Spatial and temporal resource use of native fish in the Upper Mississippi River System

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River theories (e.g., River Continuum Concept, Riverine Ecosystem Synthesis) suggest predictable changes in biological resource availability occurs when the river's physical structure shifts. Using theories to predict behavior of rivers helps us understand how river modifications may affect the ecosystem structure and function without rigorous sampling, which is difficult and often not feasible due to personnel and time constraints. However, river theories have mostly been defined from observations of natural systems and we do not know if modified rivers, which are now most of the world's rivers, follow theory. Therefore, little empirical evidence exists to know if river theories can predict shifts in resource use along environmental gradients and better understand the macrosystem structuring of modified large rivers. Here, I quantified the prey and habitat use (i.e., resources) of eight native fishes across space and time using trace element, stable isotope, and diet analyses in the Upper Mississippi River System (UMRS). The UMRS varies in its physical structure from homogenous and complex in the upper reaches (Pools 4, 8, 13) to physically simple and disparate in the lower reaches (Pool 26, the Open River reach, and the La Grange Pool of the Illinois River). I expected the resource use of fishes to follow this complexity pattern (i.e., high and similar resource use diversity among upstream reaches, low resource use diversity downstream). At the smallest scale, diets of predatory fishes were homogenous in the physically similar upper reaches. At a seasonal scale, contrary to expectations, resource use diversity increased and isotopic niche overlap decreased from upstream to downstream. And at life-long scales, fish more often originated from tributaries and other river reaches than the mainstem river moving downstream, suggesting downstream fish more often use network connectivity (i.e., mainstem river and tributary connections) than upstream fish. Combined, these data suggest that the physical environment of the UMRS affects the habitat and prey use of native fishes. Specifically, complex upstream reaches likely contain a variety of resources that fish use within the mainstem river itself, whereas in physically simple downstream reaches, fish must originate from and use resources of other water bodies rather than the mainstem river due to scarcity of resources. These results follow different riverine theories depending on scale: physically homogenous reaches exhibited similar resource use (Serial Discontinuity Concept) and physically disparate reaches exhibited stark contrasts in resource use (River Continuum Concept or Riverine Ecosystem Synthesis).

Regarding macrosystem structuring, these stark differences suggest the upper and lower reaches of the UMRS have different ecosystem structures and functions. Regarding river management, management should occur at both local (i.e., reach) and system-wide scales to ensure resources are present and that connectivity among mainstem river reaches and its tributaries remain present.