Variation of Fish Diversity in the Lower Illinois River Over a 2,000 Year Temporal Span

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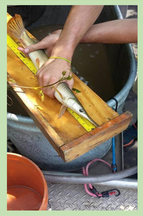
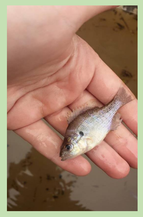
Introduction

In any locality, the number of species represented will be affected by historical and present-day processes (Wootton 1998). Local processes, which include structural complexity, abiotic conditions, and biotic interactions, determine the local assemblage and composition of fishes (Wootton 1998).

Here we explore differences in diversity of fish species throughout a 2,000 year temporal span. We tested for differences in the diversity of fishes in the Lower Illinois River and the diversity of archeofaunal collections representing fished populations from the Middle Woodland through the Late Woodland. Data used in this analysis are restricted to the Lower Illinois River Valley, and we conducted separate analyses of the two main components of diversity: patterns in the relative abundance of species and patterns in presence/absence of species.



Measuring a shortnose gar (*Lepisosteus platostomus*).



Identifying a bluegill (*Lepomis macrochirus*).

Methods

We analyzed deep-time temporal trends in fish diversity using both archeological and ecological datasets. Ecological data included in this study were collected as part of the Long Term Resource Monitoring element of the U.S. Army Corps of Engineers' Upper Mississippi River Restoration Program (Ratcliff et al. 2014), and Long Term Survey and Assessment of Large-river Fishes in Illinois (LTEF 2015). Archeological collections include both previously analyzed materials and those analyzed by students of this REU (Table 1). We limited our analysis to 20 fish taxa identified in archeological data. To make the archeological and ecological data comparable, we grouped or divided fishes based on that species' ability to be identified osteologically and its occurrence in archeofaunal collections to either the species or genus level (*Ictiobus* spp., *Pomoxis* spp., and *Moxostoma* spp.), in both datasets. Specimens identified to the family level in archeofaunal collections were separated into more specific taxonomic classification (i.e., genus or species) using ratios derived from their sum across sites in which specimens were identified to species. Our final data set included 11 archeological sites along the Lower Illinois River and 6 ecological sites (Table 1).

We used Primer 7 to conduct analyses based on Bray-Curtis Similarity, which yielded comparisons of similarity between samples based on the relative abundance of fish taxa within samples. We used ANOSIM to test for significant variation in the relative abundance of species and presence/absence of fishes among time periods. All ecology samples were considered to be in the same (modern) time period. Non-metric multidimensional scaling was used to illustrate the results of the ANOSIM analyses.

Table 1. List of the archeological and ecological samples analyzed in this study.

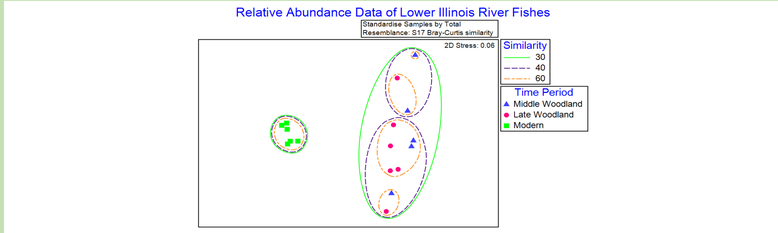
Site	Site Number	Time Period	Dates	Source
Napoleon Hollow	11PK500	Middle Woodland	164 cal BC- cal AD 388*	Styles and Purdue (1986)
Smiling Dan	11ST123	Middle Woodland	AD 250-1000	Styles, et al.(1985)
Apple Creek	11GE2	Middle Woodland	cal AD 134-805*	Parmalee et al (1972)
Mound House	11GE7	Middle Woodland	48 cal BC- cal AD 392 *	Thornton (2014), Knutzen (2015)**
Friendly Neighbor	11MD1146	Middle Woodland	AD 375	Long (2015)**
Apple Creek	11GE2	Late Woodland	cal AD 134-805*	Parmalee (1972)
Carlin Site		Late Woodland	cal AD 610-1210*	Styles (1981)
Newbridge	11GE456	Late Woodland	cal AD605-885*	Styles (1981)
Koster East Early	11GE4	Late Woodland	AD 700-800	Enzerink (2015)**
Koster East Late	11GE4	Late Woodland	AD 800-900	Ottenfeld (2015)**
Smiling Dan	11ST123	Late Woodland	AD 250-1000	Styles, et al. (1985)
Reach 7 (7-E)		Modern	AD 1957 -1993	LTEF
Reach 7(7-L)		Modern	AD 1994 -2014	LTEF
Reach 8 (8-E)		Modern	AD 1957 -1993	LTEF
Reach 8(8-L)		Modern	AD 1994 -2014	LTEF
Pool 26		Modern	AD 1994 -2014	LTRM
La Grange		Modern	AD 1994 -2014	LTRM

