Ecosystem based approach of a Lower Saone River section to assess the impact of invasive or expanding species

Approche écosystémique d'une section de Saone aval pour évaluer l'impact des espèces invasives ou en expansion

Changeux T.(1), Dragotta A. (1), Franquet E. (2), Stolzenberg N. (3), Fruget JF (4), Marion L. (5), Souty-Grosset C. (6), Anneville O. (7), Cavalli L. (2), Faure JP (8), Corget N. (9), Josserand F (10). et Bănaru D. (1)

1 : Institut méditerranéen d'océanologie (MIO) – Campus de Luminy – 13009 Marseille
thomas.changeux@ird.fr
2 : IMBE - Campus de l'Etoile – 13020 Marseille
3 : Comité national de la pêche professionnelle en eau douce - 44320 Saint-Viaud
4 : Aralep Bureau d'études - 69603 Villeurbanne
5 : ECOBIO Université de Rennes
6 : EES Université de Poitiers, 86022 Poitiers
7: INRAE - Thonon-les-Bains
8 : Fédération de pêche du département du Rhône
9 : Retraité du Service de la Navigation de Mâcon
10: Pêcheur professionnel de Saône

RÉSUMÉ

La Saône aval est une large rivière de plaine dans laquelle se développe l'écosystème le plus productif du bassin du Rhône. Au milieu des années 1990, le fonctionnement de la Saône aval a profondément changé : les processus de production primaire ont basculé d'un état turbide à un état clair. L'état turbide est caractérisé par une production estivale importante de phytoplancton, responsable d'une forte charge de matière en suspension. Inversement, l'état clair est caractérisé par une assimilation des nutriments au profit des communautés de macrophytes et une forte augmentation de la transparence de l'eau. La modélisation du fonctionnement trophique des deux états de la rivière avec le logiciel Ecopath a permis de réaliser une approche écosystémique qui prend en compte tous les compartiments de l'écosystème, depuis les producteurs primaires jusqu'aux prédateurs, ainsi que les prélèvements par pêche. Basée sur la bibliographie et les déclarations de captures des pêcheurs aux engins de 1988 à 2005, cette application a mis en évidence l'impact essentiel des espèces invasives comme les corbicules et le silure. Mené de manière collégiale avec des gestionnaires et des usagers, cette étude a également mis en évidence des manques d'information sur la période récente et des hypothèses à confirmer, notamment pour ce qui concerne les états intermédiaires de l'écosystème.

ABSTRACT

The Lower Saone is a large lowland river where the most productive ecosystem of the Rhone basin is developed. In the mid-1990s, the functioning of the Lower Saone changed profoundly: the primary production processes shifted from a turbid to a clear water state of the river. The turbid state is characterized by an important summer production of phytoplankton, responsible for a high load of suspended matter. Conversely, the clear state is characterized by an assimilation of nutrients to the benefit of macrophyte communities and a strong increase in water transparency. The modeling of the trophic functioning of the two states of the river with the Ecopath software allowed to realize an ecosystemic approach which takes into account all the compartments of the ecosystem, from the primary producers to the predators, as well as the fishing catches. Based on the bibliography and catch declarations of anglers from 1988 to 2005, this application highlighted the essential impact of invasive species such as corbiculas and catfish. Conducted in a collegial manner with managers and users, this study also highlighted information gaps for the recent period and hypotheses to be confirmed, notably concerning the intermediate states of the ecosystem.

MOTS CLES

Ecopath, fishery, invasive species, large river, trophic model.

1 INTRODUCTION

For strictly freshwater organisms, each watershed and sub-watershed can be considered as an island system that is very sensitive to species introductions. Thus, the development of invasive species is considered to be the second most important threat to aquatic ecosystems, after habitat destruction. In particular, they can modify the trophic structure in place with variable consequences on the species present before their arrival.

The Lower Saone is a large lowland river where the most productive ecosystem of the Rhone basin is developed. In the mid-1990s, the functioning of the Lower Saone changed profoundly: the primary production processes shifted from a turbid to a clear water state. The turbid state is characterized by an important summer production of phytoplankton, responsible for a high load of suspended matter. Conversely, the clear state is characterized by an assimilation of nutrients to the benefit of macrophyte communities and a strong increase in water transparency (see Diamond et al. 2021 for Loire River case).

