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Stable isotopic indicators of population structure and natal habitats of Asian carps threatening to invade the Great Lakes

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Abstract

Understanding early-life habitats is crucial for managing non-indigenous large river fishes such as silver carp that are threatening to invade the Great Lakes and may significantly impact economically valuable Great Lakes fisheries. Silver carp inhabiting the upper Illinois River directly below the electrical deterrent barrier (installed on a canal in the Chicago area that connects the Illinois River with Lake Michigan) possess the greatest potential to invade the Great Lakes. However, adult silver carp inhabiting this reach of the Illinois River may have originated from many points throughout the Mississippi River basin (e.g., Illinois River or Middle Mississippi River), and the relative importance of these potential origination locations is unknown. As such, this study was used to identify natal habitats of adult silver carp in the upper portion of the Illinois River. Based on the stable oxygen and stable carbon isotopes of otoliths (earstones) from individual fish, we have determined that silver carp inhabiting the area below the electric barrier originated from within the Illinois River itself, the Middle Mississippi River, and floodplain lakes along the lower Illinois River valley. Because of the geographically widespread points of origin for individual fish, management efforts for eradication or control of silver carp in the upper Illinois River should be directed at a similarly broad geographic scale. While potentially challenging to implement, large-scale removal of silver carp and the closely related bighead carp in the Illinois and Mississippi Rivers could greatly reduce the probability of these species breaching the electrical barriers and entering the Great Lakes.



Introduction

Silver carp are large bodied filter feeders native to rivers in Asia that were brought to the United States in the 1970's to control water quality in Southern U.S. aquaculture ponds (Freeze and Henderson 1982). After escaping such ponds, the Asian carp spread throughout the Mississippi River Basin and now inhabit 23 of the United States open waters (Kolar 2005). Known impacts of the introduction of nonnative species include habitat alteration, competition with native species, and overcrowding. Asian carp have cost over 137 billion dollars annually in damages, losses, and maintenance (Pimentel et al. 2000). This species has recently frequented headlines as it threatens to invade the Great Lakes by breaking through barriers established specifically to keep them out of fragile fisheries. The objective of this project was to determine natal habitats of Asian carp in the Illinois River, the most likely route of entry for these exotic species into the Great Lakes.



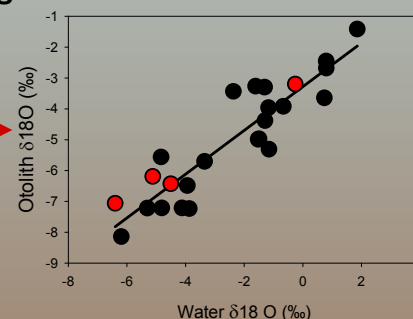
Study Area and Methods

Otoliths from young-of-year silver carp were obtained from the Missouri River, the Upper Mississippi River (upstream of St. Louis), and the Middle Mississippi River (downstream of St. Louis), to characterize relationships between water and otolith oxygen isotopic compositions. Forty-two silver carp were also collected from the Upper Illinois River (Figure 1) in August 2009 to identify natal environment of fish near the electrical barriers. Silver carp were collected by electrofishing and measured for length and weight. Otoliths were removed from each fish and stored in labeled coin envelopes in a cool dry place to dry. A Dremmel tool was then used to expose the otolith core region. The otolith and water samples were sent to the stable isotope lab at the University of Arizona and analyzed for stable oxygen and carbon isotopic ratios using a mass spectrometer.

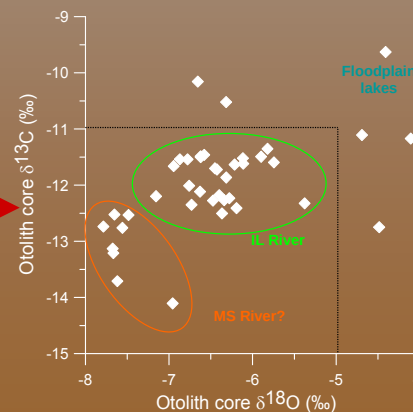


Results

Using data derived in this study (red data points) and a recent paper published by Zeigler and Whitley (2010; black data points) suggests that changes in otolith $\delta^{18}\text{O}$ are reflecting water $\delta^{18}\text{O}$ experienced by an individual fish. Ultimately this indicates that water $\delta^{18}\text{O}$ is driving differences in otolith $\delta^{18}\text{O}$ values among fish from rivers or lakes that differ in water $\delta^{18}\text{O}$.



Based on the stable oxygen and stable carbon isotopes of otoliths from individual fish, we have determined that silver carp inhabiting the area below the electric barrier originated from within the Illinois River itself, the Middle Mississippi River, and floodplain lakes along the lower Illinois River valley.



Implications

Provides knowledge of Asian carp source habitats in the Illinois River, the most likely route of entry for Asian carps into the Great Lakes.

Guide development of improved control strategies for Asian carps in the Illinois River, increasing the potential to prevent these exotic species from invading the Great Lakes.

Assist fishery managers by identifying river reaches and habitats (river channel or floodplain lakes) that should be the foci of efforts to control Asian carp abundance in the Illinois River.



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