Fish distribution and spatial structure of fish assemblages in the Danube River

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Introduction

Sampling the biota in the main channel of large rivers presents a continuing challenge for freshwater ecologists. While our knowledge of the organization of shoreline fish assemblages and their representative sampling are increasing (e.g. Jurajda et al., 2001; Erős et al., 2008), information about the composition and spatial and temporal distribution of fishes in deep channel habitats is still relatively sporadic (Dettmers et al., 2001). Inferences about how main channel habitats contribute to the bioassessment of large rivers compared with shoreline monitoring data should also be more precisely developed (de Leeuw et al., 2007; Flotemersch et al., 2011). However, detailed quantitative studies are restricted to only a very few large rivers even in the relatively well studied temperate large river systems of Europe and North-America (see e.g. Wolter and Freyhof, 2004; Gutreuter et al., 2009; Ridenour et al., 2009). It would be thus important to develop deep channel fish monitoring methods for providing data for both basic research and the conservation management of riverine fish species.

Matching habitat typology and ecological assemblage types can be useful in environmental management and conservation (Dufrene and Legendre, 1997; Heino et al., 2003). For example, river typology can aid the reliable assessment of ecological status (Hering et al., 2010). It can account for natural variations in biological data caused by natural environmental gradients, and thereby helps to reveal the effect of anthropogenic disturbances (Heino et al., 2003). Different habitat types may also require specific management and conservation activities (Angermeier and Winston, 1999; Aarts and Nienhuis, 2003; Erős, 2007). The classification of assemblages and their corresponding habitat into well definable types, however, is not an easy task. The strength of the classification depends on several factors, including for example the abiotic heterogeneity of the environment and the responses of organisms to this heterogeneity. It can also depend on taxonomic resolution or sampling efforts and data evaluation methodology (Hawkins et al., 2000; Hughes et al., 2015). Delineation of assemblages can also be conducted at several hierarchical assemblage levels and spatial scales depending on the purpose of the study (Hawkins et al., 2000; Heino et al., 2003). Researchers agree that preliminary habitat classification schemes, which portray the environmental heterogeneity of the habitat, may help in the delineation of ecological assemblages to some degree, although no single organism group is likely to show a perfect match with any classification scheme (Hawkins et al., 2000; Heino and Mykrä, 2006; Hughes et al., 2015). Although the river is the cradle of Europe’s most diverse fish fauna (Reyjol,
2007), interestingly, no study so far has dealt with the large scale typology of Danubian fish assemblages.

The invasion of fish and invertebrate species of Ponto-Caspian origin is in the forefront of freshwater research due to the extreme fast range expansion of many species and their radical effects on the structure and functioning of ecosystems in their non-native habitat (Ricciardi and MacIsaac, 2000; Borza et al., 2015). Gobiids (Pisces, Gobiidae) are one of the most characteristic examples of this process. For example, the round goby Neogobius melanostomus (Pallas 1814) was first discovered in North America in 1990 in the St Clair River (Jude, 1992). During its invasion over less than 25 years, the species spread through the Laurentian Great Lakes at a faster rate than any previous fish invader. Its invasion led to significant changes of entire food webs (Kornis et al., 2007). The proliferation of gobiids may also influence the structure of Danubian fish assemblages along the longitudinal profile of the river (Koel et al., 2005; Hansen et al., 2008). Fish assemblage surveys are usually methodically restricted to sampling shoreline habitats in very large rivers. Although offshore main channel habitats have a much larger extent than shoreline areas and have been shown to be intensively utilized by fish (Dettmers et al., 2001; Szalóky et al., 2014), detailed knowledge about the composition of offshore fish assemblages is limited. Several studies reported on the shoreline distribution and habitat use of invasive gobies in large European rivers (see e.g. Erös et al., 2005; Jurajda et al., 2005; Kakareko et al., 2009), but how and to what extent gobies utilize offshore areas is still unknown. Knowledge about the offshore distribution and abundance of gobies could help to better evaluate invasion success and ecological importance of these species.
Objectives

1. We report on the application of an electrified benthic frame trawl (EBFT), developed for monitoring the distribution and abundance of benthic fishes in the Hungarian Danube River. Specifically, we show the parameters of the EBFT device (Fig. 1.) and provide the first detailed data on sampling effort species richness relationships, abundance, and size structure of the most common benthic species in the offshore, deep channel habitats of this very large river. We also compare the results of our benthic main channel survey with an extensive shoreline electrofishing (SE) data set. Based on these comparisons we evaluate the applicability of main channel benthic surveys for the study of fish assemblages in a very large river for bioassessment and conservation purposes.

