UMRR-EMP Science Meeting Read Aheads

RESEARCH FRAMEWORKS

AQUATIC VEGETATION

WATER QUALITY

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FISHERIES

Landscape Pattern Research in the Upper Mississippi River System

*P.I. or Team Leader***:** Nathan R. De Jager, Research Ecologist, USGS-UMESC
Funding Source(s): MIPR #96514770195944 (2008-2012), MIPR #96514792531664 (2012-2015), Additional Program Elements in 2009 and 2010.
LTRMP Product Tracking Number: Landscape Patterns Research Framework (2010OUT2d2)
Covers progress from: 2008-Present

Background:

The Scientific Framework for Landscape Pattern Research on the Upper Mississippi River System (UMRS) took a hierarchical approach to identifying research objectives (De Jager 2011). At the broadest level, regional changes in land use and climate were hypothesized to drive changes in various structural attributes of the river and floodplain (e.g. flood inundation, land cover, forest fragmentation, and the diversity of aquatic areas). These broad-scale structures were hypothesized to alter local-scale ecological properties and processes (e.g. community composition and succession, nutrient availability and cycling rates). The overarching goal of the landscape patterns research framework was to link broad-scale structural patterns with local ecological processes to develop a better understanding of the ecological consequences of modifications to landscape patterns in the contexts of ecosystem restoration and climate change.

Progress/Results:
The first objective of the research framework was to develop quantitative measures of landscape structure that could be used to examine effects of regional-scale driving processes (e.g. climate and land use change), track status and trends of landscape patterns, and identify areas for ecosystem restoration at broad scales (e.g., the entire UMRS). To date, a series of maps and metrics have been developed for flood inundation (objective 1.1, work in progress); land cover composition and change (objective 1.2, De Jager et al. 2011), floodplain forest cover/connectivity (objective 1.3, De Jager and Rohweder 2011a), and aquatic area diversity (objective 1.4, De Jager and Rohweder 2011b). These data have been made available online at: http://www.umesc.usgs.gov/data_library/landscape_indicators/background.html.

The second research objective was to link broad-scale measures of landscape structure with local ecosystem properties and process to assess the potential effects of changes to landscape patterns. To date, studies have been conducted to examine relationships between flood inundation and floodplain forest community composition and succession (objective 2.1, De Jager et al. 2012, De Jager 2012, De Jager et al. 2013); effects of flood inundation on soil nutrient availability and cycling rates (objective 2.2, De Jager et al. 2012, De Jager et al. (In prep), Swanson et al. (ongoing)); effects of geomorphology (aquatic areas) and water flow velocity on spatial patterns of nitrogen and phosphorous (objective 2.4, De Jager and Houser 2012), and associated patterns in fish community composition and diversity (objective 2.3, De Jager et al. (In prep).

Implications of Results for River Management:
The landscape metrics developed in objective 1 could be useful for identifying restoration and management actions aimed at altering flood inundation, land cover, forest fragmentation, and the diversity of aquatic areas across the UMRS. Further, linking these measures with larger scale drives (e.g. climate and land use change) could help managers understand the degree to which various landscape features are likely to change in the future, in response to different management approaches or changes in regional environmental conditions. Finally, studies that examine relationships between these

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measures and local ecological processes (objective 2) can help managers understand how landscape patterns might be altered to influence desired ecological outcomes.

Next Steps or New Research Questions Suggested:
Developing the measures of landscape pattern for objective 1 had three primary purposes: 1) examine effects of regional-scale driving processes (e.g. climate and land use change), 2) track status and trends of landscape patterns, and 3) identify areas for ecosystem restoration across the river. First, no studies have explicitly tied the measures developed in objective 1 to specific climate, land use, or restoration scenarios. Land-change modeling of alternative scenarios is one task proposed in the landscape patterns research framework that could be pursued in the future. Secondly, each measure developed through objective 1 can be applied to new remotely sensed data sets as they are developed (e.g., lidar/bathymetry and land cover of the UMRS) to continue monitoring status and trends in landscape patterns. Finally, efforts could be made by the management community to begin using status and trend information to identify locations for restoration projects that seek to alter flood inundation, land cover, forest cover, and/or aquatic habitat diversity.

Research projects focusing on relationships among flood inundation, soil nutrient dynamics, and floodplain forest community composition and succession have only been conducted in the Upper Impounded Reach of the UMRS. Future studies could extend to lower river reaches to determine whether differences in geomorphic setting alter effects of flooding on plant and soil dynamics. Secondly, empirical relationships have been developed for a number of floodplain vegetation and biogeochemical processes. These relationships could be incorporated into a landscape simulation model to help managers and researchers begin exploring effects of alternative climate and management scenarios on floodplain biodiversity and biogeochemistry. Finally, opportunities exist for more research into the causes and consequences of spatial patterns of limnological conditions, submersed aquatic vegetation, fish and mussel communities.

Literature Cited

De Jager, N.R. 2011. Scientific framework for landscape pattern research on the Upper Mississippi and Illinois River floodplains. Long-Term Resource Monitoring Program Document, available at: http://www.umesc.usgs.gov/ltrmp/ateam/landscape_patterns_research_framework_final_june2011.pdf

De Jager, N.R. and Rohweder, J.J. 2011a. Spatial scaling of core and dominant forest cover in the Upper Mississippi and Illinois River floodplains, USA. Landscape Ecology 26: 697-708

De Jager, N.R. and Rohweder, 2011b. Spatial Patterns of aquatic habitat richness in the Upper Mississippi River floodplain, USA. Ecological Indicators 13:275-283.

De Jager, N.R, Rohweder, J.J., and J.C. Nelson. 2011. Past and predicted future changes in the land cover of the Upper Mississippi River floodplain, USA. River Research and Applications. 10.1002/rra.1615

De Jager, N.R. Thomsen, M.T., Yin, Y. 2012. Threshold effects of flood duration on the vegetation and soils of the Upper Mississippi River floodplain, USA. Forest Ecology and Management 270:135-146.

De Jager, N.R. 2012. The allometry of community level stem size-density distributions in a floodplain forest. American Journal of Botany 99: 1572-1576.

De Jager, N.R. and Houser, J.N. 2012. Variation in water mediated connectivity influences patch distributions of total nitrogen (TN), total phosphorous (TP) and TN:TP ratios in the Upper Mississippi River, USA. Freshwater Science 31: 1254-1272.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

De Jager, N.R., Cogger, B.J., and Thomsen, M.T. 2013. Interactive effects of flooding and deer browsing on floodplain forest recruitment. Forest Ecology and Management 303:11-19.

De Jager, N.R., Swanson, W., Strauss, E.A., Thomsen, M.T., Yin, Y. In Prep. Effects of flooding, herbivory by white tailed-deer, and invasion by reed canarygrass on spatial and temporal patterns of floodplain nitrification

De Jager, N.T. et al. In Prep. Fish communities differ between patches of high and low total nitrogen : total phosphorous ratios in the Upper Mississippi River, USA: implications for management of hydrological connectivity gradients.

Swanson, W., et al. (ongoing research). Organic matter decomposition and mineralization rates in floodplain forests and invaded reed canarygrass wetlands in response to nitrogen addition and flooding

Research Framework on Native Mussels

P.I.(s) & agency: Teresa Newton (USGS), Steve Zigler (USGS), and Mike Davis (MN DNR)
Funding Source(s): UMRR, COE, USGS, MN DNR, USFWS, NPS, TNC, Ecological Specialists
LTRMP Product Tracking Number (if applicable): Various
Covers progress from: 2010 to 2013

Progress:

Question 1: What are the spatial and temporal patterns in mussel distribution, abundance, and assemblage structure within the UMRS?

To date, UMESC and collaborators have completed pool-wide mussel surveys in 4 reaches of the UMR (Pools 3, 5, 6, and 18). These surveys documented mean densities ranging from 2.9-4.5 mussels/m^2 and population estimates of 61 to 212 million mussels. We have also completed mussel surveys in dewatered and/or shallow water areas adjacent to the predicted dewatered areas. Collectively, these results suggest that 1-10% of the pool-wide population reside in these shallow water (<0.5 m) areas. Data on pool-wide surveys in Pool 5, 6, and 18 have been published in a MS and a report on the Pool 3 data should be available in April 2014. Reports on shallow water surveys in Pools 6 and 18 have also been completed. We have made 3 presentations on this work.

Newton et al. 2011. Population assessment and potential functional roles of native mussels in the Upper Mississippi River. Aquatic Conservation: Marine and Freshwater Ecosystems 21:122-131.

Rogala, J.T. and T.J. Newton. 2009. Shallow water estimates of native freshwater mussel populations in Pool 18 of the Upper Mississippi River. Final report to the U.S. Army Corps of Engineers, Rock Island, IL. 4 pp.

Rogala, J.T. and T.J. Newton. 2008. Shallow water surveys of native freshwater mussels in Pool 6 of the Upper Mississippi River: Population estimates and sampling design evaluation. Final report to the U.S. Fish and Wildlife Service, Winona, MN. 8 pp.

Including 3 presentations

Implications of results for river management and/or other research:

These large-scale surveys provide baseline information on the effects of future management actions on mussel assemblages in the UMRS. For example, the large number of mussels in the lower section of Pool 18 contributed to the decision by managers to halt a water level drawdown on this reach due to the expected adverse effects on mussels. Our conclusion that relatively few mussels reside in shallow water (<0.5 m) is useful information to river restoration activities that are planned in shallow water.

Next steps or new research questions suggested:

Note: We do not believe that research on any question in the mussel framework is complete.

Support pool-wide and shallow water surveys to quantify spatial and temporal variation in mussel assemblages and provide baseline conditions for HREPs.

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Question 2: What ecosystem services do freshwater mussels provide to the UMRS?

UMESC scientists investigated the role that mussels play in filtering water and associated nutrients and sediments in several reaches of the UMRS. Mussels filtered a significant amount of water over a 480 km reach of the UMR, amounting to a filtration rate of 53.1 million m^3 day^{-1}. The filtration rate of mussels as a percentage of river discharge ranged from 0.5–1.4% at high flows, from 1.5–4.4% at moderate flows, and from 4.4–12.2% during low flows. Collectively, these data suggest that mussels play an integral role in this ecosystem by sequestering suspended materials that can be used by other benthic organisms. Additional research suggests that mussels play an important role as samplers and processors of particular matter in rivers and that measuring a suite of biochemical markers was useful in identifying dietary sources. Understanding nutritional profiles in mussels will help restore mussel communities, which may lead to the reestablishment of their critical role as nutrient recyclers in food webs. Collectively, this work has resulted in 1 publication and 6 presentations.

Newton et al. 2011. Population assessment and potential functional roles of native mussels in the Upper Mississippi River. Aquatic Conservation: Marine and Freshwater Ecosystems 21:122-131.

Including 6 presentations

Implications of results for river management and/or other research:

We estimated that the mussel community between Pool 5 and Pool 18 filter ~53 million m^3 of water each day. In comparison, the Minneapolis-St Paul, Minnesota metropolitan wastewater treatment plant only processes wastewater flows of 0.7 million m^3 of water each day. This work suggests that management actions that adversely affect native mussel assemblages in the UMRS may also affect the ecosystem services mussels provide to the river in terms of improvements in water and sediment quality and by processing nutrients and sediments for the benefit of numerous other aquatic organisms.

Next steps or new research questions suggested:

Note: We do not believe that research on any question in the mussel framework is complete.

Preliminary work suggests that native mussels play an integral role in the UMR ecosystem by sequestering suspended materials that can be used by other benthic organisms. Further documentation of spatial and temporal variation in the services that mussels provide is needed.

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Question 3: What are the biological characteristics of self-sustaining mussel populations in the UMRS and what limits populations?

UMESC initiated a 5-year research plan in 2012 to measure vital rates (e.g., recruitment, mortality, growth) in native mussels as a sensitive measure to detect subtle environmental changes. A MS student (Patty Ries) found that recruitment of juvenile mussels declined significantly during 2008-2012 in West Newton Chute, Pool 5, UMR. Declines in recruitment were correlated with measures of flow magnitude (July maximum flow) and flow frequency (low pulse number). We PIT tagged 577 adult mussels in West Newton Chute in August 2012 and recovered 49% of the mussels in 2013. Survival of the recovered mussels ranged from 43 to 100%. Estimates of first year survival among species were similar (92% in *Amblema plicata*, 97% in *Obliquaria reflexa*, 91% in *Pleurobema sintoxia* and 96% in *Quadrula pustulosa*). This work has resulted in 3 reports, 1 MS thesis, and 4 presentations.

Newton and Zigler. 2012. Development of vital rates to assess the relative health of UMRS mussel resources. Progress report to the Long Term Resource Monitoring Program, Rock Island, IL. 2 pp.

Zigler et al. 2012. Exploratory investigation of methods to assess recruitment of native mussels in the Upper Mississippi River. Final report to the U.S. Army Corps of Engineers, Rock Island, IL.

Newton, T.J. and S. J. Zigler. 2014. Development of vital rates to assess the relative health of UMRS mussel resources (Tracking Number 2012U2). Progress report to the Long Term Resource Monitoring Program, Rock Island, IL. 2 pp.

Ries, P.R. 2013. Inter-annual variation in recruitment of freshwater mussels and its relationship with river discharge. MS Thesis, University of Wisconsin, La Crosse, WI. 36 pp.

