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28TH ANNUAL MEETING
APRIL 25-26, 1996
Holiday Inn
La Crosse, Wisconsin

Contents

PLATFORM PROGRAM SCHEDULE

THURSDAY, APRIL 25, 1996

07:15 AM Registration (Mississippi Room)

(* Indicates Student Presenter)

SESSION I - OVERVIEW
(MODERATOR: MARK SANDHEINRICH)

07:50 AM WELCOME AND INTRODUCTION: Mark Sandheinrich, President

08:00 AM FORECASTING THE FUTURE GIVEN CURRENT MANAGEMENT PRACTICES AND USE. Robert L. Delaney

08:20 AM SURFICIAL SEDIMENT CHARACTERISTICS IN POOLS 4 AND 8 IN THE UPPER MISSISSIPPI RIVER. James T. Rogala

08:40 AM A DATA CLEARINGHOUSE FOR THE UPPER MISSISSIPPI RIVER SYSTEM... PROVIDING PUBLIC ACCESS TO ECOLOGICAL INFORMATION. Norman W. Hildrum and Linda E. Leake

SESSION II - INVERTEBRATES
(MODERATOR: SANDRA BREWER)

09:00 AM INFESTATION OF *DREISSENA POLYMORPHA* ON LARGE PROSOBRANCH SNAILS IN THE OHIO RIVER. *Kim S. Greenwood, James E. Alexander, Jr., and James H. Thorp

09:20 AM GENETIC VARIATION IN *DREISSENA* SPP. POPULATIONS IN POOLS 19 AND 20 OF THE MISSISSIPPI RIVER. *N. Carol Krumanocker, Brian L. Sloss, Richard V. Anderson and Michael A. Romano

09:40 AM THE OCCURRENCE AND AGE STRUCTURE OF ZEBRA MUSSEL POPULATIONS IN POOL 19, MISSISSIPPI RIVER. *Melissa Morgan, Jill S. Cougill and Richard V. Anderson

10:00 AM THE DYNAMIC NATURE OF BENTHIC COMMUNITIES OF SHALLOW CHANNEL BORDER HABITATS IN POOL 19, MISSISSIPPI RIVER. *Bob Kennedy and Richard V. Anderson

10:20 AM BREAK

SESSION III - FISH
(MODERATOR: ROBERT HRABIK)

10:40 AM LABORATORY FEEDING TRIALS WITH BOWFIN: SUNFISH CONSUMPTION IN SIMULATED MACROPHYTE BEDS AND PREY PREFERENCES. *Christina M. Melnytschuk and Neal D. Mundahl

11:00 AM USE OF LOWER MISSOURI RIVER SCOUR HOLES AS FISH NURSERY AND THE INFLUENCE OF CONNECTIVITY. *John Kubisiak and David L. Galat

11:20 AM FISH MOVEMENT THROUGH DAMS ON THE UPPER MISSISSIPPI RIVER. *Scott R. Marecek and Joseph H. Wlosinski

11:40 AM A TEST OF AN ASPECT OF THE FLOOD-PULSE CONCEPT OF RIVER ECOLOGY BASED ON A MODEL OF FISH GROWTH. *Andrew D. Bartels, Steven J. Gutreuter, Mark B. Sandheinrich

12:00 PM LUNCH (On Your Own)

SESSION IV - THE GREAT FLOOD
(MODERATOR: JAMES FISCHER)

01:20 PM EFFECTS OF 1993 FLOOD ON POOL 26; A GEOGRAPHIC INFORMATION SYSTEM ANALYSIS. Thomas W. Owens and Yao Yin

01:40 PM FLOODING AND FOREST SUCCESSION IN AN OPEN STRETCH ON THE REGULATED UPPER MISSISSIPPI RIVER. Yao Yin

02:00 PM IMPACTS OF THE 1993 FLOOD ON THE MISSISSIPPI AND ILLINOIS RIVERS. David TaWei Soong

02;20 PM BREAK

SESSION V - BIRDS
(MODERATOR: EILEEN KIRSCH)

02;40 PM AVIAN MONITORING AND SPRING MIGRATION RESPONSE TO THE 1993 FLOOD ON MARK TWAIN NATIONAL WILDLIFE REFUGE. Kelly J. McKay, James P. Quinlivan, and Michael S. Bornstein

03:00 PM THE IMPORTANCE OF NATURAL TREE CAVITIES FOR NESTING BY WOOD DUCKS IN ILLINOIS. Aaron P. Yetter, Christopher S. Hine, and Stephen P. Havera

03:20 PM A REVIEW OF 15 YEARS OF ISLAND NESTING MALLARD STUDIES, CONCENTRATING ON POOLS 7 & 8, UPPER MISSISSIPPI RIVER. John F. Wetzel, John S. Nelson and Douglas R. Mroch

03:40 PM BIRD SPECIES RICHNESS AND ABUNDANCE IN BLUFF AND FLOODPLAIN FOREST HABITATS OF THE UPPER MISSISSIPPI RIVER WATERSHED. Knutson, Melinda G. , and Erwin E. Klaas

04:00-06:00 **POSTERS AND SOCIAL**

06:00-09:00 **BARBEQUE**

FRIDAY, APRIL 26, 1996

SESSION VI - MUSSELS
(MODERATOR: K. DOUGLAS BLODGETT)

08:00 AM	A 1994 SURVEY FOR UNIONID MOLLUSKS FROM THE HEADWATERS OF THE ROOT RIVER SYSTEM, SOUTHEASTERN MINNESOTA, TO THE MISSISSIPPI RIVER. **Marian E. Havlik**
08:20 AM	TEN YEARS OF SURVEY DATA OF THE LOWER AND MID CHIPPEWA RIVER BASIN. **Terry Balding, Dan Kelner, and Derrik Duchesneau**
08:40 AM	MUSSEL POPULATIONS IN POOL 15 OF THE UPPER MISSISSIPPI RIVER: A DECADE OF CHANGES, 1985-1995. **Scott D. Whitney, K. Douglas Blodgett, and Richard E. Sparks**
09:00 AM	HIGH STREAM TURBIDITY MAY COMPROMISE FRESHWATER MUSSELS' ABILITY TO ATTRACT FISH. **Mark C. Hove**
09:20 AM	**BREAK**

SESSION VII - MEDLEY
(MODERATOR: MARK ENDRIS)

09:40 AM	POPULATION DYNAMICS OF THE FINGERNAIL CLAM IN FOUR BACKWATER LAKES OF POOL 9, UPPER MISSISSIPPI RIVER. **Jim Eckblad, Jim Lee, Anne Timm, and Eric Merten**
10:00 AM	RELATIONSHIPS AMONG FLOW, WATER DEPTH, SEDIMENT TEXTURE, AND FINGERNAIL CLAM DENSITIES. **Randy Burkhardt**
10:20 AM	HABITAT USE AND MOVEMENT OF PADDLEFISH IN THE UPPER MISSISSIPPI RIVER. **Steven Zigler, Michael Dewey, Brent Knights, Mark Steingraeber, and Ann Runstrom**
10:40 AM	HABITAT UTILIZATION BY THE PALLID STURGEON (*SCAPHIRYNCHUS ALBUS*) IN THE MIDDLE MISSISSIPPI RIVER: PRELIMINARY OBSERVATIONS. **Robert J. Sheehan,** Roy C. Heidinger, Paul S. Wills, Michael Schmidt, and Greg Conover.
11:00 AM	**BUSINESS MEETING**
12:00 PM	**LUNCH AT THE HOLIDAY INN (Concourse)**

SESSION VIII - ZEBRA MUSSELS
(MODERATOR: MICHELLE BARTSCH)

01:00 PM	ESTABLISHMENT AND DISPERSAL POTENTIAL OF *DAPHNIA LUMHOLTZI* IN THE ILLINOIS RIVER. **James A. Stoeckel,** K. Douglas Blodgett, Lori Camlin, and Richard E. Sparks
01:20 PM	ZEBRA MUSSEL IMPACTS ON THE POTAMOPLANKTON: THE DIFFERENTIAL ROLES OF ADULT MUSSELS AND VELIGERS. J.D. Jack **J.H. Thorp,** and A.F. Casper.

01:40 PM FACTORS AFFECTING ZEBRA MUSSEL (*DREISSENA POLYMORPHA*) RECRUITMENT: SEASONAL THRESHOLDS IN LARGE RIVERS. **Andrew F. Casper,** R. Brent Summers, Tim Sellers, James H. Thorp and James Alexander

02:00 PM CHANGES IN ZEBRA MUSSEL DENSITIES IN THE UPPER MISSISSIPPI RIVER: 1995 UPDATE. **David C. Beckett,** B. Will Green, and Andrew C. Miller

02:20 PM GROWTH OF A LARVAL FISH (PIMEPHALES PROMELAS) IS SIGNIFICANTLY REDUCED BY THE PRESENCE OF ZEBRA MUSSELS AND TURBULENCE. **W. B. Richardson,** L. A. Bartsch, and M. B. Sandheinrich

02:40 PM **BREAK**

SESSION IX - HABITAT
(MODERATOR: MELINDA KNUTSON)

03:00 PM EFFECTS OF A DRAWDOWN ON VEGETATION IN POOLS 24, 25, and 26. **Joseph H. Wlosinski,** James T. Rogala, Thomas W. Owens, Laura L. Carnal, Kenneth Dalrymple and Dave Busse

03:20 PM ESTIMATING THE EXTENT OF SUITABLE WINTER HABITAT IN OFF-CHANNEL AREAS OF THE UPPER MISSISSIPPI RIVER SYSTEM. **David M.Soballe** and James T. Rogala

03:40 PM ISLAND CONSTRUCTION AS A RESTORATION TECHNIQUE IN THE UPPER MISSISSIPPI RIVER: FROM ARTIFICIAL ISLANDS TO SEED ISLANDS. **Robert F. Gaugush,** Jon Hendrickson, David Soballe, and Aaron Buesing

04:00 PM **ADJOURNMENT**

POSTER PRESENTATION SCHEDULE
Thursday, April 25, 1996
04:00-06:00 PM

(* Indicates Student Presenter)

EPIZOIC ORGANISMS OF UNIONID MUSSELS IN CHANNEL BORDER HABITATS OF POOL 19, MISSISSIPPI RIVER. **Richard V. Anderson and** Jennifer Eichelberger

DISTRIBUTION OF GIS DATA THROUGH THE INTERNET . **Lynne Arndt,** Dave Bergstedt and Carol Lowenberg

SEASONAL CHANGES IN INVERTEBRATE COMMUNITY STRUCTURE IN LAKE ECOSYSTEMS FOLLOWING TREATMENT WITH THE HERBICIDE FLURIDONE . ***Renae B. Besser, M.D. Delong, and N.D. Mundahl**

ICHTHYOPLANKTON USE OF LAKE ONALASKA ISLANDS COMPARED TO OFF-CHANNEL AREAS WITHIN POOLS 7 & 8 OF THE MISSISSIPPI RIVER DURING 1994 AND 1995. **Randy Burkhardt**

SEASONAL PATTERNS IN ABUNDANCE AND SIZE DISTRIBUTION OF ZEBRA MUSSEL VELIGERS IN THE ILLINOIS RIVER: 1994-1995. **Lori A. Camlin,** James A. Stoeckel, K. Douglas Blodgett, and Richard E. Sparks

SHORT TERM EFFECTS OF THE 1993 FLOOD ON FLOODPLAIN FORESTS:POOL 26, UPPER MISSISSIPPI RIVER. **Robert J. Cosgriff** and John C. Nelson

PREDATION ON ZEBRA MUSSELS *(Dreissena polymorpha)* BY COMMON CARP *(Cyprinus carpio)*. **Frederick A. Cronin,** John K. Tucker, and Dirk W. Soergel

EFFECT OF ZEBRA MUSSELS ON NATIVE INVERTEBRATE COMMUNITY STRUCTURE ON HARD SUBSTRATA IN THE UPPER MISSISSIPPI RIVER. ***Deric R.Deuschle,** M.D. Delong, and J.H. Thorp

DEVELOPING A CURRENT VEGETATION MAP OF THE UPPER MISSISSIPPI BASIN FROM LANDSAT THEMATIC MAPPER SATELLITE IMAGERY AND GIS DATA. **Daniel J. Fitzpatrick,** Pete Joria, and Frank D'Erchia

ANALYSIS OF LA CROSSE AREA MIGRATORY BIRD BANDING DATA FROM 1920'S TO PRESENT. **Lara R. Hill** and Mary A. Stefanski

FISH USE OF FLOODED AGRICULTURAL LAND ON THE LOWER MISSOURI RIVER DURING THE FLOOD OF 1995. **John B. Hooker** and David R. Galat

ORGANIC CARBON INTERACTIONS BETWEEN THE OHIO RIVER, GREAT MIAMI RIVER AND ASSOCIATED OXBOW FLOODPLAIN, SOUTHEAST INDIANA. * **Richard W. Koch** and Michael C. Miller

SHORT-TERM CHANGES IN THE SUBMERSED AQUATIC VEGETATION OF LAWRENCE LAKE IN POOL 8, UPPER MISSISSIPPI RIVER SYSTEM. **Heidi A. Langrehr**

DISTRIBUTION OF THE LONG TERM RESOURCE MONITORING PROGRAM DATA ON COMPACT DISK. **Carol Lowenberg**, Tom Owens, Lynne Arndt, Dave Bergstedt, Steve Hagendorn, and Linda Leake

PREDICTIONS OF WINTER HABITAT FOR SUNFISHES AND LARGEMOUTH BASS IN POOLS 8 AND 13 OF THE UPPER MISSISSIPPI RIVER. **David R. McConville**

AVIAN SURVEY OF THE SAVANNA ORDINANCE DEPOT BOTTOMLANDS, AN UPPER MISSISSIPPI RIVER FLOODPLAIN SITE. **Kelly J. Mckay**, Peter C. Petersen, and Brian L. Blevins

MACROPHYTE/INVERTEBRATE RELATIONSHIPS IN A CONTROL LAKE AND A LAKE CHEMICALLY TREATED FOR THE REMOVAL OF MILFOIL. ***Tim Mull**, M.D. Delong and N.D. Mundahl

PRESETTLEMENT AND EXISTING LANDCOVER CHARACTERISTICS OF POOLS 25 AND 26 OF THE UPPER MISSISSIPPI RIVER AS INTERPRETED FROM U.S. GOVERNMENT LAND OFFICE SURVEY RECORDS AND MODERN AERIAL PHOTOGRAPHY. **John C. Nelson**, Lynne Arndt, Janis Ruhser, and Larry Robinson

LTRMP COMPONENT DATABASE SPATIAL QUERY TOOL. **Douglas A. Olsen**

SAFETY OF FORMALIN AND HYDROGEN PEROXIDE TREATMENTS ON FISH EGGS. Jeff Rach, George Howe, Theresa Schreier, **Jeff Olson** and Steve Redman

A SURVEY OF THE UNIONID MUSSELS OR THE ILLINOIS RIVER: A RECOVERING RESOURCE ? Scott D. Whitney, **Darin Osland**, Douglas Blodgett, and Richard E. Sparks

GIS INTERPOLATION CONSIDERATIONS: WHY WOULD DATA NEED TO BE SURFACED, SHOULD DATA BE SURFACED, AND HOW SHOULD DATA BE SURFACED? **James T. Rogala**

CHARACTERISTICS OF A PADDLEFISH (*Polyodon spathula*) POPULATION FROM THE LOWER BLACK RIVER, WISCONSIN. **Pete Rust**

IDENTIFICATION AND CHARACTERIZATION OF SEASONAL PADDLEFISH (*POLYODON SPATHULA*) HABITATS IN UPPER MISSISSIPPI RIVER POOL 5A. **Mark T. Steingraeber and Ann L. Runstrom**

ZOOPLANKTON POPULATIONS AND THE EFFECTS OF FLOW VELOCITY ON THEIR DISTRIBUTION PATTERNS IN THE FINGER LAKES. **Tanya Stellmach**

ANNUAL CHANGES IN INVERTEBRATE COMMUNITY STRUCTURE IN RESPONSE TO MACROPHYTE REMOVAL BY THE HERBICIDE FLURIDONE. ***Russell L. Swanson, Michael D. Delong, and Neal D. Mundahl**

GIS-BASED DETECTION OF VEGETATION CHANGES IN BACKWATER AREAS OF POOL NO. 8, UPPER MISSISSIPPI RIVER. **Robin W. Tyser, Thomas W. Owens, Sara J. Rogers, and Larry R. Robinson**

EFFECTS OF ZEBRA MUSSELS (DREISSENA POLYMORPHA) ON AMPHIPODS IN ARTIFICIAL STREAMS. ***D.L. Vaughn, R. Brent Summers, and James H. Thorp**

AN *IN SITU* EXPERIMENTAL STUDY OF THE POPULATION DYNAMICS OF ZEBRA MUSSELS IN THE UPPER MISSISSIPPI RIVER. ***Thomas B. Ward, Michael D. Delong, and James H. Thorp**

ABSTRACTS OF PLATFORM PRESENTATIONS
(listed in order of presentation, * = student presenter)

FORECASTING THE FUTURE GIVEN CURRENT MANAGEMENT PRACTICES AND USE

Robert L. Delaney, National Biological Service, Environmental Management Technical Center, Onalaska, WI 54650.

The Mississippi River is by far the largest riverine ecosystem in North America; the river floodplain and deltaic plain total nearly 12 million hectares (30 million acres). Draining 41% of the contiguous United States, the river is one of the most significant environmental factors influencing the Gulf of Mexico. Valued as a natural, historical, cultural, commercial, recreational, and transportation resource, the Mississippi River has been a major influence on the development and settlement of the United States. Over the past 200 years, the Mississippi River and its floodplain have been—and continue to be—seriously degraded by massive water pollution, wetland drainage, deforestation, habitat destruction, water-flow modification, and floodplain development. Two of the most deleterious river modifications have been (1) the 90% reduction in the amount of seasonally inundated floodplain because of levee construction and (2) the alignment and maintenance of the navigation channel, which traverses 85% of the river's length. Altered hydrology and sedimentation patterns have progressed to the point that geomorphic processes have been severely disrupted.
Continued fragmentation of management responsibilities among and within government agencies hinders scientifically sound management of the river and floodplain. Given current management practices, policies, and use, the ecological condition of the river and its floodplain is expected to worsen.

SURFICIAL SEDIMENT CHARACTERISTICS IN POOLS 4 AND 8 IN THE UPPER MISSISSIPPI RIVER

James T. Rogala
Environmental Management Technical Center, 575 Lester Avenue, Onalaska, WI 54650

The accumulation of sediments in the Upper Mississippi River System is a major concern of many river resource managers. Therefore, understanding the distribution of sediment character and maps of sediment character are needed to better assess the problem. Previous mapping studies have been limited in spatial extent because expensive laboratory analysis was required to characterize sediments. However, methods to rapidly characterize sediments have been developed in an attempt to expand data collection over larger study areas. In this study, an *in situ* device was used to estimate sediment characteristics at 1,262 sites in Pools 4 and 8 based on a stratified random sampling design. In general, the moisture content, which is an indicator of fine sediment accretion, was lower than expected. The mean moisture content for both Pool 4 and 8 was less than 40 % and only the deep backwater stratum in Pool 8 had a mean moisture content greater than 60 %. The Pool 8 impounded area, often considered an off-channel habitat, had sediments with a low moisture content which did not differ significantly from main channel border or side channel areas. Only 5 % of Pool 4 and 10 % of Pool 8 backwater areas had sediments with moisture content of greater than 70 %. These findings suggest that flocculent sediments resulting from fine sediment accumulation are found in a only a small portion of the off-channel habitats in Pools 4 and 8. In order to provide a visual method for identifying spatial patterns in sediment composition, maps were generated in a Geographic Information System by interpolation.

A DATA CLEARINGHOUSE FOR THE UPPER MISSISSIPPI RIVER SYSTEM . . . PROVIDING PUBLIC ACCESS TO ECOLOGICAL INFORMATION

Norman W. Hildrum, **Linda E. Leake.**
Environmental Management Technical Center, Onalaska, WI 54650-8552

We are drowning in information, but starved for knowledge. - John Naisbitt

Established in 1986 as a multi-purpose science center, the Environmental Management Technical Center (EMTC), in Onalaska, Wisconsin, manages the largest river-related inventory, monitoring, research, spatial analysis, and information sharing program in the United States. A major activity at this National Biological Service (NBS) Science Center, is the multi-agency Federal-State Long Term Resource Monitoring Program (LTRMP). Physical and biological data collected through the LTRMP are being used to help assess the potential effects of natural and human-induced activities on the 1300-mile Upper Mississippi River System (UMRS) ecosystem. In addition, EMTC staff members are actively involved in other research and technical efforts relating to navigation, biodiversity, and resource management. One legislative mandate of the LTRMP is to ensure that high quality data and information about the river system are readily accessible to resource managers and decision makers. The EMTC established a World Wide Web site in July 1994 *(http//www.emtc.nbs.gov)* and provides free access to high-quality data and information about the UMRS and related areas in seven adjoining midwestern states. *By January 1996, this web site had been visited by individuals from all 50 states and 53 foreign countries.* Over 100,000 "hits" were recorded from August 1995 to December 1995. The EMTC web site offers information on fish, vegetation, macroinvertebrates, water quality, water levels, aerial photography, satellite imagery, scientific publications, and geographic information system data. Because the UMRS has regional, national, and international significance, the EMTC web site has become a key node in a major NBS effort to establish a National Biological Information Infrastructure. This paper discusses the development of the data clearinghouse and illustrates how the public may access ecological data and information.

