The Effects of Agriculture on Fish Communities in the Upper Mississippi River System through Archaeological and Modern Time Periods

Lyric S. Buxton[1] and Brittany M. Heasley[2]

[1] Department of Biology & Environmental Science, Samford University

[2] Department of Sociology, Anthropology, and Gerontology, Youngstown State University

Introduction

Today agriculture is a major industry in the Mississippi River Basin (Figure 1). Many agricultural practices, such as the production of maize and other native species known to be domesticated thousands of years ago, were first established in the midwest United States by humans living between 500 and 1000 A.D. during the Late Woodland period. As human populations increased, so did the need for food which lead to increased agricultural production of modern day. One consequence of increased agricultural activities is nonpoint source pollution. Nonpoint source pollution is anything that does not arise from or cannot be traced back to a specific point, such as runoff of fertilizers and sediments, which can negatively impact the river's water quality (Carpenter et al., 1998; US EPA, 2017). **We hypothesized that agriculture has affected the water quality of the Mississippi River system causing changes to the frequency of occurrence of fish communities over the past two thousand years, with the effects of the Mississippian time period being similar to the effects that are apparent in modern reaches of the river.**

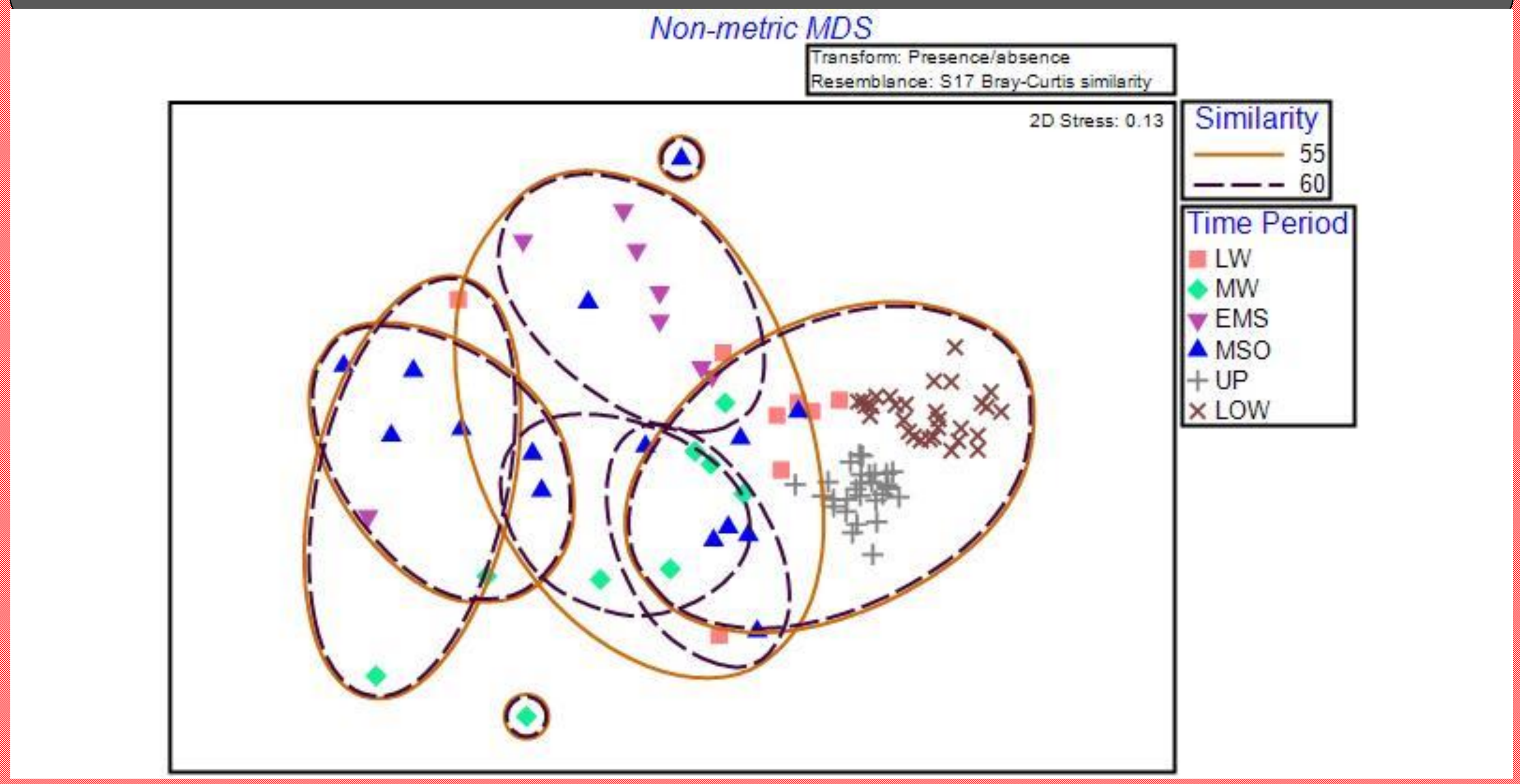
Several large cities and a large portion of agricultural lands drain into the lower reaches of the Upper Mississippi River System (UMRS). The lower reaches have a higher concentration of total nitrogen, total phosphorus, and total suspended solids relative to the upper reaches; these factors can lead to eutrophication (Houser & Richardson, 2010). Eutrophication combined with sediment build-up can cause decreases in dissolved oxygen resulting in habitat loss (Carpenter et al., 1998). In the Mississippian period, people living in and near the floodplain began farming more intensively (Bridges, 1989). These intensive agricultural practices may have affected local environments and the water quality in the river and other nearby bodies of water.

