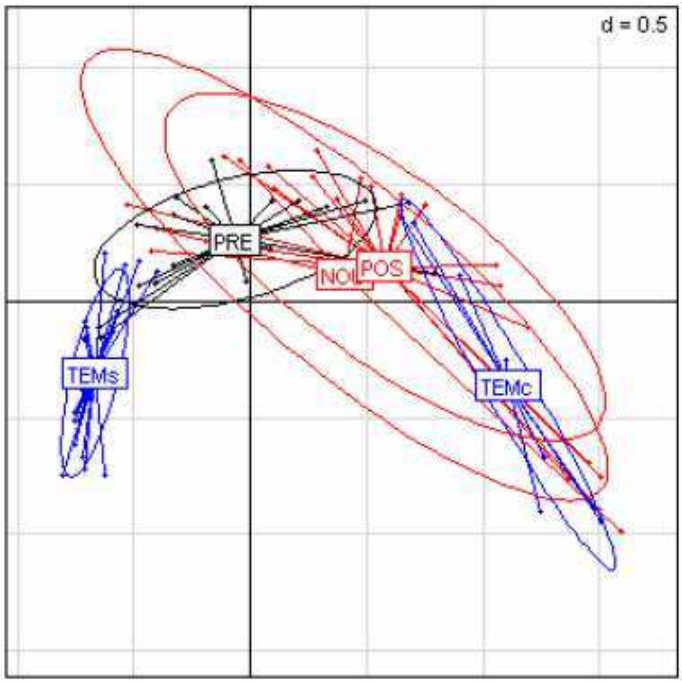

Figure 1 - Compositional changes in the invertebrate assemblages of restored cut-off channels. Blue: unrestored sites (lotic - TEMc, lentic - TEMs); black: pre-restoration sites (PRE); red: post-restoration conditions in the same sites (POS) and newly created sites (NOU). In the restored sites, the taxonomic composition shifts toward a more lotic character (right side of the plot) and the among-sites diversity increases (larger ellipses).

4 CONCLUSION

Ten years after the first flow restoration in bypassed sections of the Rhône River, our results suggest that the restoration generated measurable changes of the biotic community structure, reversing trends previously observed after dam constructions. They also show the potential of ecohydraulic models for guiding management plans and contribute to the quantification of their uncertainty. In floodplain channels, lateral connectivity represents a deterministic driving force upon ecosystem functions and macroinvertebrate assemblages. Hence, modification of the lateral connectivity leads to predictable changes in macroinvertebrate richness and composition. Therefore, the consequences of restoration programmes appear reasonably predictable, at least regarding the effect they can have upon the aquatic biodiversity. Synergistic interactions among restoration, long-term changes (e.g. climatic change, spread of alien species) and other anthropogenic activities (e.g. growing urbanization) support the need for long term monitoring to assess the durability and trends of restoration works.

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