INFESTATION OF *DREISSENA POLYMORPHA* ON LARGE PROSOBRANCH SNAILS IN THE OHIO RIVER.

Kim S. Greenwood, James E. Alexander, Jr., and James H. Thorp
Large River Program, Dept. Biology, University of Louisville, Louisville, KY 40292.

We examined the levels of infestation of zebra mussels on two species of snails (Prosobranchia: Pleuroceridae) in five navigation pools of the middle reach of the Ohio River. Using SCUBA, *Lithasia obovata* , *Pleurocera canaliculatum*, *Lithasia armigera* and the infesting mussels were collected at several depths to determine densities, size, and AFDM. Artificial streams and laboratory experiments were used to examine the effects of infestation on snail mobility. Infestation increased with depth and size of snail. *L. obovata*, which only occurs at shallow depths, has experienced low levels of infestation, while *Pleurocera* and *L. armigera* have been found to carry as much 5x their own weight in mussels. Heavy levels of infestation result in a decrease in speed, especially under conditions of low flow and warm temperatures. When compared to uninfested individuals of the same size and population, infested snails have lower AFDM. It appears that infestation will have chronic effects on the snail population, such that numbers may be reduced slowly through time by lowering the fitness of individuals and possibly reducing their ability to reproduce.

GENETIC VARIATION IN *DREISSENA* SPP. POPULATIONS IN POOLS 19 AND 20 OF THE MISSISSIPPI RIVER.

N. Carol Krumanocker, Brian L. Sloss, Richard V. Anderson and Michael A. Romano
Dept. of Biological Sciences, Western Illinois University, 1 University Circle, Macomb, IL 61455

Collection of *Dreissena polymorpha* in the summer and fall of 1995 revealed a variety of shell morphologies at 5 collection sites in pools 19 and 20 of the Mississippi River. Sympatrically collected individuals possessed distinguishing phenotypic differences leading to the conclusion that 2 species of *Dreissenid* were present at each site. Some individuals were rounded ventroposteriorly, had a much more rounded ventral surface with little or no ventrolateral shoulder or ridge, had a higher dorsoanterior slope or winglike extension, possessed a white or black stripe across the middle of the shell from the umbone toward the posterior end, and a difference in the color pattern or marks between the ventrolateral and dorsolateral sides. This description is consistent with previous documentation of *D. bugensis*. Other individuals had an angulate ventroposterior margin, an arched and flattened ventral surface with an acute shoulder or ridge ventrolaterally, consistent with *D. polymorpha*. Starch-gel electrophoresis was used to further investigate the possibility that shell morphologies were due to the presence of more than 1 species. Preliminary electrophoretic data from 11 presumptive loci are consistent for the presence of the 2 mussel species at each sampled site. Allelic variation at key diagnostic loci (*Pp, Pgm, Mdh*) in combination with corresponding phenotypic variation suggest the presence of the "quagga" mussel, *Dreissena bugensis*, in the mid-reaches of the Mississippi River.

THE OCCURRENCE AND AGE STRUCTURE OF ZEBRA MUSSEL POPULATIONS IN POOL 19, MISSISSIPPI RIVER.

Melissa Morgan, Jill S. Cougill and Richard V. Anderson, Dept. of Biological Sciences, Western Illinois University, Macomb, IL 61455

Pool 19 of the upper Mississippi River had remained relatively free of zebra mussels until 1994 as indicated by annual surveys at standard sampling locations within the pool. During the 1994 sampling, zebra mussels were present in samples collected from 3 of the 5 sites within the pool. All of the sites were in the lower reach of the pool. In 1994, density of the zebra mussels, where they were collected, was less than $5/m^2$. By 1995 all sites had large populations of zebra mussels with densities at some sites in excess of $50,000/m^2$. Surveying the same habitat type, channel border, there was an upstream to downstream density gradient, with higher zebra mussel densities occurring in the lower reaches of the pool. Frequency of infestation on native unionid mussels was higher at sample sites with coarser substrates and closer proximity to the channel. Infestation density varied between unionid species. Thin shelled species that may burrow more deeply into substrates had very low infestation densities. Consequently heavier shelled unionids which usually have more of the posterior of the shell exposed above the substrate had the highest infestation densities. As many as 3 cohorts were present in the zebra mussel population by mid September with the middle cohort having the highest number of individuals. There was some within pool variation in cohort density which may reflect small differences in habitat characteristics. There is some indication that infestation frequency and density may be lower in shallow channel border areas of previously vegetated habitat, and these sites may serve as a refuge for unionid mussels.

THE DYNAMIC NATURE OF BENTHIC COMMUNITIES OF SHALLOW CHANNEL BORDER HABITATS IN POOL 19, MISSISSIPPI RIVER.

Bob Kennedy and Richard V. Anderson, Dept. of Biological Sciences, Western Illinois University, Macomb, IL 61455

The benthic macroinvertebrate community and fingernail clam populations in particular of Pool 19 channel border habitat have fluctuated dramatically over the past 50 years. As sediment accumulated in the habitat, aquatic macrophytes covered more area and changed the density and composition of the benthic community. The link between aquatic macrophytes and the location and density of benthic macroinvertebrate communities was based on circumstantial evidence derived from an evaluation of long term data sets on location and densities of the communities. As a result of the 1993 flood, all aquatic macrophytes were removed from the pool. Subsequent sampling has shown benthic communities similar to those found in nonvegetated channel border habitat are colonizing previously vegetated habitats. These colonizing invertebrate communities are reaching densities similar to the peak densities, 100,000 organisms /m^2, found in these habitats in the 1970s. A substrate dominated by silt and an organic content of 3 to 5%, support the highest invertebrate populations. However, aquatic macrophytes began to reestablished themselves in the habitat in 1995. As the macrophyte densities increase, the benthic community dominated by fingernail clams and burrowing mayflies was displaced. The substrate composition has not changed significantly, but oxygen levels and water quality have declined as a result of accelerated decomposition processes due to the high productivity of the aquatic macrophytes. Though the aquatic macrophytes may provide a particulate organic matter food source for the invertebrate community, plant growth may alter the environment sufficiently to eliminate the burrowing benthic community. Since many fish and waterfowl depend on this invertebrate community as a food source, changes which reduce invertebrate population levels may effect other animal populations within the river system.

LABORATORY FEEDING TRIALS WITH BOWFIN: SUNFISH CONSUMPTION IN SIMULATED MACROPHYTE BEDS AND PREY PREFERENCES

Christina M. Melnytschuk and Neal D. Mundahl
Large River Studies Center and Department of Biology, Winona State University, Winona MN 55987-5838

Bowfin (Amia calva) were introduced into Lake Winona, MN, in 1984-1986 to control overabundant, stunted sunfish populations that developed when dense beds of submerged macrophytes appeared in the lake. Bowfin were expected to feed effectively on sunfish in the dense macrophyte beds, but bowfin numbers subsequently have declined dramatically and sunfish populations remain unaffected. This study was designed to examine the ability of bowfin to feed on sunfish (bluegill Lepomis macrochirus, pumpkinseed Lepomis gibbosus, green sunfish Lepomis cyanellus) in laboratory tanks in the presence of varying densities of simulated macrophytes, and to determine the food preferences of bowfin offered alternative prey (sunfish, fathead minnows Pimephales promelas, virile crayfish Orconectes virilis). Five adult bowfin (ages 4 to 7) captured from the Mississippi River were acclimated to laboratory conditions (individual 650-l tanks supplied with aerated well water flowing at 2.5 l/min, 16-18°C, 12 h light:12 h dark photoperiod) for approximately four weeks before beginning feeding trials. In a series of 48-h trials, bowfin captured similar numbers of sunfish (means = 6.0 and 5.2 fish, respectively) in empty and low macrophyte density (92 stems/m^2) tanks, but captured significantly (ANOVA, $P = 0.03$) fewer fish (mean = 1.2) in high macrophyte density (530 stems/m^2) tanks. In 1-h trials where bowfin simultaneously were offered two different types of prey (sunfish/fathead minnow, sunfish/crayfish, fathead minnow/crayfish) in empty tanks, bowfin displayed significant (Chi-square tests, $P < 0.01$) preferences for both fathead minnows and crayfish over sunfish. These experiments indicate that bowfin can eat significant numbers of sunfish, but prefer to feed on other types of prey when given a choice. Bowfin feeding performance, with sunfish as prey, declined dramatically when the density of simulated macrophytes increased to a level characteristic of Lake Winona weedbeds. If these same feeding patterns also are displayed by bowfin in Lake Winona, they may help to explain the lack of impact bowfin have had on sunfish in this lake over the past decade.

USE OF LOWER MISSOURI RIVER SCOUR HOLES AS FISH NURSERY AND THE INFLUENCE OF CONNECTIVITY.

John Kubisiak and David L. Galat, University of Missouri, Columbia, Missouri

Many riverine fish species require quiet backwaters for nursery areas early in their life history. The number and area of lower Missouri River off-channel habitats traditionally used as nurseries have been severely reduced by channelization and flood control measures. Floodplain scour holes created by the flood of 1993 may function analogously to natural backwaters, providing juvenile river fishes with a new source of rearing areas. Connectivity to the Missouri River channel is used to categorize scour holes into 4 categories: connected, seasonally connected, ditch connected and isolated. Near shore fish assemblages were collected by quantitative seining. Species composition, seasonal abundance and species richness of seined fish are compared among scour categories. Abundance and richness of fish collections increased as connectivity increased, with many typical riverine species dropping out of the catch in sites not receiving an influx of river floodwaters.

FISH MOVEMENT THROUGH DAMS ON THE UPPER MISSISSIPPI RIVER

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We analyzed the results from 89, mark-recapture and telemetry studies which were performed by others on the Upper Mississippi River as part of an investigation on fish passage opportunities. Fish were marked in Pools 4 through 18 and 26. Studies included information for 15 species of fish; black crappie, white crappie, bluegill, northern pike, common carp, channel catfish, freshwater drum, flathead catfish, largemouth bass, paddlefish, sauger, shovelnose sturgeon, smallmouth bass, walleye, and white bass. The total number of fish marked in 59 of the studies was 62,618. Totals were not available for the remaining 30 studies. Less than ten percent of the marked fish were recaptured. No black crappie, white crappie, bluegill, northern pike, or common carp were found to move across a single lock and dam, either in an up or down direction. Of the total number of fish recaptured in all studies 4,594 (79.7%) were in the pool where the fish were initially marked, 712 (12.4%) moved upriver and 458 (7.9%) moved downriver. We also investigated the head differential between headwaters and tailwaters for each day a fish was at large. Unfortunately, most fish were at large for fairly long periods, so we could not pinpoint the head differential when the fish actually crossed a dam. The minimum head differential during the period when fish were at large was used to conservatively estimate fish passage opportunities. Of the fish moving upriver through dams 88.0% crossed with a head differential less than 2.0 feet. Of the fish moving downriver through dams 72.0% crossed with a head differential less than 2.0 feet. Only 3.9% of the fish that moved upriver did so when the head differential was at least 4.0 feet and 19.4% of the fish that moved downriver did so at that head differential. Of the walleyes, which made up 53% of the total number of fish that moved, 78% moved upriver through at least one dam. Of the walleyes that moved upriver, the majority crossed 1 to 5 dams. Ninety-one percent of the sauger, which made up 15% of the observations, also moved upriver through at least one dam. In contrast, 94% of the channel catfish, which made up 20% of the observations, moved downriver through at least one dam. Of the channel catfish that moved downriver, the majority crossed 4 to 9 dams.

A TEST OF AN ASPECT OF THE FLOOD-PULSE CONCEPT OF RIVER ECOLOGY BASED ON A MODEL OF FISH GROWTH

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The Flood-Pulse Concept (FPC) of river ecology asserts that the annual flood cycle is the primary determinant of the productivity of floodplain rivers. The FPC is so general that it cannot be tested in total. Our objective was to examine one aspect of the FPC using monitoring data from the Upper Mississippi River. We hypothesized that at least some fishes should be able to acquire measurable increments of additional energy associated with floods. We examined somatic growth responses, which measure net energy gain, of bluegills *Lepomis macrochirus* and black crappies *Pomoxis nigromaculatus* captured in Navigation Pool 8. We developed a new statistical model of fish growth to test for size-specific growth differences among the 1993 flood year, two typical years, and a drought year. The model is a generalization of the difference or differential forms of the Gompertz function. The mean growth responses of bluegills were significantly different ($P<0.01$) among years, and showed an ordered progression of slowest maximum growth during the drought to greatest maximum growth during the flood year. The mean growth responses of black crappies were only significantly different between the drought year and the pair of typical years ($P=0.01$). These results are consistent with the FPC.

EFFECTS OF 1993 FLOOD ON POOL 26: A GEOGRAPHIC INFORMATION SYSTEM ANALYSIS.

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The Pool 26 reach of the Upper Mississippi River has a rich set of spatial data that allows researchers to study effects of the 1993 flood on floodplain habitats. Data include elevation models, land cover/use datasets for several years between the years 1891 and 1994, levee locations, and extent of the 1993 flood. This study compared the 1989 (pre-flood) and 1994 (post-flood) land cover/use data, along with forest surveys to document the intermediate-term impacts of the 1993 flood. The study used spatial datasets and geographic information system software to model the extent of the flood and to compare the modeled effects with the actual effects. Suggestions are made for extension of these data and modeling efforts to other reaches of the Upper Mississippi River to provide information to river managers for use in their decision making.

FLOODING AND FOREST SUCCESSION IN AN OPEN STRETCH ON THE REGULATED UPPER MISSISSIPPI RIVER

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Decline of willow and cottonwood pioneer forest has been observed on many regulated North American rivers. The study area was an 80-km stretch on the Upper Mississippi River 21 km above the mouth of the Ohio River, where the river has been locked in a fixed position by flood-protection levees, navigation structures, and navigation-related dredging activities for over six decades. Prior to a large flood disturbance in 1993, willow and cottonwood were regenerating poorly. The structure of saplings indicated that the extent of willow and cottonwood pioneer forest would decline further. The 1993 flood killed over 32% of the trees, over 77% of the saplings, and nearly 100% of the seedlings that existed prior to the flood and, consequently, interrupted the ongoing trend of succession. In the aftermath of the flood, seedlings of hardwood species occurred abundantly. Newly recruited seedlings were dominated by willow and cottonwood at nearly half of the sites investigated. Because of their ability to grow rapidly under openings, willow and cottonwood seedlings will likely outcompete other soft hardwood species in growing into overstory. Under such an assumption, it was estimated that the current extent of willow and cottonwood pioneer forest have a 69-99.8% chance of not declining further because of infrequent flood disturbances. The study implies that even under strongly regulated river environment, infrequent natural hydrological events may still be the dominant environmental factor in the dynamics of floodplain forests.

IMPACTS OF THE 1993 FLOOD ON THE MISSISSIPPI AND ILLINOIS RIVERS

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The Illinois State Water Survey (ISWS) and the Illinois Environmental Protection Agency (IEPA) conducted a joint research to investigate impacts on the Mississippi and Illinois River from the 1993 Flood. Selected water and sediment parameters include: inorganics and organics in water (CORE1 and PEST1 groups in IEPA's ambient water quality program), organics in sediment (CORE3), and nutrients and metals in sediment (CORE4.) Data were collected from Fulton, Keokuk, Locks and Dam 26, and Thebes on the Mississippi River and Valley City and Hardin on the lower Illinois River. Data collection period started from December 1993 to June 1994. The results showed that concentrations of many water quality parameters were below detection limits during this period. For those showed detectable values, their concentrations were below established standards. These parameters were chloride, sulfate, alkalinity, and TKN in CORE1; and alachlor, atrazine, cyanazine, and metolachlor in PEST1. On the other hand, it was noted that other parameters that did not show detectable values during this period had registered appearances before the Flood. Comparisons to historical data (defined as the data from their first value till March 31, 1993) identified several new maximums and new minimums in water and sediment quality parameters. In addition, there were consistent reductions in concentrations of sediment quality parameters at Keokuk and L&D 26. One possible explanation to these changes could be associated with the sediment redistribution occurred during the 1993 Flood.

AVIAN MONITORING AND SPRING MIGRATION RESPONSE TO THE 1993 FLOOD ON MARK TWAIN NATIONAL WILDLIFE REFUGE

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To permit an assessment of avian species composition, relative abundance, habitat associations, and long-term population trends on the Mark Twain National Wildlife Refuge, a point-count monitoring project has been initiated on two divisions of the refuge's Wapello District. Avian diversity and abundance have been surveyed during spring migration at the Big Timber Division from 1992-1995. Additionally, beginning in 1993, breeding season and fall migration surveys were also conducted here. The Big Timber Division is a backwater complex contiguous with the Upper Mississippi River (UMR) in Pool 17. This unit is dominated by a mature floodplain forest. Through 1994, we have identified 113 species at Big Timber, including 53 species of Neotropical Migrants (NTM). In 1993 we also began surveying the Keithsburg Division, during both migrational and breeding periods. Keithsburg is a backwater complex separated from, but adjacent to, the UMR (Pool 18) by a levee system. This division is characterized by an early successional floodplain forest. In two years (1993-1994) we have observed 124 species at Keithsburg, including 48 NTM species. Due to the record flood of 1993, we have been provided with an opportunity to examine the immediate response of the avian community to the flood event. Initially we have analyzed only spring migration data from Big Timber, during the pre-flood (1992), flood (1993), and post-flood (1994) years. Results indicated greater numbers of individuals were observed following the flood, while species diversity declined. Although not statistically significant, we suggest that these differences in diversity and abundance may be biologically important, and are possibly due to increasing numbers of some habitat generalists. Future comparisons will be possible between the Keithsburg and Big Timber avian communities, as well as a more in depth examination of the avian response to prolonged flooding on the UMR. Our project has demonstrated the importance of UMR floodplain forests to the midwestern avifaunal community.

THE IMPORTANCE OF NATURAL TREE CAVITIES FOR NESTING BY WOOD DUCKS IN ILLINOIS.

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The abundance and use of natural tree cavities suitable for nesting by wood ducks *Aix sponsa* was studied at Sanganois Conservation Area in central Illinois during springs 1994 and 1995. We inspected 264 natural cavities located in 97 0.5-ha sample plots, 80 (30.3%) of which were classified as suitable wood duck nest sites (suitable cavities). Suitable cavity density was 2.12 cavities/ha (SE = 0.23) of palustrine forested wetland. Suitable cavity producing tree species were silver maple *Acer saccharinum*, eastern cottonwood *Populus deltoides*, willow *Salix spp.*, red ash *Fraxinus pennsylvanica*, and American sycamore *Platanus occidentalis*. Minimum estimates of wood duck nest densities in natural cavities were 0.21 (SE = 0.06) and 0.12 nests/ha (SE = 0.05) in 1994 and 1995, respectively. In 1994, wood ducks used pileated woodpecker *Dryocopus pileatus* cavities as nest sites in greater proportion than their availability. In both the 1994 and 1995 nesting seasons, wood ducks utilized natural cavities with smaller entrance widths and entrance lengths as well as those in forest stands with larger basal areas. Raccoons *Procyon lotor* were identified as the primary predator of wood duck nests, and simple estimates of nest success were 33.3 percent in 1994 and no hatched nests in 1995 for a combined estimate of 21.4 percent. Raccoon predation influenced wood duck nest site selection in natural cavities on the area. Protracted flooding in fall of 1992, the Great Flood of 1993, and spring of 1995 caused a 42.7 percent mortality of suitable cavity trees on the area.