Results

Modern samples differed significantly (ANOSIM $P \leq 0.0001$) from all archaeological time periods (Figure 2). There were no significant differences ($P \geq 0.09$) among most archaeological time periods, with the exception of the Emergent Mississippian period, which differed significantly ($P \leq 0.0006$) from the Middle and Late Woodland time periods. The specific fishes we expected to be less frequent in modern times have similar frequency of occurrence in both archaeological collections and modern data.

Figure 1. National Oceanic and Atmospheric Administration map of agriculture in the Mississippi River Basin

Figure 2. Non-metric multidimensional scaling of fish communities from different time periods



Methods

We used modern data from the Long Term Resource Monitoring (LTRM) element of the US Army Corps of Engineers' Upper Mississippi River Restoration Program collected via day electrofishing in all habitat strata. Zooarchaeological data included published collections from various time periods in the UMRS with at least 500 fish bones identified. Fish taxa in the modern datasets were grouped according to zooarchaeological taxonomic identifications which can be limited by a lack of distinct osteological difference between closely related species. The archaeological database contained collections from the Middle Woodland, Late Woodland, Emergent Mississippian, and Mississippian/Oneota temporal periods in the Upper Mississippi River system. We compared these archaeological collections to modern samples from six reaches of the Upper Mississippi River System: Pool 4, Pool 8, Pool 13, Pool 26, La Grange, and the Open River. We analyzed presence/absence data from modern and archaeological collections using Primer-E software package. A Bray-Curtis similarity matrix was generated for all statistical tests. We used ANOSIM to test for differences among groups and NMDS to illustrate our findings. To further test our hypothesis, we selected certain fishes within our data that are sensitive to environmental changes. Using SIMPER, we examined variation of the frequency of occurrence of how these taxa varied among time periods. Taxa included *Acipenser fulvescens*, *Polyodon spathula*, *Moxostoma* spp., *Ictalurus punctatus*, *Ictalurus furcatus*, and *Noturus flavus.*

Discussion and Conclusion

We suspected that archaeological collections deposited during the Mississippian period would be more similar to the modern data because Mississippian people practiced rather intensive agriculture; however, we did not find evidence that this time period was more similar to the modern data than any other archaeological time period. We also found few significant differences among the archaeological time periods. We do observe other groupings among the zooarchaeological collections; we cannot determine the factors defining these groups. The frequency of occurrence of some fishes is much higher in modern data, which is likely a result of the effectiveness of electrofishing and the monitoring design. The archaeological collections were excavated and studied by different scientists, and therefore were sampled and analyzed using multiple techniques, resulting in unknown biases. Modern monitoring data were collected via electrofishing where the goal is to gather as many species as possible to accurately represent the fish community. In contrast, the collections from archaeological data represent only what people in the past ate. Factors that could explain variation in fish communities among archaeological collections include food preferences, fishing methods, various methods of food waste disposal, and/or gaps in the archaeological record.

While our current data do not support our hypothesis there is ample evidence that sedimentation caused by modern agricultural practices has impacted fish communities in the Mississippi River in modern times (Houser & Richardson, 2010). Additional analysis using datasets that may be more sensitive to sedimentation and water quality should be examined to determine how fish communities have been impacted by intensive agriculture.

Acknowledgments

Our research was funded through the National Science Foundation (NSF Award No. 1659633). Our research was possible with the support of the Illinois Natural History Survey, Great Rivers Field Station, and the Southern Illinois University Edwardsville STEM Center and Department of Anthropology. We would like to give special thanks to Drs. Carol Colaninno, and John Chick, and also Shana Springman, Lily Ward and Courtney Weldon for their guidance and support throughout our research.