Including 4 presentations

Implications of results for river management and/or other research:

An understanding of key biological characteristics in self-sustaining mussel assemblages would enable resource managers to better evaluate the potential effects of management actions (e.g., HREPs) on native mussels. Further, because mussels are long-lived, traditional measures such as abundance of adults, may not be sensitive to detect subtle environmental changes. Preliminary data suggests that vital rates (e.g., recruitment, mortality, growth) may be more sensitive response metrics to evaluate the effects of management actions on native mussel assemblages.

Next steps or new research questions suggested:

Note: We do not believe that research on any question in the mussel framework is complete.

Continue to evaluate vital rate metrics to describe characteristics of a self-sustaining mussel assemblage. Expand research to determine how these metrics vary over space and time and among species with differing life history strategies. Continue work to evaluate linkages of vital rates with hydrologic patterns. Longer-term work would use estimates of vital rates to develop population models for evaluating potential outcomes of environmental and management changes.

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Question 4: How can we most effectively monitor the health and recovery of the UMRS mussel resource?

Working with Ecological Specialists, Inc., and the USFWS, we developed a mussel community assessment tool for use by resources managers to better understand the relative health of native mussel assemblages in the UMR system. This preliminary analyses suggests that the most robust mussel communities in the UMR have the following characteristics: >5% listed species, <40% tolerant species, 37-48% Lampsilines, ≤10% fresh dead, 49 to 55% mussels ≤5 years old, 2 to 6% mussels ≥15 years old, >15 mussels/m2 in the 75th quartile, a species evenness ≥0.80, a tribe evenness >0.81, and >16 species in a sample of 100 individuals. UMESC also initiated another project to quantify patterns in the distribution of juvenile and adult mussels in the UMRS. Understanding how mussels are distributed can help us develop more efficient sampling designs for documenting status and trends, test hypotheses for the causes of their distribution, and determine if the mechanisms that promote patterning in juveniles are the same as those in adults. Preliminary results suggest adults and juveniles in Pools 5, 6 and 18 of the UMRS are generally patchily distributed and at the scales sampled (~300 m), juveniles and adult co-exist at fine scales. This work has resulted in 1 report and 8 presentations.

Dunn, H., S. Zigler, J. Duyvejonck, and T. Newton. 2012. Methods to assess and monitor mussel communities in the Upper Mississippi River System. Final report to the U.S. Army Corps of Engineers, Rock Island, IL. 46 pp.

Dunn et al. 2012. Methods to assess and monitor mussel communities in the Upper Mississippi River System. Final report to the U.S. Army Corps of Engineers, Rock Island, IL.

Including 6 presentations

Implications of results for river management and/or other research:

The mussel community assessment tool is being used by resource managers as a quantitative means to evaluate the relative health or value of mussel beds to identify and preserve mussel resources, assess impacts, and assess the efficacy of restoration techniques. This bioassessment metric is helping managers assess the overall integrity of mussel assemblages in the UMRS. Our work on spatial patterns in helping managers determine what scale of analysis is best suited for describing mussel assemblages in the UMRS.

Next steps or new research questions suggested:

Note: We do not believe that research on any question in the mussel framework is complete.

Move forward with Phase II of the mussel community assessment tool, which involves validation of the existing tool and obtaining data at sites with lower mussel densities. Use data from this tool to propose strategies to include native mussels in monitoring efforts on the UMR, especially evaluation of HREPs. Find resources to complete research on the importance of scale in describing mussel assemblages.

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Question 5: How can we expect mussel populations and assemblages to respond to future conditions and management scenarios on the UMRS?

UMESC has been developing hydrophysical models to predict suitable habitat for mussels in the UMRS for the past 15 years. Collectively, this work has shown that there are strong linkages between hydrology, hydraulics and mussel distributions and that discharge patterns are important and result in changes in suitable mussel habitat. Predictive variables often include complex hydraulic variables such as shear stress, RSS, Boundary Reynolds number. UMESC scientists have also evaluated the response of native mussels to water level drawdowns. This research suggests that drawdowns may adversely affect native mussels that reside in shallow water and that the responses of mussels to water level manipulation may be species-specific. This work has resulted in 1 MS, 2 reports and 17 presentations.

Zigler et al. 2012. Patterns in species richness and assemblage structure of native mussels in the Upper Mississippi River. Aquatic Conservation: Marine and Freshwater Ecosystems DOI: 10.1002/aqc.2255.

Newton et al. 2012. Mortality, movement, and behavior of native mussels during a planned water level drawdown in Pool 6 of the Upper Mississippi River. Letter report to the U.S. Fish and Wildlife Service, Winona, MN, and the U.S. Army Corps of Engineers, Rock Island, IL. 26 pp.

Zigler et al. 2010. Development of habitat descriptors and models of mussel distribution in Pool 18 of the Upper Mississippi River. Final report to the U.S. Army Corps of Engineers, Rock Island, IL. 21 pp.

Including 17 presentations

Implications of results for river management and/or other research:

Given that about 60% of the mussels reside in 10-15% of the area of the UMRS, understanding what constitutes quality mussel habitat is imperative. Our models show that the interaction of geomorphology and discharge produces a template of hydrophysical conditions that can be manipulated by managers to create quality mussel habitat to benefit restoration activities. We have initiated discussions with engineers at the COE to use our hydrophysical models to create mussel habitat in a future HREP.

Next steps or new research questions suggested:

Work with resource managers and use recently developed hydrophysical models to design and build physical and hydraulic features into a HREP that would create quality mussel habitat. Evaluate environmental and mussel responses to test the success of features and validate hydrophysical models.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Research Framework on Aquatic Vegetation

P.I.(s) & agency: Yao Yin (USGS), Heidi Langrehr (WI DNR), Megan Moore (MN DNR), Josh Petersen (IA DNR), Rebecca Kreiling (USGS), Thad Cook (INHS)

Funding Source: UMRR

Covers Progress (2010-Present)

Question 1. What are the primary drivers behind the spatial and temporal patterns of aquatic vegetation in the UMRS?

To date, few conclusions have been made in peer viewed journal publications. Available data and observations seem to suggest:

A. There are many spatial patterns of aquatic vegetation within the Upper Mississippi. The longitudinal pattern within a Pool is directly a product of the impoundment of the river.
B. The lateral pattern from main channel to the connected backwater is the result of connectivity, i.e., flow velocity, water depth, wind fetch and how they affect underwater light and nutrient recycling.
C. The reach scale longitudinal patterns of SAV appear to be the product of landscape (geomorphic patterns), turbidity, and hydrograph.
D. The temporal dynamics appear to be driven by the weather pattern – drought/flooding episodes that are reflected in hydrograph and turbidity. The latter could also be affected by basin-wide farming practices.

Kreiling, R.M., Y. Yin, and D.T. Gerber. 2007. Abiotic influences on the biomass of *Vallisneria americana* Michx. in the Upper Mississippi River. River Research and Applications 23:343-349

Moore, M., S.P. Romano, and T. Cook. 2010. Synthesis of Upper Mississippi River System submersed and emergent aquatic vegetation: past, present, and future. Hydrobiologia 640:103-11

Next Steps:

1. Analyses designed to test hypotheses using LTRMP field survey data as well as remotely-sensed LCU and LiDar GIS data;

Question 2. What are the long-term effects of different management tools (*i.e.* drawdowns and HREPs) on aquatic plants?

Question 2a. What are the long-term effects of drawdowns on specific life forms and species?

Yin et al. Presentations made at MRRC and AFS annual meetings. Manuscripts are in development. Preliminary results: Drawdown in Pool 8 (2001 and 2002) enabled SAV to spread into deeper areas. This effect was evident in 2003 and 2004 but became non-distinctive because improved condition in the upper reach (from Pool 4 to Pool 13). Consequently we are unable to tell how long the SAV enhancement lasted. Drawdown enhancement to the emergent vegetation cover in Pool 8 was detectable for seven years (2003-2009; 2010-2013 data have not been analyzed).

Question 2b. What are the long-term effects of HREPs on aquatic plants and how do we measure HREP success?

Yin et al. Manuscripts in development. Preliminary results: Based on modeling, the Stoddard HREP enhanced SAV in all years since 1998. SAV acres attributable to the Project varied from ~25 to ~475 acres from year to year between 1998 and 2009.

Next Steps:

1. Publish findings;
2. Test hypotheses on other drawdown experiments;
3. Test hypotheses using on other HREPs.

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Question 3. What are the main drivers limiting vegetative colonization and recolonization on the Illinois River and in Pools 1-3 and 16-26? What are the thresholds for vegetative colonization? Can sections of these Pools be managed to promote growth of aquatic plants, especially species of interest such as *Sagittaria latifolia* and *Vallisneria americana*?

Question 3a. What limits the growth of aquatic plants on the Illinois River and in Pools 1-3 and 16-26?

Cook, T.R. and M.A. Pegg. 2011. Submersed aquatic vegetation [wild celery (*Vallisneria americana*) and sago pondweed (*Potamogeton pectinatus*)] re-establishment efforts in Lake Chautauqua, Illinois River 2001-2002. Draft report to be submitted to the U.S. Army Corps of Engineers, Rock Island District

Question 3b. What are the thresholds for vegetative colonization?

Next Steps:

1. Continue field experiments to verify the impact of animal grazing.
2. Move experiment to indoor controlled environment.
3. Building simulation models.

Question 3c. Can sections of the Pools be managed or HREPs be designed to promote the growth of certain life forms and species?

Next Steps:

1. GIS analyses: mapping out areas suitable for growth at large scale based on simple criteria such as flow velocity, water level fluctuation, turbidity, etc.;
2. Computer simulation models to predict vegetation coverage at the large scale;
3. Integrate the above analyses with HREP selection process and devise monitoring to collect data for hypotheses testing and calibration of models.

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Question 4. With our current understanding of the UMRS, how can we maximize the information gathered by EMP-LTRMP to address the fundamental questions about plant distribution and relative abundance? What information is lacking?

Question 4a. Are the vegetation procedures outlined in the minimum sustainable program (MSP) enough to determine plant distribution?

Yes. Continue sampling protocol long-term at key-pools as it is;

Next Steps:

Consider outpool sampling by veteran LTRMP crews.

Question 4b. What additional information can EMP-LTRMP produce that would benefit our understanding of UMRS vegetation?

Next Steps:

1. Refer to Yin, Ingvalson, Rogala, Potter 2014, UMRR FY14 SOW. Aquatic Vegetation Cover Type Modeling in support of HREP.
2. Analyses listed above questions.

Question 4c. What additional cross-component information can the individual MSP sampling components collect to produce more useful datasets without adding additional cost to the program?

Next Steps:

1. Do not change (reduce, etc.) design for LTRMP components. Keep sampling long-term

Question 5. What are the potential effects of climate change and the establishment of aquatic invasive species on aquatic vegetation?

Question 5a. What are the potential effects of climate change on aquatic vegetation?

Next Step Approach*:* Model plant distribution and abundance at different precipitation levels, water temperatures and hydrological regimes. Determine the northward migration of exotic species such as *Eichhornia crassipes* and *Hydrilla verticillata*. Determine the effects of an increase and northward migration in herbivores such as red-eared sliders (Tucker *et al.* 2008) on aquatic plants.

Question 5b. What are the potential effects of the establishment of aquatic invasive species on aquatic vegetation?

Next Step Approach*:* Because juvenile silver carp mature in backwaters, perform exclosure experiments to determine the effect of a large number of silver carp on water quality in plant beds (Bellrichard 1994). Use this information to model potential system-wide effects of the northward movement of silver carp.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

The effects of river nutrient concentrations on metaphyton, submersed aquatic vegetation and dissolved oxygen across a connectivity gradient.

P.I.(s) or Team Leader(s) & agency: Jeff Houser, USGS (APE), Brian Gray, USGS (this product)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2009APE3a

Covers progress from 2009 to 2012

Progress/Results:

Published. See BR Gray, AM Ray, JT Rogala, MD Holland and JD Houser. 2012. Spatial and temporal variation in duckweed and filamentous algal levels in contiguous floodplain lakes of the Upper Mississippi River. Journal of Aquatic Plant Management 50: 91-100.

Implications of results for river management and/or other research:

Abstract reads as follows: This study examined how free-floating macrophyte cover (principally composed of duckweeds [*Lemna* spp.]) and prevalence of floating filamentous algal mats (metaphyton)varied within and among lakes within three reaches of the Upper Mississippi River. Data were collected using standard sampling approaches over the period 1998 to 2008. Duckweed cover varied primarily within and among lakes; in comparison filamentous algae prevalence varied primarily among lakes and lake-years. Duckweed cover increased with submersed aquatic vegetation (SAV) abundance at within lake and among-lake-year scales; in comparison, filamentous algae prevalence increased with SAV abundance at within lake, among-lake and year scales. Given adjustment for SAV, filamentous algae prevalence decreased with increasing lake connectivity but was not statistically associated with annual changes in mean river discharge; duckweed cover was not associated with either connectivity or discharge. Documenting the relatively high levels of variation within lakes and of year-to-year variation in lake means improves our understanding of the dynamic nature of aquatic plant and algal communities in the Upper Mississippi River and will assist efforts to manage or control aquatic plants and nuisance algae in this region. In particular, this work explicitly characterizes sources of variability in free-floating macrophyte cover and filamentous algae prevalence, and highlights how this variation may complicate efforts to evaluate the short-term success of management and control efforts.

Next steps or new research questions suggested:

Work completed.

