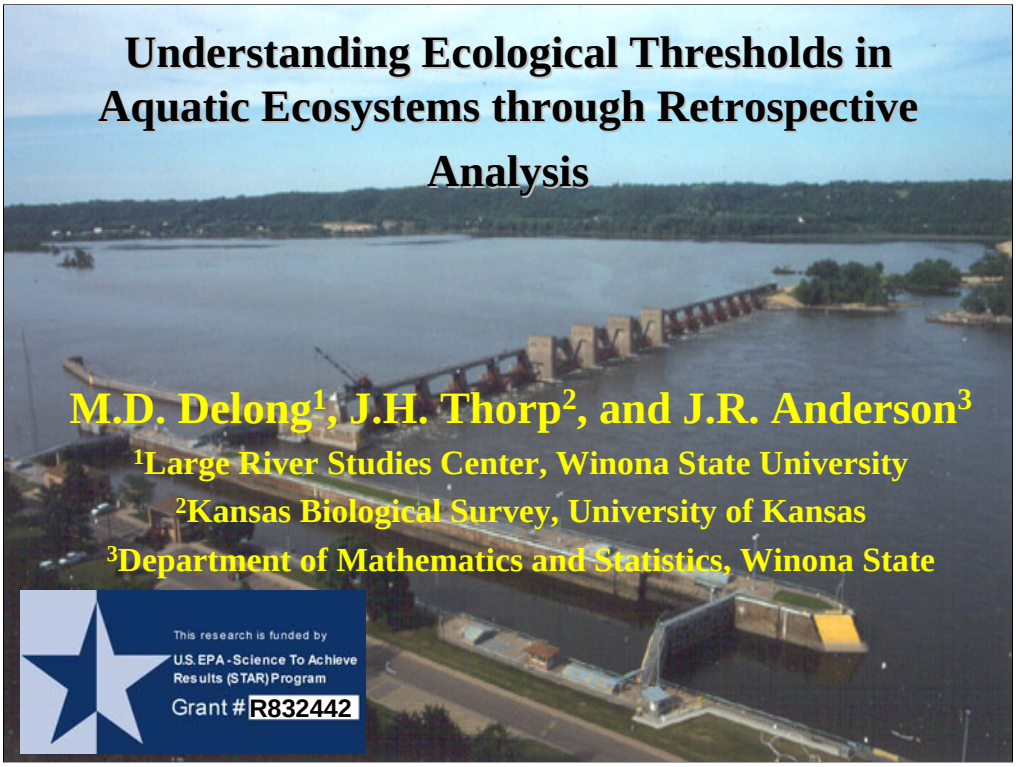
Understanding Ecological Thresholds in Aquatic Ecosystems through Retrospective Analysis
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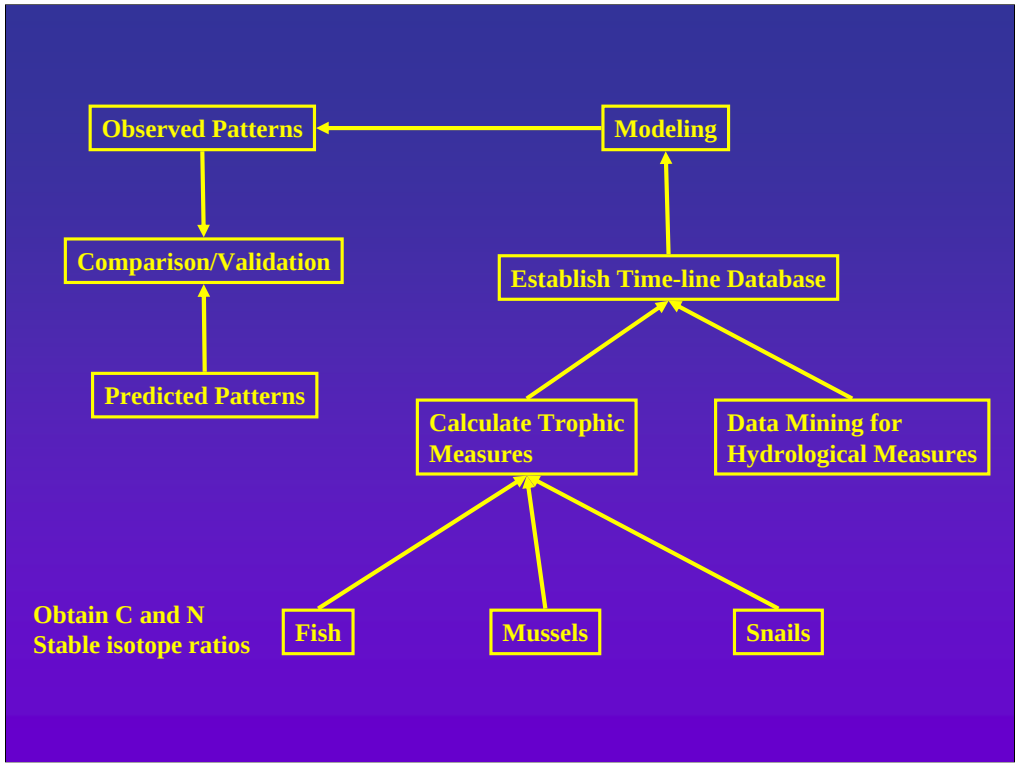
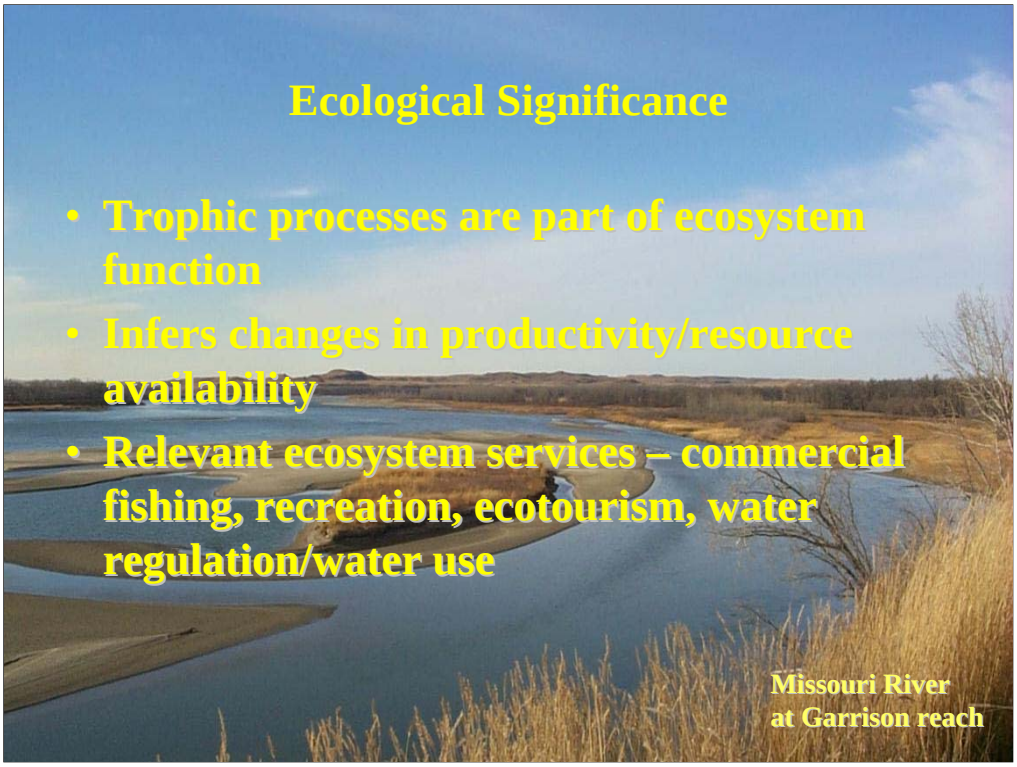
Project Objective