A REVIEW OF 15 YEARS OF ISLAND NESTING MALLARD STUDIES, CONCENTRATING ON POOLS 7 & 8, UPPER MISSISSIPPI RIVER

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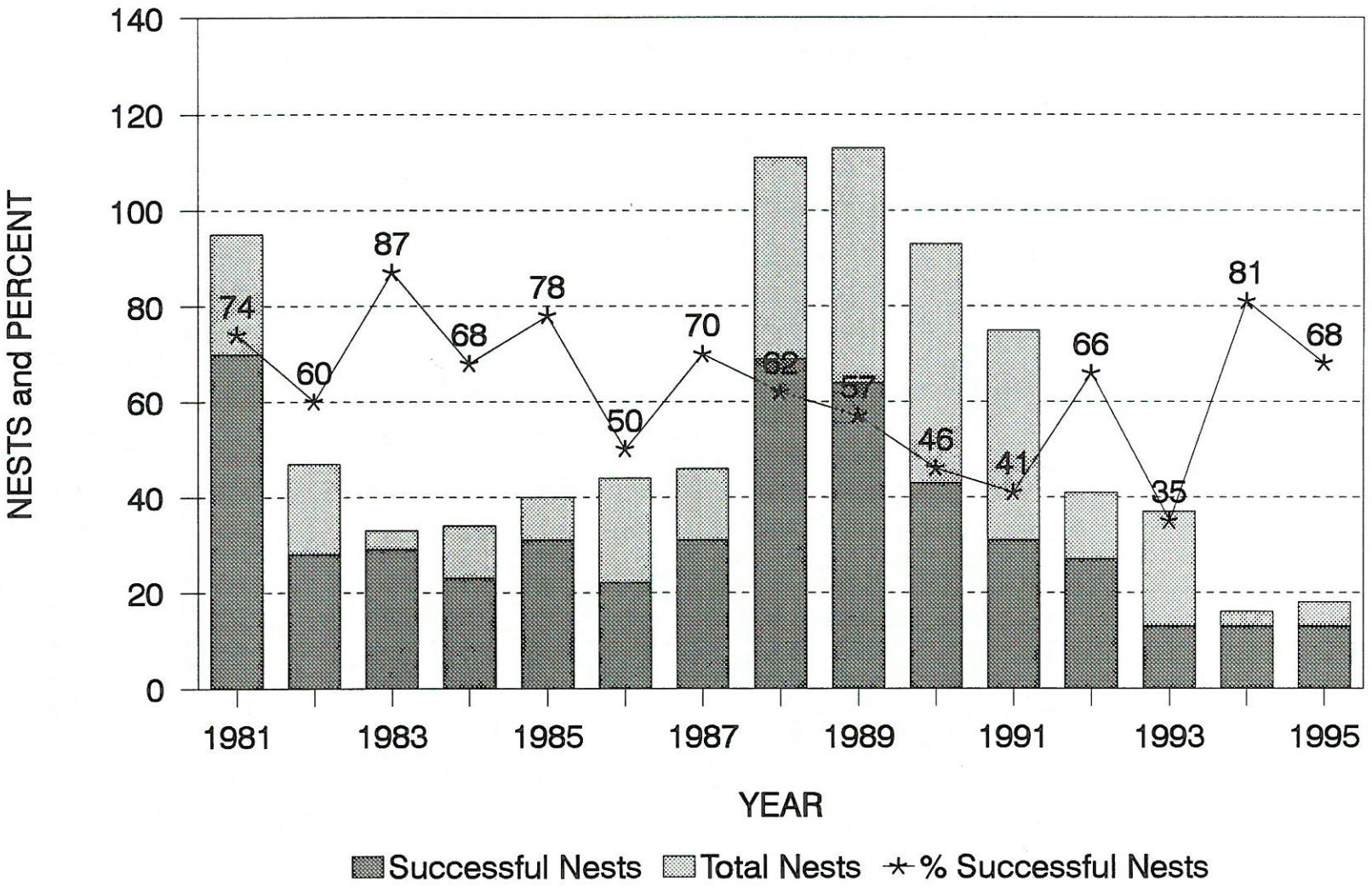
Studies of mallards nesting on small, isolated islands in the Mississippi River (MR) were begun by the Wisconsin DNR in 1981. Objectives included determination of the range of MR nesting; formulation of long-term waterfowl management strategies; and assistance with collateral studies - hen homing rates, duckling survival, etc. Mallards have nested as far south as Pool 24. Pool 8 nesting attempts ranged from 16-113 (Ave. 56) on 5 islands and success rates from 35%-87% (Ave. 61) from 1981-1995, Figure 1. These success rates are outstanding when compared with many upland nesting situations which have ranged from less than 10% to over 30% nest success with many falling below the approximate population stability level of 15%. A high of 46 nests/acre (2.4 total acres) was found in 1989 on the 4 smaller Pool 8 nesting islands. In 1994, 14.5 nests/acre were found on 5 Pool 7 islands (10.8 acres) and over 100/acre have been found elsewhere on the River. Thus, mallards will "crowd" onto small, isolated nesting islands while upland densities typically average only one nest per 5-10 acres. After a steep 50% drop between 1981 to 1982 (reason unknown), nesting attempts remained stable on Pool 8 (33-47) through 1987, Figure 1. The dramatic 141% increase in 1988 has been attributed to a redistribution of nesting birds to the MR as drought left little water elsewhere. High nesting attempts through 1990 left us speculating both on potential new heights as well as causes for an eventual decline - spectacular flood, unexpected high predation rates, etc. The severe 81% drop in nests (1990-1995, Figure 1) on Pool 8 and data from a 1991-1993 duckling survival study undertaken by Mr. Kevin Kenow and Dr. Carl Korschgen (NBS) provided an unexpected answer. The large loss of emergent brood cover (60%:30%:10% - 1985:1991:1995, respectively) in an adjacent 2,400 acre brood area, resulted in a low 15% fledgling rate for ducklings - a value that cannot support population stability. In 1992, we began investigating the importance of island "isolation" for attracting nesting birds in addition to providing mammalian predator-free nesting space. Using selected criteria (⅛ mile from other land forms and 1/10-15 acres in size), we randomly selected 14 study islands (complexes) in Pools 4-11. A 1-mile radius water::land "Isolation Ratio" was calculated for the area around each island. It was found that islands having ratios ≥4::1 (80% water) and 2-3 acres in size attracted the most mallards and had the highest nests/acre. This Isolation Ratio or "Visibility Index" has been further investigated for first versus later nesting attempts. Using data from Pools 7 and 8 for 1993 and 1995, 117 of 190 nests (62%) were judged to be second (or later) attempts. Thus, the "visibility" (lack of other confusing choices) of predator-free islands for nesting birds is important not only for attracting first nesting attempts but also for second attempts. Second (or later) nesting attempts can provide over 50% of the total use and greatly increase duckling production. Major nest losses have been attributed to three factors. Foxes have been marooned on isolated islands during ice-out; avian predation can be high when nesting cover is poor; and human disturbance has resulted in high nest abandonment. Preliminary analysis of the costs for establishment of nesting islands on the MR indicate that costs per fledged duckling ($105-$154) are comparable to that found in the prairie pothole region (up to $200/duckling). WPA purchase/development can be 3 times as expensive. A model for high use, high success nesting islands on the UMR includes: 1) Isolation Ratio of ≥4::1 (water::land); 2) Proximate to good brood cover; 3) Size range of ½-3 acres; and 4) Adequate nesting cover - grass or shrubs.

Figure 1: Mallard Nesting Summary

Pool 8 Study Islands 1981-1995



BIRD SPECIES RICHNESS AND ABUNDANCE IN BLUFF AND FLOODPLAIN FOREST HABITATS OF THE UPPER MISSISSIPPI RIVER WATERSHED.

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The landscape of the Driftless Region of the Upper Mississippi River watershed is characterized by rolling hills dominated by oak-hickory woodlands and agriculture. The adjacent floodplain of the Upper Mississippi River is broad, with large tracts of floodplain forest dominated by silver maple. The floodplain forest tracts are sinuous and bordered by marsh and open water. Point count censusing was used to characterize how the bird community changes across forested land from the broad Mississippi floodplain to the base of upland bluffs, midbluff, and high bluff habitats. We found that the bird community differs between the upland and floodplain forests in species present, species richness, and relative abundance of species present in both habitats. Prothonotary warblers and red-shouldered hawks were found exclusively in the floodplain while blue-winged warblers, scarlet tanagers, ovenbirds, wood thrushes, and rufous-sided towhees are more common in the uplands. Ground-nesters were less common in the floodplain than in the uplands. The presence of both types of habitats in close proximity increases the regional (gamma) diversity of bird species over locations where large floodplain forests are absent. Census data can be used to appropriately target new research to assess the reproductive success of selected species within an ecoregion.

A 1994 SURVEY FOR UNIONID MOLLUSKS FROM THE HEADWATERS OF THE ROOT RIVER SYSTEM, SOUTHEASTERN MINNESOTA, TO THE MISSISSIPPI RIVER.

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Thaddeus Surber (1924) walked 1000 miles to conduct a fish survey of the Root River system, southeastern Minnesota, but he made no mention of unionids even though he commented on other aspects of the River. Since the Root River has never been surveyed for unionids, we sampled from 6 - 17 June 1994 at 117 bridge and road access sites between the Root River system headwaters and the Mississippi River. The main stem of the Root River starts just NE of Lanesboro, MN, at the confluence of the North and Middle Branches, and flows easterly to its confluence with the Mississippi River, between La Crescent and Brownsville, MN. Sampling consisted of wading and shoreline searches in the headwaters and middle reaches of the Root River, and shoreline searches by boat of the lower six miles from Hokah, MN, to the river's mouth. This survey, including the main stem and four major tributaries, yielded 16 unionid species. Only three species were found alive, represented by five living mussels: *Venustaconcha e. ellipsiformis* (Conrad, 1836), Ellipse (3), and *Lampsilis radiata luteola* (Lamarck, 1819), Fatmucket (1) were found at a South Branch site, 0.5 mi N of Etna, MN, and one *Anodontoides ferussacianus* (Lea, 1834) Cylindrical Papershell, was found at a North Branch site, 4 mi NW of Dexter, MN. Several species were represented by fresh-dead shells. The most species (12) were found in the North Branch, Root River among 22 sites; the most shells were found in the South Branch among 40 sites (nine species). Eleven species were found among eight sites on the Middle Branch. No trace of unionids was found on the South Fork, Root River. The most common species found both dead and alive, *Venustaconcha e. ellipsiformis*, also lives in the Cannon and Zumbro Rivers of southeastern Minnesota, but apparently was not found in western Wisconsin for over 60 years, until 1992 -1994, when it was found in a tributary of the Chippewa River, near Cadott, WI. Data show severe impacts to the Root River system. We were unable to pinpoint the precise impacts, but our preliminary conclusions are that cumulative impacts, primarily agricultural, are apparently responsible. Since the Zebra Mussel is exploding in the Mississippi, we must quickly identify tributary molluscan fauna, or risk losing unique populations before they can be identified. We hope have funding to finish areas not sampled in 1994, including portions of the North Branch, South Branch, Root River main stem, and selected creeks, prioritized from Surber's descriptions. We also sampled sites on the nearby Upper Iowa (2) and Little Iowa Rivers (8), for a total of 127 sites. Project funded by MN Nongame Tax Checkoff Program.

TEN YEARS OF SURVEY DATA OF THE LOWER AND MID CHIPPEWA RIVER BASIN

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From 1985 to 1995 we used wading, snorkeling, a glass bottom bucket, and SCUBA to qualitatively sample each 1 or 2 km segment of a 288 km (178.8 mile) reach of the Chippewa River and 82 km (50.9 mile) of selected reaches of some tributaries. We have identified 30 species from among over 25,000 shells that were examined. Of the 30 species, 7 are on the Wisconsin Rare and Endangered Species list: *Cumberlandii monodonta, Cyclonaias tuberculata, Plethobasis cyphysus, Quadrula metanerva, Simsonaias ambigua, Trirogonia verrucosa, and Venustachoncha ellipsiformis*. Quantitative data were also collected using 1/4 m^2 quadrat samples along transects that were systematically placed in certain reaches of the Chippewa and Flambeau Rivers. The highest density recorded was 256 live unionids/m^2 on the Flambeau Rivera and 104 live unionids for the Chippewa River. Other siginficant points of interest regarding abundance, distribution and species richness will be presented.

MUSSEL POPULATIONS IN POOL 15 OF THE UPPER MISSISSIPPI RIVER: A DECADE OF CHANGES, 1985-1995.

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During the past ten years mussel populations in Pool 15 have been subjected to a number of stresses, including (1) heavy commercial harvest, (2) pollution from both urban centers and nonpoint sources, (3) increased recreational and commercial navigation, (4) massive mussel die-offs, and (5) recent introduction of the zebra mussel. Since 1985, the Illinois Natural History Survey has evaluated the effects of these stresses on mussel populations by collecting quantitative information at two sites in Pool 15, an Illinois designated mussel sanctuary (Sylvan Slough, RM 485.8) and a commercially harvested bed (Case-IH, RM 488.5). The data collected were used to evaluate changes in species richness and abundance, recruitment, mortality, growth, and age structure at each location. The primary objectives of this study were to detect significant changes, identify possible causal factors, and formulate management recommendations designed to protect, preserve, and enhance mussel populations in this area and elsewhere. Unionid mussel populations in Pool 15 are extremely rich in both species diversity and abundance, with twenty-six documented species (Table 1) and average densities as high as 290 unionids/m^2. Pool 15 is also suitable habitat for three threatened and endangered mussel species. Over the past decade there has been a significant ($p < 0.001$) decline in mussel abundance at both Sylvan Slough and Case-IH. Unionid species show substantial differences in their recruitment patterns ranging from good recruitment every year to once during the past ten years. Overall unionid mortality reached 40% in 1985 during the unexplained mussel dieoff, but has since remained relatively low (1-4%). We estimate five commercial species required from 19 to 24 years to reach minimum commercial size limit and all reach sexual maturity at an average age of 7 to 8 years (Table 2). Zebra mussel density and infestation of native unionids have both increased significantly in the past two years. In September 1995, average density of zebra mussels was near 500/m^2 and nearly 50% of the unionids are experiencing some degree of infestation.

Table 1. Species collected from three sites in Pool 15 of the Upper Mississippi River during the 1994-95 survey by the Illinois Natural History Survey. Species for each site are shown in order of decreasing abundance (avg. density). Class refers to : A° = very abundant (> 20.01/m²); A = abundant (10.01 to 20.00/m²); C = Common (1.01 to 10.00/m²); UC = uncommon (0.34 to 1.00/m²); and R = rare (< 0.33/m²).

Sylvan Slough (485.8)			Case-IH (488.6)			Illiniwek (492.4)			Overall (Pool 15)		
Rank	Species	Class	Rank	Species	Class	Rank	Species	Class	Rank	Species	Class
1.	*Q. pustulosa*	A	1.	*Q. pustulosa*	A°	1.	*T. truncata*	A°	1.	*T. truncata*	A°
2.	*T. truncata*	C	2.	*T. truncata*	A	2.	*E. lineolata*	A°	2.	*E. lineolata*	A
3.	*E. lineolata*	C	3.	*A. plicata*	A	3.	*Q. pustulosa*	A	3.	*Q. pustulosa*	A
4.	*T. donaciformis*	C	4.	*E. lineolata*	A	4.	*A. plicata*	A	4.	*A. plicata*	C
5.	*Q. metanevra*	C	5.	*O. reflexa*	C	5.	*O. reflexa*	A	5.	*O. reflexa*	C
6.	*O. reflexa*	C	6.	*M. nervosa*	C	6.	*L. fragilis*	C	6.	*M. nervosa*	C
7.	*A. plicata*	C	7.	*Q. quadrula*	C	7.	*M. nervosa*	C	7.	*L. fragilis*	C
8.	*M. nervosa*	C	8.	*L. fragilis*	C	8.	*Q. quadrula*	C	8.	*T. donaciformis*	C
9.	*Q. quadrula*	C	9.	*T. donaciformis*	C	9.	*T. donaciformis*	C	9.	*Q. quadrula*	C
10.	*L. fragilis*	C	10.	*Q. metanevra*	UC	10.	*L. cardium*	UC	10.	*Q. metanevra*	C
11.	*P. cyphyus*	R	11.	*Q. nodulata*	UC	11.	*F. flava*	UC	11.	*L. cardium*	UC
12.	*Q. nodulata*	R	12.	*F. flava*	UC	12.	*P. grandis*	UC	12.	*F. flava*	UC
13.	*L. recta*	R	13.	*L. cardium*	UC	13.	*U. imbecillis*	UC	13.	*P. grandis*	R
14.	*L. cardium*	R	14.	*P. grandis*	UC	14.	*P. alatus*	UC	14.	*Q. nodulata*	R
15.	*U. imbecillis*	R	15.	*P. alatus*	R	15.	*Q. metanevra*	R	15.	*P. alatus*	R
16.	*P. alatus*	R	16.	*O. olivaria*	R	16.	*L. recta*	R	16.	*U. imbecillis*	R
17.	*F. flava*	R	17.	*L. recta*	R	17.	*A. confragosus*	R	17.	*L. recta*	R
18.	*P. grandis*	R	18.	*L. complanata*	R	18.	*L. complanata*	R	18.	*P. cyphyus*	R
19.	*L. higginsi*	R	19.	*S. undulatus*	R	19.	*O. olivaria*	R	19.	*L. higginsi*	R
20.	*A. ligamentina*	R	20.	*L. higginsi*	R	20.	*L. higginsi*	R	20.	*L. complanata*	R
21.	*A. confragosus*	R				21.	*A. ligamentina*	R	21.	*A. confragosus*	R
22.	*S. undulatus*	R				22.	*S. undulatus*	R	22.	*O. olivaria*	R
23.	*O. olivaria*	R				23.	*Q. nodulata*	R	23.	*A. ligamentina*	R
						24.	*C. monodonta*	R	24.	*S. undulatus*	R
						25.	*P. ohiensis*	R	25.	*C. monodonta*	R
									26.	*P. ohiensis*	R
A°=0: A=1: C=9: UC=0: R=13			A°=1: A=3: C=5: UC=5: R=6			A°=2: A=3: C=4: UC=5: R=11			A°=1: A=2: C=7: UC=2: R=14		

Table 2. Estimated number of years for five mussel species to reach (a) sexual maturity and (b) minimum commercial size limit in Pool 15 of the Upper Mississippi River.

(a) Age at sexual maturity

Species	n	Estimated years to maturity		
		Mean	Std.Dev.	Range
Amblema plicata	78	8.19	1.37	6 -12
Megalonaias nervosa	29	8.17	1.10	6 - 10
Quadrula pustulosa	12	7.17	1.19	5 - 9
Quadrula metanevra	38	7.58	1.81	8 - 11
Quadrula quadrula	28	8.36	2.00	8 - 11

(b) Years to reach minimum commercial size limit

Species	Minimum height		Estimated years to reach minimum height	
	(inch)	(mm)	1994-95	1987
Amblema plicata	2.75	69.85	19	24
Megalonaias nervosa	4.00	101.60	20	26
Quadrula pustulosa	2.50	63.50	19	17
Quadrula metanevra	2.50	63.50	24	22
Quadrula quadrula	2.50	63.50	18	18

HIGH STREAM TURBIDITY MAY COMPROMISE FRESHWATER MUSSELS' ABILITY TO ATTRACT FISH

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The United States has the greatest diversity of freshwater mussels in the world. The life history of most freshwater mussels is integrally connected with co-occurring fish species. Larvae (glochidia) of most freshwater mussels must briefly attach to a fish in order to metamorphose into a juvenile. Recent discoveries reveal interesting strategies mussels have developed to increase the likelihood that their young will encounter a fish. Three strategies include: development of specialized mantles which mimic fish or fish food, packaging larvae into food-mimicking packets called conglutinates, and broadcasting individual larvae into the water column. Increased turbidity and sedimentation are frequently cited as significant contributors to the decline of freshwater mussel species. Increased turbidity decreases a fish's visual range and subsequently the mussel's ability to attract it through mantle-waving behaviors or conglutinate presentation. Deposited sediment may smother glochidia lying on the stream bottom. Increased sedimentation and turbidity likely diminishes mussels' ability to bring glochidia in contact with fish, thus adversely affecting a crucial component of mussels' life history.

POPULATION DYNAMICS OF THE FINGERNAIL CLAM IN FOUR BACKWATER LAKES OF POOL 9, UPPER MISSISSIPPI RIVER.

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The benthic macroinvertebrate populations of four backwater lakes between River Mile 670 and 675 of Pool 9 are being studied to provide a better understanding of their population dynamics. Three hundred and fifty-two samples were analyzed during 1993 and 1994 and Musculium transversum were separated into adult (4 mm shell-length) and juvenile individuals. The ovoviviparous hermaphroditic adults were examined under a dissection scope for the presence of shelled-embryos. Juvenile population densities increased during the period from mid-June to mid-July (Figure 1), and the percentage of adults carrying shelled-embryos reached 80 percent during this period (Figure 2). There is a large early summer birthing, but birthing also appears to continue throughout the summer. Of 409 adults examined in 1993, 55% were carrying shelled-embryos, and of 628 adults examined in 1994, 65% were carrying shelled-embryos. The mean number of embryos per pregnant adult was 5.4 in 1993, and 8.7 in 1994. Comparisons between lakes, sediments, years, water levels, water temperatures, and other variables will be addressed as well as how these populations compare to others studied since 1976.

