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The Effects of Connectivity on Fish Size and Community Structure in The Upper Mississippi River

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Objectives

This study examined backwater and floodplain lakes with differing hydrological connectivity in the Upper Mississippi River to determine if:

- there was a relationship between hydrological connectivity and the mean length of all fish (community-level response);
- there was a relationship between hydrological connectivity and fish length for individual species (population-level response).

Methods

Study Area

Samples were collected July – August 2013 in the Upper Mississippi River between Alma, WI and Brownsville, MN. The Upper Mississippi River is a complex, large river system with many branches frequently entering and exiting the main channel. Samples were taken from connected backwaters and floodplain lakes to capture different extents of connectivity.

Sample Methods

- Hydrological connectivity of each site was determined using ArcGIS to identify the surface elevation (commence to fill; CTF) at which water would begin to enter a patch. River stage heights were acquired from nearby gaging stations for the period covering 2009-2012, which were used with CTF to calculate the percent of time each site was connected to the channel.
- Fish were collected using fyke nets and a boat electrofisher. The fyke nets were left overnight for fish collection and retrieved the following morning (20 - 24 hr period). Multiple 8-min runs of the boat-electrofisher was used at eligible sites. Fish were identified to species and total length was measured.
- Connectivity is reported as percent hydrological connection. Spell analysis was used to determine the number of days from 2009 – 2012 that sites were hydrologically connected to a channel.
- Comparisons were made using linear regression. Data met assumptions for this analysis.

Study Area

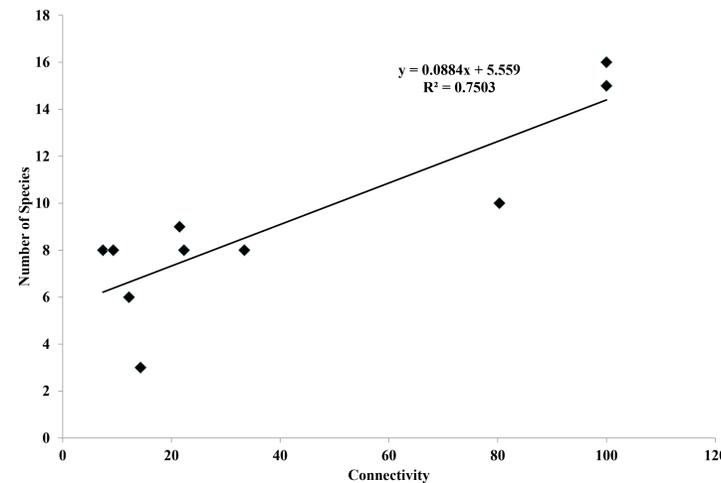


Figure 1. Total number of species in relation to connectivity in the backwaters and floodplain lakes in the Upper Mississippi River, July – August 2013. The relationship was significant ($p = 0.0012$).

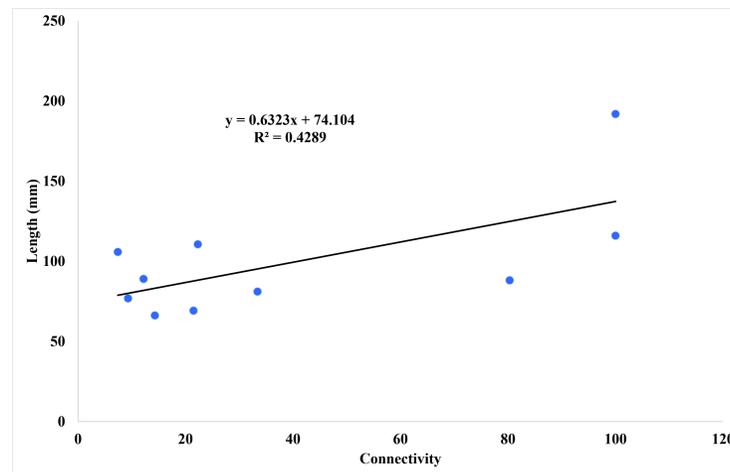


Figure 2. Mean length of all fish species in the backwaters and floodplain lakes in the Upper Mississippi River, July – August 2013. The relationship was significant ($p = 0.0398$).