- **Identify ecological thresholds and stable state shifts in trophic dynamics of large rivers**
- **Method – C and N stable isotope ratios of fish, mussels, and snails**

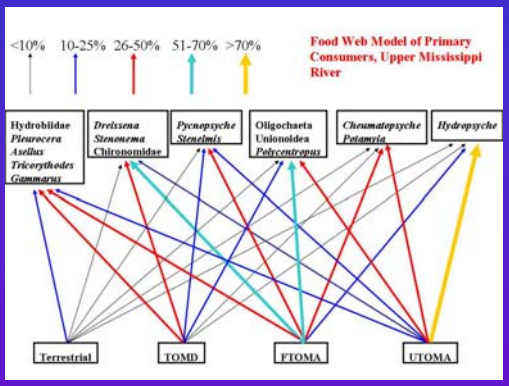
This information is collected using tissue samples from museum specimens.


Observed Patterns
Modeling
Comparison/Validation
Establish Time-line Database
Predicted Patterns
Calculate Trophic Measures
Data Mining for Hydrological Measures
Obtain C and N Stable isotope ratios
Fish
Mussels
Snails

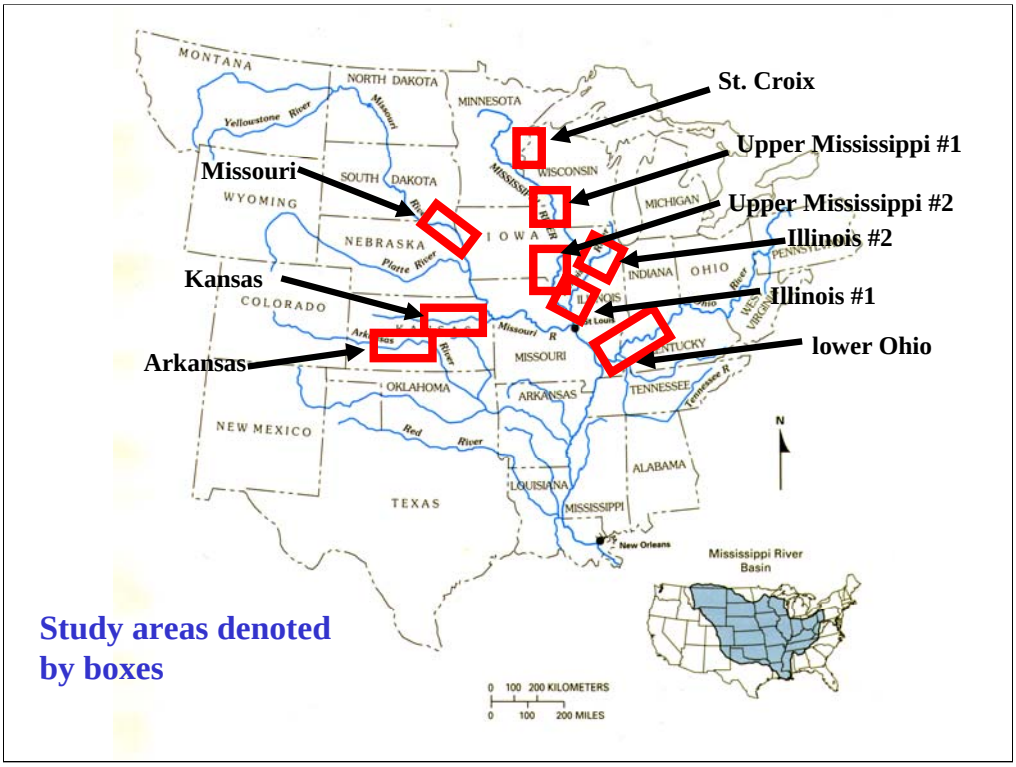

Ecological Significance
• Trophic processes are part of ecosystem function
• Infers changes in productivity/resource availability
• Relevant ecosystem services – commercial fishing, recreation, ecotourism, water regulation/water use
Missouri River at Garrison reach

Ecological Signicance

- **Nature of shift depends on**
  - **Increase/decrease basal resource availability**
  - **Change in important basal resource (e.g., benthic algae)**

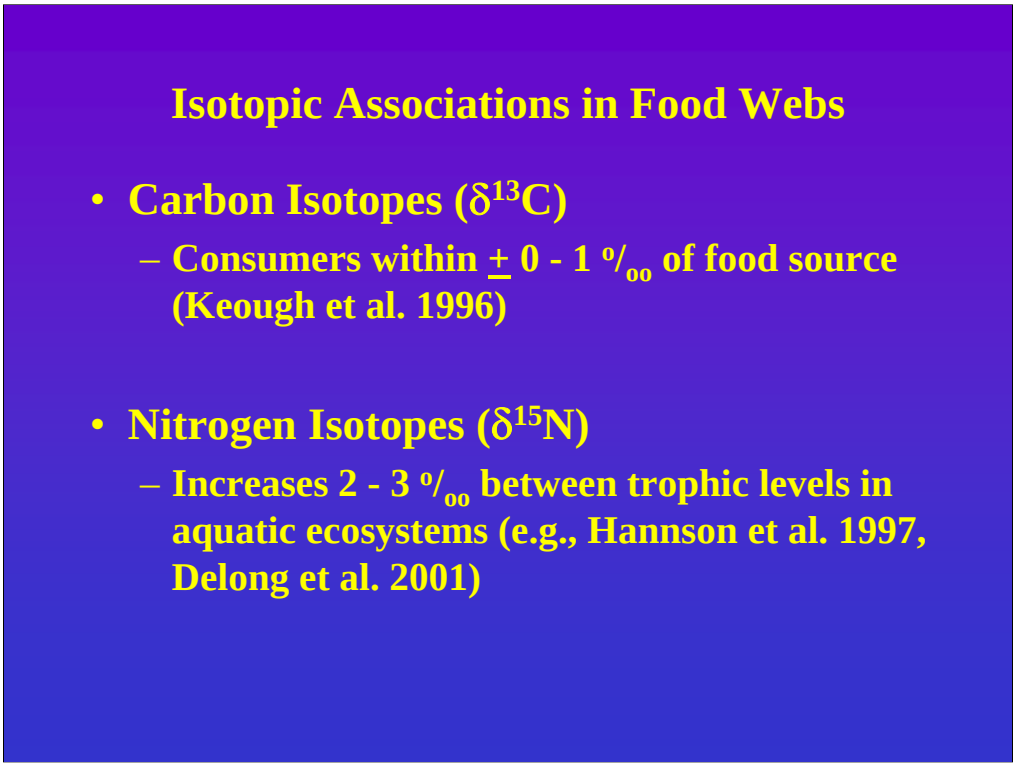


Delong and Thorp (2006)



This study focuses on Midwestern and Plains rivers. All but one of the rivers exhibit some type of hydrological alteration. The exception is the St. Croix River on the Wisconsin-Minnesota border. A large section of this river was one of the first to be designated as a National Wild and Scenic River. There is a dam on the mainstem which is used for hydroproduction. Samples are collected from the area above the dam to serve as the controls.

