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Is There a Relationship Between Fish Community Structure and Ecosystem Size or Productivity in Habitats Within a Floodplain River?



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Objectives

This study examined fish abundance and diversity in different habitat patches within a large floodplain river to determine:

- if there is a relationship between total number of individuals and gross primary production (GPP) or ecosystem size;
- if there is a relationship between number of species present and GPP or ecosystem size.

Methods

Study Area

Samples were collected between July and August 2014 in the Upper Mississippi River between Brownsville, MN and Alma, WI. The Upper Mississippi River is a complex, large river system with many branches frequently entering and exiting the main channel. Slackwater patches, areas of little or no flow are also abundant across the riverine landscape. Samples were taken from connected backwaters and floodplain lakes within the riverine landscape.

Sample Methods

- Fish were collected using a boat electrofisher and captured by net during three 4 - 8 min runs for each site.
- Catch per unit effort (CPUE) was calculated for each species within a site as well as the total number of species and CPUE for total number of individuals collected.
- Net primary production and respiration was calculated using the light bottle/dark bottle technique. Five-L cubitainers (n = 3) were placed in the water at each site 4 - 6 hr.
- Ecosystem size of each site was measured using ArcGIS and digital topographic maps provided by the Upper Midwest Environmental Sciences Center, US Geological Survey, La Crosse, WI.
- Linear regression analysis in SAS was used to determine if relationships existed.

Representative Study Site

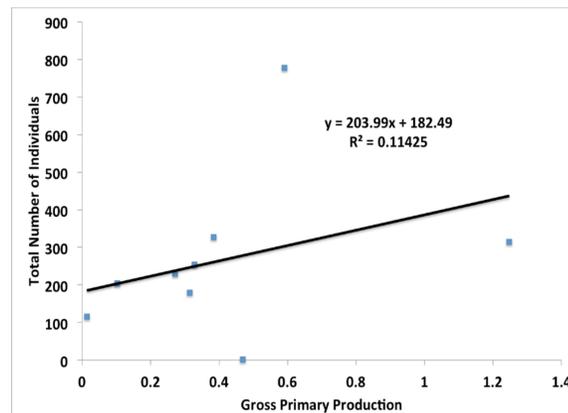


Figure 1. Relationship between gross primary production (mg O₂/L/hr) and the total number of individual fish caught (CPUE). Fish were collected in habitats in the Upper Mississippi River between July and August 2014. There was no significant relationship (p = 0.3105).

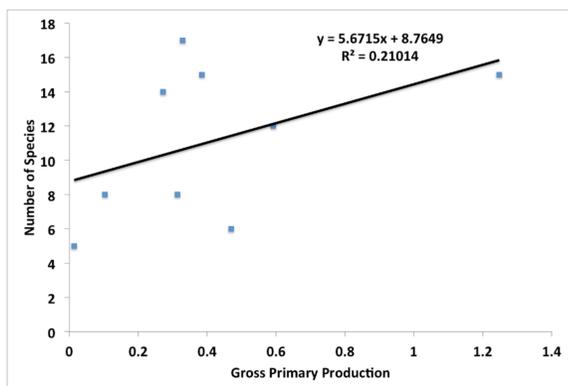


Figure 3. Relationship between gross primary production (mg O₂/L/hr) and total number of fish species. Fish were collected in habitats in the Upper Mississippi River between July and August 2014. There was no significant relationship (p = 0.1695).

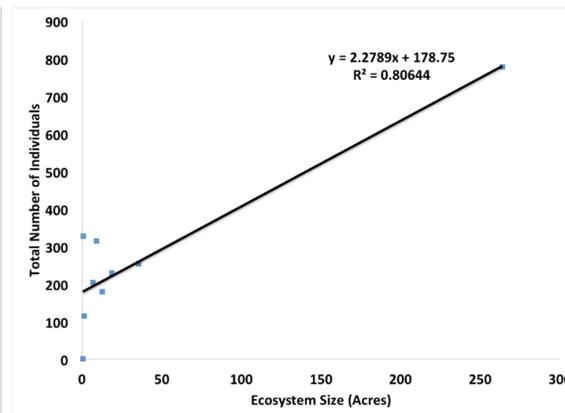


Figure 2. The relationship between ecosystem size (acres) and total number number of fish (CPUE). Fish were collected in habitats in the Upper Mississippi River between July and August 2014. The relationship was significant (p = 0.0010).