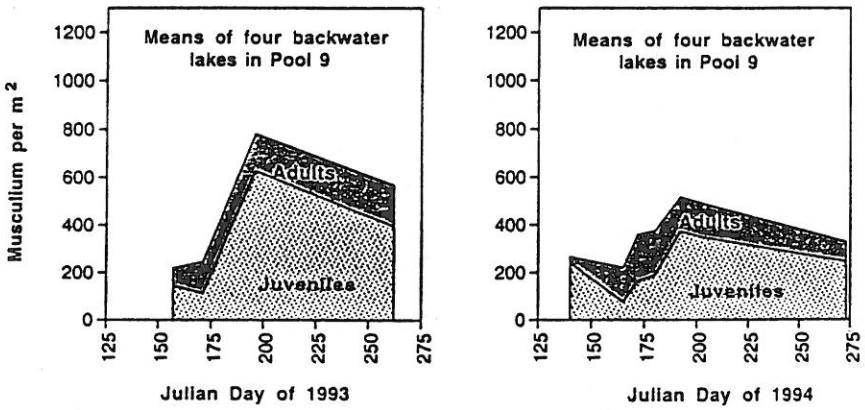

Figure 1. Population numbers of adults (shell-length ≥ 4 mm) and juvenile fingernail clams, *Musculium transversum*, from four backwater lakes during 1993 and 1994.

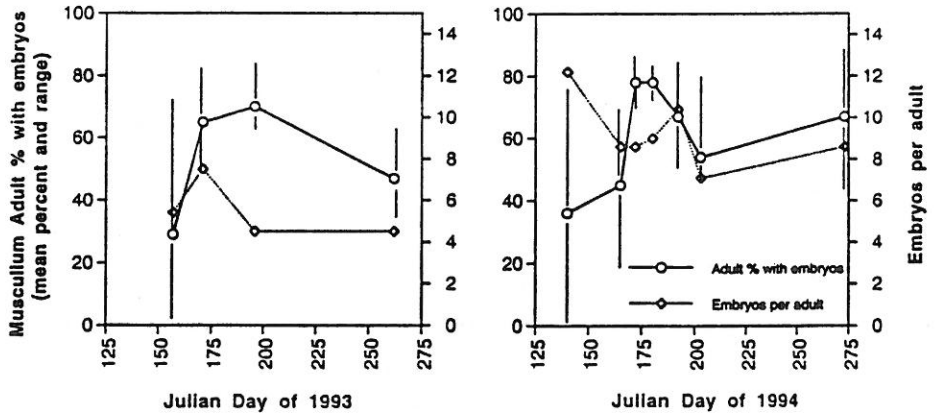

Figure 2. The percentage of adult *Musculium transversum* carrying shelled-embryos, and the mean number of shelled-embryos being carried during 1993 and 1994.

RELATIONSHIPS AMONG FLOW, WATER DEPTH, SEDIMENT TEXTURE, AND FINGERNAIL CLAM DENSITIES.

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The objectives of this study were to (1) explore the interactions among the physical conditions of sediment, water depth, flow, and the spatial distribution and abundance of fingernail clams (*Musculium transversum*) and (2) to develop and verify a model that predicts fingernail clam densities by combining a hydraulic model (FastTabs) with bathymetry coverages for Lake Onalaska. During 1995, six regions were defined in Lake Onalaska, Pool 7, Upper Mississippi River based on water flow and depth. Flows were calculated using the hydraulic model FastTabs (Corps of Engineers, St. Paul District) implemented for Lake Onalaska. Depths were calculated based on bathymetric data collected by the Environmental Management Technical Center. Forty eight sites were randomly selected within these regions and sampled using a standard Ponar (area = 0.052 m^2) during July 17 to 19 and resampled August 15 to 17, 1995. Sediment texture was determined from the top 5-cm of sediment obtained from 5-cm diameter core samples. Fingernail clams were enumerated within juvenile ($\leq$ 2 mm) and adult (> 3 mm) size classes. Significant differences in adult ($P = 0.37$) or juvenile ($P = 0.46$) densities were not observed among the regions during July. However, significant differences ($P = 0.01$) were found during August. Adult and juvenile fingernail clam densities in regions 4 and 5 increased significantly ($P = 0.01$) from July to August. Results from July suggest that fingernail clams in Lake Onalaska had no significant regional or sediment preference ($P = 0.49$). However, results from August suggest that regions with silt and sand/silt/clay were preferred over areas of sand. Favorable locations for fingernail clams were predicted with some accuracy (61%) using the FastTabs hydraulic model and bathymetry coverage. Detailed measurement of sediment characteristics over wide areas is too time consuming for widespread application. Further, sediment measurements alone do not account for additional effects of flow (water exchange). Thus, the FastTabs model may provide a tool for river managers to predict preferred areas for fingernail clams using more easily obtained measurements.

HABITAT USE AND MOVEMENT OF PADDLEFISH IN THE UPPER MISSISSIPPI RIVER

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Restoration of depleted paddlefish *Polyodon spathula* populations is a goal of several state and federal natural resource agencies. Knowledge of movements is important for defining the spatial scales for effectively managing paddlefish stocks and for evaluating the effects of habitat alterations, such as dams, on paddlefish. In 1994 and 1995, we evaluated movement and habitat use of paddlefish with radiotelemetry in Pools 5A and 8 of the upper Mississippi River, and in the Wisconsin and Chippewa Rivers. Paddlefish were tagged in the lower Black River (Pool 8, upper Mississippi River), in Pool 5A of the upper Mississippi River, near Caryville in the Chippewa River, and in the Wisconsin River below the Prairie du Sac dam. Many remained at these locations throughout the year. In spring, 1995 about half of the radio tagged paddlefish moved downstream up to 90 km in the Wisconsin and Chippewa Rivers, presumably for spawning activities. Paddlefish in Pool 8 remained in the upper portion of the pool throughout the spring. Paddlefish that moved downstream during spring returned in early summer. Diel studies conducted in Pool 8 during spring 1995 indicated greater movement at night ($\bar{x}$=525 m•h^{-1}) as compared to day ($\bar{x}$=212 m•h^{-1}), but use of habitat types did not differ among day, night, or crepuscular periods. While most paddlefish did not move great distances during summer, a few fish moved between 150 and 250 km from tributaries into the upper Mississippi River. In the lower portion of tributary rivers, which do not contain dams, paddlefish moved large distances upstream and downstream. In the upper Mississippi River, dams appear to be effective barriers to upstream paddlefish movement. Research studies are continuing to monitor seasonal patterns of habitat use and movement.

HABITAT UTILIZATION BY THE PALLID STURGEON (*SCAPHIRYNCHUS ALBUS*) IN THE MIDDLE MISSISSIPPI RIVER: PRELIMINARY OBSERVATIONS.

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Habitat use by Pallid sturgeon, listed as endangered in 1989, is not well known. Very little work has focused on their biology prior to or since their listing. Studies of their status indicate that they exist in small numbers and are probably hybridizing with a closely related species, the shovelnose sturgeon (*S. platorynchus*). It is likely that activities related to river channelization, aggregate dredging, or some other degradative processes may be limiting the spawning habitat available to either or both of these species, forcing an overlap in spawning areas. In addition, hybridization has lead to inconsistencies in the literature making difficult the identification of characteristics separating these two species. The habitats used by pallid sturgeon must be determined in order that those critical for spawning and overwintering can be avoided or enhanced in the future. Our studies, in conjunction with the Corps of Engineers and U.S. Fish and Wildlife Service, examine habitat use by pallid sturgeon using implanted ultrasonic transmitters and telemetry equipment to track movements throughout the winter, spring spawning period, and during the rest of the year. The ultrasonic transmitters being used emit at a much lower frequency, 40 hz, than those used by other researchers, allowing a high power transmitter with the longevity needed for greater than year-long studies of movements. The higher transmitter power translates into far greater range (about ½ mile) under the harsh acoustic conditions of the Mississippi river. Pallid sturgeon were obtained from commercial fishermen within the study reach of the middle Mississippi river, and implanted with the sonic transmitters. These fish are being followed throughout the year with efforts concentrated during the spring spawning period.

ESTABLISHMENT AND DISPERSAL POTENTIAL OF *DAPHNIA LUMHOLTZI* IN THE ILLINOIS RIVER

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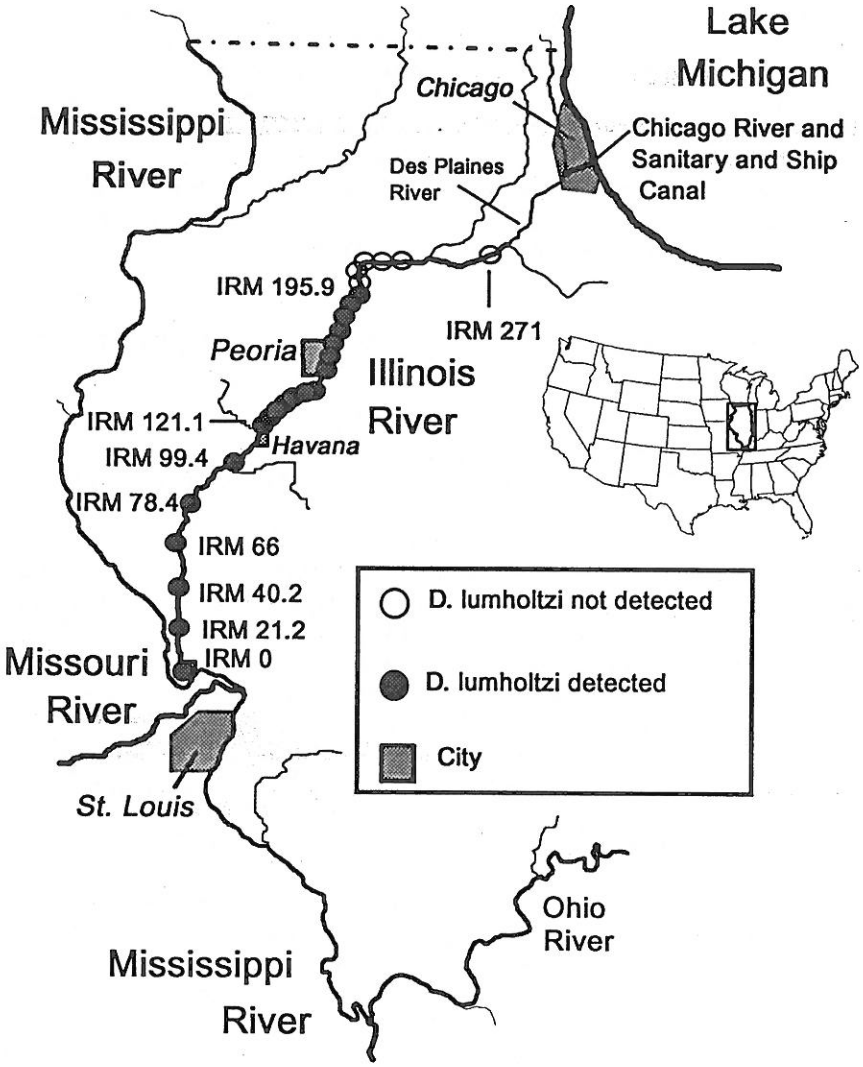
Daphnia lumholtzi, an exotic zooplankter native to Africa, Asia, and Australia, was first reported in North America after being collected from Texas and Missouri reservoirs in 1990 and 1991. Since then it has been found east to the coastal states, and is now spreading northward. In 1995, we found *D. lumholtzi* in zooplankton samples collected at IRM 121.1 near Havana, Illinois. This species was not detected in zooplankton samples collected in 1994, indicating 1995 as the year of initial establishment in the Illinois River. At IRM 121.1, this species was collected from June through October, and exhibited a peak abundance of 22.5 / L in early August. Abundances at this site matched or exceeded those reported from lakes and reservoirs in Illinois and Missouri, suggesting that *D. lumholtzi* may be adaptable to lotic as well as lentic systems. Sampling trips along the length of the Illinois River were conducted in order to determine the range of the main-channel population (Fig. 1). *Daphnia lumholtzi* were detected at all sampling sites from IRM 0 (confluence with the Mississippi River) to IRM 195.9 (near Henry, Illinois). The initial source of *D. lumholtzi* in the Illinois River was probably a backwater lake or tributary stream upriver of IRM 195.9. In light of the high abundances attainable in the main-channel habitat, and the connection of the Illinois River waterway with Lake Michigan, we believe invasion of the Great Lakes by this species may soon occur via the upriver transport of adults or ephippia in the bilge water of commercial and recreational watercraft. Dispersal into downriver waterways has already occurred. Even at the low abundance recorded at IRM 0 (0.1 / L), the Illinois River was delivering in excess of 19,000 individuals / second into the Mississippi River. It is not known whether *D. lumholtzi* was established in this part of the Mississippi River prior to the Illinois River invasion. Year-to-year sustainability of *D. lumholtzi* populations in the Illinois River and connected waterways is also unknown at this time.

Figure 1. 1995 sampling sites for *Daphnia lumholtzi* in the Illinois River



ZEBRA MUSSEL IMPACTS ON THE POTAMOPLANKTON: THE DIFFERENTIAL ROLES OF ADULT MUSSELS AND VELIGERS

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We conducted a series of *in-situ* experiments using potamocorrals to assess the impacts of zebra mussel adults and veligers on the plankton of the Ohio River. In the first experiment, adult mussels were suspended in the corrals at three different densities (0, 500, 2500 individuals) and incubated 7 days with daily plankton sampling. The presence of adult zebra mussels was correlated with a shift toward diatoms or a mixed diatom/bluegreen assemblage and a severe reduction in ciliates and some rotifers. Zebra mussel effects on larger zooplankton were taxon-dependant, but bacterial densities showed no trend between treatments. In the second, potamoplankton communities containing veligers were incubated in the presence or absence of the larger macrozooplankton. Zebra mussels will thus have varying impacts on the potamoplankton assemblages at different stages of their life cycle.

FACTORS AFFECTING ZEBRA MUSSEL (*DREISSENA POLYMORPHA*) RECRUITMENT: SEASONAL THRESHOLDS IN LARGE RIVERS.

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The strength of zebra mussel recruitment is often inferred from measurement of veliger densities, the implication being that veliger production levels eventually control the abundance and distribution of adult zebra mussels. However, the period when conditions are conducive to settlement can be short in comparison to that for veliger production. Data from the Ohio River in 1995 showed high levels veliger production beginning in early May, when water temperatures remain at or above 180C and lasting through September. However, young mussels (<4 mm) do not begin to appear in abundance until mid to late August. This difference between onset of production and significant recruitment suggests that a factor other than temperature limits recruitment. Discharge on the Ohio River drops from an annual peak in March to summer pool by late June. This seasonal decrease in discharge is accompanied by a heavy deposition of suspended sediment. With inorganic suspended sediment at a low and chlorophyll concentrations at a high, an optimal environment for initial settlement and growth is created. Summer pool conditions last from late July thru October. This is when most young of the year zebra mussels (<4 mm) first appear. This suggests that while heavy deposition may not affect veliger production, it can limit successful settlement and therefore recruitment into the population. Specific mechanisms may include physical burial of juveniles, clogging of the gills, or low food quality/availability. The occurrence of lower than normal winter precipitation may enhance chances of a strong recruitment whereas late spring flooding which can result in a poor year class recruitment.

CHANGES IN ZEBRA MUSSEL DENSITIES IN THE UPPER MISSISSIPPI RIVER: 1995 UPDATE.

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In order to monitor changes in zebra mussel density in the upper Mississippi River we have made yearly collections, since 1991, of rocks and their invertebrate fauna from two wing dams in Pool 10 near Prairie Du Chien (PDC). No zebra mussels were present in the wing dam samples in 1991 or in 1992. Zebra mussels were present in the wing dam samples in 1993, although in low densities. The wing dam collections in 1994 showed a marked increase in zebra mussel densities, e.g. 1994 had a mean of 118 *D. polymorpha* per m^2 of rock surface on the downstream side of wing dam #1, as compared to a density of 6 individuals per m^2 at the same site in 1993. Results from 1995 reveal a "population explosion" of zebra mussels has taken place in this portion of the upper Mississippi River. Zebra mussel densities on the PDC wing dams in 1995 were approximately 180 times those of 1994. Zebra mussel densities on the bottom of the east channel of the Mississippi River at PDC (where the sampled wing dams are located) were also very high in 1995; approximate densities were 50,000 to 75,000 individuals per m^2 of bottom. Our results therefore agree with similar studies, e.g. lock chamber studies, which show recent dramatic increases in zebra mussel densities in portions of the upper Mississippi River. In light of these dramatic increases in zebra mussel density, it is interesting to note that high densities of *D. polymorpha* are, at present, not a universal phenomenon in the upper Mississippi River. We sampled a wing dam in Pool 9 and one in Pool 11 in 1995 along with the sampling effort at PDC. Although zebra mussels were present on both of these wing dams, their densities were very low (e.g. the mean density on the Pool 9 wing dam equaled less than 10 individuals per m^2 of rock surface). It should be remembered, however, that zebra mussel densities on the PDC wing dams were very low two to three years ago, and it may take just a few years for zebra mussel numbers to build up on the wing dams (and other habitats) where they are presently scarce.

GROWTH OF A LARVAL FISH (*PIMEPHALES PROMELAS*) IS SIGNIFICANTLY REDUCED BY THE PRESENCE OF ZEBRA MUSSELS AND TURBULENCE.

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We know that the feeding activities of zebra mussels can significantly reduce both phytoplankton and zooplankton populations. Hypothetically, these reductions in water column trophic resources should result in reduced growth and survival of zooplanktivorous fishes. Several sets of mesocosm experiments previously conducted at the Upper Mississippi Science Center were designed to test this hypothesis. In these experiments, however, we used a facultative zooplanktivore, juvenile bluegills. Contrary to our predictions, bluegills grew better in the presence of zebra mussels because of their ability to switch to benthic prey when plankton became rare. The work we report here describes an experiment using a top predator that is an obligate planktivore (Pimephales promelas larvae) in early life stages then switches to benthic feeding as it matures (as do many fishes). In a 130-d mesocosm experiment we manipulated the presence or absence of (1) zebra mussels (5000/m^2), (2) larval fathead minnows (Pimephales promelas: 400/mesocosm), and (3) turbulent mixing (0-5 cm/sec). These factors were cross-classified, resulting in 8 treatment combinations, N=3. At the end of the experiment, total mass of fishes harvested from zebra mussel (=Z) or turbulence (=T) treatments was 20% less than that of fish-controls, and 40 % less in the Z+T treatment than in controls. Survival of fishes in the Z+T treatments was 50% less than that in controls. Individual fish from the Z+T treatments were significantly larger than those from other treatments. Turbidity, chlorophyll a concentration, and Daphnia and copepods densities were significantly reduced in Z, T, and Z+T treatments relative to controls. By the last date of the experiment (9/13/95) the fish in the Z+T treatment were ingesting mainly benthos (e.g. amphipods and isopods) while fish in all other treatments were ingesting mainly zooplankton (e.g. rotifers and Bosmina). We suspect that turbulent mixing facilitated increased removal of seston by zebra mussels (by increasing particle contact rates with zebra mussels) resulting in reduced available prey for the fish. Zebra mussels and turbulence also reduced the density of cladocerans, copepod nauplii, and rotifers, valuable as food for larval fishes. Also, turbulent mixing, at rates used here, has been shown to interfere with feeding processes of larval fish resulting in reduced growth. Finally, turbulent mixing in zebra mussel treatments appeared to increase accessibility of macroinvertebrates to larger fish, possibly by moving the invertebrates into the water column where they were consumed.