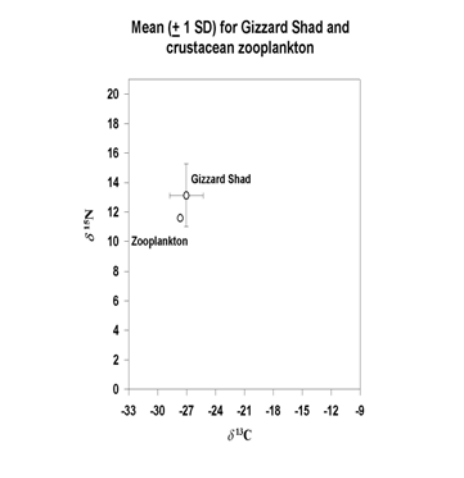
For some of the other rivers, there are two study sites. One example is the Mississippi River, with two different sites on the Upper Mississippi. The river is divided because there is a land use change and a geomorphological change in the river system around Clinton, Iowa. The Illinois River was split for the same reason. All four sites have lock and dam navigation systems. The Lower Ohio has a different, larger lock and dam navigation system that is used to ensure an adequate amount of water in the river during the summer low flow periods. In the Arkansas River, water extraction in recent years has greatly reduced flows. There are a number of reservoirs along the Kansas River. The Missouri River site is immediately below the last of the reservoir dams, the Gavins Point Dam. In the Missouri River, the annual hydrograph has been altered, with larger quantities of water released from the reservoirs during the summer. Thus, the water level is low in spring and early summer and higher in mid to late summer and through the fall.

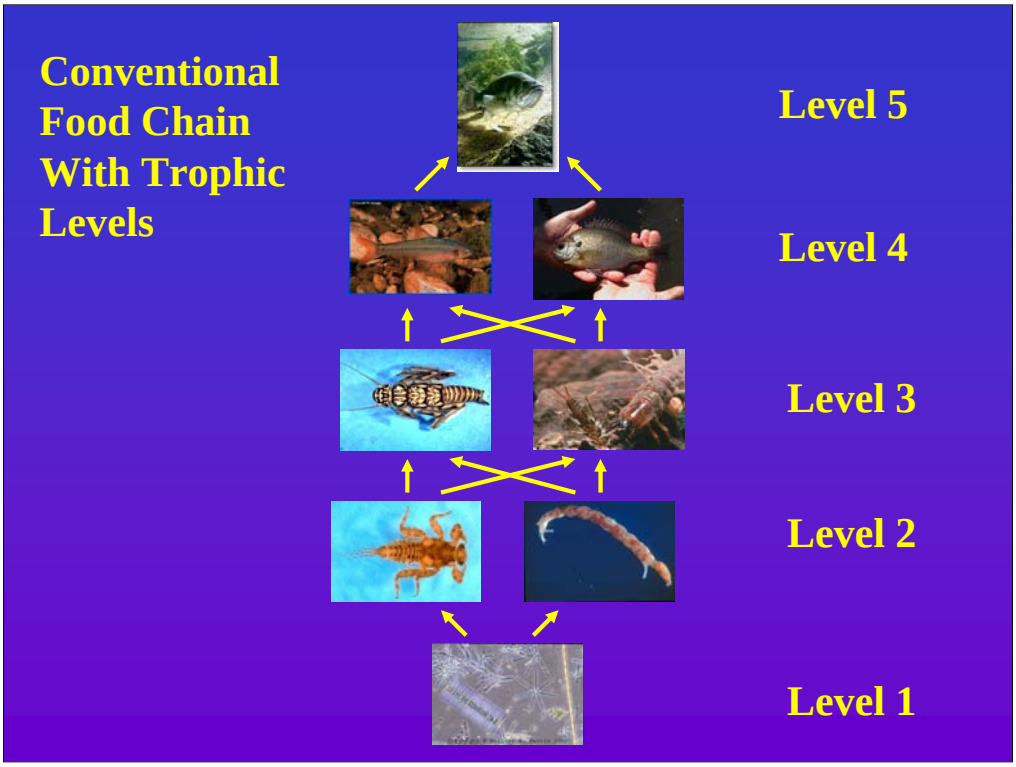


These isotopes are easily detected and change quickly from one level of the food web to the next.

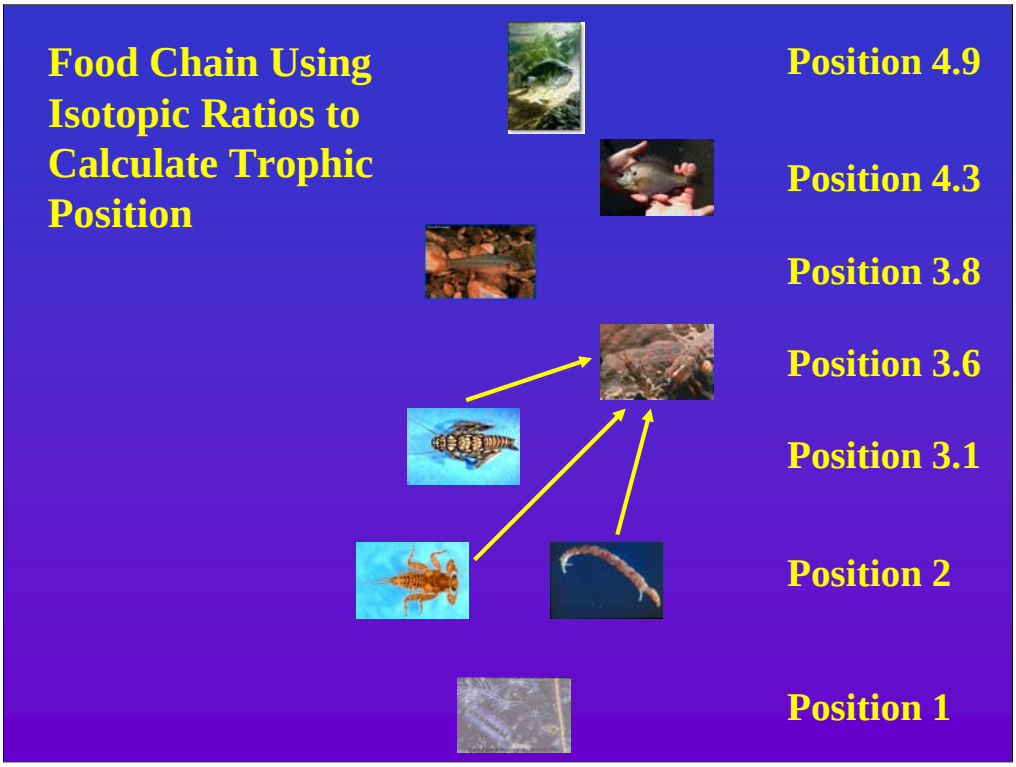
Application of Stable Isotopes

- **Predictable changes with trophic transfers allows for calculation of *trophic position***
  - **A continuous measure of position on food chain relative to basal sources**





The conventional food chain does not take omnivory into account.