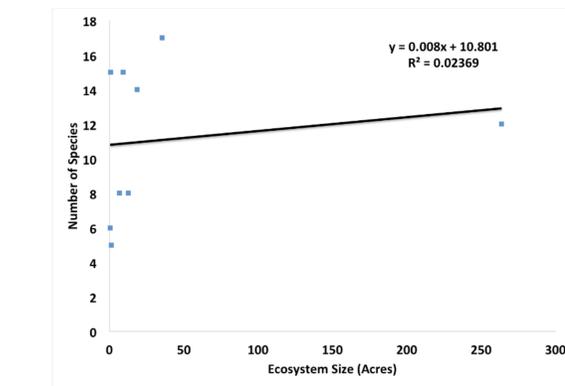


Figure 4. Relationship between ecosystem size (acres) and total number of fish species. Fish were collected in habitats in the Upper Mississippi River between July and August 2014. There was no significant relationship (p = 0.6925).

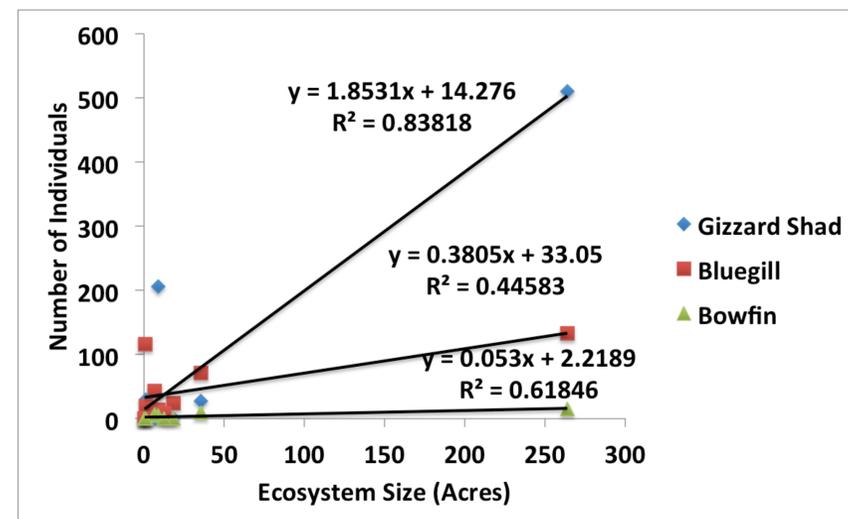


Figure 5. Relationship between ecosystem size and the CPUE of bluegill, bowfin, and gizzard shad. Fish were collected in habitats in the Upper Mississippi River between July and August 2014. These were the only species with a significant response to ecosystem size (p < 0.05).

Results

- No correlation was evident between gross primary production and the number of individuals present (Figure 1).
- There was a significant correlation between ecosystem size and the number of individuals present (Figure 2).
- No relationship was seen between gross primary production and the number of species present (Figure 3).
- No relationship between ecosystem size and the number of species present (Figure 4).
- There was a significant correlation between ecosystem size and the CPUE of bluegill, bowfin, and gizzard shad (Figure 5).

Conclusions

- The lack of a correlation between GPP and number of species and total abundance of fish indicates that productivity is not a driver of community structure. Productivity has also been shown to not influence food chain length in aquatic ecosystems (e.g., Vander Zanden & Fetzer 2007).
- We hypothesized that the number of species would increase with ecosystem size through greater availability of niches. This was not the case, as evidenced in the lack of correlation between patch size and number of fish species present. Instead, total number of individuals increased for species commonly found in slackwater patches.

Two possible reasons for a numerical response to ecosystem size are: (1) greater patch size leads to greater availability of resources; and (2) another physical attribute accounts for changes in species composition. Ecosystem size has been attributed to longer food chains (Post 2000) but increased niche availability was proposed as the primary causal mechanism. As we describe, our study does not support this. More likely, a combination of size and the physical complexity (e.g., measures of habitat morphometry) form the basis of shaping community structure. Large patches can be either quite simple or complex depending on the range of depths present and other structures (different substrate types, woody debris) that define their character. Examination of these features along with measures of community composition are needed to better understand the nature of riverine landscapes.

Literature Cited

- Takimoto, G. and D.M. Post. 2013. Environmental determinants of food chain length: a meta-analysis. *Ecological Research* 28:675-681.
- Vander Zanden, M.J. and W.W. Fetzer. 2007. Global patterns of aquatic food chain length. *Oikos* 116:1378-1388.

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