EFFECTS OF A DRAWDOWN ON VEGETATION IN POOLS 24, 25, and 26

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Water levels were held slightly lower than usual in 1995 by the U.S. Army Corps of Engineers, St. Louis District, as part of an experiment to improve ecological conditions on Pools 24, 25, and 26. The experiment was performed in cooperation with the Pool 25 Natural Resources Committee, an interagency group whose goal is to improve management of the Upper Mississippi River. Water levels were held at least 2-feet lower than the project pool elevation at Dam 25 for a 33 day period starting in mid-June, 1995. We integrated a hydrologic and spatial model for Pool 25 to predict areas that would be dewatered, thereby allowing for the possible growth of herbaceous vegetation. The model predicted that the area dewatered between the project pool elevation of 434.0 feet and the water level at drawdown covered 1,043 acres. The model predicted that areas just upriver of the dams would be affected most by water level manipulation. This area spanned about 8-miles upriver of the dam at discharges that occurred in June and July of 1995. Areas upriver of the 8-mile mark were also dewatered during the same period, but this was as a function of the decrease in discharge. As discharge changes in downriver portions of the pool, the dewatered area does not change, but at upriver portions of the pool the dewatered area does change. Vegetation surveys were performed at 20 dewatered sites. Millet was found at 80% of the sites, chufa (75%), smartweed (45%), pigweed (30%), rice cutgrass 20%, panicum (15%), and foxtail(10%). We also obtained aerial infrared photographs on July 27, 1995, at a scale of 1:15,000, for the lower stretches of the three pools where water levels were held lower than normal, and Pool 22, where no drawdown occurred. These photographs were interpreted, specifically searching areas near the water line that had signatures representing the above plants. The estimate of plants from photointerpretation, in the same 8-mile stretch of river that the model predicted dewatering, was 960 acres. We found that: (1) Acreages of plants with the above signatures were much greater in Pools 24, 25, and 26 than in Pool 22; (2) photo interpretation was a viable method to quantify results; (3) the amount of vegetation was much greater just upriver of the dam as compared to midpool or tailwaters, and 4) the Pool 25 model reasonably estimated areas of plant growth prior to actual manipulation.

ESTIMATING THE EXTENT OF SUITABLE WINTER HABITAT IN OFF-CHANNEL AREAS OF THE UPPER MISSISSIPPI RIVER SYSTEM.

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The construction of 28 dams on the Upper Mississippi River between 1913 and 1958, and similar activity on the Illinois River from 1933 to 1938 created a complex mosaic of semi-fluvial lakes and side channels that extends over 1500 km and provides critical habitat for numerous aquatic species and waterfowl. The limnological characteristics of this large, and highly diverse aquatic area have never been quantified in detail and conventional surveys over such an extensive area are not feasible with available resources. The study reported here is part of a larger effort by the Long Term Resource Monitoring Program (LTRMP) to estimate the spatial and temporal extent of sediment and limnological conditions in off-channel areas of the Upper Mississippi River System. The current study focuses on over-wintering habitat which may be a major limitation for some fish populations. Data from bathymetric surveys, aerial photography, geomorphometry, and stratified random sampling of water quality on Pools 4, 8, and 13 are combined to develop (1) a statistical estimate of habitat extent and (2) a spatially explicit model to predict probable locations of suitable habitat. Initial results indicate that suitable over-wintering habitat is rare, and varies dramatically among reaches and between years. Predicting the location and spatial extent of suitable habitat from more easily obtained measures (e.g. aerial photographs and geomorphometric relationships) shows promise.

ISLAND CONSTRUCTION AS A RESTORATION TECHNIQUE IN THE UPPER MISSISSIPPI RIVER: FROM ARTIFICIAL ISLANDS TO SEED ISLANDS.

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The Upper Mississippi River Environmental Management Program (EMP) comprises two major programs: (1) the Long Term Resource Monitoring Program (LTRMP) and (2) the Habitat Rehabilitation and Enhancement Projects (HREP). The HREPs involve site-specific projects constructed to address environmental concerns on the Upper Mississippi River System (UMRS). One type of HREP, island construction, has been carried out to address some of the environmental changes that have resulted from impounding the UMRS to support the 9-foot navigation channel. A major change that has occurred with impoundment is the loss of islands in the lower (downstream) sections of the navigation pools. Initially after impoundment, these areas exhibited a braided network of sloughs, secondary channels, and numerous islands. Subsequently, these areas have become relatively featureless as islands have been eroded and deeper portions, other than the main channel, have filled in. Island loss in Pool 8 has been particularly severe. In 1939, two years after impoundment, the area of islands was 253 ha and by 1989 the area had declined to 52 ha, a reduction of 79 percent. The lower portions of the navigation pools on the UMRS are now very wide, shallow, and exposed bodies of water. These conditions lead to highly turbid environments that support very little aquatic vegetation. In 1989, three small islands were created in Lake Onalaska (Pool 7, UMRS) in order to (1) reduce wind fetch and potentially reduce turbidity resulting from wind-driven resuspension of sediment, (2) isolate areas from the direct effects of river currents, and (3) create additional shoreline and shallow, near-shore habitat that would enhance production of aquatic vegetation, fish, and waterfowl. These islands were created from dredged material, fully shaped, and armored with rock and rock groins. Research analyzed the changes in hydrology, sedimentation, sediment distribution, wind and wave relationships, water quality, aquatic vegetation, and invertebrates in response to the physical presence of these islands. Results indicated that these islands have had a profound impact on the physical environment which, in turn, results in significant changes in the biota around the islands. Island construction has created relatively quiet areas downstream of the islands, with associated changes in water quality, sediment type and distribution, and vegetation when compared with areas not impacted by the islands. The success of the Lake Onalaska islands project lead to the development of the seed islands concept and its initial application in lower Pool 8 near Stoddard, WI. Seed islands are simple rock structures with the river providing a large portion of the energy and material to build an island. With funding from the U.S. Fish and Wildlife Service and the State of Wisconsin and associated with other island protection work in lower Pool 8, the U.S. Army Corps of Engineers was able to construct two seed islands in November 1995. Rather than being fully constructed as the Lake Onalaska islands, these seed islands are relatively small (< 70 m), linear rock structures laid out perpendicular to the advective flow. Research on these islands will document the rate of island growth, net sedimentation, and current velocity changes.

ABSTRACTS FOR POSTER PRESENTATIONS
(listed alphabetically by first author, * = student presenter)

EPIZOIC ORGANISMS OF UNIONID MUSSELS IN CHANNEL BORDER HABITATS OF POOL 19, MISSISSIPPI RIVER.

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Much of the channel border habitat in navigation pools of the Mississippi River has a soft silty substrate. As such it is not a good habitat for organisms which need a solid substrate on which to attach. Live unionid mussels which occur in this habitat provide an optimum type of epizoic substrate since their shells offer a hard surface and the mussels maintain their position at the water substrate interface, thus preventing attached organisms from being buried by sedimentation. Eighteen species of epizoic organisms were found on the surfaces of unionid mussels collected in mid to late summer. Other than zebra mussels, the dominant epizoic organism was the leptocerid caddisfly, *Oecetis*. Bryozoans and freshwater sponges were also common. Fish, insect, and other invertebrate eggs were also frequently present on shell surfaces. Of the 1200 mussels examined, over 70% contained epizoic organism. Mussel size and species was related to frequency of occurrence of epizoon. Small shells, less than 5 cm in length often had no epizoic organisms. The threeridge, *Amblema plicata*, had the highest frequency of epizoon with 96% of the shells over 5 cm in length containing attached organisms. The presence of unionid mussels in channel border habitat may significantly increase benthic community diversity in these areas.

DISTRIBUTION OF GIS DATA THROUGH THE INTERNET

Lynne Arndt, Dave Bergstedt, Carol Lowenberg. U.S. National Biological Service, Environmental Management Technical Center, Onalaska, WI 54650,

The Environmental Management Technical Center (EMTC) provides free access to a variety of geographic information system (GIS) data through its World Wide Web (web) Home Page (*http://www.emtc.nbs.gov*) and anonymous FTP site (*ftp.emtc.nbs.gov*). GIS datasets collected by the Long Term Resource Monitoring Program (LTRMP), the Upper Midwest GAP Analysis Program, and the Inland Waterways Mapping Project are accessible through the web site's Data Clearinghouse. The Data Clearinghouse uses interactive text pages and interactive graphics to locate and distribute copies of available GIS coverages, scanned images of the LTRMP's 1994 color-infrared aerial photography, spatial data applications, and metadata. The Web site also contains "links" to other GIS-related web sites.

SEASONAL CHANGES IN INVERTEBRATE COMMUNITY STRUCTURE IN LAKE ECOSYSTEMS FOLLOWING TREATMENT WITH THE HERBICIDE FLURIDONE

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The introduction of Eurasian water milfoil into Minnesota waters has led to the study of several alternatives for the removal of this exotic species. Two lakes were examined to determine monthly changes in invertebrate community structure in response to changes in macrophyte abundance following application of an herbicide intended to remove milfoil. Auburn Lake served as a control, while Lake Zumbra was treated with the herbicide fluridone in May 1994. Both lakes are located in north Carver County, Minnesota. Samples taken in 1994 (June, July, and August) from macrophyte beds of both lakes using a plastic tube with a sieve at each end. Samples were taken from three transects at depths of 1, 2 and 3 m, with three replicates taken at each depth. Results of MANOVA showed significant differences ($P \leq .0.05$) among the invertebrate densities between both lakes. The seasonal analysis showed varied patterns among the two sites. Invertebrate densities increased from June-August in Auburn Lake, whereas densities declined in Zumbra Lake over the same period. Differences in invertebrate community structure and variation in seasonal patterns were a result of the loss of macrophytes and milfoil following herbicide treatment in Zumbra Lake.

ICHTHYOPLANKTON USE OF LAKE ONALASKA ISLANDS COMPARED TO OFF-CHANNEL AREAS WITHIN POOLS 7 & 8 OF THE MISSISSIPPI RIVER DURING 1994 AND 1995.

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The objectives of this study were to (1) examine the relationships between physical and chemical conditions and spatial distribution, composition, and abundance of larval fish around the islands constructed in Lake Onalaska for the purpose of habitat restoration and enhancement and (2) compare them to off-channel areas. Daytime tandem larval fish tows (505 mm mesh) were conducted bi-weekly from May 3 to June 6 during 1994 and weekly during 1995 from March 21 until water temperatures reached 13° C (May 9) then bi-weekly until June 16. Nine off-channel areas (Marsh Lake, Mud Lake, and Lake Onalaska Islands of Pool 7, and Round Lake, Target Lake, Markel Lake, Lawrence Lake, Byers Lake, and Shady Maple of Pool 8) of the Upper Mississippi River were selected . Sites were randomly selected within each off-channel area. Larval fish were identified to family. Catostomids, centrarchids, clupeids, cyprinids, esocids, gadids, hiodontids, percids, sciaenids, and serranids were represented in the catch. Differences in relative species composition (% of catch) of larval fish communities between Lake Onalaska Islands and other off-channel areas during each year were tested using general linear models. Because sample sizes were unequal, Tukey's studentized range test was used to determine specific statistical differences among areas. Cluster analysis was used to evaluate similarities in community composition among off-channel areas. Analysis of 1994 and 1995 larval fish data indicates catostomid catches in Lake Onalaska were significantly greater ($P = 0.01$) than the remaining off-channel areas in both years. Percid catches were significantly lower ($P = 0.01$) in Lake Onalaska Islands when compared to Byers Lake (1994) and Lawrence Lake (1995). Freshwater drum catches in Lake Onalaska Islands were significantly lower ($P = 0.01$) than in Markel Lake during 1994. Catostomid relative abundance (% of catch) was significantly higher ($P = 0.01$) in Lake Onalaska and centrarchid relative abundance was significantly greater ($P = 0.01$) in Target Lake, Lawrence Lake, Round Lake, and Mud Lake than in the other off-channel areas for both years. Similarities in community composition were found between Lake Onalaska Islands, Lawrence Lake, Round Lake and Mud Lake during 1994 and Lake Onalaska Islands, Byers Lake, Markel Lake, and Marsh Lake during 1995. These results suggest that new habitats created by the construction of islands in Lake Onalaska are being used as nursery areas by most fish species commonly found in other off-channel areas.

SEASONAL PATTERNS IN ABUNDANCE AND SIZE DISTRIBUTION OF ZEBRA MUSSEL VELIGERS IN THE ILLINOIS RIVER: 1994-1995

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In river systems, an understanding of dispersal patterns of zebra mussel (*Dreissena polymorpha*) veligers can aid in the development of effective management strategies for adult zebra mussel populations. The main objective of this study was to determine veliger abundance and size distribution fluctuations throughout the year. This information will help us gain insight into locations of upriver source populations and potential downriver settlement patterns. From May 1994 through December 1995, zebra mussel veliger drift was monitored twice weekly at a single site on the Illinois River at Havana, Illinois (river mile 121.1). Veligers were collected by filtering a known volume of depth-integrated river water through a 60-µm plankton net. Veligers were identified using polarized light microscopy, then enumerated and measured using Optimas imaging and analysis software. In 1994, live veligers were found in all samples from May to October (Figure 1) when water temperatures were greater than 12 °C and sporadically from November to December when water temperatures were less than 12 °C. In 1995, veligers were found continuously from May to August (water temp > 12 °C), but sporadically in September and October (water temp > 12 °C). While the duration of spawning seasons differed, total veliger production was similar with an estimated 2.0×10^{14} and 2.4×10^{14} veligers drifting past our site in 1994 and 1995 respectively. Size distributions of veligers were also very similar, the average-sized veliger being 109.7 µm in 1994 and 109.0 µm in 1995. For both years, approximately 80% of veligers were between 95 and 135 µm (Figure 2). This suggests the majority of veligers we saw throughout our study were coming from the same upstream population(s). Locations of source and destination populations were estimated assuming a development time of 48 hours to reach D-stage at 95 µm, growth rates of 6-13 µm/day, a settling size of 180-250 µm, and an average flow rate of 0.5 m/s. Based on these assumptions, the majority of veligers passing our site were produced upriver of Illinois River mile (IRM) 185.2 and would settle downriver of IRM 37.9. Veliger abundances as high as 70 million/second indicated that the potential for significant settlement downriver from our site was high. While we saw little settlement in the lower Illinois River in 1994, significant settlement occurred in 1995. These populations suffered high mortality and virtually disappeared by fall 1995. If total veliger production follows the same pattern in coming years, potential for recolonization of downriver reaches will be high.

Figure 1. Water temperature and veliger abundance at IRM 121.1, 1994-1995.

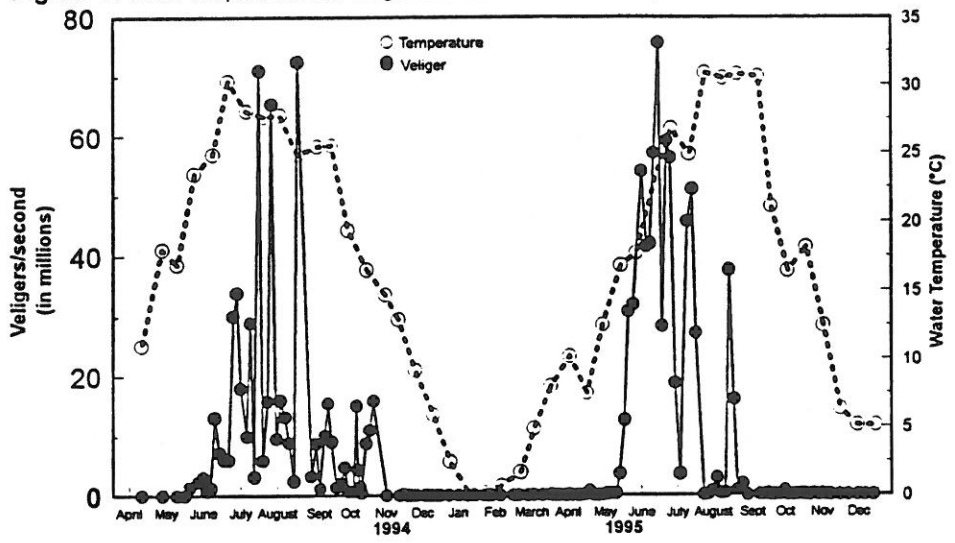
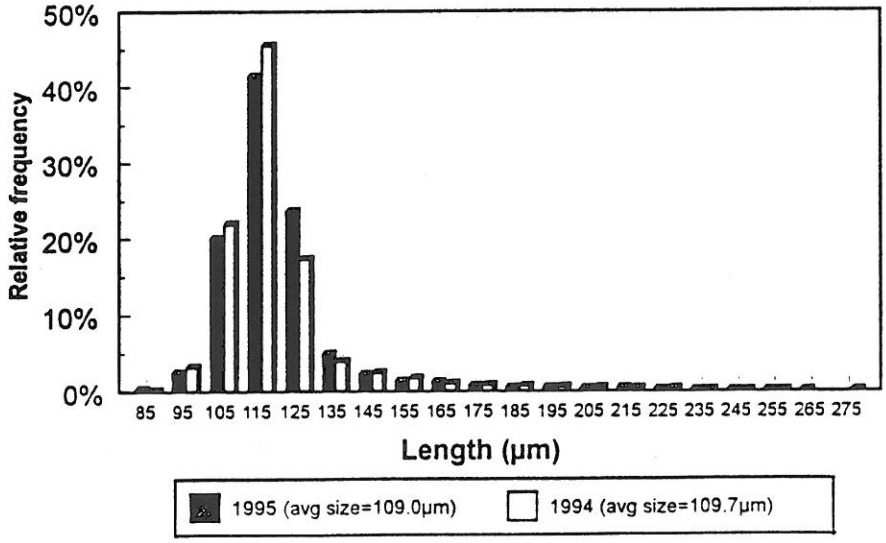


Figure 2. Size distribution of veligers in 1994 and 1995.



SHORT TERM EFFECTS OF THE 1993 FLOOD ON FLOODPLAIN FORESTS: POOL 26, UPPER MISSISSIPPI RIVER.

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The effects of extreme hydrologic events on biota in large river- floodplain ecosystems is highly theoretical, in part, because these disturbance events are so infrequent. In 1993, flooding on the Mississippi and Illinois Rivers rose to record heights. At the Pool 26 reach, the event was classified as a one in five hundred year flood. This unusual event presented a unique opportunity to examine the effects of extreme flooding on flood plain forests. A forest study was initiated in the summer of 1995 and 65 sites were randomly sampled and permanently established for future monitoring. A 10 meter radius plot was established at each site. Within each plot, we measured the dbh of trees and their combined canopy cover was measured. Within 0.5 m^2 subplots, tree seedlings were identified, counted and their coverage was determined. Similar measurements were obtained for herbaceous plants. Results indicate that oak-hickory communities dominated by pin oak (*Quercus palustris*) had the highest percent tree mortality while oak-hickory communities dominated by bur oak (*Quercus macrocarpa*) and overcup oak (*Quercus lyrata*) showed low percent mortality. Shellbark and shagbark hickory species (*Carya laciniosa* and *Carya ovata* respectively) showed high percent mortality on all sites. The maple-ash-elm forest type showed substantially lower tree mortality rates. Regeneration by oak and hickory seedlings was low on most sites while silver maple (*Acer saccharinum*) regeneration was high. On sites that showed increased tree mortality, seedling regeneration decreased while herbaceous vegetation increased. Herbaceous regeneration coincided strongly with forest mortality and the opening of the overstory canopy. The dominant herbaceous plants were tickseed sunflower (*Bidens aritosa*), great ragweed (*Ambrosia trifida*) and wild millet (*Echinochloa muricata*). The high mortality of pin oak and hickory and their low seedling regeneration raises questions about the future status of many oak-hickory floodplain forests. Their value as timber and wildlife forage make them important species to forest managers. If these communities have problems re-establishing, management practices such as planting may be necessary in order to insure their future on the floodplain.

PREDATION ON ZEBRA MUSSELS *(Dreissena polymorpha)* BY COMMON CARP *(Cyprinus carpio)*.

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We examined the gut contents from 31 common carp *(Cyprinus carpio)* collected at Mississippi River Mile 217 in late August 1995 for evidence of predation on zebra mussels *(Dreissena polymorpha)*. We found between 1 and 407 zebra mussel beaks in 83.9% of the fish we examined. For all fish examined, common carp contained 118.2 beaks per fish or about 59 zebra mussels per fish. Excluding fish that did not contain one or more beaks, we found 140.9 beaks per fish or about 70 zebra mussels per fish. The survey did not indicate that larger fish consumed more zebra mussels than smaller fish. Estimated valve length for zebra mussels consumed by common carp ranged from 1.48 to 42.52 mm with a mean 11.79 mm (SE = 0.10 mm). Individual variation existed among the 24 fish in mean valve length of zebra mussels consumed. We found that large fish tend to prey on larger zebra mussels than small fish. The general size range of zebra mussels consumed by common carp overlapped the upper portion of the size range of young-of-the-year zebra mussels living at the site and the lower portion of the size range of older zebra mussels living at the site. Other prey items found included fingernail clams *(Sphaeriidae)*, the asiatic clam *(Corbicula fluminea, Corbiculidae)*, and Lampsilis teres (Unionidae). Notwithstanding the possible impact that the common carp may have on zebra mussel demographics, our study bears directly on the controversy surrounding proposals to import other exotic molluscivorous fishes such as the black carp *(Mylopharyngodon piceus)* to effect long-term control of zebra mussel populations. If predation by the common carp is found to be widespread where zebra mussels are numerous, then there is no reason to import other fishes. Further studies of the common carp in other areas with high zebra mussel densities are critically needed.