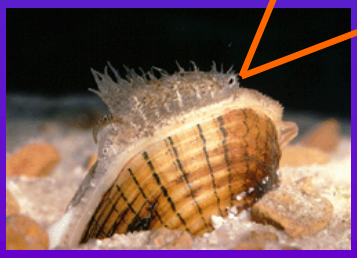
This food chain incorporates omnivory.

Trophic Position

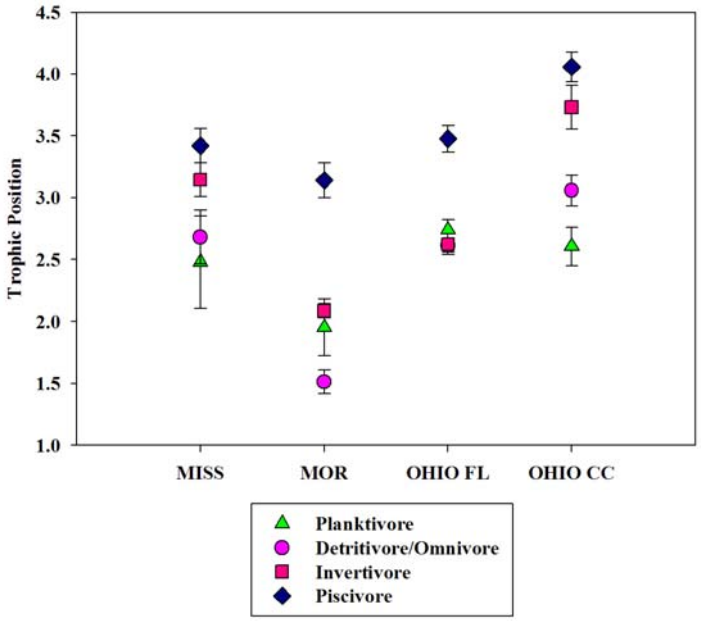
$$= \lambda + (\delta^{15}N_{sc} - [(\delta^{15}N_{base1})(\alpha + \delta^{15}N_{base2})(1 - \alpha)]/\Delta_n)$$

where,

$$\alpha = (\delta^{13}C_{sc} - \delta^{13}C_{base2})/ (\delta^{13}C_{base1} - \delta^{13}C_{base2})$$



Trophic Position of Fish 1993-1994



Methods

- Samples obtained from Museum Collections
  - Bell Museum
  - Field Museum
  - Illinois Natural History Survey
  - Illinois State Museum
  - Milwaukee Public Museum
  - Ohio State University
  - Southern Illinois University
  - University of Michigan
  - University of Wisconsin – Stevens Point

Fish Samples

- **15 – 20 species representing major trophic groups**
- **0.5 g tissue sample between dorsal fin and lateral line**
- **Frozen until processed**

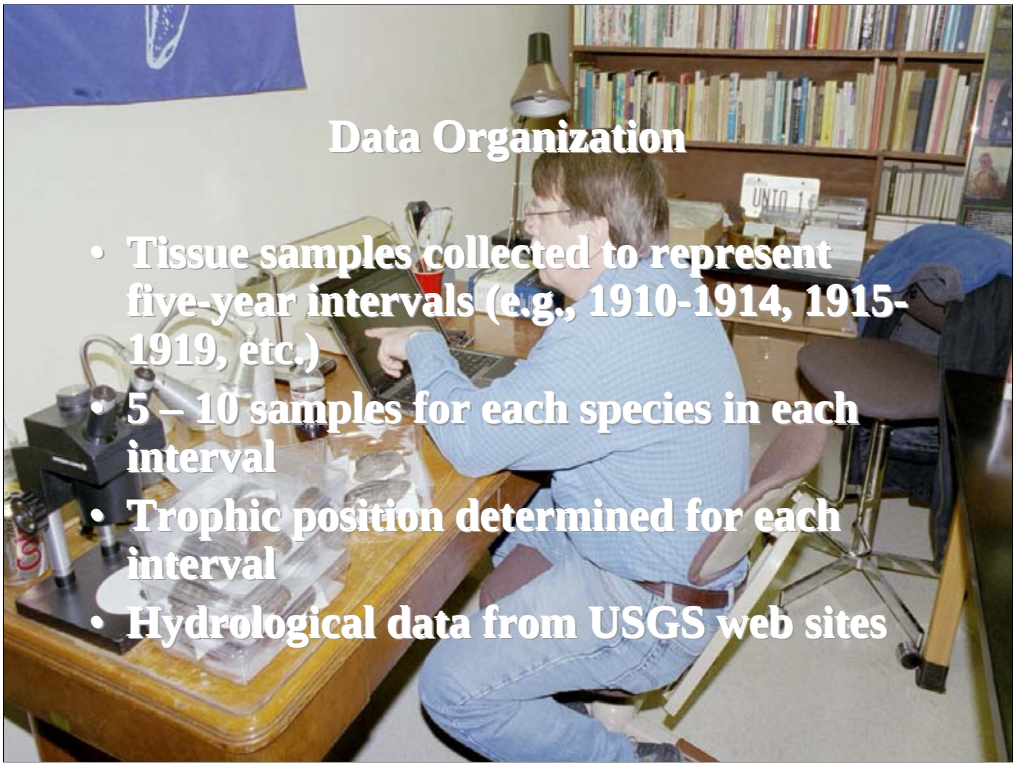
Most of the specimens were taken from fish from the 1870s or 1880s to the present.