*Calibrated dates are reported for Napoleon Hollow, Apple Creek, Smiling Dan and Mound House (King et al. 2011), Carlin, and Newbridge (Studenmund 2000). Other dates are defined by relative dating in Smiling Dan (Stafford 1985), Koster East Early, and Koster East Late (Farnsworth 1991).
**Analyzed by Research Experience for Undergraduates students.

Results

There are significant differences in the overall ANOSIM results for relative abundance between the archeological and modern times (R = 0.673; p = 0.0003; Figure 1). The relative abundance of species showed a high significance level between the Middle Woodland and modern (R = 0.936; p= 0.002; Figure 1) and the Late Woodland and modern (R = 0.898; p = 0.002; Figure 1). There is no significant difference between the Middle Woodland and Late Woodland periods (p = 0.89; Figure 1). Groupings can be seen within the archeological data, but these groups do not correspond with time periods (Figure 1).

Figure 1. Relative abundance patterns of Lower Illinois River fishes in archeological (Middle and Late Woodland) and ecological (Modern) samples.



Bowfin (*Amia calva*) and black bullhead (*Ameiurus melas*) had a greater relative abundance in the archeological data relative to modern ecological data (Figure 2 and 3).

Figure 2. Relative abundance of *Amia calva* in Lower Illinois River archeological (Middle and Late Woodland) and ecological (Modern) samples.

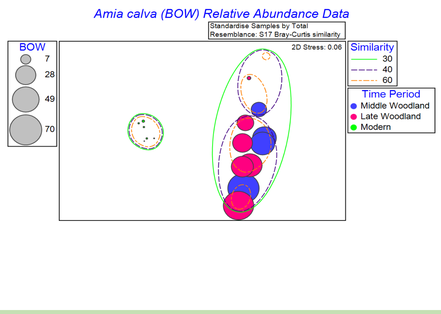
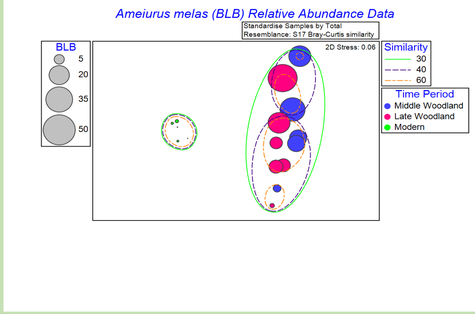
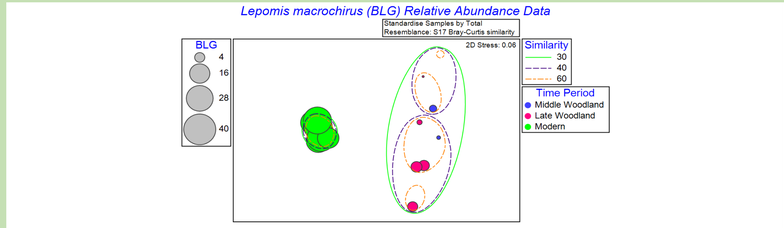


Figure 3. Relative abundance of *Amerius melas* in Lower Illinois River archeological (Middle and Late Woodland) and ecological (Modern) samples.



Centrarchid species such as bluegill (*Lepomis macrochirus*), had greater relative abundance in the modern ecological data relative to archeological data (Figure 4).

