Variation in Fish Communities among Zooarchaeological Collections, Modern Monitoring Samples, and Commercial Harvest Records from the Upper Mississippi River System

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Introduction

Humans have drastically modified the Upper Mississippi River System (UMRS) over the past century (Sparks 2010). Modifications include introducing invasive species, constructing locks and dams, leveeing floodplains, and converting floodplain habitat to agricultural lands (Johnson and Hagerty 2008; Sparks 2010). Analyzing zooarchaeological collections in conjunction with modern data can give insight into the impacts that recent human modifications have had on river systems.

When European settlers moved onto land adjunct to the UMRS in the early 19th century, they used the river's fishes for food. In the late 19th century, people established commercial fisheries on the Mississippi River (Klein 2018). Scholars suggest that commercial harvest in UMRS has remained sustainable over the years (Klein 2018). Current management efforts place restrictions on the species that can be commercially harvested, as well as those fished recreationally. For example, paddlefish (*Polyodon spathula*) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) have length restrictions, and sport fishes, like bass, cannot be commercially harvested (Maher 2019). During archaeological times people fished for food, similar to the reason fishes collected in commercial harvest are used for food (Maher 2019). To examine how human harvest of fishes has changed over the last two millennia, we compare zooarchaeological fish communities to those represented in both commercial harvest and fish monitoring data. We hypothesize that the fish communities represented in zooarchaeological collections will be more similar to the modern commercial data than to the modern monitoring data.

Methods

We analyzed three different databases each representing one of our overarching study groups: 1) modern monitoring data from the Long Term Resource Monitoring (LTRM) element of the US Army Corps of Engineers Upper Mississippi River Restoration program; 2) commercial fishing harvest reports; and 3) zooarchaeological data which included the Middle Woodland, Late Woodland, and Mississippian/Oneota time periods. We analyzed LTRM electrofishing data from 1994-2013 from four reaches of the Upper Mississippi River System: Pools 13 and 26, Open River, and La Grange, which included multiple habitat strata, representing the entire river (Ratcliff et al. 2014). The commercial fishing database consists of annual Illinois Department of Natural Resources Commercial Harvest Reports from 1994-2012, which includes information on the abundance of 15 taxonomic groups, organized by year and reach of river. The zooarchaeological database was derived from published reports. Ten outlier zooarchaeological collections were removed from our analysis (fig. 1). For the zooarchaeological and modern monitoring data we grouped fish taxa according to those groupings reported in the commercial harvest database.

We conducted our analysis with Primer-E 7 software. Data were converted to presence/absence. We then generated a Bray-Curtis similarity matrix for use in all statistical tests. Using analysis of similarity (ANOSIM), we tested for differences among archaeological time periods and modern data sources. We illustrated our findings using non-metric multidimensional scaling and used SIMPER analyses to understand which taxa were the most dissimilar between groups.

Results

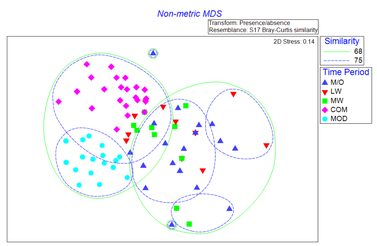

Fig. 1 Non-metric Multidimensional Scaling (NMDS) for fish community data organized by site and time period with outliers

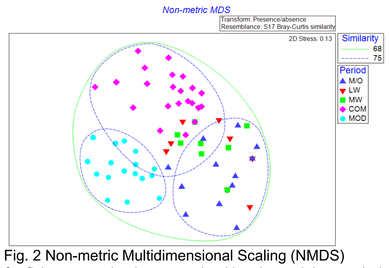

Fig. 2 Non-metric Multidimensional Scaling (NMDS) for fish community data organized by site and time period

Among the zooarchaeological collections, the Mississippian/Oneota period differed significantly from both the Late and Middle Woodland periods (ANOSIM $p \leq 0.048$). The Middle and Late Woodland periods were not significantly different (ANOSIM $p \geq 0.05$).

The commercial and LTRM data were significantly different from each other (ANOSIM $p \leq 0.0001$). Both modern commercial data and LTRM data differed significantly from all archaeological time periods (ANOSIM $p \leq 0.0002$). At 75% similarity, all commercial data and five monitoring sites group with 14 zooarchaeological collections (fig. 2). This shows partial support for our hypothesis.

The SIMPER analysis revealed that three fish taxa frequently occur in both zooarchaeological and commercial fishing data: gars (*Lepisosteus* spp.), buffalo fishes (*Ictiobus* spp.), and freshwater drum (*Aplodinotus grunniens*). Fishes that frequently occur in the modern monitoring database, but are less frequent among zooarchaeological collections include: river herring (*Alosa* spp.), whereas bowfin (*Amia calva*) and bullhead catfishes (*Ameiurus* spp.) frequently occur among zooarchaeological collections but are less common in modern monitoring database.

Discussion

Our results indicate partial support for our hypothesis that fish communities represented in zooarchaeological collections are more similar to those represented in commercial data compared to modern monitoring data. Although the commercial and zooarchaeological data differed significantly, zooarchaeological collections overlapped more with commercial data than with monitoring data. This may be an indication that ancient and modern fish consumption patterns are somewhat similar and people in archaeological time periods likely chose to target specific fish taxa for food, just as people target specific taxa today.

The zooarchaeological collections are significantly different from both modern sources of fish data for the Upper Mississippi River System. This may suggest that anthropogenic changes affected fish communities subsequent to archaeological times, though other factors may be affecting these datasets. Our analysis is limited by different biases associated with each dataset. Archaeological time periods are represented by the osteological remains of fishes, only some of which are identifiable to species or genus, whereas others are not. There is also a lack of standardization associated among archaeological excavation practices and data reported for zooarchaeological samples. This is unlike standardized modern datasets that track living organisms of known species. Further, commercial fishing is limited to 15 fish taxa legally harvested. Overall, other factors likely drive the zooarchaeological collections making them significantly different compared to modern records. Our research found partial evidence indicating that zooarchaeological collections are more similar to commercial harvest records. Future researchers should continue to explore the similarities between zooarchaeological collections and commercial harvest datasets in other systems and regions.

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