EFFECT OF ZEBRA MUSSELS ON NATIVE INVERTEBRATE COMMUNITY STRUCTURE ON HARD SUBSTRATA IN THE UPPER MISSISSIPPI RIVER*

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The zebra mussel, *Dreissena polymorpha*, has entered the upper Mississippi River, and is expected to have an impact on the ecology of the river, as it has in the Great Lakes. The objective of this study was to examine between the zebra mussel and native invertebrate communities, and how invertebrate communities may change as zebra mussel densities increase. A total of 20 cages were placed in the main channel of the Mississippi River. Half of the cages were enclosed with 1.5-cm diameter mesh to exclude large fish, while the remaining cages were left open. Two types of substrata were used; one type consisted of 12 unglazed clay tiles, while the other type consisted of 12 bundles of willow branches. The two types were used to mimic natural rock, and snag substrate respectively. This combination of factors allows a total of 4 experimental treatments. Cages were placed into the river in June 1994. This report pertains to the second year (1995) of the study. One sample from each cage was removed monthly from June to October 1995. Preliminary analysis indicated that zebra mussel densities were highest on the tiles compared to the snags. Densities were also higher in the closed cages than the open ones. These two observations seem to indicate that zebra mussels are more successful on rocky areas, a substrate of limited abundance in the Mississippi River. Invertebrate communities showed marked changes as zebra mussel densities increase. Colonization by the mussels creates new micro-habitats that become favorable for some species, and detrimental to others. Community composition varied greatly in response to differing habitats. Chironomidae populations increased as zebra mussel densities increased. The numbers and variety of predator species (e.g. Odonata, Megaloptera) that feed on Chironomidae also increased.

DEVELOPING A CURRENT VEGETATION MAP OF THE UPPER MISSISSIPPI BASIN FROM LANDSAT THEMATIC MAPPER SATELLITE IMAGERY AND GIS DATA

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The Upper Midwest GAP Analysis Program is developing a current vegetation map of the region that includes Illinois, Iowa, Michigan, Minnesota and Wisconsin. An innovative methodology developed at the Universities of Minnesota and Wisconsin takes maximum advantage of existing ancillary GIS databases to facilitate multi spectral classification of Landsat Thematic Mapper imagery. Multi-date satellite images are stratified first by Ecological Classification System Subsections, and then by National Wetlands Inventory classes before being subject to analyst-guided clustering routines for signature identification. The objective is to produce a relatively uniform vegetation classification to The Nature Conservancy/UNESCO alliance level, across the entire region.

ANALYSIS OF LA CROSSE AREA MIGRATORY BIRD BANDING DATA FROM 1920'S TO PRESENT

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Bird banding is a universal and indispensable technique for studying the movement, survival and behavior of birds. The North American Bird Banding Program is jointly administered by the United States National Biological Service and the Canadian Wildlife Service. Since the 1920's thousands of birds have been banded and recovered on the Upper Mississippi River National Wildlife and Fish Refuge - La Crosse District (District) which encompasses Pools 7 and 8. This data has been stored at the Bird Banding Laboratory (BBL) in Laurel, Maryland and used to analyze bird populations and migrational patterns at a national level. But there is a need for wildlife managers and the public to understand the migrational patterns and survivorship aspects of migratory birds that utilize the District. For this poster we obtained over 70,000 band recovery records for Pools 7 and 8 from the BBL to examine for a localized perspective. Data was analyzed spatially using a geographic information system to display recovery locations of birds banded on the District, as well as where birds recovered on the District were originally banded. A data base application was used to evaluate species composition, age, migrational patterns and method of recovery of birds associated with the District. Preliminary analyses indicates that from 8,171 recoveries made from nine waterfowl species banded under federal permit on Pools 7 and 8, over 95% of the birds were recovered by hunting, and 60% of the recoveries were from birds less than one year old. It was also found that 57% of the birds banded on Pools 7 and 8 were recovered in Wisconsin, Minnesota, and Iowa. Analysis will be completed on all the band recovery records, including those made under the State of Wisconsin permit, for the localized area of the river, and nation-wide canvasback records.

Fish Use of Flooded Agricultural Land on the Lower Missouri River During the Flood of 1995*

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Many fishes inhabiting floodplain river systems have evolved to take advantage of seasonal availability of floodplain habitat for refuge, spawning and nursery. Channelization and alteration of the hydrograph on the Lower Missouri River have virtually eliminated fish access to the river's historic floodplain. The flood of 1995 allowed fish to enter most of the Lower Missouri River's floodplain for the second time in three years. Much of this area was in agricultural production prior to flooding. From May 22 to June 6 1995, fish samples were taken across the floodplains, from levee to bluff, of three agricultural areas using experimental gill nets and a larval sled net. A total of 18 species from nine families were captured with gill nets. Catch per unit effort for all species combined was highest in areas where current velocity was < 0.2 m/s. No fish were captured where current velocity exceeded 0.4 m/s. Gizzard shad (*Dorosoma cepedianum*) and common carp (*Cyprinus carpio*) were found in spawning condition. Larval fish densities as high as 49/m^3 were collected using a larval sled net.

ORGANIC CARBON INTERACTIONS BETWEEN THE OHIO RIVER, GREAT MIAMI RIVER AND ASSOCIATED OXBOW FLOODPLAIN, SOUTHEAST INDIANA*

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Floodplain ecosystems are routinely considered as a source of particulate organic substrates for large river bio-energetics. This relationship, however, is subject to influence of site-specific variations in river-channel morphology. As an analysis of the influence which site-specific variations in river channel morphology may have on this relationship, we studied the exchange of organic matter between the Ohio River, Great Miami River (a major tributary within the Markland pool, southeastern Indiana) and oxbow floodplain formed at their confluence. Spatial and temporal variations of benthic macroinvertebrate and algal biomass, and surface water organic carbon fractions were analyzed from March 1993 to November 1994. Suspended carbon interactions between the rivers' confluence and floodplain basin were mainly limited to dissolved organic matter and lateral migrations of fauna. Although 90% of land surface within the seasonally inundated floodplain supports forest, meadow and agricultural vegetation, the arising particulate carbon was retained within the 9 ha basin. Likewise, organic matter suspended within rising flood waters quickly settled from the decreasing current velocity near the edge of the main riverine channel, prior to entry into floodplain pools. 2-factor analysis of variance (ANOVA) ($N = 112$; $p \leq 0.05$) indicated significant site and seasonal variation in total (TOC) and dissolved (DOC) organic carbon within the rivers and floodplain. TOC values, ranging from 2.68 ± 0.02 to 17.97 ± 0.55 mg/l, were consistently higher within floodplain pools. DOC dominated the organic fractions at all sites, composing 49-99% of the TOC. Overall DOC variations were directly correlated with floodplain algal biomass ($N = 17$, $r^2 = 9196$), indicating significant autochthonous productions in non-river channel sites. Particulate organic carbon variations, although not significant in regards to total site and seasonal fluctuations, did indicate seasonally significant winter river (2.09 ± 0.14 mg/l) and autumn floodplain (4.86 ± 0.71 mg/l) maxima, in response to increased current velocities and algal senescence, respectively. Benthic faunal communities within the floodplain were under significant influence of water level fluctuations and autochthonous primary production of seasonally inundated areas. Lateral migration of riverine fish into floodplain pools for opportunistic feeding and spawning was evident and offered an indirect transfer of floodplain carbon into the river. Overall findings suggest limited carbon transfers between the oxbow floodplain and Ohio River, with the floodplain mainly providing a source of DOC for riverine incorporation.

SHORT-TERM CHANGES IN THE SUBMERSED AQUATIC VEGETATION OF LAWRENCE LAKE IN POOL 8, UPPER MISSISSIPPI RIVER SYSTEM

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Submersed aquatic vegetation is an important habitat component of the Upper Mississippi River System (UMRS). Lawrence Lake, a contiguous backwater in Pool 8 UMRS, has been sampled for submersed aquatic vegetation from 1991 to 1995 by the Long Term Resource Monitoring Program (LTRMP). The LTRMP was initiated to monitor long-term trends in fish, water quality, invertebrates and vegetation in selected pools of the UMRS. Ten transects were sampled in Lawrence Lake each year. Spring of 1991 sampling showed *Ceratophyllum demersum* L.(coontail) occurring in 76% of the sampled sites. By August, however, submersed aquatic vegetation occurred in only 4% of the sites, while *C. demersum* L. occurred in 0.5% (Figure 1). Water quality data collected by the LTRMP indicated elevated turbidity readings for the month of June possibly limiting light availability. August sampling in 1992 through 1995 showed a recovery in submersed aquatic vegetation; >50% of the sampling sites were vegetated (Figure 2). *Potamogeton pectinatus* L. (sago pondweed) and *Potamogeton crispus* L. (curly pondweed) were the dominant species in 1992 possibly due to cooler water temperatures. Species dominance shifted again in 1993 and 1994 to *Ceratophyllum demersum* L. and *Myriophyllum spicatum* L. (Eurasian water-milfoil). *C. demersum* L. was again dominant in 1995. *M. spicatum* L., however, showed a decline in 1995 while *Potamogeton pectinatus* L. increased in frequency. The information collected indicates both frequency and dominance of submersed aquatic species can change rapidly from year to year.

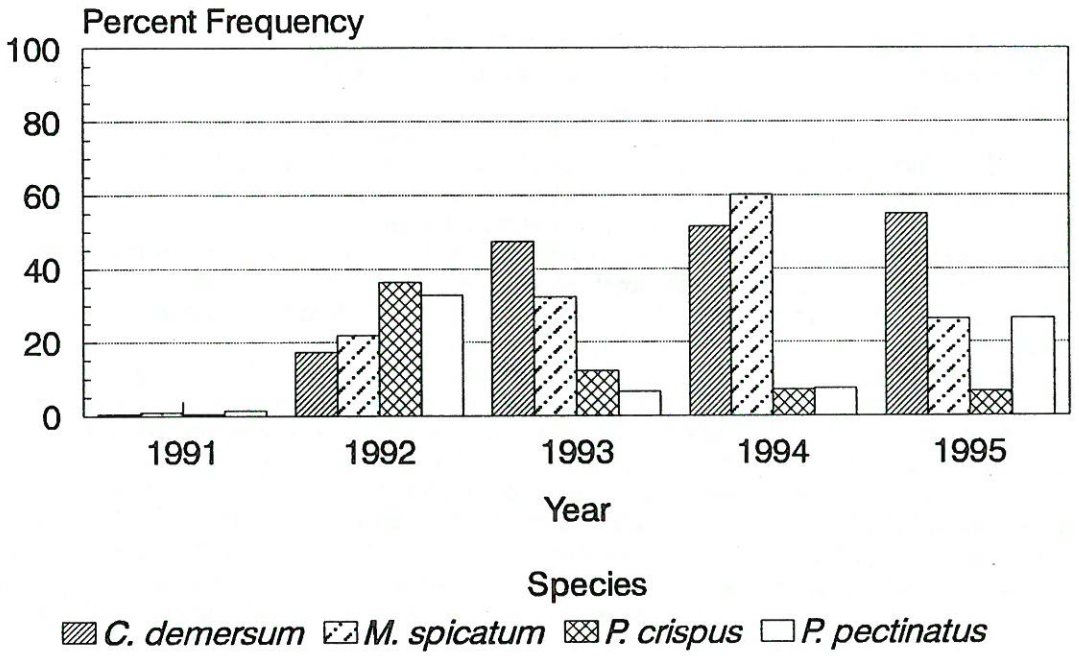

Figure 1. Frequency of species in Lawrence Lake, Pool 8 Upper Mississippi River System.

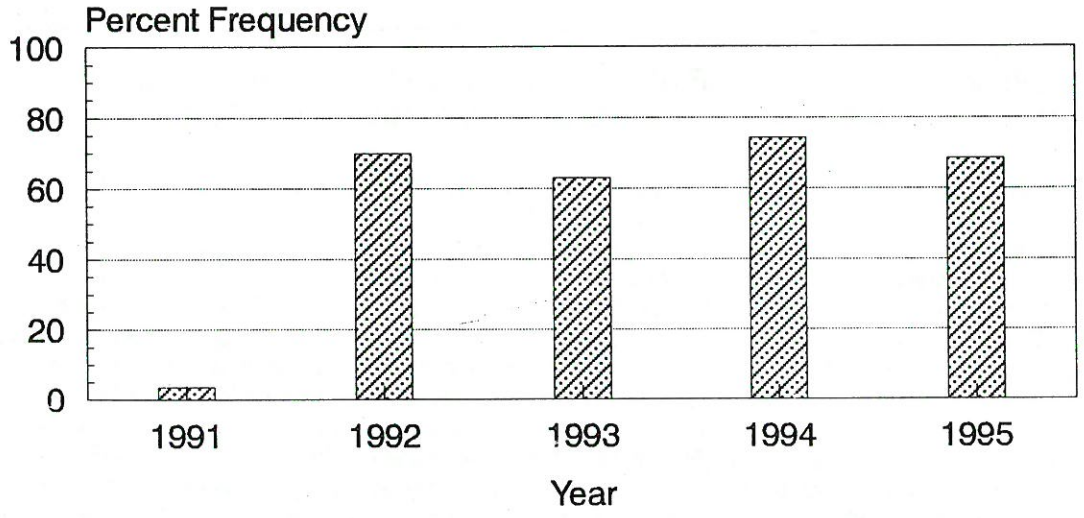

Figure 2. Frequency of vegetated sites in Lawrence Lake, Pool 8 Upper Mississippi River System.

DISTRIBUTION OF THE LONG TERM RESOURCE MONITORING PROGRAM DATA ON COMPACT DISK

Carol Lowenberg, Tom Owens, Lynne Arndt, Dave Bergstedt, Steve Hagedorn, and Linda Leake, National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, 54650

The Long Term Resource Monitoring Program (LTRMP) is the largest river-related inventory, monitoring, research, spatial analysis, and information sharing program in the United States. The mission of the LTRMP is to provide decision makers with information to maintain the Upper Mississippi River System (UMRS) as a viable large river ecosystem given its multiple-use character. One way that the program is providing access to its geographic information system (GIS) data is through a compact disk (CD) created for UMRS Pool 8. The CD contains high-resolution scanned and rectified images of UMRS Pool 8 1994 1:15,000 scale color-infrared aerial photography, UMRS Pool 8 PC ARC/INFO-format GIS coverages, LTRMP trend data collected within Pool 8, ArcView 1 data access routines, an ArcView 2 access routine, ArcView 1 data access software, and data documentation. The development of additional CDS will be dependent upon additional funding.

PREDICTIONS OF WINTER HABITAT FOR SUNFISHES AND LARGEMOUTH BASS IN POOLS 8 AND 13 OF THE UPPER MISSISSIPPI RIVER

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Today some biologists are concerned that sunfish and largemouth bass populations are not as abundant as they used to be and hypothesize that the abundance and spatial distribution of suitable overwintering habitat may be diminishing and the lack of winter habitat may hinder these species from flourishing. The potential for further loss due to sedimentation in the future makes this a crucial issue to address. Good overwintering habitat is deep enough to accumulate and hold heat (> 1° C), oxygen levels above 1.5 to 2 mg/l oxygen and no detectable current. Even if dissolved oxygen is adequate, swimming abilities decrease as water temperatures cool towards 0° C and the death rates increase. At 0° C swimming almost ceases. A predictive rule-based Geographic Information System (GIS) model was developed at the Environmental Management Technical Center (EMTC) to identify areas of the Upper Mississippi River that likely offer overwintering habitat for these fishes. The model was initially developed for Pools 8 and 13 of the UMR. The model was designed to utilize existing spatial data coverages and search for locations which met winter habitat criteria. Model assumptions were that winter ice thickness is 0.6 m (2 ft), that the minimum acceptable water depth under the ice is 0.6 m (2 ft) and areas should be nearby but not in flow. Data layers used in the model included bathymetry and elements of the EMTC Aquatic Areas coverages. The aquatic areas coverage was used as a surrogate for flow because measured or modeled flow data did not exist for either pool and also because of the desire to keep the model simple so that it might, if proven reliable, have applicability in other UMR pools. In Pool 8, 55 areas comprising 170.2 ha (420 acres) were identified as meeting model criteria and identified as areas of interest needing further study. Of these, 32 were less than 2 ha (5 acres) in size and had a mean depth of 1.4 m (4.05 ft). For areas 2 ha or more, the mean depth was 2.2 m (7.14 ft). Of the 55 areas, 12 had a mean depth of less than 0.9 m (3 ft), 26 had a mean depth between 0.9 m (3 ft) and 1.5 m (5 ft) and only 7 had a mean depth greater than 3 m (10 ft). If one hypothesizes that wintering habitat with a depth between 0.6 and 0.9 m is marginal because the water may tend to be too cool for good habitat, the total number of sites decreases to 43 with a total area of only 146 ha (360 acres). In Pool 13, 49 areas comprising 211.2 ha (522 acres) were identified. Of these, 25 were less than 2 ha in size with a mean depth of 1.2 m (3.98 ft). For areas greater than 2 ha, the depth was 1.4 m (4.5 ft). Of the 49 areas, 18 had a mean depth of less than 0.9 m (3 ft), 20 had a mean depth between 0.6 and 0.9 m and only one had a mean depth greater than 3 m. When areas with a depth between 0.6 and 0.9 m are removed, only 31 sites remain with a total area of 158.4 ha (391 acres). The predictions of this model are intriguing. Predicted overwintering habitat for the sunfishes and largemouth bass in pools 8 and 13 is minimal. The utility of this model is that it identifies potential overwintering areas and can serve to stimulate hypothesis development and testing relative to these issues.

AVIAN SURVEY OF THE SAVANNA ORDNANCE DEPOT BOTTOMLANDS, AN UPPER MISSISSIPPI RIVER FLOODPLAIN SITE

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In order to assess avian diversity and relative abundance on the Savanna Ordnance Depot floodplain forest, we conducted a point-count survey project here during the fall migration of 1993 and the spring migration and summer breeding seasons of 1994. This site is located immediately downstream of Lock and Dam 12, on the Illinois side. A total of 9 surveys were conducted (3 fall migration, 3 spring migration, and 3 summer breeding), each sampling either the early, middle, or late seasonal period. The survey route consisted of 15 points, including 7 forest interior and 8 forest edge points. We sampled each location for 5 minutes, recording all birds heard and seen. During this project we identified 112 species within the study area, including 16 Permanent Residents (RES), 38 North American Migrants (NAM), and 58 Neotropical Migrants (NTM). We identified 5995 individual birds to species. Of these, 931 were RES, 3160 were NAM, and 1904 were NTM. During the migrational periods 105 species were encountered, including 16 RES, 35 NAM, and 54 NTM. Most of these species (54%) exhibited a preference for utilizing the study area during migration. These 6 surveys accounted for 3982 individual birds (746 RES, 2029 NAM, and 1208 NTM). In comparison, we observed 71 species during the breeding season including 12 RES, 28 NAM, and 31 NTM. Only 38% of these species actually preferred using the study area during the breeding season. We identified 2012 individual birds on these 3 surveys (185 RES, 1131 NAM, and 696 NTM). Within the forest edge habitat, 83 species were encountered (12 RES, 31 NAM, and 40 NTM). Of these, only 26% exhibited a preference for the forest edge. The 8 edge points accounted for 3426 individuals including 465 RES, 2003 NAM, and 958 NTM. In contrast, 102 species were observed in forest interior habitat (15 RES, 34 NAM, and 53 NTM). Of these, 52% appeared to prefer the forest interior. We identified 2569 individuals at the 7 interior points including 466 RES, 1157 NAM, and 946 NTM. During the project, we were especially interested in the diversity and abundance of NTM species. A total of 25 species of higher management concern (572 individuals) were observed, while 30 species of lesser concern (1303 individuals) were identified. We encountered 3 species (29 individuals) which were not classified in this system of management concern. Based on this data, the primary importance of the Savanna Ordnance Depot floodplain forest appears to be as a migration corridor. Additionally, we believe management options for this site should attempt to increase the amount of forest interior habitat available, while maintaining an interspersion of edge and interior habitats.

