



Editorial

The current status and future challenges for the preservation and conservation of freshwater pearl mussel habitats[☆]



One of the most sensitive macroinvertebrate species targeted by the Water Framework and Habitats Directives is the freshwater pearl mussel (*Margaritifera margaritifera*). During the 20th century, it has become widely extinct in Central Europe (Buddensiek, 1995). In river systems where populations have survived, decreases in abundance of 90% and more have been determined (e.g. Bauer, 1988). The freshwater pearl mussel goes through a complex life cycle, with different stages requiring different habitats. A female mussel produces up to four million parasitic larvae (Skinner et al., 2003) that are released into the river and try to attach to suitable host fish – brown trout (*Salmo trutta*) or Atlantic salmon (*Salmo salar*). After having spent the winter as cysts in the gills of their hosts, they metamorphose, drop off the fish and bury themselves into the river bed, where they stay in the hyporheic interstitial for several years. Due to their longevity (up to 200 years, Mutvei and Westermarck, 2001) freshwater pearl mussels especially depend on the substrate quality in the post parasitic and adult stage (e.g. Geist and Auerswald, 2007) as well as on specific habitat characteristics (Hastie et al., 2000). An appropriate freshwater pearl mussel habitat must therefore meet two seemingly diametrically opposite requirements: there must be stable substrates that keep both juvenile and adult mussels from being swept away, and at the same time an unclogged interstitial that provides for permanent oxygen supply. In many European countries, however, substrates are either stable and clogged or, if unclogged, unstable. Fine sediments are the driving factor for that phenomenon; hence this special issue particularly focuses on catchment area matters.

The special issue contains some recent research in Freshwater Pearl Mussel Science, a multidisciplinary field of research, focusing on the development of a comprehensive understanding of the dynamics and interactions between the physical, climatic and ecological components of the freshwater pearl mussel environment. In November 2013, a conference was held in Austria (Weinberg Castle, Kefermarkt) dealing with the opportunities of preservation and conservation of freshwater pearl mussel habitats. At the conference entitled “Improving the environment for the freshwater pearl mussel” participants from all over Europe presented the latest research concerning the status of freshwater pearl mussel popu-

lations, environmental disturbances and their negative impacts on mussel habitats, and the management opportunities for the preservation and restoration of mussel rivers in the future. With regard to the status of the freshwater pearl mussel in Europe the special issue contains two detailed studies from Portugal and the Czech Republic. In Portugal (Sousa et al., 2015) onsite research in 2010 and 2013 showed very low abundances with acute signs of aging, calling into question the future survival of these populations. Due to the fact that the Portuguese pearl mussel populations are at the southern edge of the species distribution a high priority on conservation is given. Similar declines were detected in the Czech Republic (Simon et al., 2015), where by the 21st century the freshwater pearl mussel became extinct in lower and middle altitudes, and current populations are only present near the upper limit of their natural range. The current population is estimated to be only 1% of the historical abundance. Although efforts to restore mussel habitats have been conducted over the last 25 years, natural reproduction still does not occur in the Czech Republic. Based on the decreasing numbers of freshwater pearl mussels all over Europe (e.g. Austria, Germany, Ireland) most of the current research focuses on the identification of environmental factors which may harm freshwater pearl mussel populations. Five out of eleven papers presented in the special issue highlight the role of sediment quality and possible disturbances in the sediment composition as decisive indicators for reducing the habitat quality for freshwater pearl mussels. Especially the role of fine sediment accumulation reducing the redox potential and thus influencing juvenile mussel habitats has been highlighted several times. Exemplarily (Horton et al., 2015), identify diffuse and point sources of sediment as possible trigger factors within a large-scale perspective (catchment scale) for clogging river bed surfaces in Northern Ireland. In Austria, on a local scale, Scheder et al. (2015) investigated sediment clogging and its impact on the interstitial habitat quality in relation to variable hydro-morphological boundaries (near natural river sites vs. artificial millrace). In their study the need for stable substrates for all live stages and unclogged interstitial for the juveniles to guarantee the required oxygen circulation for the juveniles was highlighted. The importance of scaling hydraulic and morphodynamic processes for the freshwater pearl mussel environment was especially addressed in the review by Hauer (2015). So far, impacts of environmental changes (e.g. increased fine sediment production) have been mostly investigated on a local scale without considering

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catchment scale boundaries that might decisively influence sediment production over the short to the long term. Based on a revised sedimentary link concept the main driving processes of the increase in the fine sediment supply from tributaries are discussed for various river scales (catchment to local scale). In the study by [Leitner et al. \(2015\)](#) the role of fine sediment deposition and its impact on the benthic macroinvertebrate assemblage was investigated. The studied macroinvertebrate species richness indicated significant faunal losses in sandy and fine gravelly habitats (grain size = 1–10 mm), demonstrating a severe but still underestimated threat for invertebrate biodiversity. Compared to the fines dealt with by [Leitner et al. \(2015\)](#), which are weathering products of granite and gneiss rocks, [Gosselin's \(2015\)](#) study from England addressed much smaller grain sizes <1 mm that lead to siltation of freshwater pearl mussel habitats. The presented water quality monitoring revealed levels of turbidity and suspended sediments to be above the limit set for the investigated pearl mussel river. Her substrate sampling revealed silt was present at all sites, with the consequence of a loss of redox potential between the water column and the substrate, indicating non-suitable conditions for juvenile pearl mussels.

Beside the given environmental pressures, management opportunities to improve the status of mussel populations are addressed in nearly all papers. Those management opportunities range from specific stocking strategies ([Denic et al., 2015](#)) to the re-distribution of infested host fish ([Österling, 2015](#); [Österling and Wengström, 2015](#)) to hydro-morphological (sedimentological) management issues. The third mentioned management approach contains the highest number of counts in the special issue. Most of them include a catchment-wide view for the implementation of mitigation strategies; [Simon et al. \(2015\)](#) state that a complete restoration of oligotrophic streams is the key to the future presence and natural reproduction of freshwater pearl mussels in the Czech Republic. The restoration strategy for the Rede pearl mussel population (England case study presented by [Gosselin \(2015\)](#)) should focus mainly on limiting sediment and nutrient input into the river throughout the catchment in order to improve habitats for juvenile pearl mussels. Land use was also addressed on the catchment scale, both by [Popov \(2015\)](#) who points out that the preservation of forest vegetation along the river banks correlates with the presence of pearl mussel populations; – and by [Horton et al. \(2015\)](#), who mention a number of different hard and soft engineering techniques for remediation, like fencing for cattle alongside the river. Different wording but similar meaning according to possible mitigation measures on various spatial scales have been reviewed and discussed by [Hauer \(2015\)](#), concerning possible structural (e.g. boulder placement) and non-structural measures (e.g. inducing self forming processes of tributaries).

In conclusion, the special issue contains a comprehensive overview of the state of the art in freshwater pearl mussel science and habitat restoration. The next steps in the conservation of freshwater pearl mussels in Europe could be a pan-European database about the catchment scale characteristics of mussel rivers, containing an overview of the population status and also local scale habitat requirements. Those local scale habitat requirements could be used for modeling possible reintroduction sites of juvenile mussels. Moreover, on a national level, conservation and restoration actions, capacity building among land owners, and development of the National Action Plan for freshwater pearl mussels should be targeted.

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