Fourteen years (1998 – 2011) of SAV in Pool 4 of the Upper Mississippi River

P.I.(s) or Team Leader(s) & agency: Megan Moore (MNDNR)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): SOW 2012A6

Covers progress from: 2012 to 2014

Progress/Results:

Pool 4 has consistently shown a distinct pattern of sparse vegetation in the upper portion of the pool when compared to the expansive beds of vegetation in the lower portion of the pool. However, in recent years SAV has increased in both of these segments. This study seeks to provide insight on temporal and spatial changes from 1998-2011 in SAV species assemblages associated with water quality and hydrological variables. Data analyses are proceeding and include NMDS ordination using PRIMER E software. Examining individual species at individual sites in Upper and Lower Pool 4 has been technically difficult given the large volume of data. After discussing analysis strategies with Nate DeJager, the data are being reconfigured using mean species abundance by strata by year level.

Implications of results for river management and/or other research:

This research will enhance our knowledge of the stressors driving the vegetation in Pool 4 and likely other pools. Additionally, this study may have implications for river mangers concerning the use of drawdowns that mimic summer low flows and other UMRR-EMP projects to improve habitat.

Next steps or new research questions suggested:

In the very near term, I will begin report writing following data analysis. In terms of future research, I believe this report should lead to additional research projects. Depending upon the outcome of the current study, consideration will be given to a similar analysis of SAV in Pools 8 and 13 in FY'15 for a more systemic overview of SAV in the UMR.

Additionally, this research can be applied to the study of ecological succession in backwaters within the constraints of key physical or chemical drivers. I believe Big Lake in Lower Pool 4 will be an appropriate location to focus this analysis. Personal observations and a review of data results lead me to believe there has been a temporal shift in SAV species.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Sampling Pools 2 & 3 for SAV

P.I.(s) or Team Leader(s) & agency: Megan Moore (MNDNR)

Funding Source(s): USEPA (2006-2010); MNDNR (2011-2012)

LTRMP Product Tracking Number (if applicable): LTRMP # 2013A6

Covers progress from: 2012 to 2012

Progress/Results:

River managers have been concerned for the aquatic life found within the turbidity and nutrient impaired reach of the Mississippi River that extends from the confluence of the Minnesota River downstream to mid-Lake Pepin. An index of ecological condition using submersed macrophytes has been developed and applied to this impaired reach. Using sampling methods similar to the LTRMP SAV monitoring protocol (details outlined in Moore et al. 2012. A submersed macrophyte index of condition for the Upper Mississippi River. Ecological Indicators 13: 196-205) data were collected in 2012 in the main and side channel borders of Pools 2, 3 and upper 4, as has been done every year since 2006. Percent frequency of SAV and species richness was calculated. SAV remains below the South Metro TMDL target frequency of 21%. A graphical summary report including maps and frequency data was submitted in Dec 2012 to UMRBA, USGS, USACE, WI DNR, MN PCA, MNDNR, Dakota County, MN and Audubon's Mississippi River Program.

Implications of results for river management and/or other research:

River managers are using this information to determine if this impaired stretch of the river is meeting water quality and submersed aquatic vegetation standards set by the TMDL. These results should also be used by the UMRR-EMP in planning habitat improvement projects in Geomorphic Reach 1

Next steps or new research questions suggested:

Work Completed

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Have the recent increases in aquatic vegetation in Pools 5 and 8 been the result of water level management drawdowns, HREPs, or natural fluctuations

P.I.(s) or Team Leader(s) & agency: Yao Yin

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2009APE1a

Covers progress from 2009 to

Progress/Results: UMRRC presentation Abstract

MODELING SUBMERSED AQUATIC VEGETATION IN THE UPPER MISSISSIPPI RIVER

Yao Yin[1], Becky Kreiling[1] and Heidi Langrehr[2], Megan Moore[3]
[1]United States Geological Survey Upper Midwest Environmental Sciences Center, La Crosse, WI 54603
[2]Wisconsin Department of Natural Resources, La Crosse, WI 54603
[3]Minnesoda Department of Natural Resources, Lake City, MN 55041

The Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System initiated a pool-scale, stratified random sampling protocol in 1998 to monitor aquatic plants. Since then the program has accumulated 12 annual increments of an unbroken string of data in Pools 4, 8 and 13. We are analyzing this data set to reveal and estimate the effects of recent adaptive management actions of island constructions (HREP) and water level reductions (Drawdown).

We developed a statistical model to predict probability of submersed aquatic vegetation (SAV) occurrence at individual sites based on a few site-specific and a few pool-wide variables. A subset of the LTRMP data was used to estimate the parameters of the model while the rest of the data set was used to validate the prediction of the model. Vegetation changes inside the Stoddard HREP project area, both observed and predicted, were compared with a reference area of Pool 8. Daily water level in Pool 8 during summers of 2001 and 2008 under the assumption of no Drawdown were estimated based on historical discharge-water level relationship. The estimated daily water levels were entered into the statistical model to predict vegetation occurrence under the no Drawdown assumption.

Our analysis revealed distinct signals of HREP enhancement inside project area where SAV occurrence rose sharply immediately after construction was completed and remained near 100% since 2002. SAV occurrence in the non-project reference area was at the lowest level in 2002 at 25%. Occurrence increased progressively thereafter, reaching 80% by 2009.

SAV occurrence in Pool 8 was at 45% (excluding isolated backwater stratum) during the summer of 2001 while water level was being lowered. Since then, occurrence increased progressively to 80% by 2009.

Our model indicated a small amount of reduction of SAV in 2001 and a sizable net gain in 2003. We are still searching for an innovative analysis to reveal how long Drawdown enhancement lasted after 2003.

Platform presentation

Yao Yin, USGS Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Road, La Crosse, WI 54603. yyin@usgs.gov, (608) 781-6350

Next steps or new research questions suggested:

Submit to Journal

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Analysis and support of aquatic vegetation data in Pools 6, 9, 18 and 19

P.I.(s) or Team Leader(s) & agency: Yao Yin and Joseph Lundh

Funding Source(s): UMRR

Progress/Results:

Report was produced and delivered to The Upper Mississippi River Conservation Consortium (UMRCC): Yin, Y. and J. Lundh, 2012. Results of Applying the LTRMP Protocol for Submersed Aquatic Vegetation in Pools 6, 9, 18 and 19.

Data collected by UMRCC organized volunteers provided accurate profile of the composition of SAV communities in the four pools sampled. In Pools 9 and 19 where data were collected consecutively in 2005 and 2006, both pools had an increase trend from 2005 to 2006 which is consistent with the trend displayed in LTRMP key Pools (Polls 4, 8 and 13).

The primary drawback of the UMRCC volunteers collected data, using the LTRMP protocol, is the difficulties in clearing the errors on data sheets. It is a very lengthy and sometime painful process in data entry and analysis.

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Extension of modeling capacities for aquatic vegetation

P.I.(s) or Team Leader(s) & agency: Yao Yin and Jim Rogala; USGS

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013A8

Covers progress from July 2013 to Sept 2014

Progress/Results:

This project is ongoing, with product is scheduled for delivery in FY14.

SAS codes have been developed to fit curves of SAV distribution along flow velocity gradient.

Implications of results for river management and/or other research:

The threshold flow velocity criteria will be useful to HREP designs for restoring SAV.

Next steps or new research questions suggested:

Fit and calibrate SAV distribution curves to identify threshold.

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Identification of maximum velocity for *Vallisneria*

P.I.(s) or Team Leader(s) & agency: Yao Yin, Derek Ingvalson, David Potter

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2014A7 (also 2013A8)

Covers progress from FY14 to FY16

Progress/Results:

Ongoing. Refer to 2013A8.

Implications of results for river management and/or other research:

Thresholds and criteria will be incorporated in models of aquatic vegetation types for UMR.

Next steps or new research questions suggested:

Ongoing model development for SAV and Emergent cover types and rooted floating leave.

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Temporal trends in water quality and biota in segments of Pool 4 above and below Lake Pepin, Upper Mississippi River: indications of a recent ecological shift.

P.I.(s) or Team Leader(s) & agency: W. Popp, R. Burdis, S. DeLain, M. Moore (MN DNR LTRM Field Sta.)
Funding Source(s): UMRR
LTRMP Product Tracking Number (if applicable): 2013D10
Covers progress from: 2013 to present

Progress/Results:

High suspended sediment loads from the heavily agricultural Minnesota River Basin and the sediment trapping efficiency of the 34 km long Lake Pepin have together created a navigation pool unlike any other in the Upper Mississippi River, with upper and lower segments that are sharply and uniquely dissimilar. This study sought to better understand the relationships among the biota, hydrology, and physical/chemical habitats in Upper and Lower Pool 4 and to present evidence indicating a recent ecological shift in both segments using 19 years of Long Term Resource Monitoring Program data. Upper Pool 4, above Lake Pepin, is turbidity impaired and sparsely vegetated. Lower Pool 4 is a heavily vegetated mosaic of secondary channels and backwaters whose primary characteristic is the clear water that flows from Lake Pepin. Decreases in discharge, water elevation and total suspended solids during the period 2005 through 2011 drove changes in the submersed macrophyte and fish communities in both Upper and Lower Pool 4. Lower Pool 4 exhibited a 29% increase in frequency of submersed vegetation during this period and the upper pool showed a 36% increase, with even greater increases in the backwaters. A more diverse flora also developed in the upper pool during this period relative to the earlier high flow period of 1998-2004. Relative frequency of most centrarchid species increased as the frequency of emerald shiners, an open water species, decreased in both upper and lower pool during the low flow period (2005-2011). There was a large increase in abundance of fish species with an affinity for vegetation in the lower pool, such as weed shiners, yellow perch, largemouth bass, and young-of-year bluegills, during this low flow period. Likewise, largemouth bass and bluegills also increased in abundance in the upper pool.

These results demonstrate a clear, but shifting pattern of dissimilarities in water quality and biota between upper and lower Pool 4, as the upper pool exhibited a relatively rapid shift toward the ecological condition of the lower pool. Our findings also indicate that several consecutive years of low discharge can reset the ecological dynamics of the system and that one or two years of high flow interspersed among the low flow years do not necessarily reverse the changes underway.

Implications of results for river management and/or other research:

The results observed in this study may be temporary and driven by hydrology, but they demonstrate that the degraded habitat and biota in upper Pool 4 and the other pools of Geomorphic Reach 1 can be ameliorated with long-term improvements in water quality, mimicking the natural summer low-flow hydrograph through water level management, and through projects that enhance and restore degraded habitat.

Next steps or new research questions suggested:

This study will be published as a completion report early in 2014. Work will then begin on converting it into a manuscript.

Temporal evaluation of factors influencing metaphyton biomass, distribution and composition within UMR backwaters

P.I.(s) or Team Leader(s) & agency: Shawn Giblin, WDNR

Funding Source(s): UMRR APE (FY 2010)

LTRMP Product Tracking Number (if applicable): 2010out2a

Covers progress from 2010 to Present

Progress/Results:

Manuscript published in Wetlands titled "Thresholds in the Response of Free-Floating Plant Abundance to Variation in Hydraulic Connectivity, Nutrients, and Macrophyte Abundance in a Large Floodplain River."

Implications of results for river management and/or other research:

Duckweed and other free-floating plants (FFP) can form dense surface mats that affect ecosystem condition and processes, and can impair public use of aquatic resources Management actions on the Upper Mississippi River are often designed to manipulate water velocity and hydraulic connection between channel and off-channel areas. (e.g., constructing islands to reduce wind fetch and create shallow, sheltered areas). The results of this study significantly expand those of the previous study (Houser et al. 2013) by providing initial estimates of thresholds in the relationship between FFP and selected physical and chemical characteristics, and a more detailed assessment of the effects of connectivity on nutrient concentration and FFP abundance. These threshold estimates, along with observed patterns in nutrient limitation, will help managers and project planners understand likely effects of project design on FFP abundance. Furthermore, the estimated TP threshold is consistent with the numeric P criterion of < 0.1 mg l^{-1} TP for Wisconsin non-wadeable rivers (Wisconsin Administrative Code NR 102.06(3)); achieving this value may reduce the frequency of occurrence of large FFP mats in the UMR.

Next steps or new research questions suggested:

I would be interested in quantifying the spatial area under FFP mats (e.g. In the UMR in 2010, an area half the size of Rhode Island was covered by FFP mats). I think this approach would resonate with the public and demonstrate the severity of local eutrophication effects on the UMR.

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Nutrients, chlorophyll, and suspended sediments in channel and off-channel areas of the Upper Mississippi River (UMR)

P.I.(s) or Team Leader(s) & agency: Jeff Houser

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2012D10

Covers progress from _________ to _________

Progress/Results:

Houser J.N. Contrasts between channel and floodplain aquatic areas in a large, flood-plain river: testing our understanding of nutrient cycling, algal abundance and suspended sediment dynamics. In Review.

In rivers that are hydraulically connected to their floodplain, spatial variability across the floodplain in the connectivity of various aquatic areas to the channel and the resulting physical, chemical and biological patterns can strongly affect floodplain and channel characteristics. Here we present results from a data set collected across an unusually large longitudinal (1300 km) and lateral (main channel, side channel, contiguous backwaters, floodplain lakes, and impounded regions) gradient in the Upper Mississippi River System (UMRS) from 1994 through 2011. We used this data to investigate the extent to which the observed patterns in nutrients, chlorophyll and suspended solids are consistent with our current understanding of the dominant mechanisms determining the distribution of these constituents. We found that summer median total phosphorus in backwaters (TP_{bw}) was generally higher than TP in the main channel (TP_{mc}), and TP_{bw} exceeded TP_{mc} more often during summer than during other seasons. The largest contrasts between TP_{bw} and TP_{mc} were observed during low discharge. During fall and winter, main channel soluble reactive phosphorus (SRP_{mc}) was generally higher than backwater SRP (SRP_{bw}) whereas during summer and to a lesser extent spring, concentrations tend be higher in backwaters than in channels. In most seasons and all study reaches, nitrogen concentrations were nearly always higher in backwaters than in the main channel. The magnitude of the difference was largest during low discharge conditions in summer and fall. Generally, when significant differences were observed, backwater chlorophyll concentrations were higher than those of channel areas, especially during summer. Except during winter, TSS was most often lower in off channel areas than in channel areas, but this pattern varied with discharge. At low discharge, TSS_{bw} generally exceeded TSS_{mc}, whereas at high discharge the opposite was true. These spatial patterns in nutrients, chlorophyll and suspended solids were largely consistent across 1300 km of the UMR suggesting consistency in dominant mechanisms causing these patterns.