MACROPHYTE/INVERTEBRATE RELATIONSHIPS IN A CONTROL LAKE AND A LAKE CHEMICALLY TREATED FOR THE REMOVAL OF MILFOIL*

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Eurasian milfoil, an species exotic to North America, has invaded many lakes in Minnesota and the surrounding areas, including the Mississippi River. It out competes native lentic macrophytes to become the dominant macrophyte species. This change in the macrophyte community should lead to alterations of the invertebrate community structure. A comparison between invertebrate densities and macrophyte biomass was undertaken in two lakes west of Minneapolis, MN. One lake, Lake Zumbra, was treated with the chemical herbicide, fluridone, in May 1994. A second lake, Auburn Lake, served as a control. Three transects were marked perpendicular to shore on both lakes before treatment. Transects were chosen on the basis of the amount of milfoil present in relation to the amount of natural macrophyte species. Each lake contained a transect with native vegetation, a mix of native and milfoil, and a transect of only milfoil. Samples were collected by divers using a plastic tube with a sieve at each end. Samples were taken from a depth of 1, 2, and 3 meters, with three replicates taken at each depth. Samples were collected during the summers of 1993, 1994, 1995. Each sample was filtered through sieves leaving macrophytes and invertebrates greater than 180 μm. Invertebrates were separated from the macrophytes using a microscope at 40x magnification and classified to the lowest possible taxonomic unit. Macrophyte biomass was measured by drying each sample in an oven for 48 hr at 60°C. Macrophyte biomass and invertebrate densities were analyzed for August 1993-1995 to determine the effect of macrophyte loss on the relationship between macrophyte biomass and invertebrate densities. Relationships between macrophyte biomass and invertebrate density were comparable between the two lakes in 1993. Declining macrophyte abundance in Lake Zumbra following application of fluridone resulted in significantly lower invertebrate densities in August 1994, compared to densities observed in Lake Auburn. This same pattern was observed in August 1995 because of the failure of macrophyte to return to pretreatment levels.

PRESETTLEMENT AND EXISTING LANDCOVER CHARACTERISTICS OF POOLS 25 AND 26 OF THE UPPER MISSISSIPPI RIVER AS INTERPRETED FROM U.S. GOVERNMENT LAND OFFICE SURVEY RECORDS AND MODERN AERIAL PHOTOGRAPHY.

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We reconstructed the presettlement landscapes of Pools 25 and 26 of the Upper Mississippi River (UMR) using Geographic Information System (GIS) and survey records of the U.S. Government Land Office (GLO). The GLO survey of our study area was conducted in 1816, prior to the landscape modifications that resulted due to extensive Euro-American settlement of the region. The survey records contained three types of information useful to our investigation: township plat maps, bearing trees, and line descriptions. Plat maps were used to quantify the extent and location of presettlement prairie, and timber, as well as rivers, streams, lakes, and islands. Bearing tree data were used to evaluate presettlement forest composition and structure. Section line descriptions contained qualitative information about the presettlement floodplain landscape. In conjunction with modern GIS landcover maps and field data, presettlement reconstructions can be used to describe plant communities and species distributions, as well as to gain understanding about the processes that shaped and maintained the landscape. Perhaps most importantly, these data can be used to quantify the degree of change that has been imposed upon the landscape and to help identify threatened and endangered ecosystems. Results indicate prairie was once the dominant plant community on the floodplain and covered an estimated 47 percent of the study area. These floodplain prairies were very extensive and some extended into the adjacent uplands. In contrast, current floodplain prairies (areas with any grass/forb cover) comprise only 5 percent of the study area and most often occur as small isolated tracts surrounded by agricultural land. Forest dominated the islands of the Mississippi River in 1816, but on the floodplain, forests most often occurred along the margins of the river, as well as along tributary streams and backwater lakes. These forests once covered 35 percent of the study area, but have been reduced to a current level of 19 percent. Bearing tree data indicate that oak-hickory communities were common on the presettlement floodplain, whereas the current forests consist primarily of maple-ash-elm-cottonwood communities. Early settlers in 1816 relied on small farm fields established within native prairies to grow crops. Today, agricultural land comprises 54 percent of the study area. While landcover changes on this portion of the UMR floodplain have been dramatic during the past 180 years, they are still less severe than changes that have occurred across most upland landscapes within the UMR basin. Information from GLO studies and other sources should be used to preserve and enhance the biological diversity of the UMR by restoring endangered and damaged ecosystems such as floodplain prairies and forests.

LTRMP COMPONENT DATABASE SPATIAL QUERY TOOL

Douglas A. Olsen. National Biological Service, Environmental Management Technical Center 575 Lester Avenue, Onalaska, WI 54650

The EMTC stores point sampled data for fisheries, water quality, and invertebrates in a relational database management system. These component data are collected at fixed and random sites in each of the key LTRMP study pools: 4, 8, 13, 26, the Open River reach on the Mississippi River, and the LaGrange pool on the Illinois River. While the geographic locations of these data are also collected and stored, the tools to automate the integration of these data with spatial data had not previously been developed. A need existed for an application that would facilitate spatial subsetting and visualization of the distribution of sites meeting certain query criteria. The LTRMP Component Database Spatial Query Tool is an application that integrates the component data with spatial data by taking advantage of the graphical display and query capabilities of the ARC/INFO Geographic Information System (GIS). The application features an easy-to-use graphical user interface and requires only very basic knowledge of GIS to use effectively.

SAFETY OF FORMALIN AND HYDROGEN PEROXIDE TREATMENTS ON FISH EGGS

Jeff Rach, George Howe, Theresa Schreier, **Jeff Olson** and Steve Redman. Upper Mississippi Science Center, P.O. Box 8181, La Crosse, Wisconsin 54602 USA.

Hydrogen peroxide and formalin are effective fungicides that are used extensively in fish culture. Researchers at the Upper Mississippi Science Center have conducted target animal safety studies on hydrogen peroxide and formalin with an effort to extend the use of the compounds. Eggs of walleye (*stizostedion vitreum*) northern pike (*esox lucius*), white sucker (*catastomus commersoni*), carp (*cyprinus carpio*), lake sturgeon (*acipenser fulvescens*), and channel catfish (*ictalurus punctatus*) were cultured in miniature egg hatching jars similar to those used in hatchery operations. Treatment groups were triplicated and each replicate consisted of 30 mls of fish eggs. Eggs were treated with three concentrations of each chemical either every other day up to hatching for formalin or every week day through hatch for hydrogen peroxide. The safety of a treatment was evaluated by statistically comparing the hatching success of treatment groups to a control group. Results from the studies indicated that a margin of safety exists for both chemicals and normal treatment concentrations improved hatching success. The data from this research will be used to extend the chemical-label of formalin to include other species of fish. The hydrogen peroxide data will be submitted to the U. S. Food and Drug Administration to increase the maximum treatment concentration (Low Regulatory Priority drug status) of 500 μL/L (ppm) to 1000 μL/L.

A SURVEY OF THE UNIONID MUSSELS OR THE ILLINOIS RIVER: A RECOVERING RESOURCE ?

Scott D. Whitney, **Darin Osland**, Douglas Blodgett, and Richard E. Sparks
Illinois Natural History Survey, River Research Labs, 704 N. Schrader Ave., Havana, IL 62644

The last comprehensive mussel survey of the Illinois River, conducted in 1966-69, indicated 25 of the 49 species once found in the river had been extirpated; extensive stretches of the upper river, once densely populated with mussels, did not yield a single living specimen. What was once the most productive mussel resource per rivermile in the United States, had been severely degraded by habitat loss, exploitation, and pollution. In the past three decades mussel populations in the Illinois River have been subject to three major changes: (1) renewed commercial exploitation for the Japanese cultured pearl industry; (2) dramatic improvements in water quality; and (3) the recent invasion of two nonindigenous bivalves, the Asiatic clam (*Corbicula fluminea*) and the zebra mussel (*Dreissena polymorpha*). In 1993, we began a comprehensive survey to assess the impacts of these changes and determine the current status of mussel populations in the Illinois River. Wading and brailing were used for preliminary site assessment and for comparisons with previous studies. However, the majority of the collections were made by divers using quantitative and qualitative sampling techniques. The information we have collected indicates that mussel populations in some areas of the river are showing signs of recovery after decades of decline. The most dramatic improvements were recorded in the upper reaches of the river, where we found live mussels representing 12 unionid species, including juveniles; a live mussel had not been reported from this part of the river since the early 1900's. Throughout the entire river, we collected a total of 23 species, including five species once listed as extirpated. Average densities ranged from less than 1 live mussel/m^2 to 38/m^2, with population density and species abundance at our sample sites showing an increase in the downriver direction. Most mussel beds in the lower river are now comprised of several abundant species rather than one or two dominant species reported in past surveys. The age and size structure of mussel populations indicate higher growth rates than mussels collected from Pool 15 of the Upper Mississippi River and stable recruitment patterns for most species. Despite signs of improvement in unionid density and species diversity at some sites, the future of Illinois River mussels remains questionable. The recent invasion and proliferation of the zebra mussel coupled with increased anthropogenic demands on the river and its resources may set back years of recovery of the Illinois River mussel populations.

GIS SPATIAL INTERPOLATION CONSIDERATIONS: WHY WOULD DATA NEED TO BE INTERPOLATED, SHOULD DATA BE INTERPOLATED, AND HOW SHOULD DATA BE INTERPOLATED?

James T. Rogala
Environmental Management Technical Center, 575 Lester Avenue, Onalaska, WI 54650

Most would agree that a Geographic Information System (GIS) is a powerful tool for spatial analysis, but most would also agree that spatial data are difficult to generate. Some data can be generated through remote sensing and other "data" predicted from models, but aquatic data obtainable from remote sensing and such models are few. The remaining option for creating continuous coverages of data is interpolating among data points collected in the field at a limited number of sampling locations. The ease by which an investigator can use interpolation to generate data in a GIS can lead to data generation prior to answering some basic questions regarding whether the interpolation is justified. These questions include the following: (1) Will the results from analysis with interpolated data far exceed results from non-spatial analysis? If not, the extra work will at best only provide "glitz" to the presentation of the data. (2) Can the limited number of sample points adequately represent an entire interpolated area for the investigation, or will artifacts of the interpolation lead the investigator to the wrong conclusion? and (3) Which algorithms and options within the algorithms will produce the "best" interpolated data? This study will not provide the answers to these questions, but instead demonstrate the need to take these questions seriously.

CHARACTERISTICS OF A PADDLEFISH (*Polyodon spathula*) POPULATION FROM THE LOWER BLACK RIVER, WISCONSIN.

Pete Rust, Steve Zigler, Brent Knights and Mike Dewey. National Biological Service, Upper Mississippi Science Center, P.O. Box 818, La Crosse, WI 54602.

Paddlefish (*Polyodon spathula*) were common components of the fish assemblage and commercial fish harvest in large rivers of the Mississippi River drainage before 1900. More recently, construction of dams in large rivers has altered traditional paddlefish habitats and contributed to declines in paddlefish populations, especially in the perifery of the species range. Knowledge of population characteristics such as abundance, length-frequency distribution, length-weight relations, and fish movement is essential for documenting the status of endangered paddlefish and determining management options. In fall of 1994 and in 1995, we captured 52 paddlefish from the lower Black River (Pool 8, Upper Mississippi River) with commercial seines and gill nets. Each fish was measured from eye to fork, weighed and marked with a uniquely numbered jaw band. Additionally, radio transmitters were surgically implanted into 19 of the paddlefish to evaluate movement. Eye to fork length of captured paddlefish ranged from 300 to 1330 mm, but most fish (63%) were between 575 and 725 mm in length. A modified Schnabel population estimate revealed the population to be 91 fish (64-145, 95% CI). However, this may be an overestimate because 3 radio-marked fish migrated from Pool 8 during the end of the study. The length-weight relationship of paddlefish captured in the lower Black River was similar to other paddlefish populations in the Chippewa and Wisconsin Rivers and appears to be dissimilar to the length-weight relationship reported for paddlefish in Pool 13 of the Mississippi River. The lower Black River in Pool 8 appears to support a significant number of paddlefish. Our data provides the first, baseline information on the characteristics of this population.

IDENTIFICATION AND CHARACTERIZATION OF SEASONAL PADDLEFISH (*POLYODON SPATHULA*) HABITATS IN UPPER MISSISSIPPI RIVER POOL 5A.

Mark T. Steingraeber and Ann L. Runstrom, U.S. Fish and Wildlife Service, La Crosse Fishery Resources Office, 555 Lester Avenue, Onalaska, WI 54650.

We identified the locations of some preferred seasonal habitats of paddlefish (*Polyodon spathula*) in Upper Mississippi River Pool 5A during 1994-95 and evaluated several physical characteristics at these sites. Netting operations captured a total of 9 paddlefish and radio transmitters were surgically implanted in 5 individuals. Locations of these fish were determined periodically by standardized radio telemetry procedures and global positioning system technologies. Dissolved oxygen concentration, temperature, and current velocity were determined near the surface, the bottom, and at a mid-depth location in the water column at each site, as well as depth and substrate textural composition. Fish locations were plotted on a land-water geographical information system database coverage map of Pool 5A. Six areas of paddlefish habitat were identified based on the combination of locations where paddlefish were most frequently observed during netting and telemetry operations. These included island shore, mainland shore, and open water areas of a backwater lake, a main channel-channel border site, the tailwaters below Lock and Dam 5, and a secluded boat harbor. Radio implanted paddlefish were observed at the island shore site throughout the year but were present here most often in the summer and fall. Main channel-channel border habitat near an upstream entrance to the lake was used by fish during fall, winter, and spring and was where fish were observed most frequently (63%) during winter. All observations of paddlefish in mainland shore habitat occurred during the spring and accounted for the majority (45%) of sightings at this time. Small but similar percentages of fish observations were made in tailwater habitat during summer (23%) and fall (17%) and open water habitat during spring (11%) and summer (16%). The boat harbor area was seldom used and only during mid-summer. Long distance (1-12 km) movements of several individuals between habitat areas in late-spring were associated with decreased river discharge. Seasonal comparisons of mean physical characteristics for these habitats while occupied by paddlefish indicated a high degree of similarity regarding temperatures and dissolved oxygen concentrations throughout the water column during most seasons. Mean seasonal water temperature and dissolved oxygen concentrations at these sites generally ranged 22.4-27.3°C and 8.2-9.2 mg/L in summer, 12.5-15.7°C and 9.4-10.5 mg/L in fall, 0.0-0.6°C and 13.3-14.8 mg/L in winter, and 5.5-15.6°C and 9.8-13.5 mg/L in spring, respectively. Mean depth was significantly different for several of the habitats and generally ranked in the following order: main channel-channel border $\geq$ tailwater >> boat harbor > island shore $\geq$ mainland shore > open water. Moreover, current velocities in the tailwater and main channel-channel border sites were significantly greater than all other habitats during spring, summer, and fall when mean velocities in these swift areas ranged 0.60-0.70 m/s, 0.27-0.46 m/s, and 0.33-1.01 m/s, respectively. Mean seasonal current velocities in all other habitats ranged 0.04-0.20 m/s. Substrates in quiescent paddlefish habitats were primarily composed of silt- and clay-sized particles while substrates in the swifter habitats were composed of a mixture of sands and either gravel or rock.

ZOOPLANKTON POPULATIONS AND THE EFFECTS OF FLOW VELOCITY ON THEIR DISTRIBUTION PATTERNS IN THE FINGER LAKES

Tanya Stellmach National Biological Service, Environmental Management Technical Center, Onalaska, WI 54650, and the University of Wisconsin-La Crosse, La Crosse, WI 54601.

The objectives of this study were to (1) determine the present pattern of zooplankton distributions within the Finger Lakes complex and (2) evaluate the effects of flow on the zooplankton community. The Finger Lakes Habitat and Rehabilitation and Enhancement Project (HREP) includes ongoing studies which focus on changes in hydrology, water quality, sedimentation, vegetation, fish, and invertebrates affected by hydrologic modifications. Evaluation of zooplankton abundance is relevant to the evaluation of this project because zooplankton are a source of food for many fish, particularly early life-stages and planktivorous adults. During 1994 and 1995, vertical zooplankton tows, velocity, secchi depth, and water quality measurements were obtained biweekly from June 14 to August 23. Four littoral sites and four pelagic (open water) sites were sampled from Clear, Lower Peterson, and Third Lakes. In Clear, Third, and Lower Peterson Lakes the zooplankton densities decreased from June to August during both 1994 and 1995 sampling periods. The most common species found throughout the Finger Lakes were cyclopoid copepods, copepod nauplii, *Daphnia*, and rotifers. Lower Peterson and Third Lakes had significantly higher zooplankton densities than Clear Lake ($P< 0.05$). Open water supported significantly higher densities of cyclopoid copepods, copepod nauplii, *Daphnia*, rotifers, and *Diaphanasoma* ($P< 0.05$) than littoral areas. Although velocity is significantly different ($P< 0.05$) between the lakes, the population densities suggest that the difference in velocity does not effect the distribution.

ANNUAL CHANGES IN INVERTEBRATE COMMUNITY STRUCTURE IN RESPONSE TO MACROPHYTE REMOVAL BY THE HERBICIDE FLURIDONE*

Russell L. Swanson, Michael D. Delong, and Neal D. Mundahl
Large River Studies Center, Biology Dept., Winona State University, Winona, MN 55987

Eurasian water milfoil is an exotic aquatic macrophyte that out competes native aquatic vegetation, eventually becoming the dominant plant species in a lentic system. This dominance leads to lower overall diversity in the plant community and may have an adverse secondary effect on the macroinvertebrate population. Chemical treatment of lentic systems is one possible option for removing milfoil from aquatic habitats. This study examined the secondary effects, specifically habitat loss, of treating Eurasian water milfoil with the herbicide fluridone. Two similar lentic systems, in respect to macrophyte composition, were chosen as the study sites; Auburn Lake and Lake Zumbra. Auburn Lake was designated as the control, while Lake Zumbra was treated with Sonar in May, 1994. Samples were taken form 1993-1995 to track changes in invertebrate community structure before and following application of the herbicide. Macrophyte samples were taken by divers using a flexible plastic tube with a sieve fixed at one end and a removable sieve at the other end. Macrophytes were enclosed in the bag and the sieve was attached to the open end to retain the invertebrates inside. Three samples were taken at 1, 2, and 3m depths and at three different transects on each lake. While densities differed, invertebrate community composition was comparable between the two lakes in 1993. The communities differed considerably in 1994, following herbicide treatment, as they did in 1995 when only minimal regrowth of macrophytes was observed. Continued low densities of most major taxonomic groups in Lake Zumbra in 1995 demonstrates the potential impact of macrophyte loss via fluridone treatment.

GIS-BASED DETECTION OF VEGETATION CHANGES IN BACKWATER AREAS OF POOL NO. 8, UPPER MISSISSIPPI RIVER

Robin W. Tyser [1,2], Thomas W. Owens[1], Sara J. Rogers[1], and Larry R. Robinson[1].
[1]Environmental Management Technical Center, National Biological Service, Onalaska, WI and [2]River Studies Center, University of Wisconsin-La Crosse, La Crosse, WI.

Impoundment of the upper Mississippi River in the 1930s created highly productive and biologically diverse backwater habitats. Concern now exists that several factors, including sedimentation and fluctuating water levels, may be reducing the productivity and diversity of these areas. For example, if significant sedimentation has occurred, one would expect associated landscape-level changes, i.e., less open water and submergent vegetation but more emergent and terrestrial vegetation. The presence of such changes and, more generally, the nature of spatial and temporal variation of backwater vegetation have not been well studied. This study was undertaken to describe short term (yearly) and long term (ca. 20 year) variation in vegetation cover classes occurring in several backwater areas in navigation Pool 8 of the upper Mississippi River. Spatial databases of these areas were prepared from color infrared aerial photographs taken during 1975, 1991, 1992, 1993, 1994, and 1995 and analyzed with ARC/INFO software. Analyses include construction of transition matrices and comparisons of among-site and among-year variation in vegetation cover, thus describing changes in landscape pattern that have occurred at different temporal and spatial scales.

EFFECTS OF ZEBRA MUSSELS (DREISSENA POLYMORPHA) ON AMPHIPODS IN ARTIFICIAL STREAMS*

D.L. Vaughn, R. Brent Summers, and James H. Thorp. Large River Program, University of Louisville, Louisville, KY 40292.

We examined the effects of zebra mussel and non-zebra mussel (gravel) substrates on amphipod densities, biomass, and size-class distributions. Equal amounts of substrate (either zebra mussels or gravel) were placed in independent channels of an artificial stream mesocosm. Equal amounts of similar sized substrate were used to ensure that any differences encountered were not artifact of differences in habitat heterogeneity. Water was pumped directly from the Ohio River to the stream mesocosm, which allowed for amphipod colonization of the channels. Amphipods were allowed to colonize and grow in the channels for a four week period. At the end of the four week period, amphipods were removed and enumerated for densities, biomass, and size-class distributions. The data is currently being analyzed, however, initial trends indicate that channels with zebra mussel substrates support higher amphipod densities and biomass than channels with gravel only. This difference may be due to the retention of organic matter, to include faeces and psuedofaeces produced by the zebra mussels which in turn may result in a higher quality detrital food source for the amphipods thus resulting in higher densities and biomass.