Mollusc Samples

- 2 – 3 species each for mussels and snails
- Preserved tissues mostly after 1980s
- Scraping from periostracum when tissue not available

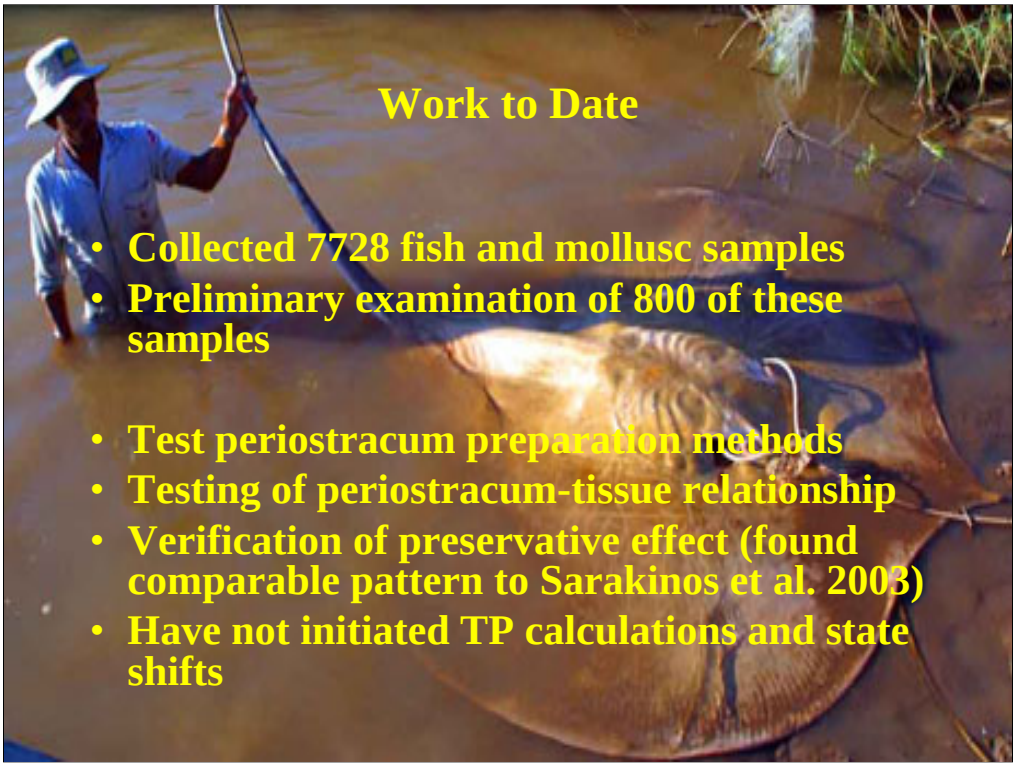
Mollusc Samples

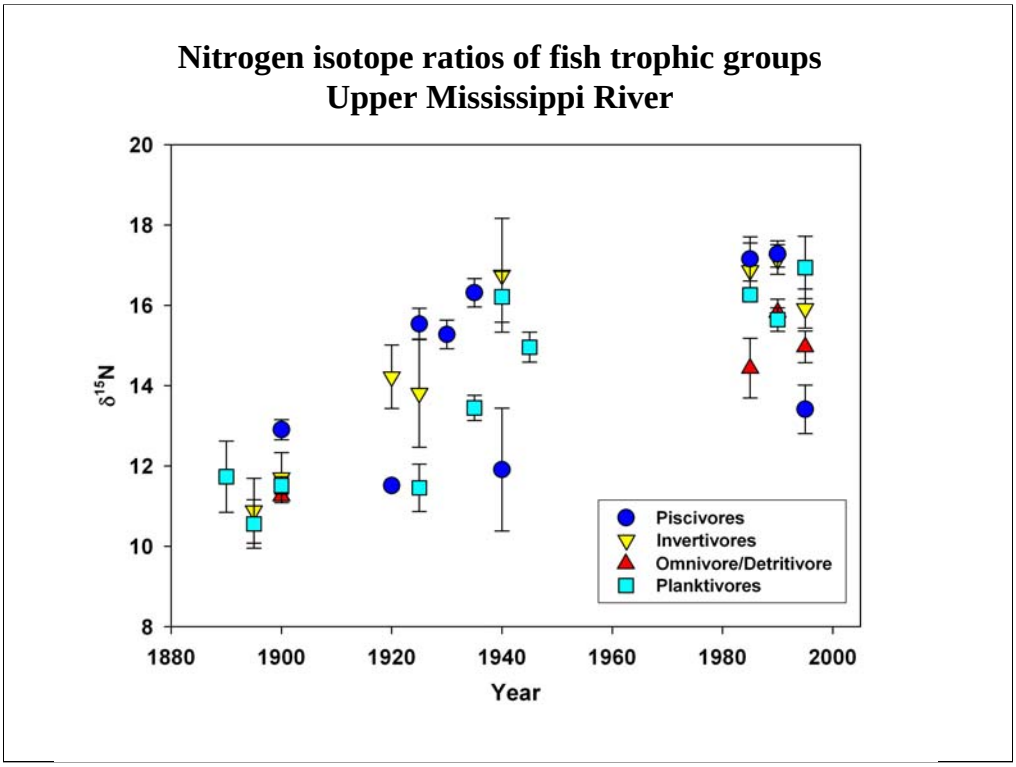
- **Why periostracum?**
  - **Mostly protein**
  - **Can identify most recent deposits**
  - **Comparison of tissue and shell indicates difference is small**
  - **Difference is predictable**



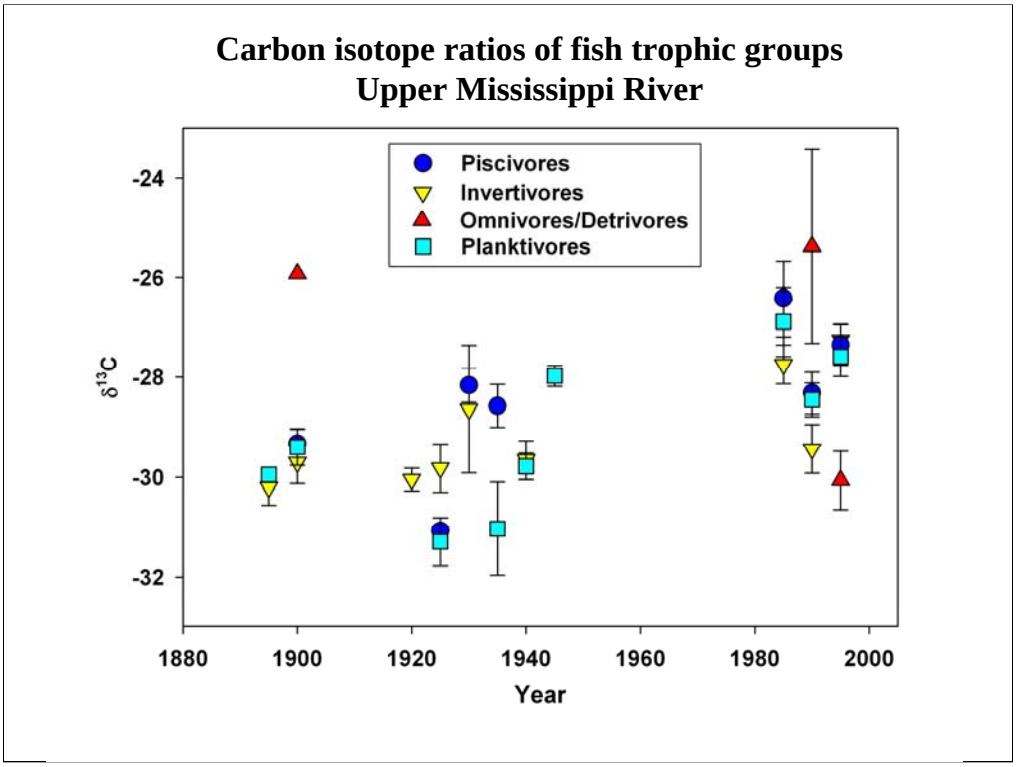
Data Organization

- Tissue samples collected to represent five-year intervals (e.g., 1910-1914, 1915-1919, etc.)
- 5 – 10 samples for each species in each interval
- Trophic position determined for each interval
- Hydrological data from USGS web sites