2. The purpose of this study is to establish a large scale typology of a great river (Danube River, Europe) using fish assemblages. We characterize fish assemblage types in the non-wadeable, more than 2000 km long main channel section of the Danube River. Our first objective was to determine whether large scale changes in abiotic conditions along the longitudinal profile of the river are mirrored in fish assemblages. Furthermore, our objective is to examine whether different sampling methodologies (day and night shoreline electric fishing and offshore benthic trawling) provide consistent typological results.

3. Third aim is to present the first standardized catch per unit effort offshore data on the distribution and actual abundance of gobies in the main channel of the more than 2200 rkm long section of the Danube River.

Fig. 1. Schematic picture and parameters of the electrified benthic framed trawl (EBFT)
Materials and Methods

The Danube has a drainage area of approximately 817 000 km² and a mean discharge of 6,500 m³ s⁻¹ at its mouth. With its 2860 km length, the Danube River is the second longest river in Europe. At present, the river can be subdivided into three main sections based on its hydromorphological features, namely the Upper-, the Middle-, and the Lower-Danube. The Upper-Danube extends from the source of the Danube in Germany to Morva River (1880 rkm) in Slovakia. The Middle-Danube is the largest of the three sub-sections, extending from Morva River to the dams of the Iron Gate Gorge (942 rkm) on the border between Serbia and Romania. Beyond the Iron Gates, the Lower-Danube (including the Danube Delta) flows across a wide plain and finally reaches the Black Sea.

To construct the sampling device (electrified benthic frame trawl) to be effective in catching small sized benthic species we combined the design of conventional trawl nets and framed sledge nets, the latter used to sample fish fry in deep habitats. This consisted of a 3.4 cm diameter stainless steel frame (2 m long × 1 m high) to which a drift net was attached. The drift net was 5 m long and consisted of an 5 mm-stretch inner mesh bag and an 8 mm-stretch outer mesh bag. A buoy was attached to the codend with a rope to indicate the position of the net while fishing. We used weighted metal wheels to help keeping the device close to the bottom and also keeping the frame 6 cm above the bottom to prevent the filling of the net with the substrate material. We electrified the frame with a 40 m long electrode cable which was connected to a generator powered electrofishing device. A 6 m long copper cathode cable was hanged freely and pulled approx. 2 m before the electrified frame. When starting trawling, the EBFT operators lowered the frame to the bottom while the boat was slowly moving downstream with the flow. Trawling route was started to be measured by a GPS only after EBFT reached the bottom, which could be easily felt while holding the central rope and right after electroshocking started. The direct current (approx. 350 V, 33 A) was given for 5-8 s with 3-5 s breaks between the operations to minimize fright bias and injury of fish. The applied trawling speed was slightly higher than the current velocity of the river (approx. 60 cm s⁻¹). Each haul had a length of 500 m. Trawling was carried out during daytime.

We collected altogether 175 EBFT samples, 500 m long each, along a ~ 350 km stretch of the 417 km in the Hungarian Danube River section. We used a stratified design to select segments in order to get a representative coverage of the whole main channel area (excluding the section where the capital, Budapest can be found). In each of these segments several, but a minimum of 3 transects were selected randomly, perpendicular to the bank. Along each
transect, across the width of the main channel, we generally distributed 5-6 trawl paths, excluding the littoral, less than 2 m deep shoreline zone. These paths were approximately equispaced and centred over the approximate place of the main channel centreline.