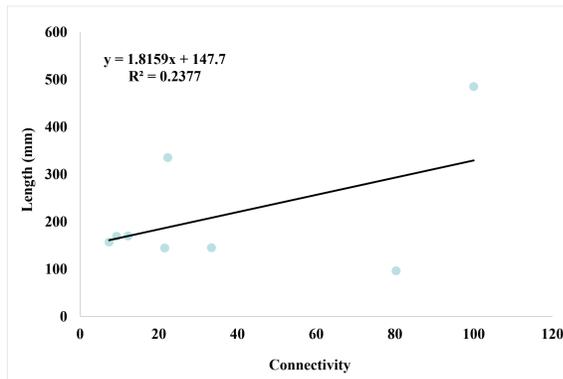


Figure 3. Length of northern pike in the backwater and floodplain lakes of the Upper Mississippi River July – August 2013. No significant relationship ($p = 0.2203$).

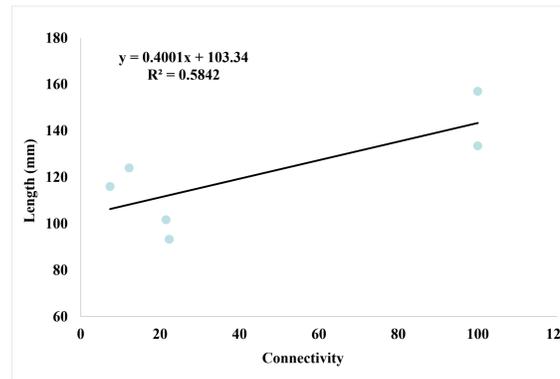


Figure 4. Length of pumpkinseed sunfish in the backwater and floodplain lakes of the Upper Mississippi River July – August 2013. No significant relationship ($p = 0.0767$).



Results

- The total number of species present at each site revealed a significant positive relationship with percent connectivity (Figure 1).
- Mean length of all fish collected at each site revealed a significant positive relationship with percent connectivity (Figure 2).
- There was a negative relationship between individual species size and connectivity (Figure 3 & 4).
- There was no correlation between mean length of northern pike and connectivity (Figure 3).
- There was no relationship between mean length of pumpkinseed sunfish and connectivity (Figure 4).
- Species composition did change as a function of connectivity. Of note was the presence of large-bodied riverine species in highly connected sites.

Conclusions

- There is a relationship between number of species present and connectivity at each site during the sample period July – August 2013. Highly connected sites allow for a more diverse community of fish species to be present in a given site.
- There is a relationship between the total mean length of all species of fish collected and connectivity. More connected areas have a greater opportunity for hosting larger species of fish.
- There is was no relationship between mean length of individual and hydrological connectivity. This suggests that connectivity functions is a strong driver of community structure. Further research may be needed to determine if individual species length correlates with connectivity and if other factors play a role. There may be other factors such as available nutrients which can play a role in species size.

In conclusion, connectivity influences fish size and community structure at community level, affecting the mean length of the fish species present. This likely results from: (1) the role of off-channel habitats as fish nurseries (King et al. 2009); and (2) the duration of migratory corridors relative to duration of connectivity (Warfe et al. 2013). In contrast, the absence of a population-level response suggests segregation of different sized conspecifics to habitats with different durations of hydrological connectivity.

Literature Cited

- King, A.J., Z. Tonkin, and J. Mahoney. 2009. Environmental flow enhances native fish spawning and recruitment in the Murray River, Australia. *River Research and Applications* 25:1205-1218.
- Warfe, D.M. et al. 2013. Productivity, disturbance and ecosystem size have no influence on food chain length in seasonally connected rivers. *PLoS ONE* 8(6): e66240. doi:10.1371/journal.pone.0066240

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