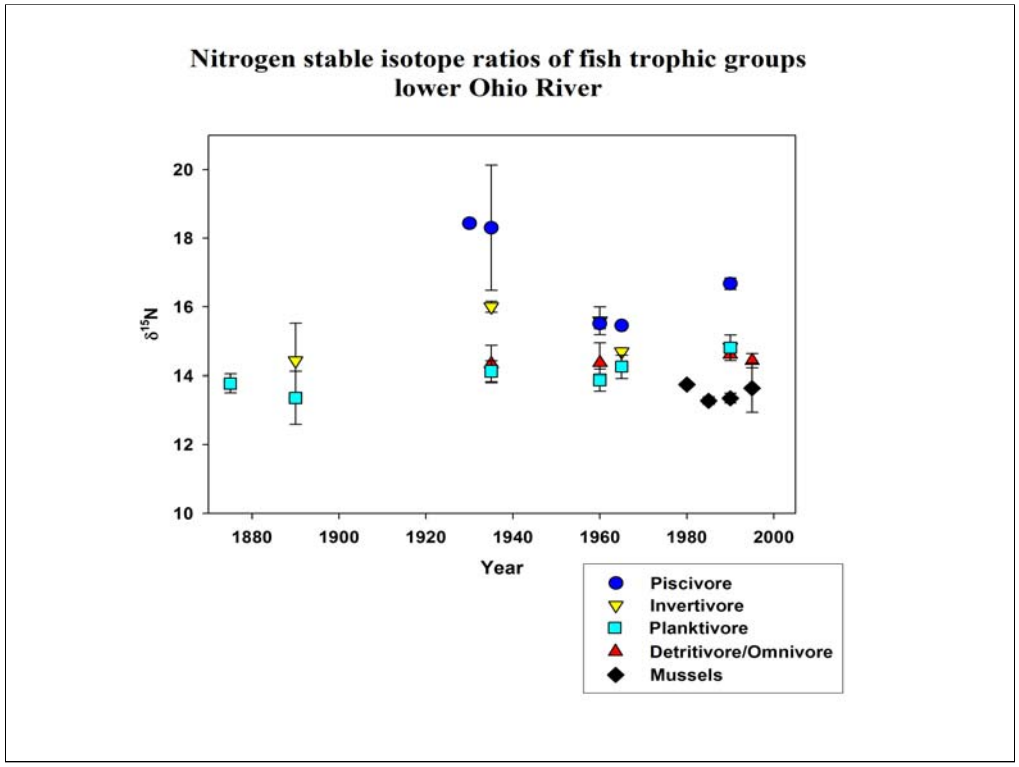

Work to Date
• Collected 7728 fish and mollusc samples
• Preliminary examination of 800 of these samples
• Test periostracum preparation methods
• Testing of periostracum-tissue relationship
• Verification of preservative effect (found comparable pattern to Sarakinos et al. 2003)
• Have not initiated TP calculations and state shifts



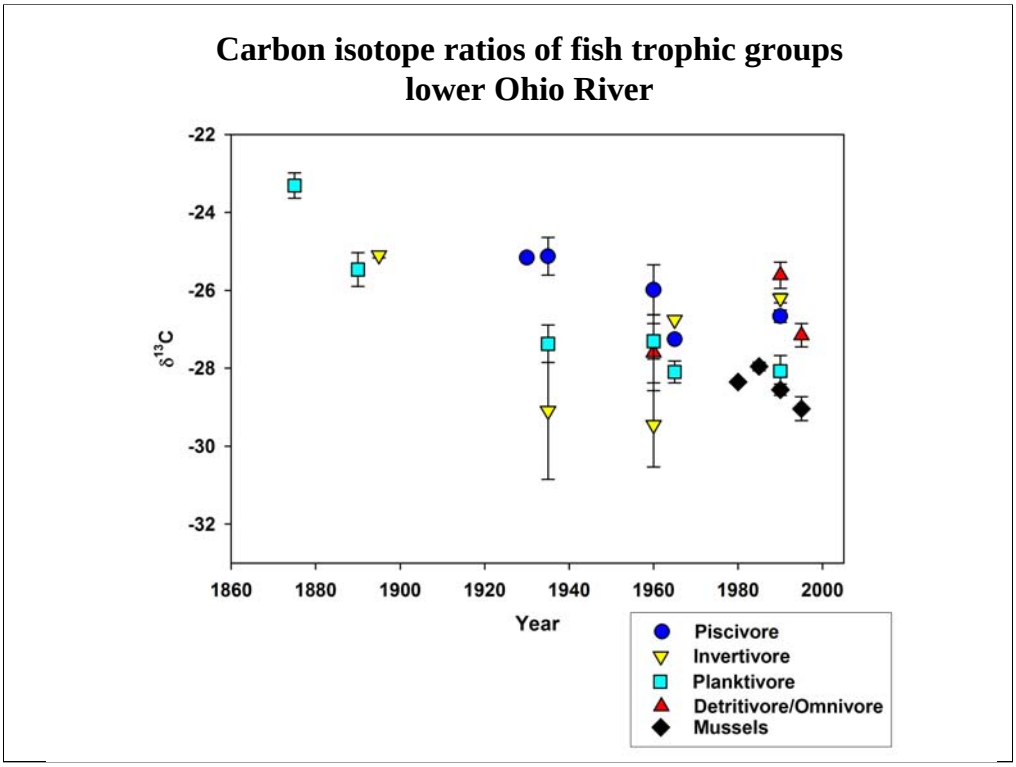
This graph, showing an increase in the nitrogen isotope ratio over time, is based on a limited amount of preliminary data.