Figure 4. Relative abundance of *Lepomis macrochirus* in Lower Illinois River archeological (Middle and Late Woodland) and ecological (Modern) samples.



The overall ANOSIM results for presence/absence of the species indicate significant differences among time periods (R = 0.276; p = 0.008; Figure 5). The modern time period differed significantly from both the Middle Woodland (R = 0.584; p= 0.002; Figure 5) and Late Woodland (R = 0.298; p= 0.006; Figure 5) periods. There was no significant difference (p = 0.788; Figure 5) between the Middle Woodland and Late Woodland time periods. Some groupings can be seen within the archeological data, but these groups do not correspond to time period (Figure 5 and 6). Species richness was greater in modern ecological samples relative to archeological samples (Figure 6).

Figure 5. Presence/absence data of Lower Illinois River fishes archeological (Middle and Late Woodland) and ecological (Modern) samples.

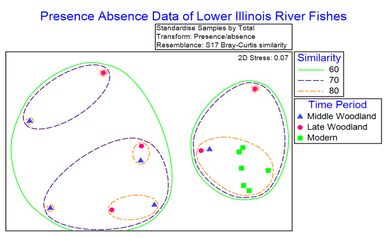
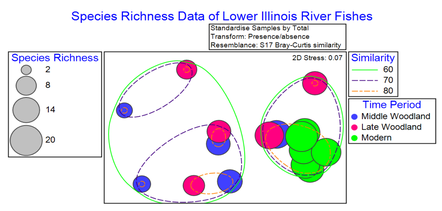


Figure 6. Species richness of Lower Illinois River fishes archeological (Middle and Late Woodland) and ecological (Modern) samples.



Discussion

There was a significant difference between the diversity of the modern time and the archeological time periods based upon the relative abundance and presence/absence of fish taxa. We found no significant differences between the archeological time periods and there was a greater variation among archeological samples relative to ecological samples. Relative to archeological time periods, modern ecological data had lower abundance of species such as bowfin (*Amia calva*) and black bullhead (*Amerius melas*), greater relative abundance of species such as bluegill (*Lepomis macrochirus*), and greater species richness.

There are several possible variables that may explain similarities within the archeological time periods. Factors such as sampling biases in screen mesh sizes, preservation of the faunal data, and the restricted spatial extent limited to Lower Illinois River Valley are all influencing these data. Other factors such as river discharge variation from climate change or heightened water withdrawal can limit freshwater biodiversity (Xenopoulos 2005).

Although this study cannot determine the ultimate cause for patterns we observed there are many opportunities for expansion that might further our understanding of how and why fish diversity has changed through archeological and ecological time. For example, this analysis could be expanded to other samples within the Mississippi and Illinois river floodplains; increasing the sample size would provide a greater opportunity to find significant patterns within the archeological data.

Conclusions

We concluded that there was a greater difference in ecological diversity than there was in archeological diversity. There was a greater overlap between archeological data and ecological data for our species richness analysis than for our relative abundance analysis. Groupings were seen within the archeological sites and to further explain these groupings, added data sets including more sites are required. Standardization of the archeological site collections would help make these data sets more comparable to ecological site collections. The significant difference between the diversity of archeological and modern samples could be influenced by factors such as climate change and human interactions, which may reflect the health of the Illinois River.

Acknowledgments

Funding for this project was provided by the National Science Foundation Research Experience for Undergraduates (Award No.1460787, PI Colaninno, Co-PI Chick). We thank the Center for American Archeology for hosting and administering this program. Dr. Terrance Martin provided support and access to the comparative collection at the Illinois State Museum. We thank Dr. John Chick and his staff for their assistance with our project. The Illinois National History Survey (University of Illinois), and National Great Rivers and Research Education Center provided equipment and facilities used to conduct this project. Funding for the collection of ecological data was provided, the Illinois Department of Natural Resources, U.S. Fish & Wildlife Service, Sport Fish Restoration Program, and the U.S. Army Corp of Engineers. Special thanks to Dr. Carol Colaninno, Autumn Beyer, Kelly Brown, and our fellow students for their assistance. The authors are responsible for all contents, including any errors, herein.