Implications of results for river management and/or other research:

Hydrologic connectivity of off channel areas to the main channel is generally believed to be a fundamental driver of conditions in off channel areas. However, there is relatively little data from large rivers available to test these ideas. The LTRMP monitoring data provide data a rare opportunity to test the various ideas regarding the contrasts in conditions between channel and off channel areas under a broad range of hydrologic and seasonal conditions. Many river management and restoration actions are designed to improve conditions in off channel areas. The results of this study improve our basic understanding of the relationship between channel and off channel conditions that may inform future management of off channel areas.

Next steps or new research questions suggested:

A next step in extracting additional understanding of river processes from the LTRMP data is to investigate which Limnological (or water quality) parameters tend to exhibit very similar behavior across the system through time (suggesting they are largely driven by large scale, regional variables (e.g., precipitation and climate), and which tend to vary more independently across pools and strata, suggesting local (likely biological) control.

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Nutrient cycling, connectivity and free-floating plant abundance in backwater lakes of the Upper Mississippi River

P.I.(s) or Team Leader(s) & agency: Jeffrey N. Houser, Shawn M. Giblin, William F. James, Heidi A. Langrehr, James T. Rogala, John F. Sullivan, Brian R. Gray. USGS, WDNR, USACE.

Funding Source(s): UMRR (APE)

LTRMP Product Tracking Number (if applicable): **2011D6**

Progress/Results:

Houser, J.N., Giblin, S.M., James, W.F., Langrehr, HA., Rogala, J.T., Sullivan, J.F., and Gray, B.R. 2013. Causes and consequences of abundant duckweed and filamentous algae in backwater lakes of the Upper Mississippi River near La Crosse, Wisconsin. River Systems 21:71-89

River eutrophication may cause the formation of dense surface mats of free floating plants (FFP; e.g., duckweeds and filamentous algae) which may adversely affect the ecosystem. We investigated associations among hydraulic connectivity to the channel, nutrient cycling, FFP, submersed aquatic vegetation (SAV), and dissolved oxygen concentration (DO) in ten backwater lakes of the Upper Mississippi River (UMR) that varied in connectivity to the channel. Greater connectivity was associated with higher water column nitrate (NO3-N) concentration, higher rates of sediment phosphorus (P) release, and higher rates of NO3-N flux to the sediments. Rates of sediment P and N (as NH4-N) release were similar to those of eutrophic lakes. Water column nutrient concentrations were high, and FFP tissue was nutrient rich suggesting that the eutrophic condition of the UMR often facilitated abundant FFP. However, tissue nutrient concentrations, and the associations between FFP biomass and water column nutrient concentrations, suggested that nutrients constrained FFP abundance at some sites. FFP abundance was positively associated with SAV abundance and negatively associated with dissolved oxygen concentration. These results illustrate important connections among hydraulic connectivity, nutrient cycling, FFP, SAV, and DO in the backwaters of a large, floodplain river.

Implications of results for river management and/or other research:

Differences in duckweed and filamentous algae abundance were associated with differences in water column nutrient concentrations suggesting that nutrient availability at times affects duckweed abundance in these backwaters. However, the weak relationship observed between abundance and water column nutrient concentrations, the frequent occurrence of nutrient concentrations above minima for duckweed growth proposed in the literature, and the frequent occurrence of relatively high FFP tissue nutrient content suggest that the eutrophication of the UMR is such that backwaters are often nutrient replete relative to FFP requirements. When the backwaters are nutrient replete, duckweed is likely to be abundant whenever and wherever physical conditions are amenable.

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Connectivity of off-channel areas are deliberately managed in a variety of contexts such as to improve habitat for centrarchid fishes and waterfowl, and has been discussed as a way to reduce nutrient transport—especially that of N--to the Gulf of Mexico by the UMR. Our results add to those of other recent studies that suggest that the effects of changes in connectivity on local nutrient cycles and therefore duckweed abundance and summer oxygen conditions should also be considered as part of such efforts.

Next steps or new research questions suggested:

Free-floating plant (FFP) research to date has generally used a comparative approach. An implicit assumption is that differences observed in space (in connectivity, nutrients, etc.) provide information on what would occur if changes were made over time in a specific place. A reasonable next step would be to see how changes in connectivity, nutrient concentration etc. over time at various sites are associated with changes in FFP abundance. Such research could be conducted as part of an HREP that is altering connectivity of an off channel area.

Related publications:

Giblin, S. M., J. N. Houser, J. F. Sullivan, H. A. Langrehr, J. T. Rogala, and B. D. Campbell. 2013. Thresholds in the Response of Free-Floating Plant Abundance to Variation in Hydraulic Connectivity, Nutrients, and Macrophyte Abundance in a Large Floodplain River. Wetlands. DOI 10.1007/s13157-013-0508-8

Gray, B.R., A.M. Ray, J.T., Rogala, M.D. Holland, and J.N. Houser. 2012. Spatial and temporal variation in duckweed and filamentous algal levels in contiguous floodplain lakes of the Upper Mississippi River Journal of Aquatic Plant Management 50:91-100

Longitudinal trends and discontinuities in nutrients, chlorophyll and suspended solids in the Upper Mississippi River: implications for transport, processing, and export by large rivers

P.I.(s) or Team Leader(s) & agency: J. Houser, D. Bierman, R. Burdis, L. Soeken-Gittinger,
Funding Source(s): UMRR-EMP-LTRMP
*Covers progress from:*Study has been completed and published

Progress/Results:

Houser, J.N., D.W. Bierman, R.M. Burdis, and L.A. Soeken-Gittinger. 2010. Longitudinal trends and discontinuities in nutrients, chlorophyll and suspended solids in the Upper Mississippi River: implications for transport, processing, and export by large rivers. Hydrobiologia 651:127–144.

Across the distances spanned by large rivers, there are important differences in catchment characteristics, tributary inputs, and river morphology that may cause longitudinal changes in nutrient, chlorophyll and suspended solids concentrations. We investigated longitudinal and seasonal patterns in the Upper Mississippi River (UMR) using long term data (1994 – 2005) from five study reaches that spanned 1300 km of the UMR. Lake Pepin, a natural lake in the most upstream study reach, had a clear effect on suspended material in the river. Suspended solids and total phosphorus concentrations (TP) were substantially lower downstream of the lake and percent organic material in suspension (OM%) was higher. Below L. Pepin, mean total and organic suspended solids (TSS, OSS) and total phosphorus increased downriver and exhibited approximately log-linear relationships with catchment area, whereas OM% declined substantially downriver. Despite the downriver increase in TSS and OSS, concentrations similar to those above L. Pepin do not occur until ~370 km downriver indicating the extent of the influence of L. Pepin on the UMR. Chlorophyll concentrations were lower in the most downstream study reach, likely reflecting the shorter residence time and poor light climate, but there was not a consistent longitudinal decline in chlorophyll across the study reaches. Dissolved silica (DSi), DSi:TN, and DSi:TP declined downriver suggesting that DSi uptake and sedimentation by river phytoplankton may be reducing DSi transport in the river, and indicating that the eutrophication of the river may contribute to a reduction of DSi export to the Gulf of Mexico.

Implications of results for river management and/or other research:

The results of this study illustrate the changes in limnological conditions that occurred across seasons and over the length of the UMR. These changes affected fundamental ecosystem properties including light availability, nutrient concentration, and the concentration of suspended organic material and phytoplankton. The changes along the length of large rivers such as the UMR reflect changes in the complex set of driving variables such as land use, geomorphology, tributary input, anthropogenic modification, and in-river processing of suspended material. The strong relationship with catchment and discharge in combination with results from previous studies suggest that for suspended solids and TP, cumulative tributary inputs were the primary factor determining the observed longitudinal patterns and resulting export. For other variables such as OM%, CHL and DSi, in-river processes were likely important and additional study of the processes affecting algal abundance, nutrient cycling, and organic matter production and decomposition are needed. The wide range of limnological conditions within the UMR highlights the complexity of understanding, managing and restoring large river ecosystems. Importantly, these results describe the basic longitudinal patterns in water quality that can inform ongoing efforts to manage and rehabilitate the UMRS.

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Ecosystem metabolism in the main channel and backwaters of the Upper Mississippi River: the roles of light, discharge, nutrients and hydraulic connectivity

P.I.(s) or Team Leader(s) & agency: Jeff Houser (USGS) (co-PIs: L.A. Bartsch (USGS), W. B. Richardson (USGS), J.T. Rogala (USGS), and J. Sullivan (WDNR)

Funding Source(s): UMRR (APE)

Progress/Results:

Houser, J.N., L.A. Bartsch, W.B. Richardson, J.T. Rogala. Ecosystem metabolism in the main channel and backwaters of the Upper Mississippi River: the roles of light, discharge, nutrients and hydraulic connectivity. In review.

Large floodplain river ecosystems are highly productive and support abundant populations of fish and waterfowl. In addition to various inputs from the watershed, primary production of algae and macrophytes within the river supports these populations. In situ primary production is one of the main drivers of dissolved oxygen in the river. During the summers of 2006 and 2007 we measured rates of aquatic metabolism, algal abundance (chlorophyll), and nutrient concentrations at main channel and backwater sites on the Upper Mississippi River near La Crosse, WI (USA) to determine the factors most associated with variability in rates of ecosystem metabolism and nutrient concentrations in a large flood plain river. Time series analysis indicated that physical drivers, such as solar irradiance, discharge, and temperature, accounted for most of the observed variability in primary production rather than nutrient availability. The primary difference in significant covariates of GPP between the main channel and backwater sites was that discharge was consistently (negatively) associated with GPP only in the main channel and temperature was consistently (positively) associated with GPP only in backwaters. At main channel sites during mid-summer, GPP exceeded R, resulting in a positive net production, and persistent oxygen supersaturation from late June through early August. Oxygen concentrations were lower in backwaters, and extensive periods of hypoxia were observed in backwaters with abundant vegetation. Maximum chlorophyll concentrations were observed at main channel, rather than backwater sites. Nitrogen concentrations declined with hydraulic connectivity to the main channel. We conclude that nutrient concentrations, oxygen dynamics, and ecosystem production appear to be a complex function of connectivity to the main channel and vegetation abundance.

Implications of results for river management and/or other research:

Rates of aquatic ecosystem metabolism in the UMR were similar to those observed in other large, eutrophied rivers and much higher than rates observed in undeveloped rivers. The high primary productivity of the UMR indicates an ability to support abundant biological production. However, the extensive temporal extent of hypoxia at some sites indicates the river may be experiencing some negative consequences of eutrophication as well.

Next steps or new research questions suggested:

Estimating rates of primary production (and more generally, ecosystem metabolism) in a large ecosystem benefits from continuous monitoring of dissolved oxygen, temperature, solar irradiance and wind speed. We measured these variables as part of this focused research study, but we are not

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currently collecting additional, similar data. However, initial deployments of continuous monitoring buoys have been tested by scientists from NGRREC and additional deployments are anticipated. Data from these buoys may present an opportunity to estimate primary production across broader temporal and spatial scales and expand our understanding of the primary drivers of these fundamental ecosystem processes in the UMRS.

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Ecosystem Metabolism in the Middle Mississippi

P.I.(s) or Team Leader(s) & agency: Molly Sobotka, Quinton Phelps, Missouri Dept. of Conservation

Funding Source(s): MDC

Progress/Results:

A study of ecosystem metabolism in 'off channel' habitats of the Mississippi River (currently side channels and wing dike areas) using continuous DO and Temp monitoring. Currently collected continuous data from mid Aug 2013 to Jan 2014. Initial results suggest different temperature regimes in side channels. Initial metabolism modeling suggests that both wing dike and side channel sites may be much more productive than the main channel of the river.

Implications of results for river management and/or other research:

Findings of localized areas of high productivity could result in recommendations for protection. An understanding of conditions that encourage high productivity could result in a better understanding of what habitats need to be protected/restored to encourage productivity.

Next steps or new research questions suggested:

Continue monitoring to gather data on rising and high water levels. Long term monitoring will allow modeling of annual metabolism rates and correlation to river stage. Also, monitoring in the thalweg of the main channel if possible will allow further understanding of the lateral patterns of metabolic activity.