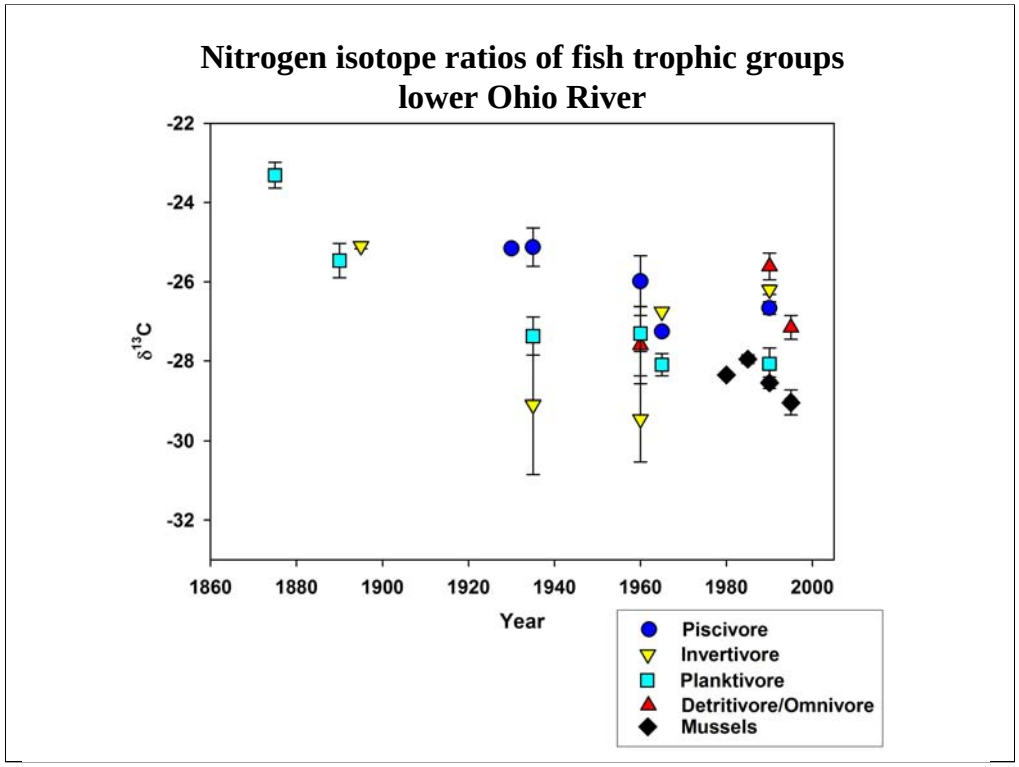
This graph, showing a change in the carbon isotope ratio over time, is based on a limited amount of preliminary data. It is important to remember that phytoplankton as a water column food source generally has a stable carbon isotope ratio around -30, whereas benthic sources usually have a ratio between -20 and -24. The preliminary data above shows a possible shift from pelagic sources to more benthic-dominated sources.



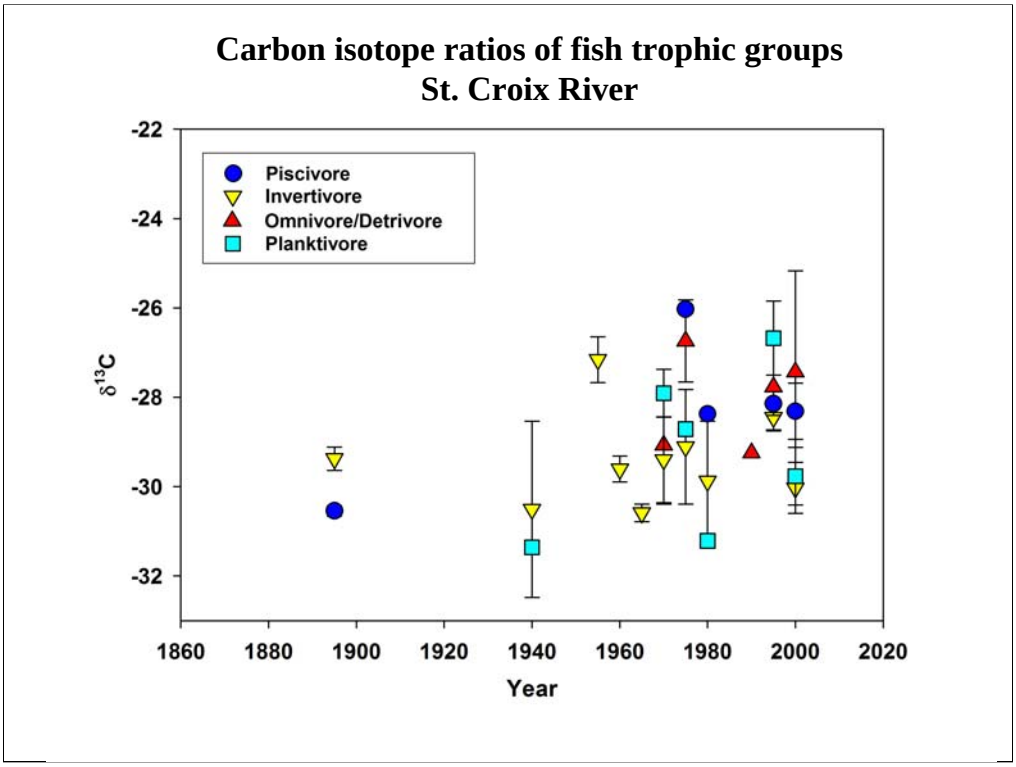
This graph is based on a limited amount of preliminary data.



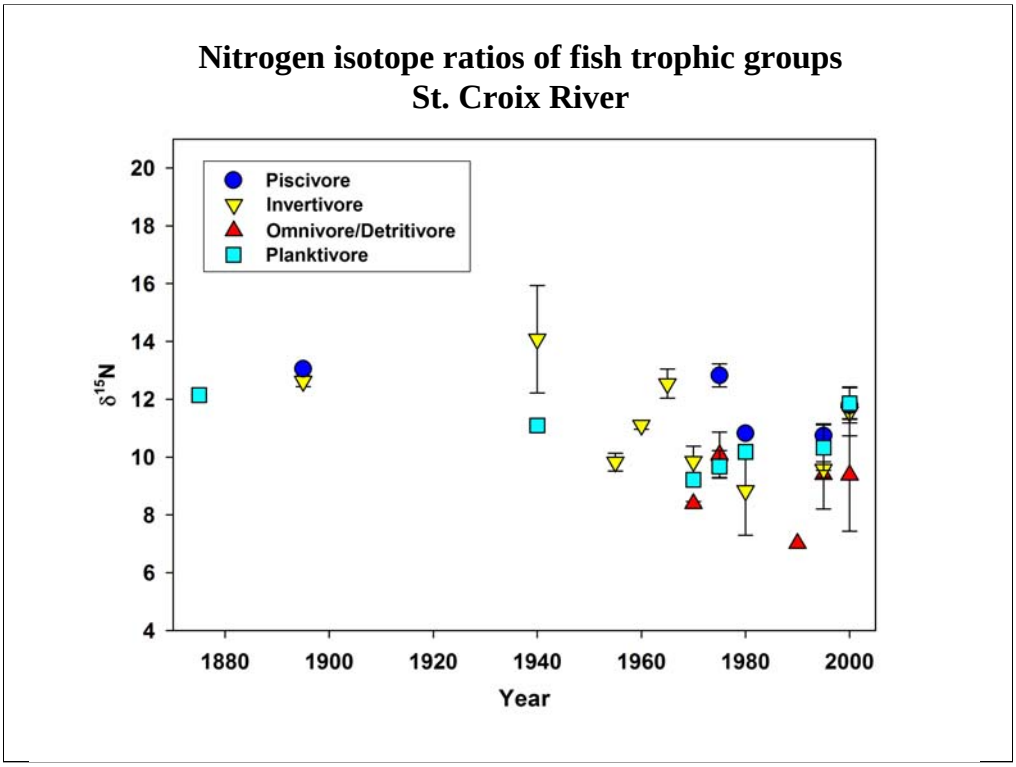
This graph, showing a possible shift from benthic sources to pelagic sources, is based on a limited amount of preliminary data.



