*Michigan Department of Natural Resources*
*Fisheries Research Report 2073*

# Untangling Relationships between River Habitat and Fishes in Michigan's Lower Peninsula with Covariance Structure Analysis

**Troy G. Zorn**

*Michigan Department of Natural Resources, Marquette Fisheries Research Station*
*484 Cherry Creek Road, Marquette, Michigan 49855*

**Michael J. Wiley**

*University of Michigan, School of Natural Resources and Environment*
*Ann Arbor, Michigan 48109-1115*

*Abstract.*–Biologists need to understand causal relationships among key habitat elements and fishes to effectively protect and manage river systems. Though much groundwork has been laid, development of an analytic framework that incorporates spatial hierarchy of river habitat to predict characteristics of habitat and fish assemblages has been challenging. A key issue is the complex web of direct and indirect effects that arises when one attempts to include all pertinent habitat parameters in analyses. Covariance structure analysis (CSA) was specifically developed for untangling such webs and was used throughout this study. We developed a Habitat Model to quantitatively describe relationships between landscape- and local-scale habitat variables commonly associated with fish distribution and abundance in rivers of Michigan's Lower Peninsula. Catchment-scale variables characterizing river size, land use, and surficial geology had significant direct and indirect effects on (and explained 48-84% of spatial variation in) mean depth, velocity, July mean temperature, 90% exceedence flow yield, and total phosphorus values at sites. These variables also had significant direct effects on substrate composition at sites, but could not account for more than 26% of the spatial variation in any individual substrate class. Covariance structure analysis also provided an excellent tool for examining the relative importance of abiotic and biotic causal factors on fish abundance because it allowed us to distinguish among direct effects of habitat and biota, and indirect effects of habitat as mediated through the biota. In addition, CSA enabled us to determine the extent to which the set of sample sites chosen for analysis influenced the relative importance of local-scale habitat and biotic factors to fish abundance. The direct effect of habitat variables on brook trout biomass was 32 times greater than that of brown biomass when all streams were studied, but declined to 0.3 times that of brown trout when the analysis was restricted to trout streams. In a similar analysis for smallmouth bass, habitat factors had the strongest effects on fish standing crops when the analysis was based on all streams. However, when the sample was limited to smallmouth bass streams, direct effects of forage fish abundance and indirect effects of habitat via forage fish abundance were more prominent. In both the trout and smallmouth bass analyses, regional data sets (which included sites where the species of interest was absent) emphasized the importance of habitat factors on fish abundance, whereas restricting the sample to only sites where the species of interest was present, elevated the importance of biotic factors. Thus, both habitat and biotic factors are important to these species, with the set of streams being studied having an overriding influence on the relative importance of one versus the other. These findings help to resolve apparently conflicting results of other studies on the relative importance of biotic and abiotic factors to fish standing crops.