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Trends in suspended solids, nitrogen, and phosphorus in six UMR tributaries from 1991 until 2011

P.I.(s) or Team Leader(s) & agency: Becky Kreiling and Jeff Houser, USGS

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013D13 and 2013D14

Covers progress from 2012 to present

Progress/Results:

Using LTRMP fixed site water quality data and USGS gaging station discharge data, we modeled changes in concentration and flux in total nitrogen, total phosphorus, soluble reactive phosphorus, nitrate, and suspended solids from 1991 until 2011 in six tributaries of the UMR. The tributaries that were monitored were the Chippewa, Cannon, Black, Maquoketa, Wapsipinicon and Cuivre Rivers. We saw a general decline in total phosphorus, soluble reactive phosphorus and total suspended solids concentration and flux in most of the tributaries. The exceptions were the Black and Cuivre Rivers where total phosphorus concentration did not change substantially. Total nitrogen concentration and flux did not change substantially in the tributaries except for in the Chippewa and Cuivre Rivers where total nitrogen decreased. Nitrate trends varied, with concentration and flux increasing in the Chippewa and Black Rivers, decreasing in the Cuivre, and remaining unchanged in the Cannon, Maquoketa, and Wapsipinicon Rivers.

Implications of results for river management and/or other research:

Declines in phosphorus and total suspended solids in the majority of the monitored tributaries suggest that improved land use practices have reduced surface run-off. However, we did not observe similar reductions in nitrogen concentration and flux. This suggests that more restoration work needs to be done to reduce nitrogen leaching and run-off. Because tributaries often respond more rapidly to changes in the water shed than the larger rivers into which they flow, these results suggest that river managers may expect similar trends in the main stem of the UMR over the next few years.

Next steps or new research questions suggested:

As additional land use changes occur, will eventual reductions in tributary nitrogen occur?

Are the trends observed in the tributaries also observed in the UMR?

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Spatial and Temporal Dynamics of Phytoplankton Assemblages in Selected Reaches of the Upper Mississippi River: Navigation Pools 8, 13, and 26

P.I.(s) or Team Leader(s) & agency: Jeffrey N. Houser, USGS (John Manier (USGS), Roger Haro (UW-La Crosse)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2010OUT2C

Covers progress from: 2010 to 2014

Progress/Results:

The purpose of this study was to examine the effects of hydrology, nutrients, and water clarity on phytoplankton community composition of the Upper Mississippi River (UMR). Phytoplankton and water quality samples were collected, as part of the Long Term Resource Monitoring Program (LTRMP) from 1988 to the present.

We chose a subset of samples taken during 2006-2009 from navigation pools 8, 13, and 26 of the UMR. The samples were collected from three distinct habitats (main channel, backwater, and impounded areas). John Manier (a graduate student at the University of Wisconsin- La Crosse) enumerated the samples, and is conducting the data analysis.

The results indicate that phytoplankton of the UMR are strongly influenced by spatial and temporal variations in hydrology. Discharge was a crucial factor in controlling diversity; years with high discharge exhibited higher diversity (possible due to recruitment from backwaters), while low discharge years showed lower diversity. Moreover, this pattern was repeated in pools 8, 13, and 26. This may indicate that connectivity between main and off-channel areas is a strong factor, influencing phytoplankton of the UMR.

We also found that phytoplankton communities within backwater and main channel habitats were markedly different. The backwaters were typically dominated by a mixture of cyanobacteria and diatoms; cryptomonads were seen to a lesser extent. A few genera were found much more commonly in the backwaters, such as the euglenoids (i.e. *Euglena* and *Phacus*). The main channel, on the other hand, was dominated by a mixture of cyanobacteria and diatoms, with green algae seen to a lesser extent. Common species of cyanobacteria (within the main channel) included *Aphanizomenon* and *Microcystis*, while the diatoms were usually dominated by *Aulacoseira* and *Stephanodiscus*.

As of yet, we did not find direct correlations between nutrient concentrations and phytoplankton biovolume. This may indicate that nutrient limitation is rare in the UMR, which has been observed in past studies. However, it is possible that nutrient limitation occurs in certain backwaters with low

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connectivity. As a result, future analyses may determine the effect of nutrient concentrations on phytoplankton community composition.

Implications of results for river management and/or other research:

Result of our study can be applied to a variety of river management decisions and future research. For example, we found that physical factors are critically important in dictating phytoplankton community composition. As a result, changes to flow regimes could alter phytoplankton communities, which would likely impact higher trophic levels.

Our results also challenge some commonly held assumptions regarding large river phytoplankton communities. For example, researchers assumed that backwaters are generally more suitable for blue-green algae than the main channel. Our findings indicate, however, that cyanobacteria (at least during the summer) are common in both main channel and backwater areas.

We also learned that there are stark differences between main channel and backwater communities, and this may impact higher trophic levels. For example, cryptomonads and euglenoids were much more common in the backwaters, than the main channel. These species are well known for having high energy and nutritional value, thus may impact higher trophic levels, including zooplankton and larval fish.

Next steps or new research questions suggested:

Next, we will use multivariate statistics to help us determine which variables or combination of variables; best explain the phytoplankton communities we observed. We will use principle component analysis to narrow down the list of variables. Once we have finished analyzing the data, a report will be put together (in the form of a master's thesis) and delivered to USACE for distribution.

Lastly, the unique part about this project is that it covered a wide expanse of the UMR, both spatially and temporally. As a result, data from this study could be used for the following purposes:

1) Set a baseline. Future studies may identify long term trends due to climate change or the impact of exotic species such as Asian carp..

2) Help us to answer broad ecological questions (i.e. how do phytoplankton communities contribute to the overall energy flow of large rivers?)

3) Help us to answer more specific questions (i.e. why haven't Asian Carp established here? Do they have the proper food resources?)

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Relationship between the temporal and spatial distribution, abundance, and composition of zooplankton taxa and hydrological and limnological variables in Lake Pepin

P.I.(s) or Team Leader(s) & agency: Rob Burdis MN DNR Lake City Field Station

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013D17

Covers progress from: 2013 to 2014

Progress/Results:

Lake Pepin zooplankton data from1995 through 2012 have been summarized and exploratory analysis using non-metric multi-dimensional scaling has been performed. Modeling results of water residence time (WRT) specific to segments of Lake Pepin based on water discharge and elevations have just recently become available. The WRT data along with a suite of LTRMP water quality variables will enable us to examine the association of environmental variables with the zooplankton community to determine the most explanatory variables. Early analysis indicates that WRT may be the most important variable affecting the zooplankton community in Lake Pepin during late summer and fall. .

Implications of results for river management and/or other research:

Lake Pepin provides a unique lentic habitat on the Upper Mississippi River that substantially increases zooplankton abundance. Zooplankton are an important prey item for most young of the year fishes and planktivorous adults and serve as an important link in the food web of most aquatic ecosystems. Surprisingly little information is available about zooplankton in most river systems including the Upper Mississippi River and Lake Pepin. This study will provide a greater understanding of the hydrological and limnological mechanisms controlling zooplankton distribution, abundance, and composition in this unique geomorphic lake. Lake Pepin supports important sport and commercial fisheries and a better understanding of zooplankton dynamics and baseline conditions may be of interest to fisheries managers, particularly with the threat of planktivorous carps becoming established. Because long term zooplankton data sets on large river systems are rare and allow for analysis not possible with shorter term studies, results of this study are likely to be of interest to river ecologists worldwide.

Next steps or new research questions suggested:

Complete analyses on the zooplankton community and associated environmental variables and prepare a manuscript for publication.

In addition to the crustacean zooplankton data in this study, phytoplankton and rotifer samples are available for processing and analysis at four fixed sites in Lake Pepin. Examination of these additional components of plankton would provide additional insight into the seasonal relationships among phytoplankton, rotifer and crustacean zooplankton communities that comprise an important trophic level and link in the ecosystem.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Trends in water movement of Upper Mississippi River floodplain lakes

P.I.(s) or Team Leader(s) & agency: J.T. Rogala[1], B.R. Gray[1], J. Houser[1] and J. Cochran Biederman[2]; [1]USGS-UMESC, [2]PhD candidate, University of Minnesota
Funding Source(s): UMRR
LTRMP Product Tracking Number (if applicable): 2010E1
Covers progress from 2010 to 2013

Progress/Results:

Paper submitted to River Research and Applications in 2013.

Ecological processes of backwater lakes in large floodplain rivers can be affected by rates and patterns in water movement. Changes in lake water movement can be associated with changes in discharge, morphometry (e.g., connectivity with channels) and aquatic vegetation. This study used water speed measurements from within backwater lakes to estimate trends in the mean and variance of water movement in three reaches of the Upper Mississippi River over a recent 14-yr period. Trends in variance were estimated at both among- and within-lake scales using coefficients of variation (CV). Trends were observed in mean water speed, but were not observed after adjusting for a trend in discharge. No temporal trends were detected in CVs at the among-lake scale. In contrast, a positive trend in within-lake CVs was seen in two of the three study reaches, indicating an increase in within-lake heterogeneity in water speed. Increases in heterogeneity of water speeds within-lakes can affect the habitat characteristics available for river flora and fauna, and may affect nutrient processing and biological productivity of floodplain lakes.

Implications of results for river management and/or other research:

The lack of trends detected in backwater water velocities, after adjusting for discharge, at the pool and lake scales suggest that river morphometry has not changed dramatically at these scales in the recent 14-yr period. These findings suggest that the ecological processes that are affected by water movement have not been altered by changes in water movement at these scales. However, the increasing trend observed in within-lake heterogeneity, including more area of very low velocity, may have affected some ecological processes that might cause concerns for river managers.

The analytical methods used in this project can not only be replicated in future years to continue tracking this system attribute, but these methods may be applied to other investigations of interest at pool, lake, and within-lake scales.

Next steps or new research questions suggested:

Investigating the ecological implications related to within-lake changes in heterogeneity would be the logical next step. One approach would be to conduct intense spatial sampling in a selected set of backwater lakes to look at specific associations between water velocity and system drivers. Such investigations could be conducted in lakes planned for HREP projects, taking advantage of contrasts before and after construction.

Five Year Summary of LTRMP Fish Data on Pool 4, Upper Mississippi River, 2009-2013

P.I.(s) or Team Leader(s) & agency: S.A. DeLain (MN DNR/LTRMP)

Funding Source(s): UMRR

Covers progress from 2013 to 2014

Progress/Results:

This report contains summaries of (1) surface water elevation, (2) total number of fish and species collected annually, (3) annual gear allocation, (4) total number of fish sampled by each gear type and stratum, (5) catch–per-unit effort (CPUE) and standard error, and (6) length frequencies for selected species caught by selected gear types and in selected strata.

Implications of results for river management and/or other research:

Results from this report can be used by river managers / biologists to detect fish species abundance, size, and richness trends in Pool 4.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

A research framework for aquatic over-wintering issues in the Upper Mississippi River Basin

P.I.(s) or Team Leader(s) & agency: B.S. Ickes (USGS/UMESC/UMRR)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): N/A

Covers progress from Aug 2005 to present

Progress/Results:

This UMRR-sanctioned plan details a framework for research into an over-arching hypothesis of winter habitat limitation on the production of limnophilic fishes in the Upper Mississippi River System (UMRS). The goal of this plan is to lay a foundation of background material, outline a sequence of pertinent research questions, and identify approaches and methodologies for study. The framework is expected to direct research into this topic through the auspices of the Long Term Resources Monitoring Program (LTRMP).

The research framework was drafted and submitted for partnership review in August 2005. To date, as far as the PI is aware, it has yet to be vetted and approved by the partnership. This framework represents the first research framework prepared under the auspices of the UMRR-EMP-LTRMP.

No research has been funded or conducted under this framework, to date.

Implications of results for river management and/or other research:

The Upper Mississippi River System (UMRS) was impounded in the 1930's by a series of 29 low-head navigation dams from St. Louis, MO to Minneapolis, MN (Figure 1). Impoundment fundamentally altered river morphology and key fluvial processes that maintained diverse river environments in the pre-impoundment era. Some of the most notable changes have occurred in backwater environments of the UMRS. For example, impoundment artificially raised and stabilized water levels, reduced flow velocity, and increased sediment deposition rates in backwater environments (U.S. Geological Survey 1999; McGuiness 2000; River Resources Forum 2004). Backwater environments are accumulating sediment at a rate of 0.12 cm to 0.80 cm per year (Rogala and Boma 1996). Increased aquatic surface area following impoundment also resulted in greater wind fetch and wave-induced erosion rates (River Resources Forum 2004). The process of erosion in shallow areas and sediment deposition in deeper areas has led to dramatic declines in morphometric diversity within many UMRS navigation pools. Loss of geomorphic diversity and the resulting changes in biogeochemical processes are often cited as causes of habitat degradation in backwaters (Bodensteiner et al. 1990; Sheehan et al. 1990; Pitlo 2001; Knights et al. 1995; Gent et al. 1995; Raibley et al. 1997).

From 1988-2003, about US$146M were spent on Habitat Rehabilitation and Enhancement Projects (HREPs) on the UMRS. HREPs have restored, protected, or enhanced over 67,000 acres of habitat and projects encompassing 74,000 additional acres are in progress. Many of these projects focus on backwaters, largely by re-engineering the morphology of these environments. Management tools include backwater dredging, island construction, and pool-scale drawdowns; each designed in some way to increase and recover lost morphometric diversity.

Implicit in backwater rehabilitation efforts is an assumption that habitat limits the production of target biota. However, such limitation has not been adequately demonstrated (Gutreuter 2004). Determining if, and how, habitat limits biotic production will have numerous benefits. First, effective use of finite resources for rehabilitation will benefit significantly from knowing where and when habitat limits biota. Second, rehabilitation efforts are management experiments that can enhance scientific understanding of how the UMRS functions. Finally, research into habitat limitations must address the physiochemical template that defines habitat for any given species or assemblage. Such research will provide insights into a host of biogeochemical relationships, as well as water quality dynamics, small scale hydrology and bathymetry, and pathways of overall system productivity.

Next steps or new research questions suggested:

Prioritize research topics within the framework and implement strategic studies accordingly (regard framework).