Besides evaluating main channel fish data, we compared EBFT data with shoreline electrofishing (SE) monitoring data collected in the Hungarian Danube River section. Briefly, the SE data set contains electrofishing data of altogether 207, 500 m long stretches in the frame of which approximately 48,000 individuals were caught. The stretches were fished from a boat using generator powered electrofishing machine. Fish were caught with one hand held anode (2.5 m long pole with a ring anode of 40 cm diameter and a net mesh size of 6 mm) while slowly moving downstream with the boat. The cathode, a 5 m long copper cable, was floated at the rear of the boat. We used night time sampling because former surveys of the Danube and other systems justified that it is more efficient than daytime sampling of shoreline fish assemblages.

Sampling in offshore areas of the navigable Danube river (more than 2200 rkm) was done using the EBFT. We collected altogether 154 samples, 500 m long each. At each station 6 hauls were conducted on average (min 3 max 9) along predefined transects, excluding the littoral, less than 2 m deep shoreline zone.

Sampling in inshore areas was based on the Austrian national guideline for fish sampling in running waters, which is in agreement with international standards. The standardised sampling procedure for each site followed a habitat specific approach. The major mesohabitat types (i.e. rip-rap and natural stretches) were preliminary mapped and were sampled in their proportional distribution at the site level (i.e. fishing along an 5 km long section) both day and night to maximize the representativeness of the fish assemblage.
New scientific results and conclusions

- The EBFT proved to be very effective in detecting both benthic and water column species in offshore areas of the Danube River.
- Our large scale spatial survey revealed that offshore areas are intensively used by a variety of species. These are distributed relatively homogenously, but their abundance can vary largely in the river.
- Night-time sampling of the shoreline using boat electrofishing was highly more effective in detecting species regarding unit sampled length and increasing sampling effort than offshore bottom trawling.
- The EBFT provided essential information on the occurrence and abundance data of some benthic species in the river, which would have been highly underestimated using only SE. Most importantly, we revealed the commonness and relatively high abundance of strictly protected Zingel species with the EBFT. Therefore, the EBFT should be an essential device for monitoring spatial and temporal changes in the abundance of these species of high conservation concern.
- Larger specimens of many species were generally caught offshore, which suggests that older age classes prefer these areas to shoreline areas as habitats.
- Overall, no defined boundaries in fish assemblages were observed, which would justify the clear separation of fish assemblages along the course of the river.
- We found more or less gradual changes in fish assemblage composition and relative abundance, but variability in fish assemblages was high within the same habitat classes.
- Our study of the >2200 km long potamal part of the Danube indicates that the Upper Danube can be identified as the barbel zone, while the Middle and Lower Danubian zones may belong to the bream zone.
- The EBFT proved, that altogether 6 goby species use the offshore area as habitat in the potamon section of Danube River.
  - *Neogobius melanostomus* was the most abundant species in the overall catch of gobies, and clearly the most dominant species in the Middle- and Upper Danube region. *Neogobius fluviatilis* was the second most abundant species in the catch, its abundance and density increased significantly in the Lower Danube. *Babka gymnotrachelus* and *Ponticola kessleri* were relatively rare, although they were found along the longitudinal profile of the whole river. *Benthophilus stellatus* and *Proterorhinus semilunaris* were rare species in the offshore habitat and were found only in the Lower Danube region.
Related publications


Related presentations and posters


György ÁI, Weiperth A, **Szalóky Z.** 2015. The electrified benthic frame trawl (EBFT) as a potential tool for sterlet (*Acipenser ruthenus*) sampling in large rivers – Results from the third Joint Danube Survey (JDS3). Freshblood for Freshwater Meeting, Mondsee, Austria, poster.


Szalóky Z, György ÁI, Szekeres J, Csányi B. 2012. Fish Survey for JDS3, Deep water fish sampling. 1st Core Team Meeting of Joint Danube Survey 3, Vienna, Austria, presentation.


References


Hughes RM, Herlihy AT, Sifneos JC. 2015. Predicting aquatic vertebrate assemblages from environmental variables at three multistate geographic extents of the western USA. *Ecological Indicators* **57**: 546-556.