AN *IN SITU* EXPERIMENTAL STUDY OF THE POPULATION DYNAMICS OF ZEBRA MUSSELS IN THE UPPER MISSISSIPPI RIVER*

Thomas B. Ward[1], Michael D. Delong[1], and James H. Thorp[2].
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Zebra mussels, *Dreissena polymorpha*, have invaded the upper Mississippi River and have established themselves as a major macroinvertebrate species inhabiting hard substrata. An experiment was designed to examine the population dynamics and possible predation effects in the upper Mississippi River. The experiment entailed use of two types of cages: open cages, on which only the upstream side was covered with 1.5 cm diameter mesh; and closed cages, which were completely covered with 1.5 cm diameter mesh. Each cage was fitted with either 12 clay tiles or 12 bundles of willow dowels (snags) to serve as hard substrata. The resulting design consisted of four combinations of experimental units. Cages were initially deployed in June 1994. Data for this report discuss the second year of the project. One substratum was removed from each cage monthly from June to October 1995. Zebra mussels and other invertebrates were removed from substrata and preserved for later taxonomic separation, counting and measurement. Zebra mussel colonization was higher on tiles than on snags, and was much greater in closed than open cages. The greater abundance on tiles suggests that cobble substratum are preferred over woody debris. Similarly, their abundance in the closed cages compared with that of the open cages suggest that fish predation may be a factor influencing population size. Zebra mussel densities were approximately the same in open and closed cages for zebra mussels 0-8 mm long. Densities of mussels greater than 8 mm are much lower in open cages than in closed cages, suggesting size-specific removal of mussels by fish predators.

1996 BUSINESS MEETING AGENDA
MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.
28TH ANNUAL MEETING

FRIDAY APRIL 26, 1996, 11:00 AM

HOLIDAY INN, LA CROSSE, WISCONSIN

1. Call to Order

2. Announcements and Acknowledgments
   a. Acknowledgments
   b. Presentation of Best Paper Awards

3. Secretary's Report
   a. Approval of the Minutes of the 1995 Business Meeting

4. Treasurer's Report
   a. Final 1995 Financial Report
   b. Preliminary 1996 Financial Report

5. Old Business
   a. MRRC Logo
   b. Other

6. New Business
   a. Nomination and Election of the 1996-1997 Board of Directors
   b. Meeting Notice for the 29th (1997) Annual Meeting
      1. April 24-25, 1997
   c. Meeting Format
      1. Length of meeting
      2. Length of presentations
      3. Number of papers presented by an author
      4. Poster versus platform format
   d. Acceptance criteria for abstracts
      1. Date of submission of abstracts
      2. Quality of abstracts
      3. Revision of abstracts after deadline
   e. Additional permanent or *ad hoc* committees needed (examples--Posters, Awards, Fund-Raising, etc.)
   f. Other?

7. Adjourn

MINUTES OF THE BUSINESS MEETING, 27th ANNUAL MEETING
OF THE MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC., APRIL 29, 1995

Business Meeting
The meeting was called to order at 11 am. President Sandheinrich, Treasurer Neal Mundahl, and Secretary Michael Delong and approximately 75 people in attendance.

President Sandheinrich thanked everyone for the job done on this year's meeting. The awards for best poster, best student oral presentation, and best oral presentation were presented.

Secretary Report
Presented by Michael Delong. The minutes of last year's business meeting were included with the program. The secretary was not directed to send any letters on the behalf of the MRRC. M/S/P acceptance the minutes of the 1994 meeting as presented in this year's proceedings.

Treasurer's Report
Presented by Neal Mundahl. Explained that, despite the report included with the program, that last year's meeting did make a profit. The reason for the loss of money was due to the late arrival of some registration fees. M/S/P approval of treasurer's report.

Old Business
There was no old business

New Business
A. Nomination and election of the 1995-1996 Board of Directors.
Rob Maher changed jobs during the year and his new position will make it impossible to take over as President. Mark Sandheinrich volunteered to serve one more year as President. The executive board nominated Terry Dukerschein for Vice President and Neal Mundahl for Treasurer. M/S/P to accept the executive boards nominations.

B. Ron Rada indicated that the increasing size of the meeting is making it difficult to get judges. He suggested that awards be given only for best student oral and poster presentation. Students could present on the first day and the awards could be given on Friday during the business meeting. After some discussion a motion was put to the floor to limit award presentation for the best student oral and poster presentation. The motion was seconded and passed.

C. M/S/P to hold next year's meeting at the Holiday Inn, La Crosse, on 25-26 April 1996.

Marian Havlik commented on the job done on this year's proceedings. D. David McConville discussed the history of the MRRC. He suggested that the MRRC look into a way of acknowledging the work of Mike Vander Ford from 1980-81 in reigniting interest in the MRRC. M/S/P for the executive board to look into a way of acknowledging Mike Vander Ford.

E. Richard Anderson pointed out that it is difficult to reproduce the MRRC logo and suggested that it be changed to something more simplistic. Donna Wilson suggested that the original artist be contacted and asked if the logo can be simplified. The board agreed to look into the matter.

With no further business, the raffle was held.

M/S/P to adjourn at 11:40 am.

Respectfully submitted,

Michael D. Delong

CONSTITUTION OF THE MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

ARTICLE I. NAME AND OBJECT

1. This organization shall be named Mississippi River Research Consortium, Inc.

2. The objective of this organization shall be:

   a. To establish and encourage communication between river scientists and between the scientific community and the public.

   b. To encourage pure and applied research concerning the water and land resources of the Mississippi River and its valley.

   c. To provide an annual meeting where research results can be presented, common problems can be discussed, information can be disseminated, and where river researchers can become acquainted with each other.

   d. To encourage cooperation between institutions and to encourage the sharing of facilities.

   e. To function as an advisory group to other agencies.

   f. To aid in the formation of a concerted and organized research effort on the Mississippi River.

ARTICLE II. ORGANIZATION

1. The organization of the Mississippi River Research Consortium shall be provided for by the enactment of suitable bylaws.

2. The bylaws of this organization shall designate the officers and standing committees, the provisions for the election of officers, the conduct of meetings, and for any other matters which are necessary for the government of this organization.

ARTICLE III. MEMBERSHIP AND DUES

1. The membership of this organization shall consist of any persons who demonstrate an interest in any aspect of the Mississippi River and who express a desire to join the organization.

ARTICLE IV. AMENDMENTS

1. The constitution or the bylaws of the MRRC may be amended by an affirmative vote of two-thirds of the eligible voting members present at the annual meeting.

BYLAWS OF THE MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

ARTICLE I: NAME, PURPOSES, AND DUTIES

1.01 There is hereby established a Board under the name of the Mississippi River Research Consortium, Inc., having the purpose and duties of governing all matters relating to this corporation. These shall be deemed to include the following without limitation:

   (a) To have the ultimate decision making authority for any and all affairs of the Mississippi River Research Consortium, Inc. which includes, but is not limited to, the authority to create and terminate the corporation, to determine the budget and expenditure of funds, to manage affairs, to determine the manner, location, and extent of services performed

by the corporation, to determine the number of, location, and job duties of any employees, and to do all other and necessary work for the benefit of the corporation.

(b) To formulate all policies necessary for the effective and continuous operation of the corporation.

© To coordinate and make decisions regarding priorities of services.

1.02 The purposes of the organization shall be as follows:

(a) To establish and encourage communication between river scientists and between the scientific community and the public.

(b) To encourage pure and applied research concerning the water and land resources of the Mississippi River and its valley.

© To provide an annual meeting where research results can be presented, common problems can be discussed, information can be disseminated, and where river researchers can become acquainted with each other.

(d) To encourage cooperation between institutions and to encourage the sharing of facilities.

(e) To function as an advisory group to other agencies.

(f) To aid in the formation of a concerted and organized research effort on the Mississippi River.

ARTICLE 2: OFFICES

2.01 Principal and Business Offices.
The corporation may have such principal and other offices, either in or out the State of Wisconsin as the Board of Directors may designate or as the business of the corporation may require from time to time.

2.02 Registered Office.
The registered office of the corporation required by the State of Wisconsin corporation law to be maintained in the State of Wisconsin may be, but need not be, identical with the principal office in the State of Wisconsin, and the address of the registered office may be changed from time to time by the Board of Directors or by the Registered Agent. The business office of the registered agent of the corporation shall be identical to such registered office.

ARTICLE 3: OFFICERS AND BOARD OF DIRECTORS

3.01 General Powers, Responsibility, and Number.
The business and affairs of the corporation shall be managed by its Board of Directors. It shall be the responsibility of the Board to carry out the objectives of the organization and to jointly organize, hold, and preside over the annual meeting. The Board of Directors of the corporation shall consist of an elected president, vice-president, secretary, and treasurer.

3.02 Election and Terms of Officers.
Each Board member will be elected for a two year term after the 1991 election. In odd numbered years a treasurer and a vice-president will be elected, with at least one being a representative of either a state or federal agency. In even numbered years a secretary and a vice-president will be elected, with at least one being a representative of an academic institution. After a vice-president serves for one year, he or she shall become president for the next year. In 1991 all four officers will be elected. The term for president and secretary elected in 1991 will be for one year. The term for the treasurer elected in 1991 will be for two

years. The vice-president elected in 1991 will become president in 1992. The term of each officer begins at the annual meeting.

3.03 Removal From Office.
Any officer may be removed by the Board of Directors whenever in its judgment the best interests of the corporation shall be served thereby, but such removal shall be made without prejudice to the contract rights of any person so removed. Election or appointment shall not of itself create contract rights. An officer may be removed from office by affirmative vote of a majority of the Board of Directors, taken at a meeting by the Board of Directors for that purpose. A director may resign at any time by filing a written resignation at the registered office. Any officer who is absent from three (3) consecutive meetings of the Board shall, unless excused by action of the Board, cease to be a member of the Board of Directors and shall be removed forthwith.

3.04 Meetings.
The Board of Directors shall meet on the times and dates to be established by them but at least once during the annual meeting. Meetings of the Board of Directors may be called by or at the request of any officer. The president or secretary may fix the place of the meeting and if no other place is designated or fixed the place of the meeting shall be at the principal business office of the corporation in the State of Wisconsin. Telephone conference calls can be used in place of regular meetings except during the annual meeting.

3.05 Notice; Waiver.
Notice of such meetings of the Board of Directors shall be given by written or verbal notice delivered personally, by phone or mailed or given by telegram to each director at such address or telephone number as such director shall have designated with the secretary, not less than ten (10) days, or a number of days to be decided by the Board, prior to such meeting. Whenever any notice whatever is required to be given to any director of the corporation under the Articles of Incorporation or By-Laws or any provision of law, a waiver thereof in writing, signed at any time, whether before or after the time of the meeting, by the director entitled to such notice, shall be deemed equivalent to the giving of such notice. The attendance of a director at a meeting shall constitute a waiver of notice of such meeting, except where a director attends a meeting and objects to the transaction of any business because the meeting is not lawfully called or convened. Neither the business to be transacted at, nor the purpose, or any regular or special meeting of the Board of Directors need be specified in the notice or waiver.

3.06 Quorum.
A majority of the elected members of the Board is necessary for the transaction of business at any meeting and a majority vote of those present shall be sufficient for any decision or election.

3.07 Conduct of Meetings.
The president, and in his or her absence, a vice-president, and in their absence, any director chosen by the directors present shall call meetings of the Board of Directors to order and shall act as the presiding officer of the meetings. The secretary of the corporation shall act as secretary of all of the meetings of the Board of Directors, but in the absence of the secretary, the presiding officer may appoint any assistant secretary or any director or other person present to act as secretary of the meeting.

3.08 Vacancy.
Any vacancy occurring in the Board of Directors because of death, resignation, removal, disqualification, or otherwise, shall be filled as soon as possible by the majority action of the Board. If the president vacates office, the vice-president shall become president and the Board shall fill the vice-president position. A vacancy shall be filled for the unexpired portion of the term.

3.09 Executive Director of the Corporation.
The Board may retain, compensate, and give directives to an executive officer. Said executive director shall not be considered as a member of the Board of Directors.

3.10 Duties of Officers.
All officers have the responsibility of carrying out the objectives of the organization, assisting in the organization of the annual meeting, and preparing a Procedures Manual for the organization. In addition:

The president shall:

(a) Act as chairperson of the Board and of any executive committee,
(b) Appoint all committees unless otherwise specified by the Board,
© Be executive on behalf of the Board of all written instruments except as provided or directed by the Board,
(d) Be responsible for the agenda to be used at the meeting,
(e) Perform all duties incident to the office of a president and such other duties as shall from time to time be assigned to him by the Board.

The vice-president shall:

(a) Perform the duties and exercise the functions of the president at the request of the president and when so acting shall have the power of the president,
(b) Be responsible for the preparation and updating of the Procedures Manual for the organization,
© Perform such other duties as delegated by the president.

The secretary shall:

(a) Keep the minutes of the meetings of the Board,
(b) See to it that all notices are fully given in accordance with the provisions of the By-Laws,
© Be custodian of the records of the Board,
(d) Perform all duties incident to the office of the secretary of the Board and such other duties as from time to time may be assigned by the president of the Board.

The treasurer shall:

(a) Be responsible for financial record keeping and assessment of dues as established by the Board of Directors,
(b) Supervise the preparation of the annual budget,
© Receive all funds paid to the organization and shall pay all bills incurred by the Consortium,
(d) Perform other duties as from time to time may be assigned by the president.

3.11 Other Assistance to Acting Officers.
The Board of Directors shall have the power to appoint any person to act as an assistant to any officer, or agent for the corporation in his stead, or to perform the duties of such officer when for any reason it is impractical for such officer to act personally, and such assistant or acting officer or other agent so appointed by the Board of Directors shall have the power to perform all of the duties of the office to which he or she is so appointed to be assistant or to which he or she is so appointed to act, except as such powers may be otherwise defined or restricted by the Board of Directors.

ARTICLE 4: MEMBERSHIP AND DUES

4.01 Membership and Eligibility.
Membership to include anyone interested in the research and study of the Mississippi River and its valley.

4.02 Membership and Dues.
Membership to be for one (1) year with annual dues determined by the Board of Directors.

ARTICLE 5: COMMITTEES

5.01 Nominating Committee.
The Board of Directors shall serve as the nominating committee and file its report with the members at the annual meeting.

5.02 Other Committees.
The Board may, by resolution, provide for such other committees as it deems advisable and may discontinue the same at its pleasure. Each entity shall have the power and shall perform such duties as may be assigned to it by the Board and shall be appointed and the vacancies filled in the manner determined by the Board. In the absence of other direction, the president shall appoint all committees.

ARTICLE 6: MEETING OF MEMBERSHIP

6.01 Annual Meeting.
The annual meeting of the organization shall be held in La Crosse, Wisconsin. The time of the meeting shall be established by the Board of Directors and announced at the previous annual meeting. Reports of officers and committees shall be delivered at the meeting. The Board of Directors shall be elected from those individuals nominated by the Nominating Committee and those nominated from the floor with prior consent of the nominee. All persons attending the annual meeting shall be required to pay membership dues for that year and be a member of the organization in order to participate. Notice of the annual meeting shall be sent in writing to all members.

6.02 Special Meetings.
Special Meetings may be called by the president or by a majority of the Board and shall be called by the secretary on request of five (5) members in writing. The time and place of special meetings shall be announced at least two (2) weeks in advance.

6.03 Quorum.
At all meetings the members of the corporation present shall constitute a quorum for the transaction of business.

ARTICLE 7: AMENDMENTS

7.01 By The Membership.
These By-Laws may also be altered, amended or repealed and new By-Laws may be adopted by the Board of Directors by affirmative vote of two-thirds (2/3rds) of the members present at a meeting at which a quorum is in attendance.

PAST MEETINGS AND OFFICERS OF THE MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

Meeting	Year	Location	President
1st	1968	St. Mary's College, Winona	Brother George Pahl
2nd	1969	Wisconsin State Univ., La Crosse	Dr. Thomas Claflin
3rd	1970	Winona State College, Winona	Dr. Calvin Fremling
4th	1971	St. Cloud State College, St. Cloud	Dr. Joseph Hopwood
5th	1972	Loras College, Dubuque	Dr. Joesph Kapler
6th	1973	Quincy College, Qunicy	Rev. John Ostdiek
7th	1974	No Meeting	---
8th	1975	Monmouth College, Monmouth	Dr. Jacob Verduin
9th	1976	St. Mary's College, Winona	Mr. Rory Vose
10th	1977	Winona State University, Winona	Dr. Dennis Nielsen
11th	1978	Univ. of Wisconsin-La Crosse	Dr. Ronald Rada
12th	1979	Cancelled	Dr. Edward Cawley
13th	1980	Loras College, Dubuque	Dr. Edward Cawley
14th	1981	Ramada Inn, La Crosse	Mr. M. Vanderford
			Executive Committee
15th	1982	Radisson Hotel, La Crosse	Dr. Richard Anderson Dr. Dave McConville Dr. Jim Wiener
16th	1984	Radisson Hotel, La Crosse	Dr. Ken Lubinski Ms. Rosalie Schnick Dr. M. Smart
17th	1985	Radisson Hotel, La Crosse	Mr. Ray Hubley Dr. John Nickum Ms. Pam Thiel
			Board of Directors
18th	1986	Radisson Hotel, La Crosse	Dr. Jim Eckblad Dr. Carl Korschgen Dr. Jim Peck
19th	1987	Univ. of Wisconsin-La Crosse	Mr. Hannibal Bolton Dr. Leslie Holland Dr. Mike Winfrey

Meeting	Year	Location	Board of Directors
20th	1988	Univ. of Wisconsin-La Crosse	Mr. John Pitlo Mr. Verdel Dawson Dr. Nani Bhowmik
21st	1989	Holiday Inn, La Crosse	Dr. Larry Jahn Mr. Jerry Rasmussen Dr. Bill LeGrande
22nd	1990	Island Inn, La Crosse	Mr. Doug Blodgett Dr. John Ramsey Mr. John Sullivan
23rd	1991	Holiday Inn, La Crosse	Mr. Kent Johnson Dr. Mike Romano Dr. Joe Wlosinski
24th	1992	Holiday Inn, La Crosse	Dr. Richard Anderson Mr. Mike Dewey Mr. Kent Johnson Dr. Joe Wlosinski
25th	1993	Holiday Inn, La Crosse	Dr. Richard Anderson Dr. Teresa Naimo Mr. Chales Theiling Dr. Joe Wlosinski
26th	1994	Holiday Inn, La Crosse	Dr. Teresa Naimo Dr. Mark Sandheinrich Mr. Charles Theiling Dr. Neal Mundahl
27th	1995	Holiday Inn, La Crosse	Dr. Mark Sandheinrich Mr. Rob Maher Dr. Michael Delong Dr. Neal Mundahl
28th	1996	Holiday Inn, La Crosse	Dr. Mark Sandheinrich Ms. J. Therese Dukerschein Dr. Michael Delong Dr. Neal Mundahl

ACKNOWLEDGMENTS

The following persons or institutions have contributed substantially to the planning, execution, support, and ultimately, the success of the 28th Annual Meeting of the Mississippi River Research Consortium. The 1995-1996 Board of Directors gratefully acknowledges their involvement.

Local Meeting Arrangements, Meeting Announcements, and Mailings

Mark B. Sandheinrich, Department of Biology/Microbiology, University of Wisconsin--La Crosse, La Crosse, Wisconsin

J. Therese Dukerschein, Wisconsin Department of Natural Resources and Long Term Resource Monitoring Program, Onalaska, Wisconsin

Michael Delong, Department of Biology, Winona State University, Winona, Minnesota

Neil Mundahl, Department of Biology, Winona State University, Winona, Minnesota

Program and Proceedings

J. Therese Dukerschein, Wisconsin Department of Natural Resources, Long Term Resource Monitoring Field Station, Onalaska, Wisconsin 54650

Registration Table

Georginia Ardinger, U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin

Poster and Display Arrangements

Mark B. Sandheinrich, Department of Biology/Microbiology, University of Wisconsin--La Crosse, La Crosse, Wisconsin

Visual Aids

Aquatic Science Students, Department of Biology & Microbiology, University of Wisconsin-La Crosse

Raffle Prizes

J. Therese Dukerschein, Wisconsin Department of Natural Resources, Long Term Resource Monitoring Field Station, Onalaska, Wisconsin 54650

Platform Session Moderators

Michelle Bartsch, National Biological Service, Upper Mississippi Science Center, Box 818, La Crosse, Wisconsin, 54602

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Mark Sandheinrich, River Studies Center, Department of Biology, University of Wisconsin-La Crosse, La Crosse, Wisconsin 54601

Judges for Best Student Paper Awards and Best Student Poster Award

Names of the judges for best student platform paper and best student poster paper awards were unavailable at the time of printing. Their considerable effort is greatly appreciated.

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Environmental Management Technical Center
National Biological Service
Onalaska, Wisconsin

River Studies Center
Department of Biology & Microbiology
University of Wisconsin-La Crosse
La Crosse, Wisconsin