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Spatially-explicit habitat models for 28 fishes from the Upper Mississippi River System

P.I.(s) or Team Leader(s) & agency: B.S. Ickes (USGS/UMESC/UMRR), and others

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013B27

Covers progress from May 2012 to present

Progress/Results:

This UMRR-sanctioned study sought to model species occurrences (presences) as a function of site-scale environmental covariates as an expression of habitat suitability.

Fifty-six “regionalized” models for 28 species were attempted using UMRR-EMP LTRMP fish component data sources, representing 1300 km of river environment and 20 years of time.

Models were fit and a report detailing the methods, results, and application of the models was submitted for review on 8 August 2013. Presently, the report remains in review.

Scoped obligations are fulfilled.

Implications of results for river management and/or other research:

Environmental management actions in the Upper Mississippi River System (UMRS) typically require pre-project assessments of predicted benefits under a range of project scenarios. The U.S. Army Corps of Engineers (USACE) now requires certified and peer-reviewed models to conduct these assessments. Previously, habitat benefits were estimated for fish communities in the UMRS using the Aquatic Habitat Appraisal Guide (AHAG v.1.0; AHAG from hereon). This spreadsheet-based model used a habitat suitability index (HSI) approach that drew heavily upon Habitat Evaluation Procedures (HEP; USFWS 1980) by the United States Fish and Wildlife Service (USFWS). The HSI approach requires developing species response curves for different environmental variables that seek to broadly represent habitat. The AHAG v.1.0 model uses species-specific response curves assembled from literature values, data from other ecosystems, or best professional judgment.

A recent scientific review of the AHAG indicated the model's effectiveness is reduced by its dated approach to large river ecosystems, uncertainty regarding its data inputs and rationale for habitat-species response relationships, and lack of field validation (Abt 2011). The reviewers made two major recommendations: (1) incorporate empirical data from the UMRS into defining the empirical response curves, and (2) conduct post-project biological evaluations to test pre-project benefits estimated by AHAG.

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Our objective was to address the first recommendation and generate updated response curves for AHAG using data from the Upper Mississippi River Restoration Environmental Management Program (UMRR-EMP) Long Term Resource Monitoring Program element (LTRMP). Fish community data have been collected by LTRMP (Gutreuter et al. 1995; Ratcliff et al., in press) for 20 years from six study reaches representing 1300 km of river and > 140 species of fish. We modeled a subset of these data (28 different species; occurrences at sampling sites as observed in day electrofishing samples) using multiple logistic regression with presence/absence responses. Each species' probability of occurrence, at each sample site, was modeled as a function of 17 environmental variables observed at each sample site by LTRMP standardized protocols. The modeling methods used (a) a forward selection process to identify the most important predictors and their relative contributions to predictions; (b) partial methods on the predictor set to control variance inflation; and (c) diagnostics for LTRMP design elements that may influence model fits.
Models were fit for 28 species, representing three habitat guilds (Lentic; Lotic; Generalist). We intended to develop "systemic models" using data from all six LTRMP study reaches simultaneously, however this proved impossible. Thus, we "regionalized" the models, creating two models for each species: "Upper Reach" models, using data from Pools 4, 8, and 13; and "Lower Reach" models, using data from Pool 26, the Open River Reach of the Mississippi River, and the La Grange reach of the Illinois River. Thus, 56 total models were attempted. For any given site-scale prediction, each model used data from the three LTRMP study reaches comprising the regional model to make predictions. For example, a site-scale prediction in Pool 8 was made using data from Pools 4, 8, and 13. This is the fundamental nature and trade-off of regionalizing these models for broad management application.

Next steps or new research questions suggested:

The models, as constructed and reported under stated assumptions, are fit and detailed within the report, presently in review. The report simply provides (1) a description of the methods used to generate the models; (2) the data sources used; and (3) model predictions, which are spatially explicit in nature (e.g., map-able). Only examples of maps that can be generated from these results are provided in the report, so if maps of all predictions are desired, a separate effort dedicated to this task should be undertaken. The models DO NOT provide a habitat suitability assessment, merely the spatial context within which to create one. As such, HREP practitioners and managers should make efforts towards arriving at a suitability assessment considering (1) whether the regionalized models serve their management needs; (2) how multiple species should be handled in such suitability assessments; and (3) define a process by which a suitability assessment may be gained.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

UMRR-EMP data mensuration task: Quality assurance results UMRR-EMP LTRMP Fish Component – Mapping of the electrical fields on the new fleet of electrofishing rigs

P.I.(s) or Team Leader(s) & agency: B.S. Ickes (USGS/UMESC/UMRR), and others

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013B13

Covers progress from May 2012 to present

Progress/Results:

This UMRR-sanctioned study sought to test/demonstrate continuity and conformity in the *in situ* performance of the new fleet of electrofishing rigs used by the UMRR-EMP LTRMP Fish Component.

The quality assurance audit resulted in the determination that all fish component electrofishing rigs are operating within permissible *in situ* tolerances, as expressed within the component's standardized procedures.

Study completed - A summary letter was submitted for review on 2 November 2012. At this time, the PI is unaware whether the summary letter has been remitted to the Rock Island offices of the US Army Corps of Engineers.

Scoped obligations (for the PIs) are fulfilled.

Implications of results for river management and/or other research:

This study provides the results of a quality assurance audit performed to evaluate the effective fishing fields of the UMRR–EMP LTRMP (LTRMP) Fish Component electrofishing fleet. In a highly standardized field sampling program like the LTRMP, it is necessary to ensure, through quality assurance audits, that field equipment is performing as originally designed and specified. Now that the LTRMP has entirely replaced its aging electrofishing fleet, we report the results of a quality assurance audit on the new electrofishing rigs. Our evaluation sought to achieve two key objectives: (1) complete a continuity test on all major components of the electrical circuitry of each electrofishing rig in the LTRMP fleet; and (2) map the electrical field, *in situ*, with the rig operating under LTRMP standard procedures (Gutreuter et al. 1995). Our over–arching goal is to demonstrate that the replacement fleet exhibits sampling specifications analogous to the original fleet, developed in 1989.

Results from the quality assurance audit demonstrate all LTRMP electrofishing rigs were operable and in good repair. While nominal and minor resistance was observed in a few rigs, the continuity of the circuitry of each rig in the fleet was found to be acceptable or exemplary. Instances of observed, yet nominal, resistance in the circuitry were rectified to zero resistance on each rig prior to field testing and mapping of the aqueous

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electrical field. Finally, the electrical field of each LTRMP electrofishing rig was found to be within operational specifications for sampling under LTRMP Fish Component protocols.

Next steps or new research questions suggested:

None – all rigs passed the audit and are deemed compliant with LTRMP Fish Component standard operating procedural requirements. Future assessments need only be made when key components of the rigs are repaired or replaced (see summary letter for details).

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UMRR-EMP data mensuration task: UMRR-EMP LTRMP Fish Component hoop net study – Results from comparative in situ bait trials seeking comparable substitute bait for standardized LTRMP hoop net sampling

P.I.(s) or Team Leader(s) & agency: B.S. Ickes (USGS/UMESC/UMRR), and others

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013B14

Covers progress from October 2012 to 8 March 2013

Progress/Results:

This UMRR-sanctioned study sought to present results of paired hoop net bait trials, conducted to identify and evaluate alternative and demonstrably equivalent bait, required to maintain standardized sampling efforts in the UMRR–EMP LTRMP Fish component.

This quality assurance study resulted in the determination that the substitute bait resulted in non-significant effects on the catches of channel catfish (study target) in LTRMP hoop net samples in Pool 8. The Open River study site design was compromised by an unprecedented drought, at least in the observational history of UMRR-EMP upon which data the study was designed.

Study completed - A summary letter was submitted for review on 8 March 2013. The summary letter has been remitted to the Rock Island offices of the US Army Corps of Engineers.

Scoped obligations (for the PIs) are fulfilled.

Implications of results for river management and/or other research:

This study details the results of paired hoop net bait trials, conducted to identify and evaluate alternative and demonstrably equivalent bait, required to maintain standardized sampling efforts in the UMRR–EMP LTRMP Fish component. We evaluated our standard bait (mechanically extruded and dried soy bean cake) relative to a prospective substitute (a mechanically processed non–caked soy bean product). This assessment was necessary because the plant that manufactures our present standardized bait does not plan to continue production in the near future.

Paired baited sets were made in two LTRMP river reaches (Pool 8 and Open River), representing the widest range of flows possible. Bait performance was assessed as the catch–per–unit–effort of channel catfish (*Ictalurus punctatus*) in standardized LTRMP large hoop nets (Gutreuter et al. 1995). The standard bait received a standard and full annual sample allocation as per standardized LTRMP sampling protocols. The alternative bait was fish adjacent and opposite–bank of the standard LTRMP set in identical nets. This assured the bait scents did not interfere with each other. Tolerable deviances in catches between bait treatments were defined *a priori* to the study by the full complement of LTRMP

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Fish Component staff. Moreover, acceptable assurances of observing these deviances were set by LTRMP Fish Component staff and used to set requisite sample sizes to assure observing a stated effect. No difference in channel catfish mean CPUE between paired bait trials were observed in the Pool 8 study reach. The design of the study, which considered existing catch rate data and its variance, assured sufficient power to detect a stated effect size at a stated level of confidence. Thus, for Pool 8, we can definitively conclude that both baits, as fished procedurally in the study, produce comparable catches of target organisms in large hoop net methods used as part of LTRMPs standardized fish community assessments (Gutreuter et al. 1995). This conclusion supports transitioning to the alternative bait (Mercer) when it becomes necessary.

Similarly, no differences in the mean CPUE of channel catfish were observed in the Open River study locality during the study. However, several issues preclude a definitive conclusion on bait effects on catch for the Open River locality. First, due to drought issues, pre-defined sampling requirements to achieve a stated effect size at a given level of confidence, were compromised. Drought conditions resulted in 16% fewer samples than intended due to standardized procedure issues with deploying LTRMP compliant hoop net sets (Gutreuter et al. 1995). Secondly, catches during the 2012 assessment were much more variable that historically observed, and upon which sample size requirements were determined *a priori*, perhaps also a consequence of low flow and river stages through the drought period. Correspondingly, *post hoc* power assessments demonstrated that the intended power of the sampling design was compromised by these issues. Thus, while formal tests revealed no differences in catch between the bait types in the Open River study area, our power to detect these differences given the study data were insufficient to draw definitive conclusions.

The Open River study location was chosen to maximize differences in flow environments across the study. However, given the drought in 2012, this study objective was at least partially compromised. Given the unusual circumstance of the drought of 2012, we recommend repeating the Open River study again in 2013, considering the assessment complete for the Pool 8 study area. In doing so, the sample design should incorporate the 2012 data in pre-project design, given the unique and unprecedented variation observed in 2012 at the Open River study locality. The nets are on site and repeating the study in 2013 would only require the procurement of new quantities of Mercer baits, and minimal commitments of field staff time, since test bait nets are fished synoptically with our standard LTRMP sample allocations.

Next steps or new research questions suggested:

Due to drought conditions in the Open River reach study locale in 2012, the study was repeated at this locale in 2013. Sampling is complete and data are actively arriving at UMESC. Following quality assurance audits, the Open River locale will be assessed again using data from the 2013 effort, and an addendum to the 2013 summary letter will be remitted with these updated results. Once complete, the quality assurance audit will be complete and once the bait transition needs to occur (based upon market forces), we can transition with assurances of “no effects” upon the long term observational data (assuming the Open River 2013 study reveals no “bait effect”).

UMRR-EMP data mensuration task: UMRR-EMP LTRMP Program Procedures - Fish Monitoring (2nd edition)

P.I.(s) or Team Leader(s) & agency: E. Ratcliff and E. Gittinger (NGRREC/INHS), T.M. O'Hara (IlDNR), and B.S. Ickes (USGS/UMESC/UMRR)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013B5

Covers progress from October 2012 to present

Progress/Results:

This UMRR-sanctioned project sought to update the Standard Operating Procedures for the UMRR–EMP LTRMP Fish component.

Standard sampling procedures in the UMRR-EMP LTRMP assure that sources of error actually under program control (sampling and non-sampling error) are controlled, minimized, and understood. The procedures manuals assure "common practices and procedures", in sampling methods, field behaviors, and sampling design over the entire spatial and temporal domain of LTRMP (1300 river km and 20+ years of time). The point of the Procedures Manuals are to describe, in detail, "how" LTRMP monitors the Upper Mississippi River System.

Report draft completed. Internal and external review and reconciliation of those reviews have been achieved. Layout and formatting review has been achieved. Presently the report is considered "in press".

Scoped obligations (for the PIs) are fulfilled.

Implications of results for river management and/or other research:

This manual constitutes the second revision of the U.S. Army Corps of Engineers' Upper Mississippi River Restoration-Environmental Management Program (UMRR-EMP) Long Term Resource Monitoring Program (LTRMP) element Fish Procedures Manual (Burkhardt et al. 1988; Gutreuter et al. 1995). The original (1988) manual merged and expanded on ideas and recommendations related to Upper Mississippi River fish sampling presented in several early documents (Burkhardt et al. 1988; Gutreuter 1997). The first revision to the manual was made in 1995 reflecting important protocol changes, such as the adoption of a stratified random sampling design. The 1995 procedures manual has been an important document through the years and has been cited in many reports and scientific manuscripts. The resulting data collected by the LTRMP fish component represent the largest dataset on fish within the Upper Mississippi River System (UMRS) with more than 42,000 collections of approximately 5.5 million fish.