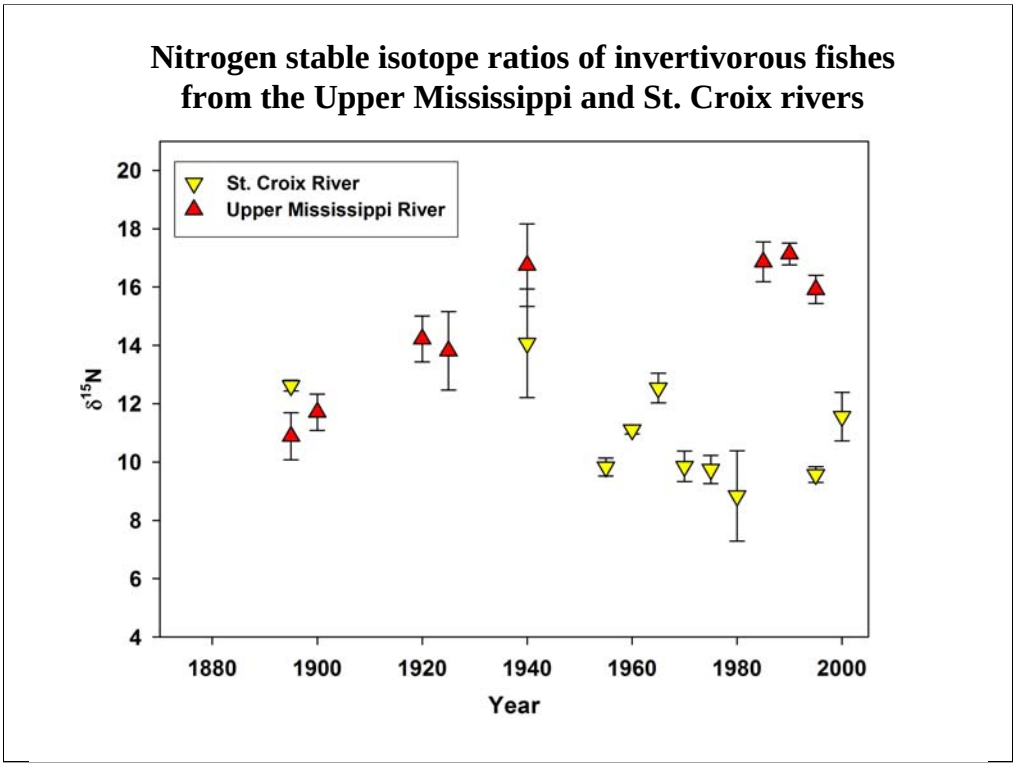
This graph, showing nitrogen isotope ratios decreasing over time, is based on a limited amount of preliminary data.



This graph, showing unchanged carbon isotope ratios, is based on a limited amount of preliminary data.



This graph, showing unchanged nitrogen isotope ratios, is based on a limited amount of preliminary data.



This graph is based on a limited amount of preliminary data; it shows a minimally disturbed river (St. Croix) versus a moderately disturbed river (Mississippi). It appears that some trophic position and state shifts may be occurring in the Mississippi.

Lessons Learned/Surprises

- **Isotope ratios of fish alone indicate temporal changes in trophic processes**
- **Surprise – strong similarity of mussel tissue and periostracum isotope ratios**

Potential Application

- **Probably greatest for rehabilitation projects – restoration of “natural” hydrological patterns**
- **Flow targets in development of new hydro projects (alternative energies)**

Project Interest/Collaboration

- **Great interest among scientists at academic museums**
- **Develop similar projects for Australian and European rivers**

Acknowledgements

- Museums and staff
- WSU Large River Studies Center Research Assistants
  - James Hofmann
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  - Lindsey Rice

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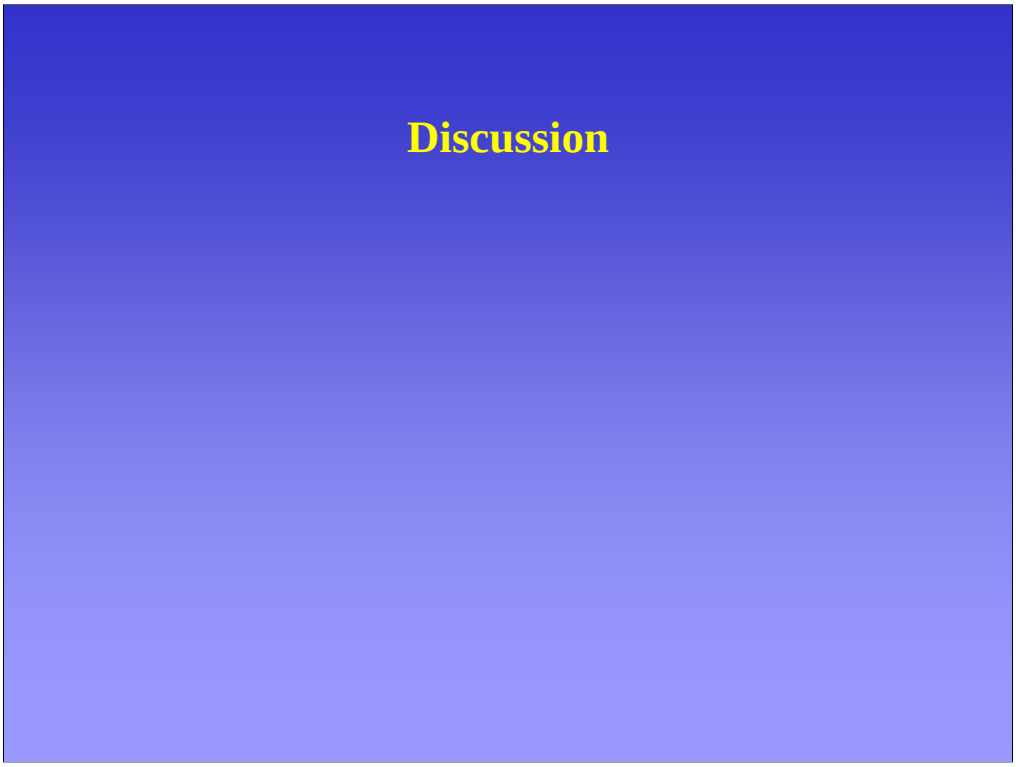

A participant asked if the increasing nitrogen isotopes in rivers follow the increase in fertilizer runoff from cities. Dr. Delong answered that some enrichment from fertilizers is expected, but if the runoff has an effect on fish, it will have an effect on the entire food web. The advantage of using trophic position is that, if this effect occurs throughout the food web, the trophic position will most likely remain unchanged.

A participant asked if there is a way to examine cascading effects. Dr. Delong thinks this is possible. For example, there should be shifts in trophic systems as species are lost or gained.

One participant asked how Dr. Delong accounted for the possibility of picking up snails representing only a small area. Dr. Delong responded that he and his colleagues collect snails from many different sites at the same time in a 100-km area.