In parallel to the methods developed to assess the quality of ecosystems, based on different biological indices, there are integrative approaches that take into account the ecosystem as a whole. Among these approaches, trophic modeling seeks to quantify the biomass and matter flows between species gathered in trophic groups. It allows to better understand the ecological functioning of the whole ecosystem, to identify the key species, to calculate indices of ecosystem functioning and assess the impact of fishing activities and invasive species. Taking into account all the links of the food web in this model, from primary producers, such as macrophytes, phytoplankton and periphyton, to predators, such as the European Catfish or the Great Cormorant, is comparable to an ecosystem approach.

This kind of approach, widely used in the marine environment, has rarely been applied to rivers where hydroclimatic forcing is favored and where qualitative studies of ecological status are preferred over quantitative studies of biological production. Our study therefore consists in developing a food web model of the Lower Saone for the two functioning states of the ecosystem.

2 MATERIEL ET METHODES

A large lowland river such as the Lower Saone appears to be a particularly suitable ecosystem for the application of such an approach because it develops a highly productive food web, which has allowed the river to host for a long time the largest concentration of fishermen in the basin. This situation has produced several data chronicles exceeding ten years now available to reconstruct past situations in order to make a retrospective analysis. We have mainly used the National Monitoring of Fishing Gear Fishery (NMFGF), a category of fishermen specially authorized to use nets, dip nets, traps and long lines that target adult fish or crayfish, the majority fraction of the biomass of the high trophic levels of the ecosystem. Ornithological counts, analysis of NMFGF data from 1988 to 2005 and observations of the benthic macrofauna show the development of the Great Cormorant, the European Catfish and the arrival of the Corbicula from 1994. Thus, two periods were distinguished: the first from 1988-1993, and the second from 1994 to 2005.

The Ecopath with Ecosym (EwE) software suite, widely used in marine fisheries management (Bănaru et al. 2013), has led to a few past applications in the riverine environments that have shown the trophic importance of Chironomid insects. More recently, EwE has been used in Annecy and Geneva Lakes (Anneville 2017). The two ecosystem states of the Lower Saone were modeled with Ecopath using the above data, supplemented by information from the literature. The results of the model were validated, in a collegial way, by a selection of experts of the different trophic groups.

3. RESULTATS ET DISCUSSIONS

Ecopath modeling of these two ecosystem states (the first from 1988-1993 and the second from 1994 to 2005) shows that the Corbicula is probably responsible for the ecosystem's shift towards a functioning where phytoplankton is less present and that the European Catfish has taken an important place in the trophic edifice, contrary to the Great Cormorant, which has little influence (Figure 1). Several parameters of the model still need to be investigated in order to get closer to the reality of the Lower Saone ecosystem. Nevertheless, this approach has the major interest of gathering for the first-time information acquired on each group independently.