The goal of this revision of the procedures manual is to document changes in LTRMP fish sampling procedures since 1995. Refinements to sampling methods become necessary as monitoring programs mature (Ickes and Burkhardt 2002). Possible refinements are identified through field experiences (e.g., sampling techniques and safety protocols), data analysis (e.g., planned and studied gear efficiencies and reallocations of effort), and technological advances (e.g., electronic data entry). Other changes may be required because of financial necessity (i.e., unplanned effort reductions). This version of the LTRMP fish monitoring manual describes the most current (2013) procedures of the LTRMP fish component. To document the full scope of history and changes, this manual (with future addenda), and the previous (1995) manual are provided online at http://www.umesc.usgs.gov/data_library/fisheries/fish_page.html (accessed December 11, 2013).

This second edition also contains considerable new information, conveyed as appendix material, on equipment specifications, information that is useful as others beyond LTRMP adopt and deploy LTRMP methodologies.

Next steps or new research questions suggested:

Publish and disseminate

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UMRR-EMP data mensuration task: Monitoring Rationale, Strategy, Issues, and Methods - UMRR-EMP LTRMP Fish Component

P.I.(s) or Team Leader(s) & agency: B.S. Ickes, J. Sauer, and J. Rogala (USGS/UMESC/UMRR)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2014B5

Covers progress from October 2013 to present

Progress/Results:

This UMRR-sanctioned project (considered part of the "base" monitoring mission) seeks to provide information on "why" the LTRMP Fish Component monitors fishes in the Upper Mississippi River System. As such, this report is intended as a companion document to the LTRMP Fish Component Procedures Manual, which presents "how" LTRMP samples.

Report draft completed. Presently in USGS review, and considered "in review".

Implications of results for river management and/or other research:

- The Upper Mississippi River System (UMRS) provides habitat to a wide array of fish and wildlife species distributed among a complex assortment of flowing channels, floodplain lakes, backwaters, wetlands, and floodplain forests. With an ecosystem as diverse and complex as the UMRS, many of its processes and their interrelationships are not well known. Long-term monitoring is perhaps most effective, and in some cases, the only means by which large, complex ecosystems such as the UMRS can be studied and managed.

- The Long Term Resource Monitoring Program (LTRMP), an element of the multi-agency partnership Upper Mississippi River Restoration Environmental Management Program (UMRR-EMP), has been monitoring fishes in the Upper Mississippi River System for over two decades, using scientific and highly standardized methods. Today, the LTRMP's data assets represent one of the largest and most extensive datasets on a great river, in the world.

- Methods and procedures used over the past two decades have been documented (Gutreuter et al. 1995, and subsequent revisions in Ratcliff et al. in press), and have proven a key tool towards gaining data that are (a) scientifically valid; (b) comparable over time; and (c) comparable over space. These procedure manuals coordinate and standardize methods, procedures, and field behaviors in the execution of long term monitoring, permitting the informed management and control of important sources of error actually under program control.

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• As LTRMP databases have matured in scope and duration, their utility in research and management in the UMRS basin has increased notably. To maximize their utility, data users need not only be aware of "how the data were collected", as portrayed in the procedures manuals, but also "why the data were collected in the way they were, at the scales they were, and in the manner that they were". Whereas the procedures manuals contribute information as to the "how" the data were gained, this document seeks to contribute information as to the "why". As such, this document is intended to be a companion document to the procedures manuals.

• Herein, we present information on the rationale for monitoring nearly one-fish of the entire North American freshwater fish fauna (representing the greatest freshwater fish diversity on the planet at temperate latitudes); strategies employed and their reasoning; and discussions on issues associated with the sampling design itself, data arising therefrom, and uses of those data in different contexts.

• It is our sincerest hope that this document aids prospective investigators and natural resource managers in navigating and understanding these globally-unique empirical assets. We also expect this report will aid distributed uses of UMRR-EMP data in issue identification, analytical efforts, modeling activities, and distributed collaborative research opportunities.

Next steps or new research questions suggested:

Finalize reviews, reconcile reviews, and submit for print.

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Why aren't Asian carp everywhere in the Upper Mississippi River System? Testing alternative hypotheses using large scale assessment data

P.I.(s) or Team Leader(s) & agency: B.S. Ickes (USGS/UMRR-EMP LTRMP)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): non-scoped leveraged

Covers progress from December 2013 to present

Progress/Results:

Recently solicited book chapter for the American Fisheries Society.

Analyses completed. Literature review and manuscript draft underway. Full draft due late-April 2014.

Presently considered "in draft".

Implications of results for river management and/or other research:

Invasive species have been cited as a leading threat to native biodiversity. When large aquatic ecosystems are invaded (i.e., Great Lakes, Mississippi River, Everglades), the ability to assess threats and impacts is often limited because baseline ecosystem conditions are unavailable. This is due, in part, to their size and the multitudinous nature of their management and use, which complicates standardized assessments of ecological condition and dynamics.

To test several novel hypotheses about invasion dynamics of Asian carps, I use fish community data, and other standardized data sources, collected 1993-present over 1200 km of the Upper Mississippi River System (UMRS) through the Long Term Resource Monitoring Program, an element of the Upper Mississippi River Restoration-Environmental Management Program. Hypotheses related to the functional ecology of the system and of extant fish communities, as well as environmental and river use management patterns will be explored and tested to infer contemporary patterns in Asian carp distribution throughout the UMRS basin.

Next steps or new research questions suggested:

None at this time.

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Ecological shifts in a large floodplain river during a transition from a turbid to clear stable state

P.I.(s) or Team Leader(s) & agency: S. Giblin (WDNR) and B.S. Ickes (USGS/UMRR-EMP LTRMP)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): not assigned to date

Covers progress from October 2013 to present

Progress/Results:

Fisheries (species and guild), water quality, and aquatic vegetation data have been assembled and formatted for analysis. Cross component canonical ordinations completed. Threshold response modeling is underway. Literature review is underway.

Presently considered “in analysis”.

Implications of results for river management and/or other research:

Ecological restoration can be defined as a set of intentional interventions that seeks to accelerate the recovery of an impaired ecosystem. Restoration ecology is the scientific discipline that supports the practice of ecological restoration. A key concept in restoration ecology is the idea that alternative stable states can exist, and that some states are more beneficial or favored than others. Generally ecological restoration concerns itself with shifting ecosystems from unhealthy states to more healthy ones. The science of restoration ecology concerns itself with understanding the functional processes and associations within the ecosystem so that informed management can be practiced upon the ecosystem to shift ecosystem state to more socially acceptable and ecologically healthy outcomes.

Ecological shifts between a clear, macrophyte-dominated stable state and a turbid stable state dominated by phytoplankton and high inorganic suspended solids have been well described in shallow lake ecosystems (Scheffer, 2004). Recent studies have documented the presence of alternate stable states among regulated rivers (Hilt et al., 2011). The majority of rivers worldwide are impounded and characterized by increased hydraulic retention time relative to free-flowing rivers (Hillbricht-Ilkowska, 1999). Long retention-time rivers can alternate between phytoplankton and macrophyte dominance (Hilton et al., 2006). Multi-decadal datasets such as the Long Term Resource Monitoring Program (LTRMP) dataset collected on the Upper Mississippi River (UMR) can provide unparalleled insight into these dynamics among regulated floodplain river ecosystems.

The positive relationship between submersed aquatic vegetation (SAV) and water clarity is well understood (Scheffer, 1998). The prevalence of SAV is known to drive a variety of ecological processes in aquatic ecosystems (Meerhoff et al., 2003). Proliferation of SAV can result in a variety of feedback mechanisms including: reduced sediment resuspension (James, 2004), reduced phytoplankton biomass via competition for nutrients and sinking (James and Barko, 1994), increases in invertebrate biomass (Engel, 1988), increased refuge for zooplankton (Schriver et al., 1995), increased denitrification (Weisner et al., 1994), production of allelopathic substances (Jasser, 1995), and increases in waterfowl abundance (Rybicki and Landwehr, 2007).

The presence or absence of SAV is one of the major factors driving fish community characteristics (Grift, 2001). Vegetated systems tend to be dominated by visual predators such as yellow perch and northern pike (Kipling, 1983). Piscivorous fish such as northern pike are often able to substantially reduce recruitment among planktivorous fishes (Sondergaard et al., 1997). This reduction in planktivorous fish can alter food webs and result in further increases in SAV and water clarity (Persson et al., 1988). Alternatively, benthivorous fish such as common carp tend to be abundant in turbid systems and can keep these systems in a turbid state due to resuspension during their feeding activities (Miller and Crowl, 2006). Once substantial populations of common carp and other benthivores are high, establishing SAV can become difficult due to poor water transparency (Havens, 1991).

This work will identify indexed functional relationships between water quality, aquatic plant, and fish responses over a 20-year period, over which each of these ecosystem attributes has varied notably. A primary objective is to identify management-relevant "thresholds" in responses. Thresholds represent changes in the relationships such that the relationship shifts to a new state or behavioral dynamic. Such thresholds, we surmise, will be incredibly important in considerations focused upon siting applied management projects throughout the UMRS.

Next steps or new research questions suggested:

Finalize threshold response modeling, draft methods and results. Begin preparations for one or more manuscripts.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

An Assessment of Changes in Fish Communities within Large River Ecosystems of the United States

P.I.(s) or Team Leader(s) & agency: (all are USGS staff) Craig Paukert (MO Coop Unit), David Ward (Grand Canyon), Jen Bayer & Jacque Schei (Pacific NW Aq. Monitoring Partnership), Barry Johnson (UMRR-EMP), Tim Counihan (Columbia River Lab), Elise Irwin (AL Coop Unit), Robb Jacobson (Columbia MO Lab), Andrea Ostroff (Reston, Core Science Analytics)

Funding Source(s): USGS

LTRMP Product Tracking Number (if applicable): None (included in FY13 SOW, but no tracking number)

Covers progress from Fall 2012 to January 2014

Progress/Results:

A number of large rivers in the U.S. have some form of fisheries monitoring. The project objective is to determine if data from these disparate programs can be used to compare whether fish communities and populations are structured similarly among rivers, whether they are changing in similar ways among rivers, and if changes can be related to similar environmental factors. We will also examine the monitoring programs and their sampling designs to formulate recommendations on how to implement large river monitoring to improve the potential for cross-system analyses.

Work began in fall 2012 with a workshop (funding for salary and travel provided by USGS). We identified 7 large river fish monitoring programs for possible inclusion in the study (Upper Miss, Missouri, Ohio, Illinois, Columbia, Colorado, and Coosa-Tallapoosa (Alabama)). We submitted a proposal to the USGS Powell Center for Analysis and Synthesis in spring 2013, which was not funded.

Implications of results for river management and/or other research:

Understanding how specific larger rivers are similar or dissimilar will help all river managers to understand their river and learn from others. This project should help us understand what kinds of data are useful for cross-system analyses, and how to implement river fish monitoring programs to enhance that capability. This concept is the basis for UMRR-EMP's interest in helping develop other large river monitoring programs, both nationally and internationally.

Next steps or new research questions suggested:

Based on reviews of the Powell Center proposal, some of the project PI's (funded by USGS) are looking at data sets from the Upper Miss (LTRMP) and Colorado River to explore the type of comparisons that would be possible. This information will be used to improve the proposal, then we will continue to look for funding. Progress will be reported to the Partnership.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Pool 12 Overwintering HREP Adaptive Management Fisheries Response Monitoring

P.I (s) or Team Leader(s) & agency: Dave Bierman, Mel Bowler, Kirk Hansen (Iowa DNR); Chuck Theiling (USACE, Rock Island)

Funding Source: UMRR

LTRMP Product Tracking Number: 2013B8 (Titled: Rehabilitation of backwater habitat in selected Pool 12 backwaters, not sure of FY14 Tracking Number at this time)

Progress/Results:

An adaptive management plan was developed to investigate fish response to backwater restoration (dredging) of several backwater lakes in Pool 12 in 2006. Iowa DNR Bellevue LTRM staff and other local Iowa DNR fisheries personnel have conducted pre-project monitoring studies (using LTRMP sampling methodology) since then to better understand fish use of backwaters during winter and their spring dispersal patterns to quantify preferred habitat conditions within backwaters, quantify the area of influence of restoration actions beyond restored backwaters, and determine appropriate spacing of future backwater restoration projects. Post-project monitoring will compare fish community responses in restored and control lakes and it will compare pool-wide fish community response in Pool 12 to Pool 13 which will not have additional restoration.

An annual increment of pre-project fisheries sampling, along with annual reporting of netting and electrofishing results from the Pool 12 Overwintering HREP project area will be completed in FY14. This includes otolith extraction for aging/sexing of bluegill from the project area to determine annual mortality, which has been ongoing since 2006. A summary report including this increment of data will be provided to program partners.

This HREP is nearing the construction phase, as the first lake (Sunfish Lake) will be dredged beginning in April 2014.

Scoped obligations to date are fulfilled, with other milestones to be met in FY14.

Implications of results for river management and/or other research:

The Pool 12 Overwintering HREP is being designed and implemented using active adaptive management principles to assess fisheries benefits beyond individual backwaters, whereas prior HREP monitoring considered condition and behavior within specific backwaters. This work is designed to specifically address long-standing questions related to the longitudinal spacing of fisheries overwintering HREP projects, which are very important questions to river managers. This project is also important because we will have several years of pre- and post-HREP project fisheries data, which will inform the adaptive management process that many river managers are interested in as the UMRR-EMP evolves.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

The pre- and post-dredging fisheries monitoring of this HREP will inform other river managers who are working on topics such as standardized HREP project sampling protocols, bluegill overwintering models, and research frameworks associated with aquatic overwintering issues in the Upper Mississippi River Basin. This work supports all overwintering projects undertaken by UMRR-EMP because it can help optimize the spacing of habitat restoration projects.

