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Native Mussels Alter Nutrient Availability and Reduce Blue-Green Algae Abundance

Background:

Freshwater mussels (Bivalvia: Unionidae) (Figure 1) are an important group of filter feeding and long-lived (6 to 100 years) mollusks that live and burrow in river sediments. Freshwater mussels occur in large multi-species groups (mussel beds). However, the biodiversity of these sentinel organisms continues to decline rapidly in many rivers across the United States and they are considered North America's most imperiled faunal group. These valuable filter feeders remove nutrients and particulates from the water column. They make limited nutrients more locally available for other species while reducing total rates of downstream nutrient export. Trans-location (movement) and transformation of nutrients by animals is an important biogeochemical process that can enhance primary production across ecosystems and may have large effects on community composition and ecosystem function. Mussels can even generate spatial heterogeneity to support habitat in rivers and subsidize adjacent terrestrial ecosystems. As part of EPA's ongoing work to evaluate how natural and engineered structures in rivers alter nitrogen processing, determining the influence of mussels on nitrogen ecosystem services is critical to better management and decision making in aquatic ecosystems under anthropogenic and climatic stress. Since dense aggregations of consumers like mussel beds can create biogeochemical hotspots of nitrogen processing in aquatic ecosystems, we wanted to understand the importance of mussels to streambed nutrient dynamics, to determine whether mussels enhance benthic algae composition in rivers.

Findings and Implications:

In a collaborative effort between The University of Oklahoma and the EPA's Office of Research and Development, recent cutting edge research shows that mussels greatly influence ecosystem processes by modifying nutrients that limit primary productivity in rivers of southern Oklahoma (Figure 2). Sites without mussels were nitrogen limited with ~26% higher relative abundances of N-fixing blue-green algae, while sites with high mussel densities were co-limited (N and P) and dominated by diatoms. Blue-green algae are known for forming toxic algal blooms, while diatoms are typically a high quality food for grazing invertebrates. This suggests that through the formation of biogeochemical hotspots, native mussels reduce blue-green algae populations while promoting diatoms, thus creating better habitat patches for other aquatic organisms.

This work shows that translocation of nutrients by mussel aggregations are important to nutrient dynamics and algal species composition in rivers. The findings demonstrate that nitrogen translocation and transformation by a biologically diverse, imperiled faunal group controls nutrient limitation, community assemblages, and highlights the importance of native consumers in aquatic ecosystems. Entire assemblages of mussels have been extirpated from many rivers due to a variety of anthropogenic and climatic causes like dams, dredging, sedimentation, and prolonged drought. The full ramifications of past and future losses are yet unknown, but these results suggest that further loss of species could dramatically change community composition and ecosystem properties of riverine ecosystems, potentially damaging water quality.

Figure 1. Native unionid mussels in rivers convert water column nitrogen to more bioavailable forms to support algal community structure, actually slow nitrogen movement downstream, and potentially enhance sustainable water quality for healthy communities.

Figure 2. Rivers are under multiple stressors from human pollutants and climatic effects. These systems support diverse ecosystem services, including those of native mussels, which can enhance sustainable healthy communities and improve water quality.

Publications:

Atkinson, C. L., C. C. Vaughn, K. J. Forshay, and J. T. Cooper. 2013. Aggregated filter-feeding consumers alter nutrient limitation: Consequences for ecosystem and community dynamics. Ecology doi.10.1890/12-1531.1.

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