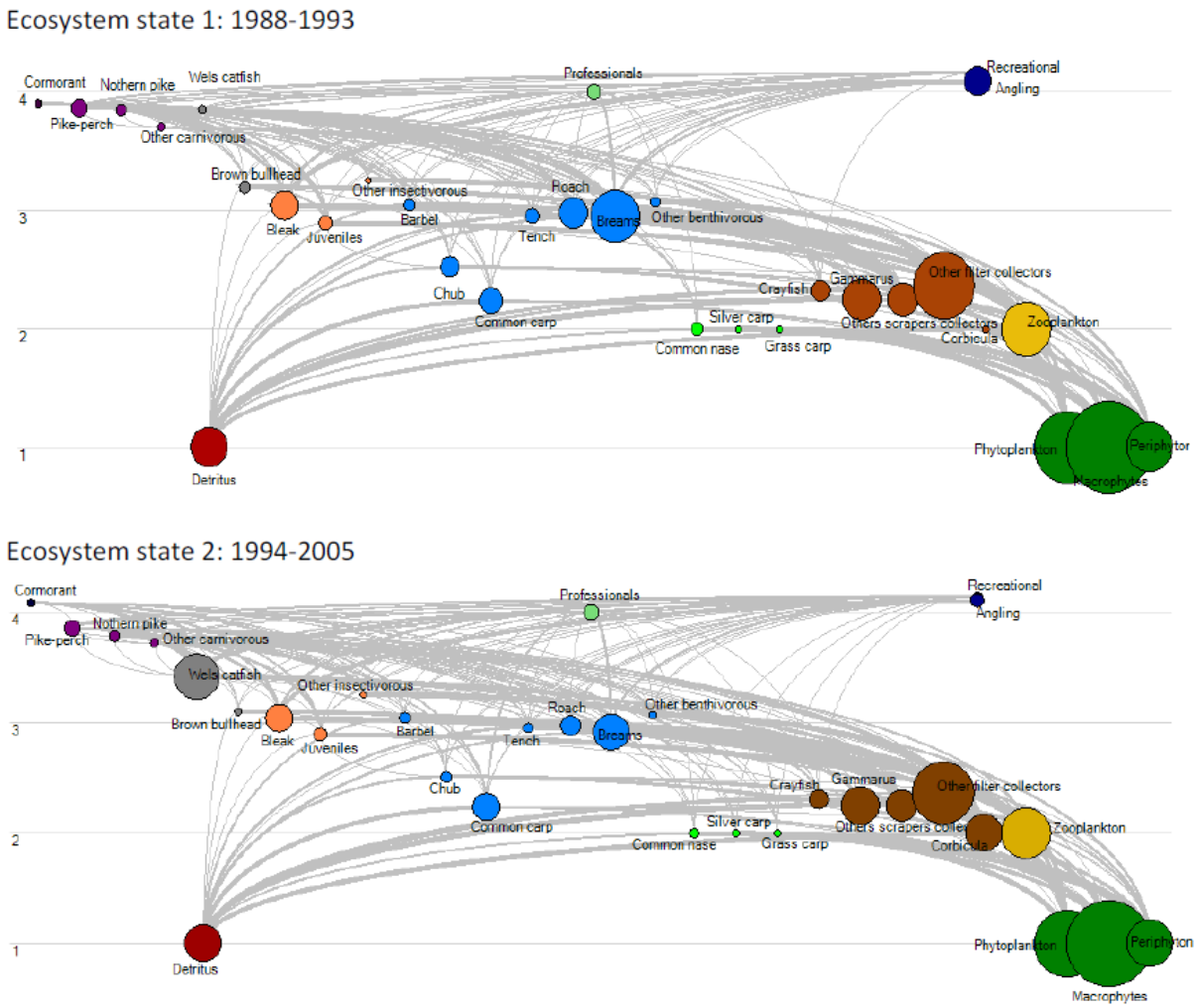

Figure 1 : Food web diagrams provided by Ecopath for both ecosystem states (circles are proportional to the biomass of each trophic group ; trophic level is indicated on the ordinate, the predator-prey links are plotted in gray).

BIBLIOGRAPHIE

Anneville, O. Vogel, C. Lobry, J. and Guillard, J. (2017). Fish Communities in the Anthropocene: Detecting Drivers of Changes in the Deep Peri-Alpine Lake Geneva. *Inland Waters,* 7(1), 65 76.

Bănaru, D. Mellon-Duval, C. Roos, D. Bigot, J.L. Souplet, A. Jadaud, A. Beaubrun, P. and Fromentin, J.M. (2013). Trophic interactions in the Gulf of Lions ecosystem (northwestern Mediterranean) and fishing impacts. *ICES Journal of Marine Systems*, 111–112, 45–68.

Diamond, J.S. Moatar, F. Cohen, M.J. Poirel, A. Martinet, C. Maire, A. and Pinay, G. (2021). Metabolic Regime Shifts and Ecosystem State Changes Are Decoupled in a Large River. *Limnology and Oceanography*, lno.11789. https://doi.org/10.1002/lno.11789.