This work represents a uniquely intensive assessment of the local (individual backwater), backwater aquatic area (all backwaters within a navigation pool), and pool-scale (all aquatic areas within a navigation pool) effects of off-channel fish habitat improvement in a UMR pool. We intend to test the following hypothesis: Backwater rehabilitation as implemented through HREP projects on the UMR improves centrarchid population abundance, biomass, and fish available to the recreational creel at the individual-backwater, backwater aquatic area, and pool scale.

Next steps or new research questions suggested:

As the dredging work is completed (over the course of two to three years), the next increment of adaptive monitoring and management is to document fish dispersal from rehabilitated overwintering areas to estimate the area of influence these projects may support. This will be accomplished via continued fish community sampling post-project (netting and electrofishing) as well as radio tracking individual fish from each rehabilitated backwater. Individual fish will be radio-tagged in late fall/early winter after they have moved into the overwintering areas. Fish dispersal from these areas will be evaluated by tracking fish moving out from overwintering sites in the spring. Abundance, biomass, and condition of centrarchids will be evaluated from pool-wide and backwater fish community surveys.

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Relationship of Weed Shiner and Young-of -Year Bluegill and Largemouth Bass Abundance to Submersed Aquatic Vegetation in Navigation Pools 4, 8, 13 of the Upper Mississippi River, 1998-2012

P.I.(s) or Team Leader(s) & agency: S.A. DeLain and W.A. Popp (MN DNR)

Funding Source(s): LTRMP

LTRMP Product Tracking Number (if applicable): Technical Report 2014-T001

Covers progress from 2010 to 2013

Progress/Results:

Aquatic vegetation provides food resources and shelter for many species of fish. This study found a significant relationship between increases in submersed aquatic vegetation (SAV) in four study reaches of the Upper Mississippi River (UMR) and increases in catch-per-unit-effort (CPUE) of weed shiners (*Notropis texanus*) and age-0 bluegills (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) when all of the study reaches were treated collectively using Long Term Resource Monitoring Program (LTRMP) vegetation and fish data for 1998–2012. The selected fishes were more abundant in study reaches with higher SAV frequencies (Pool 8 and Lower Pool 4) and less abundant in reaches with lower SAV frequencies (Pool 13 and Upper Pool 4). When each study reach was examined independently, the relationship between SAV frequency and CPUE of the three species was not significant in most cases, the primary exception being weed shiners in Lower Pool 4. Results of this study indicate that the prevalence of SAV does affect relative abundance of these vegetation-associated fish species. However, the poor annual relationship between SAV frequency and age-0 relative abundance in individual study reaches indicates that several other factors also govern age-0 abundance. The data indicate that there may be a SAV frequency threshold in backwaters above which there is not a strong relationship with abundance of these fish species. This is indicated by the high annual CPUE variability of the three selected fishes in backwaters of Pool 8 and Lower Pool 4 when SAV exceeded certain frequencies.

Implications of results for river management and/or other research:

Changes in aquatic vegetation frequency can affect abundance of some fish species and cause a shift in relative frequency within the fish community. The major shift in the relative frequency of weed shiners in Pool 8 and Lower Pool 4 encouraged us to investigate in a separate study other fish community changes during this period of abundant aquatic vegetation.

River managers and researchers have long had an interest in using the UMR Long Term Resource Monitoring Program (LTRMP) water quality, aquatic vegetation, and fish data for exploring relationships among hydrological, physical, chemical, and biological variables. However, because the LTRMP sampling design for each ecological component was developed independently and at different scales and frequencies, some questions remained about whether the design was sufficiently robust to allow for investigation of significant relationships among the variables of two or more components. The gradual increase in SAV in the early to mid-2000s in the two segments of Pool 4 and Pools 8 and 13, following significant declines in the late 1980s through the early 1990s, provided an opportunity to determine whether a relationship could be established between the increasing abundance of weed shiners and other vegetation associated fish species and the prevalence of SAV.

Next steps or new research questions suggested:

Although this analysis has been completed, observation of the relationship between these and other vegetation-affiliated species and SAV will continue. The increased abundance of these species may occur with a concomitant decrease of more open-water species. There are some indications in the LTRM data of a recent decline in some riverine species, such as river shiners, in pools of the Upper Impounded Reach. The LTRM fish data set is the ideal tool to track these trends in UMR fish species abundance. Focused research to determine the mechanism driving species shifts should be pursued.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Population dynamics of invasive Asian carp in the La Grange Reach of the Illinois River

P.I.(s) or Team Leader(s) & agency: L. E. Solomon, R. M. Pendleton, A. F. Casper (INHS)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2014B6

Covers progress from November 2011 to present

Progress/Results:

This study seeks to assess population demographics (age, growth, recruitment, mortality) of Asian carps (*Hypophthalmichthys spp.*) within the La Grange Reach of the Illinois River. Since 2011, a total of 770 fishes (747 silver carp and 23 bighead carp) have been collected, weighed, measured, sexed, and postcleithra removed for aging. Age estimates from 2011 and 2012 have been completed with 2013 estimates currently ongoing. Data show that the sampled population of silver carp in the Illinois River during 2011 and 2012 consists of larger, 3 and 4 year old fish. Length frequency histograms appear similar among years, and in both years catch of larger (presumably older) and smaller (presumably younger) fish are minimal or absent from collections in all strata sampled.

Implications of results:

The arrival of Asian carp in the La Grange Reach of the Illinois River in the mid-90s has become a concern because of the significant potential to either mask gains or to cause degradation of environmental rehabilitation projects. While the potential is clear and significant, better information about the status and trends of Asian carps is needed to assess their true impact. Data collected by staff at the Illinois River Biological Station will aid in the understanding of the potential impacts of Asian carps and their influence on the Illinois River and Upper Mississippi River basin.

Next steps or new research questions suggested:

Data collection will continue annually during subsequent field seasons with existing methods as time and funding allow. All existing aging structures will be read and ages determined by 2 independent readers. Further analysis of the data will be conducted, including population dynamics (age, growth, recruitment, mortality), individual fitness (relative weight [Wr], as outlined by Nuemann et al. (2012)), and other metrics as determined by the P.I.s. These data, supplementing continuing Long Term Resource Monitoring Program (LTRMP) monitoring data, should help the U.S. Army Corps of Engineers and the Upper Mississippi River Restoration-Environmental Management Program (UMRR-EMP) better understand the relationship between Asian Carp population dynamics and factors like flood/drought events, potential changes in commercial fishing pressure, and habitat rehabilitation and enhancement activities.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Documenting the use of the Long Term Resource Monitoring Programs Fish Monitoring methodologies throughout the Midwest

P.I.(s) or Team Leader(s) & agency: L.E. Solomon (IRBS/INHS) and A.F. Casper (IRBS/INHS)

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable): 2013S3

Covers progress from February 2012 to present

Progress/Results:

The methods used by the UMRR-EMP's Long Term Resource Monitoring Program Fish Component could potentially have spread beyond the Upper Mississippi River System (UMRS) and have been adopted by other programs and biologists across the Midwestern U.S. This study attempted to quantify the use of these methods in the professional community.

A nine question survey was sent out electronically via SurveyMonkey.com to members of American Fisheries Society (AFS) State Chapter email list-serves and the Upper Mississippi River Conservation Committee (UMRCC). All states chapters from the AFS North Central Division and the UMRCC participated in distribution.

This survey reached ~2000 fisheries professionals through the state chapters and the UMRCC. Participation was ~11%. Results show that 95% of respondents use standardized methods of some kind, most being adopted from other projects or existing literature. 48% of all respondents were familiar with LTRMP Fish methods and 35% of all respondents had used the methods at some point in their career. 78% of all respondents who use the methodologies have modified them to suit their sampling needs.

Implications of results:

The results of this survey indicate that the LTRMP Fish Components methodologies have spread far beyond the LTRMP field stations and the UMRS. Respondents to the survey have indicated that the methods represent an easily useable, justifiable, and defensible way to sample fishes using multiple gears in multiple habitats. While we are unable to extrapolate results to the rest of the professional community (e.g. are 48% of *all* fisheries professionals familiar with LTRMP methods?), our results indicate that LTRMP methods have become an established and well known method to conduct fisheries research. Past efforts have been made to document spread and adoption of the methods, and this survey is another tool to use to capture the spreading of the LTRMP methods throughout the U.S and the world.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Next steps and future research:

Results of this survey are to be presented to the EMP-CC and subsequently summarized in a report. Results will also be presented at future meetings as time and funding allow. Future research should include a concerted effort to document all adoptions of LTRMP protocols that have been facilitated by those who work (and formally worked) under the UMRR-EMP. Unfortunately, a *complete* list may be impossible to complete as the methodologies have been published for nearly 20 years.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

Examining Age -0 Recruitment of Fishes from the Middle Mississippi River

P.I.(s) or Team Leader(s) & agency: John West, Quinton Phelps, Missouri Dept. of Conservation

Funding Source(s): UMRR

LTRMP Product Tracking Number (if applicable):

Covers progress from 1993 to present

Progress/Results:

This study sought to model recruitment of age-0 fishes in the Open River Reach.

Akaike Information Criterion (AIC) was used to identify the models that best describe recruitment for age-0 fish abundance based on the environmental variables of water temperature, river stage, and the interaction of river stage and temperature. This was attempted by using UMRR-EMP LTRMP fish component data sources, UMRR-EMP LTRMP water quality component data sources, and U.S. Army Corps of Engineers' historical river stage data.

Age-0 abundance of the commonly collected species Gizzard Shad, Freshwater Drum, Channel Catfish, Emerald Shiners, and White Bass were most related to the interaction of river stage and water temperature. Emerald Shiners and Gizzard Shad showed an asynchronous trend in recruitment with Gizzard Shad more abundant in a higher average river stages and Emerald Shiners more abundant in lower average river stages.

Implications of results for river management and/or other research:

River stage and water temperature are major influential factors that shape biotic communities in lotic systems. These environmental variables can influence community structure, recruitment, growth, as well as mortality. The Middle Mississippi River, added with unpredictable Mid-western weather patterns, can provide various spawning conditions for fish species that inhabit this stretch of river. . The successful or unsuccessful recruitment of certain fishes in the Middle Mississippi River System may be important in understanding the overall success of these species on a systematic scale.

Next steps or new research questions suggested:

Our data demonstrates that river stage and its interaction with temperature contributes to recruitment. Further investigation to determine the specifics of each variables specific contribution is needed. More fine-scale temporal resolution in rapid increases or decreases in river stages or water temperatures could further explain recruitment of fishes. Other determinant factors involving age-0 fish recruitment will include fish origin, habitat usage, abundance of adults, and predation presence and diet. Along with the 5 species already evaluated, additional species' age-0 fish recruitment will also be determined.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.

LTRMP-standardized electrofishing in Pools 19 and 20

P.I. or Team Leader: Jim Lamer, Manager Kibbe Field Station, Western Illinois University
Covers progress from: 2013-Present

We finished up our first year of LTRMP-standardized electrofishing this year over three time periods in pools 19 and 20 (MCB, SCB, CBW, IMP). Due to high water and waiting on the completion of our new electrofishing boat, we were not able to start sampling during the first time period until mid-July. Many pool 19 sites were inaccessible during low water including many MCB sites on the lower pool and the majority of CBW sites. This being our first year, we ended up jugging most of our small fishes to make sure we weren't missing anything and to build a robust reference collection. We are still finishing sorting and identifying all jugged specimens and hope to have all the data complete by mid-February.

Although the entire data set isn't complete yet, some anecdotal results are available. Centrarchid abundance and diversity is much higher in pool 19 vs. pool 20. A banded killifish was collected at a SCB site in pool 20 and several banded killifish were collected in pool 19 (seine haul MCB) which is a significant range extension for this species (closest populations collected in pool 15, 2012). Several age cohorts of Northern pike and yellow perch are found in pool 19, but none collected in pool 20. This data may indicate that Pool 19 is the furthest south range for populations of these two species. Although blue catfish are abundant in pool 20, we were only able to pick up one individual using electrofishing and none were collected above LD19. This is consistent with commercial fisherman reports indicating that blue catfish are rarely seen above LD19, making LD19 the northernmost range for this species as a result of the limited fish passage of LD19. The addition of hoop netting will likely enforce these findings. Western mosquitofish were collected in both pools, which indicate the northernmost detection (out of RTAs) of this species in appreciable numbers. Densities of Asian carp are much lower in pool 19 than in pools below LD19. One silver carp was collected at one site in pool 19 even though several more were observed jumping during sampling. I believe this is the first Asian carp collected in any RTA above LD19 during SRS sampling. The most common shiner species from both pools were emerald shiners, channel shiners, river shiners, Mississippi silvery minnows, spottail shiners, spotfin shiners, bullhead minnows, and golden shiners.

We hope to be able to continue sampling in 2014. Now that we have our protocols and methodology down, we'd also like to include wing dam, tributary mouth, and tailwater shockings into our sampling framework. Although, we were restricted to electrofishing this year, we hope to include additional gears in the future. Additionally, in cooperation with the Illinois DNR, we will be expanding our sampling effort into Pools 17, 18, and 21 on MCB sites only.

Non-citable. Any information in this document used for other purposes should acknowledge the principal investigator.