Variation in Fish Size Distribution Through Time Within the Lower Illinois River Valley

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Abstract

Anthropogenic forces have occurred throughout the duration of human occupation of our river systems. Their effects currently are ongoing and observable within river systems today. We tested for differences in the size distributions of fishes from archeological and ecological sites in the Lower Illinois River Valley (LIRV). There is a temporally related change in fish sizes between the two genera we tested, catfishes (*Ictalurus* spp.) and buffalo fishes (*Ictiobus* spp.), which may be attributed to anthropogenic influences, although other factors also impact observed temporal trends.

Figure 1. Demonstration of archeological methods for estimating size class

Introduction

Throughout human occupation, people have harvested fish at the confluence of the Mississippi and Illinois rivers. This is verified by remains of fish bones and artifacts related to fishing technologies dating back to the Early Archaic period (Styles 2011; Table 1).

Changes in fishing technology, the advent of water management techniques, nutrient loading from agricultural and municipal sources, and the addition of dam and levee systems all potentially impact the ability for fishes to grow among archeological, historical, and present-day populations. Previous researchers have documented decreases in fish size with increased fishing, although other factors impact fish growth (Braje et al. 2012).

We hypothesized that as human-river dynamics shifted and evolved, fish responded to the subsequent changes within the environment, resulting in a quantifiable temporal trend in fish size distribution. We expect to see significant variation in the size distributions of catfishes (*Ictalurus* spp.) and buffalo fishes (*Ictiobus* spp.), which have both been harvested by humans in archeological and modern times.

Methods

We chose to work with two genera prevalent in both archeological and ecological datasets: catfishes and buffalo fishes. We selected 5 LIRV archeofaunal collections (Table 1) with 10 or more specimens of each of the two genera respectively in the assemblages. Ecological data were acquired from two long-term monitoring programs: the Long Term Survey and Assessment of Large River Fishes in Illinois (LTEF), and the Long Term Resource Monitoring element (LTRM) of the U.S. Army Corps of Engineers' Upper Mississippi River Restoration program (Ratcliff et al. 2014). After combining individuals from both genera into 16-cm interval size classes, we used Primer 7 to conduct analyses based on Bray-Curtis Similarity and ANOSIM to test for significant variation in the size distribution of each genera among time periods. Non-metric multidimensional scaling was used to illustrate the results of the ANOSIM analyses.

Table 1. Archeological and ecological site data

Site Name and #	Time Period	Dates	Analyst
Apple Creek: 11GE2	Middle & Late Woodland	cal AD 134-805*	Parmalee (1972)
Carlin	White Hall	cal AD 610-1210*	Styles (1981)
Koster East Early: 11GE4	Late Woodland	AD 700-800	Ottenfeld (2015)**
Koster East Late: 11GE4	Late Woodland	AD 800-900	Enzerink (2015)**
Worthy Merrigan: 11C382	Mississippian	AD 1000-1300	Dopson (2015)**
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

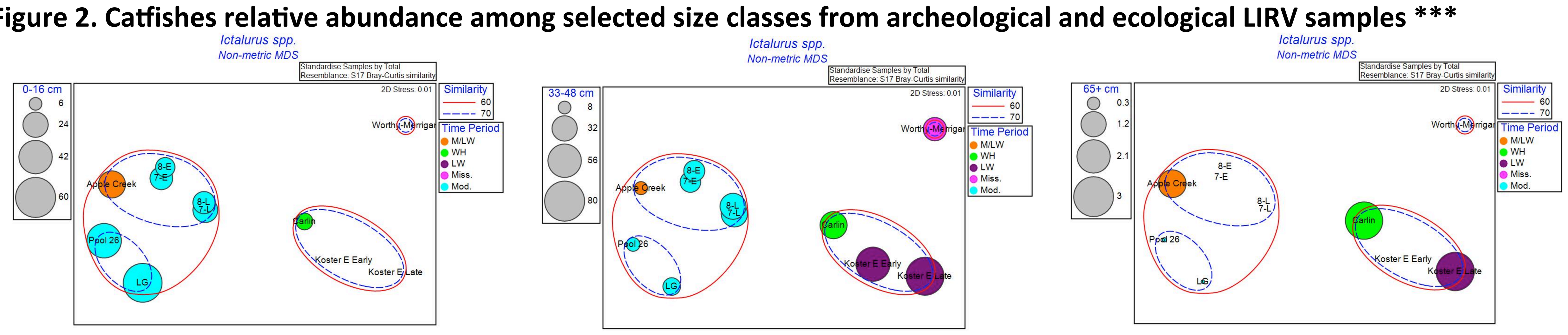
*Calibrated dates are reported for Apple Creek (King et. al. 2011) and Carlin (Studenmund 2000). Other dates are defined by relative dating in Koster East Early, Koster East Late (Farnsworth 1991) and Worthy Merrigan (Wettersten 1983).

