Biological Conservation 226 (2018) 311–320

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Comprehensive analysis of > 30 years of data on stream fish population trends and conservation status in Bavaria, Germany

Melanie Mueller, Joachim Pander, Juergen Geist*

Aquatic Systems Biology Unit, Technical University of Munich, Mühlenweg 22, D-85350 Freising, Germany

ARTICLE INFO

Keywords:
Fish population decline
Neobiota
Biodiversity
Freshwater conservation
Fisheries
Water framework directive
Extinction

ABSTRACT

Freshwater fishes are among the most threatened groups of vertebrates, with 39% of all European fish species facing extinction. Herein, we provide a comprehensive analyses of historical data as well as fish monitoring data from 1989 through 2013 from Bavaria, Germany. The results of this study indicate that the most pronounced species-turnover already had occurred before the 1990s. Severe loss of species (21 out of 69 species lost until 1990s), decrease in spatial distribution (51 species, 27 reduced to < 50% of historical distribution), decrease of abundance, shifts towards potamal species and the establishment of novel communities due to increasing colonization with non-native species was evident. Declines were strongest for gravel-spawning species of the hyporhitral and epipotamal in medium-sized and large rivers (e.g. grayling (*Thymallus thymallus*), nase (*Chondrostoma nasus*), barbel (*Barbus barbus*)), suggesting that effects of increasing water temperatures and increased fine sediment loads probably strongly contribute to the decline of those species. Our results generally confirmed the validity of current conservation status for most species, but also identified species (dace (*Leuciscus leuciscus*), chub (*Squalius cephalus*), trout (*Salmo trutta*), minnow (*Phoxinus phoxinus*), nase and barbel) and habitats (medium-sized and large rivers) that deserve higher priority in conservation management. More consistent sampling of the same sites over years and a quantitative monitoring of environmental impact factors in appropriate spatial and temporal resolution is crucial to allow a future prioritization in freshwater fish conservation.

1. Introduction

Freshwater fishes are in serious decline in various parts of the world (e.g. Moyle and Leidy, 1992; Burkhardt-Holm et al., 2005; Xenopoulos et al., 2005; Freyhof and Brooks, 2011), being one of the most threatened groups of vertebrates (Reid et al., 2013) with 39% of all European species facing extinction within this century (Darwall and Freyhof, 2016). Comprehensive global assessments of the conservation status of freshwater fishes are of great importance for their conservation management, but strongly depend on the availability of regional assessments (Arthington et al., 2016). Assessment methods are usually more consistent within the regional scale, the legal basis for fish conservation also follows political boundaries and the factors affecting fish populations mostly act on catchment scales. Moyle and Williams (1990) provided a valuable example of a regional assessment of the status of the Californian fish fauna in the 1980s. During the early 2000s, systematic governmental fish monitoring programs have been established in Germany and many countries, which now provide a systematic data basis for regional fish population trend estimations, but such data have only rarely been used in meta-analyses. With the introduction of the European Water Framework Directive (WFD, European Parliament, 2000), fishes have become one of four important biological quality elements in the monitoring of river ecological condition (Geist, 2014).

In this study, we provide a comprehensive meta-analyses of changes in fish assemblage in Bavaria, which is the largest federal state of Germany and covers three major central European drainage systems (Danube, Rhine and Elbe) as well as different ecoregions from alpine areas (max. 2962 m a.s.l.) to low mountain range (min. 102 m a.s.l.). In Bavaria, 68% of all fish species are currently listed on the federal Red List of threatened species (Bohl et al., 2003), making it an ideal case study area for assessing changes in fish assemblage. Our analysis is based on historical baseline data (river specific potentially natural fish fauna, Schubert, 2007) and data from systematic fish assemblage assessments from 1989 through 2013, considering different spatial scales. Specifically, we hypothesize that 1) Fish communities of the 1990s differed significantly from historical baseline data and have further changed until the 2000s. 2) The direction of population trends is species-specific, with declining distribution and abundance in species

* Corresponding author.
E-mail addresses: melanie.mueller@tum.de (M. Mueller), joachim.pander@tum.de (J. Pander), geist@wzw.tum.de (J. Geist).

https://doi.org/10.1016/j.biocon.2018.08.006
Received 7 June 2018; Received in revised form 31 July 2018; Accepted 10 August 2018

currently listed as endangered. 3) There are regional differences (major drainage systems, geological regions, stream size) in the strength of assemblage and population change. 4) A recent spread of non-native species resulted in major changes of fish assemblage and establishment of novel communities has occurred.

2. Methods

2.1. Data sets and sources

To analyze fish population trends in Bavarian streams, we used three different data sets. The first data set comprises historical baseline data (HBD), which represent the potentially natural fish fauna. This data set was established by the Bavarian governmental fisheries authorities based on historic records (1783–1905), recent data (1989–2005), stream morphology (historical and recent) and expert knowledge (Schubert, 2007). HBD was established stream and reach specific (327 reaches in 212 streams) and contains relative abundances (i.e. percentages) for each species. The deviation of the current fish assemblage from HBD is used as ecological quality indicator in the EU WFD (Geist, 2014; Hering et al., 2010). The second data set originates from the first systematic fish monitoring in Bavaria from 1989 to 1997 (later referred to as 1990s). The data set includes 2834 sampling reaches distributed throughout Bavaria, which were sampled by electrofishing of 100 m to 500 m bank length depending on stream size, following a standardized protocol (Leuner et al., 2000). The third data set comprises all data from the governmental fish monitoring in context of the EU WFD, which was established in 2004 and includes fish sampling data from 398 sites that were investigated from 2004 to 2013 by electrofishing of 100 m to 6000 m bank length following a standardized protocol (Dußling, 2009). All datasets assessed in our analyses are based on the same technical monitoring standard used in the governmental monitoring programs (CEN, 2003). This standard included electrofishing from the boat or wading using an electrofishing generator with continuous current and a single anode by specifically trained personnel with in-depth training on correct species identification. All caught fish were classified into species-specific size classes and numbers were recorded, distinguishing juveniles, subadults and adults.