**Analyzed by Research Experience for Undergraduates students.

Results

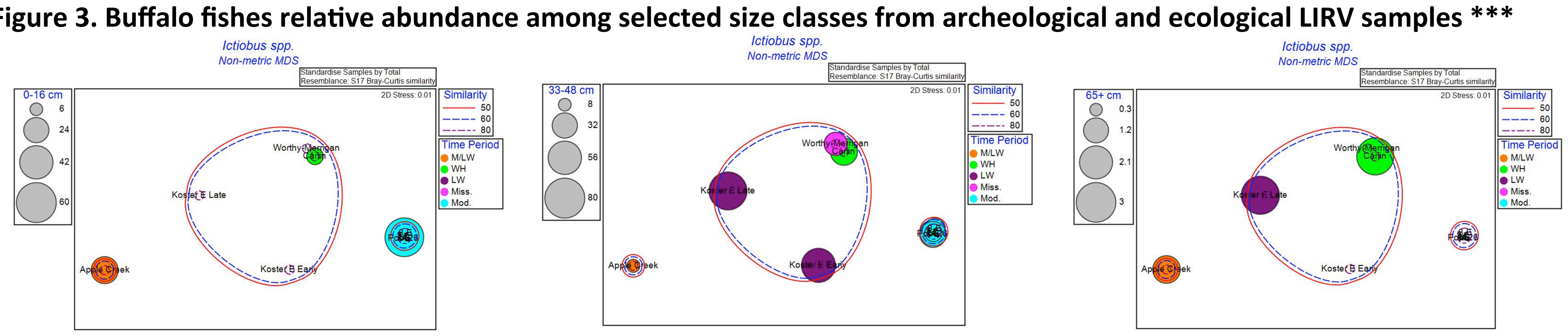
The ANOSIM analysis indicates that there is a significant difference among the time periods for both catfishes ($R=0.763$, $p=0.003$) and buffalo fishes ($R=0.971$, $p=0.003$). The ecology data differed significantly from the archeological data, but there were no significant differences among time periods within the archeological data. Larger sized fishes are represented in greater abundance in the archeological data, whereas smaller individuals are more abundant in the ecological data. Although the exact distribution of the fish sizes differs between catfishes (Figure 1) and buffalo fishes (Figure 2), the general time-size relationship was similar for both genera.

Figure 2. Catfishes relative abundance among selected size classes from archeological and ecological LIRV samples ***



***Mod- modern ecological data; M/LW, LW, Miss, White Hall- archeological data (Table 1).

Figure 3. Buffalo fishes relative abundance among selected size classes from archeological and ecological LIRV samples ***



***Mod- modern ecological data; M/LW, LW, Miss, White Hall- archeological data (Table 1).

Discussion

Our data yielded a distinct pattern of fish size distribution between modern and archeological time periods. Research confirms that size-selective fishing yields increased evolutionary pressures, which then affects trends in size among fish populations (Jorgensen et al. 2007). Generally, fishing technologies are designed to select individuals based on body size. Human exploitation of the fish would change the composition of the stock population, leaving the smaller, less desirable individuals to mature and reproduce. As a result of increased fishing pressures, genetic change would be magnified over time and would not be readily reversible (Stokes 2000). This progression towards a population of smaller fish is consistent with the shift in size distributions of both catfishes and buffalo fishes from the time to present-day (Figures 2 and 3). It is possible that human induced fishing pressure could be responsible for the observed differences in the datasets from these different time periods, although this study cannot determine the ultimate cause.

The differences in size distribution of fish can be influenced by several possible causes, all yielding the same result. Climate fluctuations, habitat loss/degradation, or behavioral changes also result in varied growth rates and sizes within fish populations. Collection biases in both the archeological and ecological data, such as screen sizes, netting techniques, electro-fishing limitations and human error, also affect these datasets.

Conclusions

The relative abundance of fish in larger size classes was greater for the archeological datasets than for the ecological datasets. Precise causes of these differences cannot be determined in this study. These temporal differences are significant in that they are likely to follow the same trajectory in the future (Figure 4). Further analysis is needed to determine causes of this trend.

Looking at how population trends correspond to harvest trends could determine the validity of the relationship between fishing pressures and fish size trends versus ecological factors, sampling bias, or other anthropogenic factors. If human induced fishing pressures are causing the shift towards smaller catfishes and buffalo fishes, the resulting evolutionary pressures will continue to affect the populations.

Figure 4. Modern catfish and buffalo

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