2.2. Data preparation

Fish assemblage data from the 1990s and 2000s were normalized to a Catch per Unit Effort (CPUE) per 100 m river length prior to analysis. For comparisons with historical baseline data, absolute abundance values had to be transformed into relative abundance percentages for each species. When interpreting the results it has to be noted that changes in relative abundance are more difficult to interpret than changes in CPUE, because relative abundance is affected both by changes in the abundance of the focal species and changes in abundance of all other species. To compare fish monitoring data from the 2000s with data from the 1990s, a subset of geographically matching pairs of sampling sites was selected using near-analysis in ArcGIS 10.2 and manually checked for plausibility on the ArcGIS map. The same GIS based procedure was also used to identify respective historical baseline data for all fish sampling sites of all data sets. The GIS based matching procedure resulted in 146 triples of historical baseline data, fish sampling data from the 1990s and fish sampling data from the 2000s (Fig. 1).

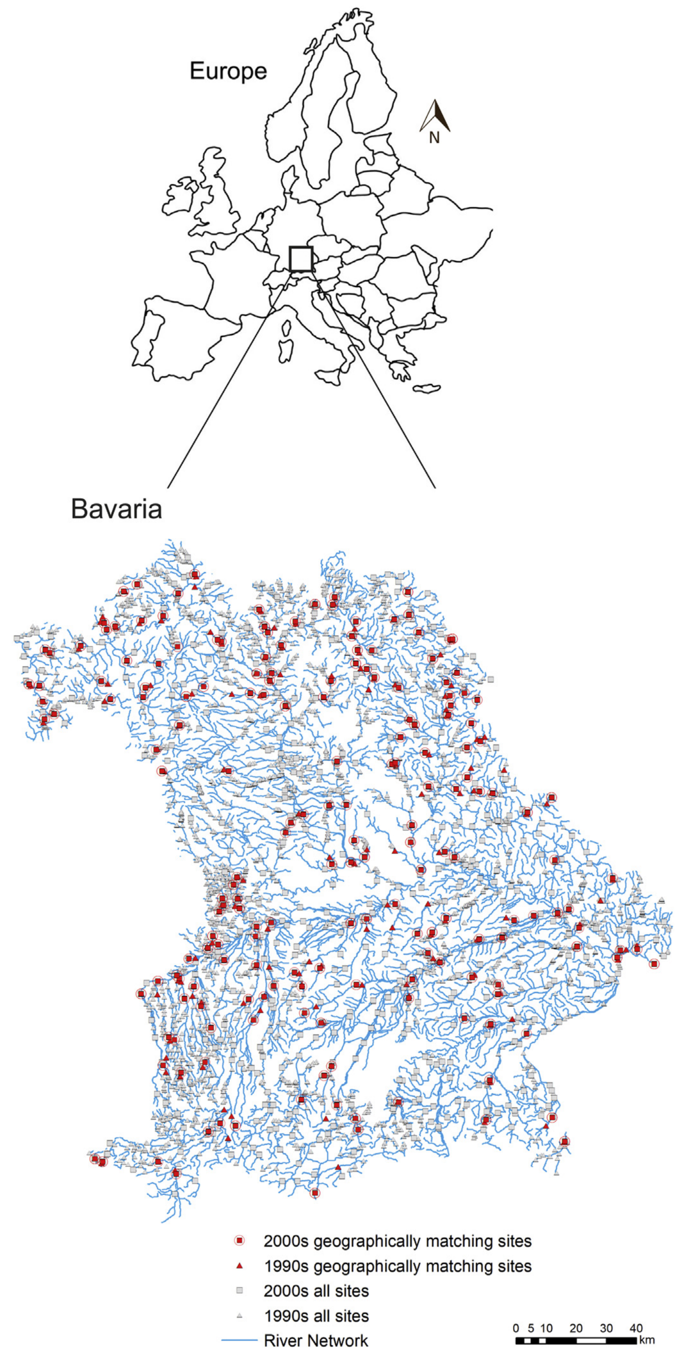

Fig. 1. Map of the study area. Red squares indicate sampling reaches from the 2000s which geographically match the sampling reaches of the 1990s. Red triangles indicate sampling reaches from the 1990s which geographically match the sampling reaches of the 2000s. Unfilled triangles and squares indicate the full set of fish sampling reaches for each time period respectively. Red circles around sampling reaches indicate location of historical data that was assigned to the pairs of fish sampling sites. Blue lines symbolize the river network. Note that the scale bar only applies to Bavaria. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2.3. Data analyses

The geographically matching sub-dataset was used for pairwise comparisons of fish assemblage between all three time periods (historical baseline data, 1990s and 2000s) and to analyze single-species trends. All sampling sites of the full datasets of the 1990s and 2000s for which HBD were available were used to investigate population trends in different geographic regions (the Alps, foothills of the Alps and lower mountain range), major drainage systems (Danube, Rhine and Elbe) and different stream-sizes (small rivers with a catchment area $\leq 100\,km^2$, medium-sized rivers with a catchment area $> 100 \leq 1000\,km^2$ and large rivers with a catchment area $> 1000\,km^2$, following national river type classifications and mirroring the fish regions salmonid region, cyprinid region and potamal region).